Fire Severity Assessment in the Allegheny Highlands of Virginia

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Abstract

In 2006, land managers and ecologists from several Appalachian states met to develop approaches for restoring the historic role of fire to oak- and pine-dominated ecosystems throughout the region. This meeting launched the Appalachian Fire Learning Network (FLN), a collaboration of seven agencies, representing four states. During the spring of 2012, wildfires burned approximately 40,000 acres within the Allegheny Highlands of western Virginia, one on the FLN demonstration landscapes. Known as the Easter Complex, these wildfires were an unprecedented event for a region that has not historically experienced wildfires at this scale. The fires affected a variety of ecological systems and national forest management areas, including previously treated prescribed burned areas and designated wilderness. The fires resulted from a variety of ignition sources and were managed through a combination of natural progression and different firing techniques and patterns. Taking advantage of the opportunity to learn about the effects of fire on a landscape-scale, FLN partners embarked upon a fire severity assessment in summer 2012, utilizing Rapid Assessment of Vegetation Condition after Wildfire (RAVG) satellite imagery and the Composite Burn Index (CBI) protocol. The goals of the study include: mapping fire severity in conjunction with firing patterns and techniques, illustrating variances in fire severity throughout wildfire and prescribed fire areas, and evaluating the Easter Complex as a case study for wilderness area management. The assessment will continue through the 2014 growing season to evaluate long-term fire effects with the aid of Monitoring Trends in Burn Severity satellite imagery.

Project Site

The Fire Severity Assessment project sites are located in the Allegheny Highlands in western Virginia (Figure 1). The sites are comprised of three incidents, which total 20,422 acres. The Porter's Mill (838 acres) and Rich Hole wildfires (15,279 acres) were part of the Easter Complex which took place in April 2012, and the Big Wilson prescribed burn (4,305 acres) was a controlled burn conducted in two phases during March and April 2012 (Figures 3-4). The Porters Mill wildfire and Big Wilson prescribed burn are included in an 18,000-acre collaborative forest restoration project spanning the George Washington and Jefferson National Forest and The Nature Conservancy's Warm Springs Mountain Preserve. Located in the Ridge and Valley province, the site is typical of a region characterized by linear, even ridges, with long, continuous valleys in between. Elevations in the burned areas range from 1100 feet to 3,800 feet. Central Appalachian Dry Oak-Pine Forest, Southern Appalachian Oak Forest, and Northeastern Interior Dry-Mesic Oak Forest are the dominant ecological systems in the project sites (Simon 2011). Bedrock along the ridge is primarily Tuscarora sandstone, a resistant and thick white quartzite, with calcareous mudstones, shale, and other sandstones underlying the lower slopes (Ludwig et al. 1999). Temperature averages 10.5°C annually, with a maximum average of 21.6°C in July and a minimum of -1.1°C in January (NWS 2010). Precipitation averages 1,085 mm per year, with May the wettest month and December the driest. The site receives approximately 660 mm of snow annually (NWS 2010).

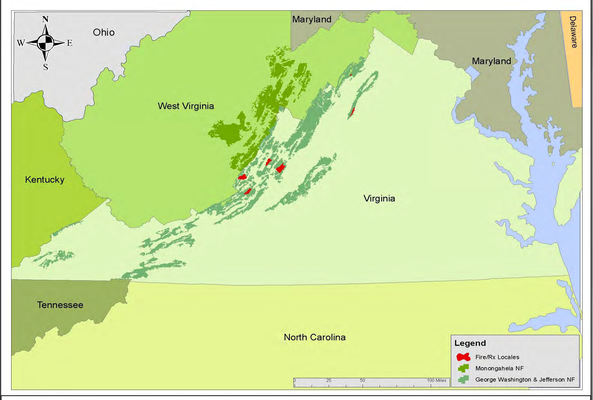


Figure 1: Vicinity map of Easter Complex site and Fire Severity Assessment in the Allegheny Highlands of Virginia project site. *Map by John Moncure USFS*

