

A CUMULATIVE FIRE SEVERITY INDEX FOR THE 2000-2008 LINVILLE GORGE WILDFIRES

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INTRODUCTION

The acreage of land burned annually in the Appalachian region has increased steadily over the last thirty years, with the rate of increase nearly doubling in recent years (Lafon and others 2005). Projected increases in fire activity in the southeast due to climate change strongly suggest the area of recently burned land in the southern Appalachian Mountains is likely to continue increasing (Bachelet and others 2001). As a result, there will be a growing need for managers to understand the effects of fires returning to recently burned stands in relation to how repeated fire affects management goals. Unfortunately, information on re-burns in the southern Appalachian Mountains is limited (Arthur and others 1998), and managers in the region can only use inference from past studies from the Western United States for insights into effects of previous fires on re-burn severity (Romme 1982, Thompson and others 2007). With little information available from within the region, it is difficult for land managers in the southern Appalachian region to understand variability and predict wildfire effects.

Past studies on areas subject to re-burn in the Western United States indicate that fire severity depends on the response of live fuels to carry fire (Romme 1982, Thompson and others 2007). The abundant pine regeneration and vigorous sprouting of hardwood trees and ericaceous shrubs typical after fire in the southern Appalachian Mountains suggest that live fuels may respond rapidly and are likely capable of carrying severe fire soon after an initial burn. In this scenario, young pine and oak regeneration may be destroyed prior to reaching maturity, and subsequent regeneration will depend on input of seeds from outside areas. However, if mature pines and oaks can survive them, higher severity re-burns may be more successful than initial burns at eliminating understory shrubs and saplings and reducing litter and duff depth. These effects would further promote regeneration of desirable species [e.g., Table Mountain Pine (*Pinus pungens*)] as well as promoting diversity in the understory.

The occurrence of several large fires from 2000 to 2008 in and around Linville Gorge, North Carolina afforded a unique opportunity to study how landscape characteristics and recent burn history (including sites that burned twice) interact to influence fire behavior in the southern Appalachian Mountains. The specific objectives of this study were to:

- Develop a field-based Composite Burn Index (CBI), based on readily obtainable litter and vegetative characteristics, to quantify fire severity.
- Use the CBI to examine severity patterns in areas subject to initial and repeated wildfire across major environmental gradients.

MATERIALS AND METHODS

Linville Gorge is in the Appalachian Mountains of western North Carolina and contains a 10,843-acre federally designated wilderness area. Steep slopes and complex topography within the gorge create a wide range of environmental gradients, which results in an extremely diverse landscape. From 2000 to 2008, five wildfires burned a large portion of the area in and surrounding Linville Gorge (fig. 1; table 1). The 2000 fire (a.k.a. the Linville Gorge Fire) was the first major surface fire in the area since the 1950s and burned approximately 4,000 acres. In spring 2007, three separate fires (Pinnacle, Dobson Knob, Shortoff Mountain) burned a large portion of the landscape previously burned in 2000, as well as much of the remaining unburned area surrounding Linville Gorge. Another large wildfire (Sunrise) occurred in 2008 and burned much of the area immediately adjacent the area that burned in 2000 and 2007.

A Composite Burn Index (CBI) was applied in 57 plots established across gradients of burn severity in Linville Gorge. The goal was to capture the full spectrum of fire impacts, from low to high severity, in sites burned once or twice. We used a modified version of the Fire Effects

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Citation for proceedings: Waldrop, Thomas A., ed. 2014. Proceedings, Wildland Fire in the Appalachians: Discussions among Managers and Scientists. Gen. Tech. Rep. SRS-199. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 208 p.

Inventory and Monitoring (FIREMON) protocol (Lutes and others 2006) to visually estimate fire effects in four categories within a 50-foot radius of plot center on a 300 point scale. This slight modification of the FIREMON protocol allows variables of local importance to be used. The four categories were percent duff consumption, percent mortality of shrubs, percent mortality of subcanopy trees, and percent mortality of overstory trees. We then summed the fire effects scores for each category (maximum score=1200) to calculate CBI values for each plot. In order to test how well our remotely sensed estimates of fire severity predicted actual fire effects, we created regression models using *RdNBR* values and estimated wildfire effects for each year. A regression model was created for each year using the *RdNBR* and CBI values. The models were then applied to the *RdNBR* raster data for each year to create a spatial model of CBI values within each wildfire. All pixels in each wildfire were then sampled for CBI, elevation, slope, and aspect. We compared the distributions of CBI values across each of these gradients in each landscape.

RESULTS AND DISCUSSION

All wildfires resulted in extremely heterogeneous patterns of fire severity across the landscape, ranging from low levels of litter consumption to total litter and duff consumption and complete midstory and canopy mortality. The distributions of CBI values over major environmental gradients were similar among each of the five burn units, although they were highly variable within each landscape. CBI values were generally higher in landscapes subject to repeated fire and showed similar patterns along gradients in elevation, slope, and aspect (figs. 2-4). Severity was highest at mid to upper elevation on steeper southwestern facing slopes in both cases but was generally higher in re-burned forests.

We propose that re-burn severity in the southern Appalachians is higher due to the rapid response of live vegetation following initial fire. Abundant regeneration of conifers from serotinous cones, a dense layer of sprouting ericaceous vegetation, and large increases in herbaceous cover provide the fine fuels necessary to carry fire. Elevated amounts of dead and downed woods from mortality in the first fire provide larger fuels which increase residence time and heat output. However, if the second fire is soon enough after the first, the forest floor may not have had sufficient time to reach pre-burn levels, thus exposing soil and creating conditions of greater severity.

CONCLUSIONS

The results of this study highlight the utility of linking a field-derived burn severity index with remote sensing for assessing wildfire severity in the southern Appalachian Mountains. Estimates of fire severity were easily generated based on simple field observations, yet they facilitated robust comparisons across a complex mountain landscape. Overall our findings suggest that landscape heterogeneity is a major driver of spatial patterns of fire severity, and that higher severity fires may occur when an area is burned for the second time. This information will benefit land managers as it will help them identify area most severely impacted by wildfire, thereby enabling a more efficient allocation of resources for post-fire rehabilitation and restoration.

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