



Southern Appalachian/Piedmont Fire Effects Monitoring Annual Report, 2015



Plot 26 Preburn – Bodie Island 1.3, Cape Hatteras NS



Plot 26 Year 2 Postburn – Bodie Island 1.3, Cape Hatteras NS

On the Cover:

Repeated photos from Plot 26 at the Bodie Island 1.3 burn unit of Cape Hatteras National Seashore provide clear evidence that burning has been effective at meeting goals for shrub reduction in marsh habitat.

Southern Appalachian/Piedmont Fire Effects Monitoring Annual Report, 2015

Robert N. Klein Jr.

E. Wylie Paxton

J. Matthew Wood

National Park Service

Southern Appalachian/Piedmont Fire Effects Monitoring Program

Great Smoky Mountains National Park

107 Park Headquarters Road

Gatlinburg, TN 37738

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Introduction

The Southern Appalachian/Piedmont fire-effects monitoring team conducted pre-burn, pre-mechanical treatment, short-term, and long-term vegetation and fuels monitoring at seven NPS units during 2015 (**Table 1**), and also supported prescribed burning operations at four parks (**Table 2**). The annual total for plots completed was 100 (**Table 1**), which is indicative of a very productive year. The majority of the workload involved monitoring of short and long-term fire effects in NPS-standard FMH forest plots. However, increased reliance on faster, non-FMH, data collection methods has allowed the crew to actually increase the number of plots over past years, even as we are completing work at a larger number of parks.

Every forested area that was burned in our park network during 2015 contained long-term monitoring plots (**Table 2**). This included interesting third-entry burns at Arbutus Ridge and Wash Ridge at GRSM, a third burn of the Turkeybeard site at KIMO, the third prescribed burn of Darrow Ridge at BISO (4th total burn since 2001), and the second burn of Hoot Owl Hollow at



The third-entry burn at Wash Ridge (GRSM) was very effective at top-killing re-sprouting Mountain Laurel. Note the open stand conditions that have been created from three dormant-season prescribed burns.

CUGA. These sites that have now had three burns offer exciting opportunities to gain much more substantial knowledge about the long term process of restoring fire-maintained forests and woodlands. Each of these units will be a site of additional monitoring in the upcoming year.

Other highlights from the past year include the development and implementation of a newly designed protocol for monitoring the effects of mechanical fuel reduction at Congaree National Park. The crew installed 17 new, pre-treatment monitoring plots in a 100-acre project area adjacent to the park's

Visitor Center, and will be re-reading those plots after the treatment is completed. The crew also established 7 plots in the Air Bellows Burn Unit at BLRI using a new monitoring protocol that combines ground-based sampling with dNBR Burn Severity Mapping. This protocol is designed to maximize the coverage of monitoring in parks where the amount of time for fieldwork is heavily constrained. Finally, the crew had a very successful week of monitoring at Cape Hatteras National Seashore, re-sampling 12 plots in the Bodie Island 1.3 unit. Again, monitoring at CAHA is designed to maximize coverage, while assessing management goals for shrub reduction and exotic plant management. More details and results from these exciting monitoring trips are provided in each park's respective section of this report.

**Table 1. Appalachian/Piedmont Fire Effects Monitoring Program:
2015 Plot Workload and Total Plots Installed**

Park	Monitoring Unit	Plot Type	Pre-burn 2015	Immed. Post 2015	Postburn (1-20 yrs) 2015	Annual Total (2015)	Total Plots
Big South Fork (BISO)	Little Bluestem	FMH Forest Plot		1	1	2	4
	Shortleaf Pine	FMH Forest Plot				0	2
	White Oak	FMH Forest Plot		1	1	2	13
	LFEM	Modified FIREMON Species Composition			5	5	12
	CBI	CBI				0	9
	Fuels Transect	Fuels Transect				0	4
Blue Ridge Parkway (BLRI)	Chestnut Oak	FMH Forest Plot				0	2
	LFEM	Modified FIREMON Species Composition	7			7	7
	Fuels Transects	Fuel Transect				0	6
	Photo Points	Photo Point				0	2
Cape Hatteras (CAHA)	LFEM	Modified FIREMON Species Composition			12	12	15
	Photo Points	Photo Point			12	12	33
Congaree (CONG)	Loblolly Pine	FMH Forest Plot				0	5
	Longleaf Pine	FMH Forest Plot				0	5
	Harry Hampton Mastication (LFEM)	Modified FIREMON Species Composition	17			17	17
Cowpens (COWP)	Southern Red Oak	FMH Forest Plot				0	2
Cumberland Gap (CUGA)	Scarlet Oak	FMH Forest Plot		2	2	4	16
	LFEM	Modified FIREMON Species Composition				0	7
Great Smoky Mountains (GRSM)	Black Oak	FMH Forest Plot			4	4	8
	Scarlet Oak	FMH Forest Plot	1	5	6	12	16
	Yellow Pine	FMH Forest Plot	1	5	7	13	29
	LFEM	Modified FIREMON Species Composition				0	29
	CBI					0	70
	Fuels Transect	Fuels Transect				0	3
Kings Mountain (KIMO)	Blackjack Oak	FMH Forest Plot		3	4	7	8
	Chestnut Oak	FMH Forest Plot			3	3	21
	LFEM	Modified FIREMON Species Composition				0	18
	Fuels Transect	Fuels Transect				0	3
Moore's Creek (MOCR)	Photo Points	Photo Point				0	2
Total			26	17	63	100	368