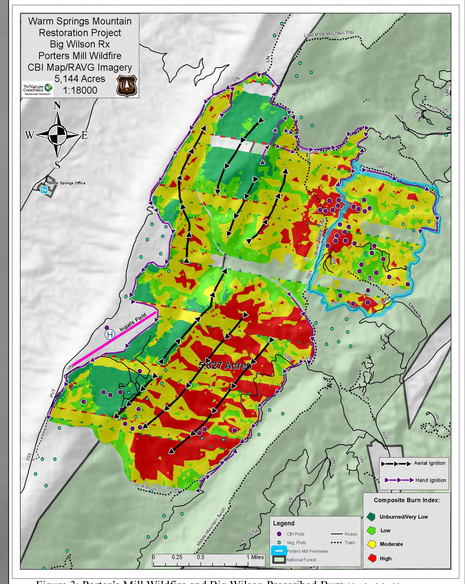


Figure 3: Porter's Mill Wildfire and Big Wilson Prescribed Burn *Map by John Moncure*

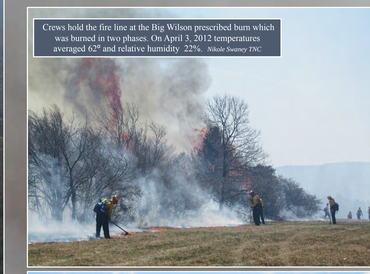
Objectives

- Demonstrate relationships between firing patterns and techniques with observed fire severities.
- Illustrate variances in fire severity throughout the Rich Hole and Porter's Mill wildfire areas and the Big Wilson prescribed burn area.
- Identify variations between CBI scores results and RAVG imagery data.
- Use fire severity analysis for a case study in wilderness area fire management

Aerial view of backing and flanking fire on the Rich Hole wildfire which burned a total of 15,279 acres and the entire wilderness management area on the Warm Springs Ranger District of the George Washington & Jefferson National Forest, located near Covington, VA. *John Moncure USFS*

Methods

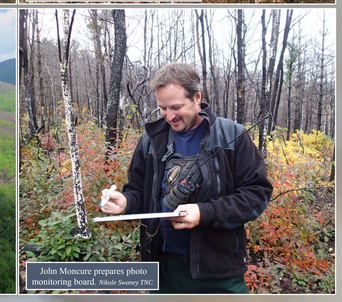
Composite Burn Index (CBI) surveys were conducted using a method developed by the United States Geological Survey (USGS); Northern Rocky Mountain Science Center. Survey plots were established using RAVG satellite imagery from the Remote Sensing Applications Center. The imagery was arranged and displayed by severity levels; Unburned-Very Low, Low, Moderate, and High burn severities. The RAVG data was downloaded to a Trimble GPS (Juno SB) which was used as a guide to locate areas representing all of the displayed severities. For every CBI plot surveyed, a GPS waypoint was collected and four photo points were taken in each cardinal direction (Figures 7-9). Data was collected during the first growing season post burn event. When evaluating burn severity with the CBI, fuel and fire behavior relationships are emphasized while strata species composition was less important. The main objective was to make reasonable interpretations on 1 to 5 strata and then combine those to derive composite ratings which summarize severity throughout the understory, overstory, and the total plot. The strata was defined by five categories; 1) substrates-rock, soil, duff, litter, and downed woody fuels 2) herbs, low shrubs and trees less than 1 meter (3ft) 3) tall shrubs and trees 1 to 5 meters (3 to 16 ft.) 4) intermediate trees (pole-sized trees, sub canopy) 5) big trees (dominant and co-dominant trees, upper canopy). The goal was not so much a high degree of precision in rating a specific factor, as it was a consistent rating of severity that aggregates a variety of burn-effects over multiple levels of the plot (Key and Benson 2006). All data was collected in the field on CBI survey forms and then entered into a FEAT and FIREMON Integrated (FFI) database where values were calculated and used to generate an overall CBI rating. These ratings were given a value of 0.0-<0.3 Unburned to Very Low, 0.3-<1.3=Low, 1.3-,<2.4=Moderate, 2.4-3=High burn severity (Key and Benson 2008).



