Five Years of Monitoring Forest Structure and Composition for a Landscape-Scale Controlled Burning Project in the Allegheny Highlands of Virginia

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Abstract and Introduction

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 and Southern Blue Ridge Fire Learning Networks (FLN), a collaboration of ten demonstration landscapes representing nine states. Partners in the Allegheny Highlands FLN, one of those landscapes, spent two years working through a four-step process designed to develop the scientific basis for landscape-scale fire restoration and management and then launched their first demonstration project along the eastern slope of Warm Springs Mountain in Bath County, Virginia. Centered along a 21-km shared boundary between The Nature Conservancy's Warm Springs Mountain Preserve and the George Washington National Forest (GWNF), the 18,000-acre[1] project area includes eleven burn units ranging in size from 150 to 5,600 acres. From May 2008 to May 2012, the Conservancy, GWNF and other FLN partners have conducted controlled burns on four burn units totaling nearly 6,000 acres. To document baseline (pre-burn) conditions and assess changes in forest structure and composition due to controlled burning, macroplots randomly stratified by ecological system type were monitored using a nested plot design and data recorded for species at all strata layers. Results from pre- and post-burn monitoring of macroplots where burns have been implemented indicate changes in woody stem densities, size class distribution and species composition. Changes in canopy cover and basal area also indicate progress towards collaboratively-developed management objectives for the project area.

Northern red oak (*Quercus rubra*) acorn germinating.

Methods

To document baseline (pre-burn) conditions and assess changes in forest structure and composition due to controlled burning, macroplots randomly stratified by ecological system type were monitored using a nested plot design and data recorded for species at all strata layers. Macroplot centers were generated in ArcGIS using Hawth Tools to be at least 30 m from a road or trail, and 30 m apart to avoid duplicate sampling. Macroplot centers were georeferenced in the field with a handheld global positioning system unit and marked with steel rebar. Within each macroplot, a BAF 10 prism was used to determine basal area and tally individual live and dead (snag) trees. Within a 3.59 m radius circular sample (0.01 acre), all woody tree and shrub stems > 1 m tall were counted and their diameter at breast height (dbh) recorded in two size classes: <2.5 cm and 2.5-10 cm dbh. Within four 1 m² quadrats located 3.59 m from macroplot center in four cardinal directions, all woody stems 15 cm to 1 m in height were counted and the percent aerial cover of graminoids, forbs, woody trees/shrubs, woody vines, and non-native invasive species was estimated using six cover classes (1=<1%, 2=1-5%, 3=6-25%, 4=26-50%, 5=51-75%, 6=76-100%). Using a Geographic Resource Solution densitometer, canopy cover (categorized as evergreen or deciduous) was determined at five points along each of four transects (20 points total) located in the cardinal directions from macroplot center. Two photographs were taken from the center of each macroplot, one facing south and one facing north. All macroplots were visited and data recorded at least one growing season prior to conducting a controlled burn (pre-burn or baseline condition) and re-visited the first growing season one-year after a controlled burn (post-burn). Macroplots will be re-visited five years after pre-burn monitoring if no controlled burns are conducted. All data was entered in Microsoft Excel and analyzed using JMP statistical software (SAS Institute, Inc.).

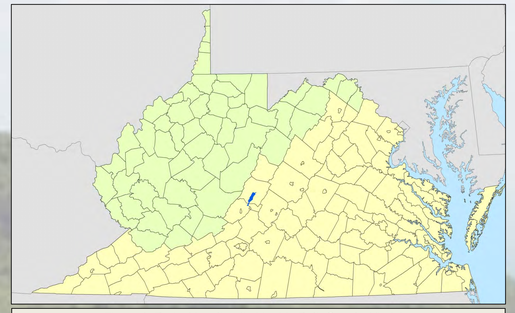


Figure 1: Project location (in blue) in Bath County, Virginia.

Controlled burn conducted in Mare Run unit, May 2008.

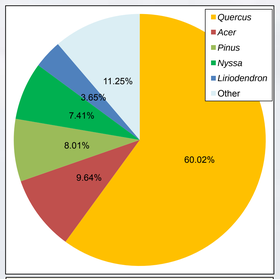


Figure 3: Pre-burn relative frequency of woody species groups in plotless prism samples.