Crews hold the fire line at the Big Wilson prescribed burn which was burned in two phases. On April 3, 2012 temperatures averaged 62º and relative humidity 22%. *Nikole Swaney TNC*

Justin Showalter conducts hand ignitions in the Porter's Mill drainage *Beth Buchanan USFS*

Examples of contour and ridge ignition on Brushy Mountain in the Big Wilson prescribed burn. Photo taken one month after burn was conducted. *Marek Smith TNC*



John Moncure prepares photo monitoring board. *Nikole Swaney TNC*

Figure 4: Rich Hole Wildfire *Map by John Moncure*

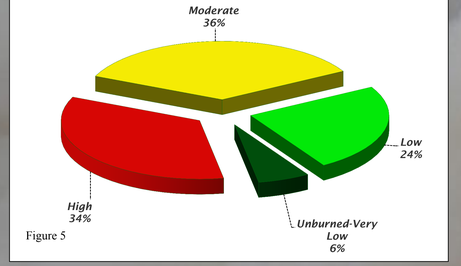


Figure 5

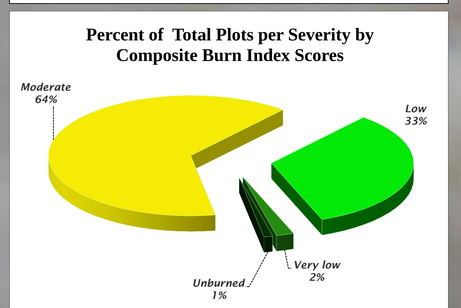


Figure 6

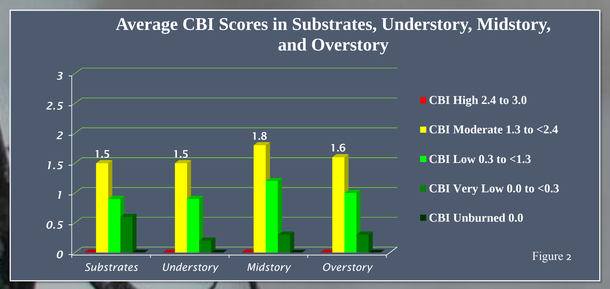


Figure 2

Table 1: Average CBI Strata

CBI Strata Averages Throughout the Fire Severity Assessment	Average Substrate	Average Herbs / Low Shrubs	Average Tall Shrubs / Trees 3-16 feet	Average Intermediate Trees	Average Big Trees	Average Understory	Average Overstory	Average Total Plot
RAVG High	1.4	1.4	1.7	1.6	1.5	1.5	1.5	1.5
RAVG Moderate	1.0	1.1	1.5	0.7	0.6	1.2	1.2	1.0
RAVG Low	0.8	0.7	1.0	0.3	0.2	0.8	0.8	0.6
RAVG Very Low-Unburned	0.6	0.6	0.8	0.6	0.1	0.7	0.7	0.5

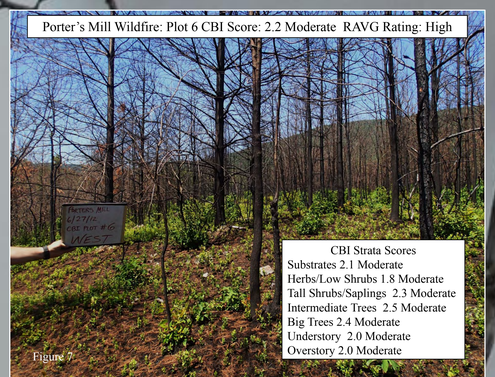


Figure 7

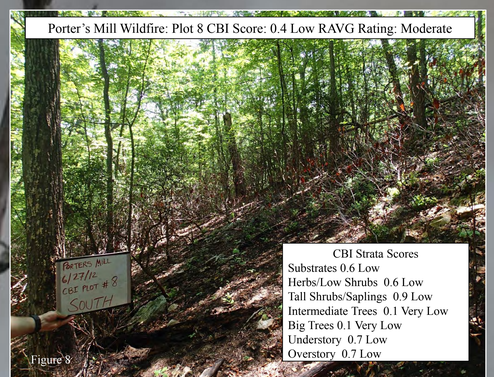


Figure 8

Figure 9

Results and Discussion

Ninety plots, stratified by RAVG severity types, were sampled using CBI methodology across the three incidents (Figures 3-4). Although plots were initially designed to be stratified evenly across high, medium and low severity types, some plots were placed into projected unburned or very low severity areas, resulting in a slightly uneven distribution (Figure 5).

During this assessment it was evident that a significant difference between the CBI scores and RAVG imagery projections existed. Although RAVG data displayed areas of high burn severity, CBI "ground truthing" categorized these areas in the moderate category (Figure 6, Table 1). There were no plots that scored high severity. Sixty four percent of CBI plots scored moderate with an average score of 1.5. Thirty three percent of CBI plots scored low with an average of 0.6. Two percent of CBI plots scored very low with an average of 0.5. One percent of CBI plots scored unburned with an average of 0.0. The highest overall plot CBI score was 2.2 (moderate) and the lowest was 0.0 (unburned). These results suggest an overestimation of observed burn severity by RAVG imagery and the need to further research RAVG calibration for eastern forests.

Additional examination of observed fire severities via CBI within strata categories revealed a range of variation (Figure 2). For analysis purposes, intermediate trees and big trees were grouped to represent overstory, while tall shrubs and trees 1-5 m, herbs, low shrubs, and trees <1 m tall were assumed to represent midstory and understory, respectively. The average CBI score for the substrate strata was 1.1 (low). This suggests that, although litter and light fuels were consumed, duff layers were minimally impacted, and mineral soil remained intact. Substrata scores ranged from a low of 0.4 to a high of 2.2. The average CBI score for the understory was 1.2 (moderate) with a range from 0.2 to 2.1. The average midstory score was 1.4 (moderate) and the average overstory score was 1.2 (low), with ranges of 0.3 to 2.6 and 0.2 to 2.0, respectively. Though subtle, midstory appeared to be more susceptible to high and moderate fire effects and fire's influence on overstory was relatively low.

Although differences between strata were apparent, fire severities also varied based upon slope and ignition sequences. In areas where slope aligned with ignition operations, particularly where aerial and hand ignitions were conducted along contours, uphill runs occurred and canopy mortality was more prevalent. Backing and flanking fire occurred in areas where aerial and hand ignitions were conducted along ridge tops, thus reducing fire severity. Time of day for ignition operations was also significant, with changes in hourly weather conditions directly affecting fire intensity.

As shown on the RAVG image maps (Figures 3-4), band-width display errors show lines of missing data. These scan line errors caused discrepancies in plot placement and stratification. In spring of 2003, Landsat 7 developed this now well-known scan line corrector problem, which results in missing lines of data through portions of each scene. This data can still be used in some burn assessments, where missing data does not impact the burned area, or where multiple scenes can be patched together to fill the missing lines (Key and Benson 2006). RAVG imagery depends heavily upon the satellite's ability to filter through the forest canopy. The canopy in many places in the project site was dense, which may have also produced less accurate image data.

The results of this CBI survey have presented the opportunity to ask the question whether CBI protocols can be revised or adjusted to more accurately reflect the fire effects of Appalachian forests. The assessment of fire severity in the Rich Hole Wilderness Area serves as documentation for further analysis of fire management activities in congressionally designated wilderness areas. This also fosters debate for fire management and a continued fire regime within wilderness areas on the George Washington and Jefferson National Forest.

Literature Cited

Key, C.H., Benson, N.C., 2006. Landscape Assessment Sampling and Analysis Methods. USDA Forest Service General Technical Report, RMRS-GTR-164-CD.

Key, C.H., Benson, N.C., 2008. Summary Descriptions of General Burn Severity Categories. Northern Rocky Mountain Science Center. nrmsc.usgs.gov/science/fire/cbi/severity_def

Ludwig, J.C., Roble, S.M., and Fleming, G.P. 1999. A preliminary natural heritage inventory of Warm Springs Mountain, Bath County, Virginia. Natural Heritage Technical Report 99-19. Virginia Department of Conservation and Recreation.

National Weather Service (NWS). 2012. NOAA Online Weather Data. Retrieved October 1, 2012 from http://www.weather.gov/climate/xmacis.php?wfo=rnk

Simon, Steven A. 2011. Ecological Zones on the George Washington National Forest: First Approximation Mapping. The Nature Conservancy, Virginia Field Office. Unpublished report.