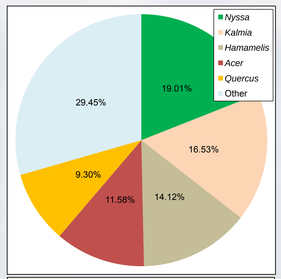


Figure 4: Pre-burn relative frequency of woody species groups in stem counts 2.5-10 cm dbh.

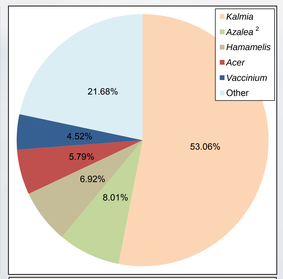


Figure 5: Pre-burn relative frequency of woody species groups in stem counts <2.5 cm dbh.

	All Macroplots	Oak Forests	Pine Forests	Mesic Forests
Total # of Macroplots	225	168	32	25
Mean # Live Stems 2.5-10 cm dbh/acre	617.33	581.52	878.13	550.00
Mean # Live Stems <2.5 cm dbh/acre	1916.32	1795.70	2415.63	2155.56
Mean Live Basal Area (feet²/acre)	75.87	74.97	81.88	74.82
Mean Snag Basal Area (feet²/acre)	2.99	3.09	0.94	2.99
% Total Canopy Cover	92.96%	93.57%	80.71%	96.11%
% Evergreen Canopy Cover	5.68%	5.73%	12.14%	2.04%
% Deciduous Canopy Cover	87.28%	87.83%	68.57%	94.07%
Mean % Graminoid Groundcover	0.65	0.42	2.45	0.18
Mean % Forb Groundcover	8.65	7.41	11.99	9.28
Mean % Tree/Shrub Groundcover	19.54	20.95	30.52	11.41
Mean % Vine Groundcover	0.81	0.73	0.99	0.87
Mean % Non-native Groundcover	0.22	0.04	0.00	0.66
Mean # of Regenerating Oak Stems/m²	0.67	0.62	1.66	0.39
Mean # of Regenerating Pine Stems/m²	0.005	0.002	0.036	0.000
Mean # of Regenerating Fire-intolerant Stems/m²	13.71	15.17	17.40	4.22

Table 1: Summary of pre-burn forest structure characteristics.

Figure 2: Map of Warm Springs Mountain Restoration Project area.

Project Site

The Warm Springs Mountain Restoration Project is located in western Virginia, approximately 15 km from the West Virginia border (Figures 1-2). The Project spans 3,700 acres of the Warm Springs Mountain Preserve, owned by The Nature Conservancy, and over 14,600 acres of the adjacent George Washington National Forest. Elevations range from approximately 580 m above sea level near Mare Run in the northeastern portion of the site to 1287 m at Bald Knob, the highest elevation in the area. 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. Bedrock along the ridge is primarily Tuscarora sandstone, a resistant and thick white quartzite, with calcareous mudstones, shales, 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). Central Appalachian Dry Oak-Pine Forest, Southern Appalachian Oak Forest, and Northeastern Interior Dry-Mesic Oak Forest are the dominant ecological systems in the study site (Simon 2011).

Smoke plume along western fireline of Mare Run controlled burn.

Figure 6: Number of live woody stems with dbh 2.5-10 cm per acre for plots monitored pre-burn and one year post-burn.
* Paired t-test, N=62, correlation=0.72, p<0.0001

Figure 7: Number of live woody stems with dbh <2.5 cm per acre for plots monitored pre-burn and one year post-burn.
* Paired t-test, N=62, correlation=0.60, p=0.002

Literature Cited

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.

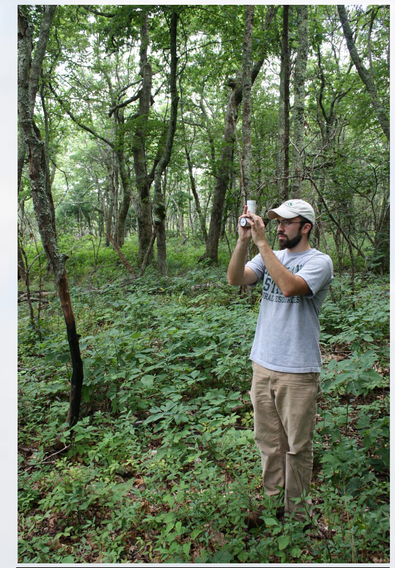
National Weather Service (NWS). 2012. NOAA Online Weather Data. Retrieved October 1, 2012 from http://www.weather.gov/climate/xmacis.php?wfo=rnk

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

[1] Acre used as primary unit of area with a few exceptions. 2.47 acres = 1 hectare
[2] Azalea denotes *Rhododendron periclymenoides*; used to distinguish from *R. maximum* and *R. catawbiense*

Photos taken facing south within plot 8-8 during growing seasons of 2008 (pre-burn), 2011 (one year post-burn), and 2012 (two years post burn).

Sassafras albidum regeneration in plot 10-03 one year after the second controlled burn in the unit.



Sampling one-year post-burn canopy cover using a densitometer.

Results

During the growing seasons of 2007-2010, 225 macroplots were sampled for pre-burn conditions throughout all 11 burn units. The canopy, determined from plotless prism samples, was dominated by oak (*Quercus* spp.), with maple (*Acer* spp.), pine (*Pinus* spp. not including *Pinus strobus*), and blackgum (*Nyssa sylvatica)* next in importance (Figure 3). Midstory and understory layers, determined from stem counts in the 2.5-10 cm dbh and <2.5 cm dbh size classes, were dominated by more mesophytic species including blackgum, witch hazel (*Hamamelis virginiana*), and maple, along with ericaceous shrubs including mountain laurel (*Kalmia latifolia*), pinxter azalea (*Rhododendron periclymenoides*), and blueberry (*Vaccinium* spp.) (Figures 4-5). Importance by size class (2.5-10 cm dbh and <2.5 cm dbh) for oak (9.30% and 2.6%, respectively) and pine (0.07% and 0.0%, respectively) was far less for these two lower strata than the canopy layer. Overall pre-burn forest structure is best described as a closed canopy with dense midstory and understory, sparse groundcover, and negligible oak and pine regeneration (Table 1).

After controlled burns on three units, 62 macroplots were re-sampled for post-burn conditions. Woody stem densities in the 2.5-10 cm dbh and <2.5 cm dbh size classes were significantly reduced (Figures 6-7). Canopy cover was also reduced from 92.50% to 85.83% (Table 2). Seven plots were re-sampled after a second controlled burn (three years after the first) in the Bear Loop unit. Stem densities remained significantly reduced from pre-burn conditions, but a shift in species composition is apparent with sassafras (*Sassafras albidum*) and mountain laurel now dominating the 2.5-10 cm dbh size class (Figure 8).

Canopy Cover Type	Pre-Burn %	Post-Burn %
Deciduous	79.17	75.83
Evergreen	13.33	10.00
None	7.50	14.70

Table 2: Canopy cover by for plots monitored pre-burn and one year post-burn.

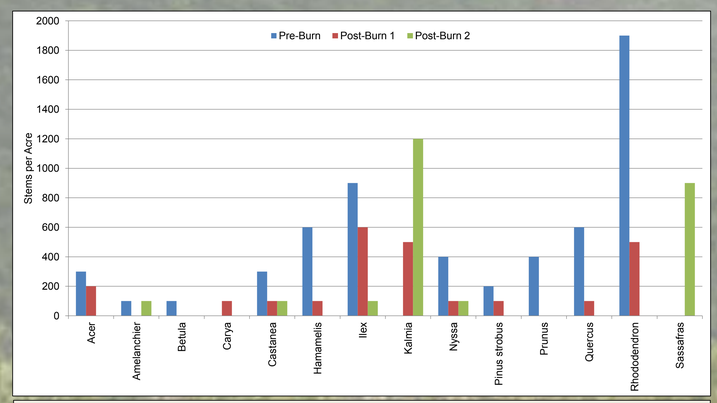


Figure 8: Live woody stems with dbh 2.5-10 cm per acre for species groups in the Bear Loop unit after two controlled burns.