Looking at the bigger picture, the Fire Effects/Fire Ecology program continued to make progress in advancing important long-term programmatic goals: customizing monitoring to meet the wide-ranging needs of numerous fire programs, collaboration with other NPS fire ecology programs to advance the science of monitoring in eastern systems, promoting research that advances the science and education goals of parks and the NPS, and communicating results to various partners to improve fire management planning and outcomes throughout the region.

Table 2. Summary of 2015 Prescribed Burns and Monitoring

Park	Burn Unit	Plots?	Other Monitoring	Acres
Big South Fork (BISO)	Darrow Ridge	Yes (Full Plots)	Yes (Qualitative, LFEM)	528
Cumberland Gap (CUGA)	Hoot Owl Hollow	Yes (Full Plots)	Yes (FEMO, Qualitative)	105
Great Smoky Mountains (GRSM)	Arbutus Ridge	Yes (Full Plots)	Yes (FEMO, Qualitative)	877
	Wash Ridge	Yes (Full Plots)	Yes (FEMO, Qualitative)	562
	Tipton Oliver	No	No	80
Kings Mountain (KIMO)	Turkey Beard	Yes (Full Plots)	Yes (FEMO, Qualitative)	61
	East Garner	Yes (Full Plots)	Yes (FEMO, Qualitative)	207
Total	7	6	6	2420

Another major advance for the fire effects monitoring program in 2015 was the start of a transition to digital data collection. Late in 2014, the program was able to purchase two Panasonic Toughpad tablets. After some delays, the crew was able to begin incorporating the tablets into plot data collection, ultimately collecting field data at two of our parks. Equipped with excellent GPS and GIS capabilities, the tablets also provide a superior way to view, interact with, and map spatial data in the field. So far, the tablets and the mobile version of the fire-effects database (“FFI Lite”) have performed well in the field, and this system provides an enormous benefit by greatly reducing data processing in the office. Current plans are to fully implement digital data collection during the 2016 field season, and to develop mapping projects that support fire and resource management goals at our parks.

For most of 2015, the Fire Ecology/Fire Effects Monitoring program was fully staffed in accordance with approved future target organization (FTO) levels (**Table 3**). With the departure of Bob Dellinger in July (to become the Lead Monitor at Big Thicket NRR), a critical vacancy was created, and we are hoping to fill that position after we receive a final FY16 budget. We also expect to fill a temporary position for the summer field season.

Table 3. Fire Ecology/Fire Effects Staffing 2015

Ecologist and Monitors	Starting Date	Ending Date	# of Pay Periods	READ Qualified (Yes or No)	Training and Development
Rob Klein (Fire Ecologist)	1/1/15	12/31/15	26	Yes	Acting Regional Fire Ecologist and Acting GRSM FMO. Guest lectures at Western Carolina University and Congaree NP Fire Education Workshop. FMP/EA Scoping and review at Kings Mt. NMP, Congaree NP and Chickamauga-Chattanooga NB. Provided major review for white paper on NPS policy on Fire & Climate Change. Co-author on two refereed publications. 2 week fire assignment on Engine Crew to Canyon Creek Complex Oregon.
Wylie Paxton (Lead Monitor)	1/1/15	12/31/15	26	Yes	Participated in Carolina Vegetation Survey annual PULSE, and Southern Blue Ridge FLN meeting. NCTC wetland plant identification training; Attended 2nd annual Shortleaf Pine workshop. Prescribed burns CUGA, GRSM, KIMO. HECM Fire Assignment to Texas. FFT2 Cherokee Indian Reservation.
Matt Wood (Assistant Lead)	1/1/15	12/31/15	26	No	Attended Southern Blue Ridge FLN meeting. Prescribed burns at GRSM, and KIMO. Wildfires at GRSM and Cherokee Indian Reservation.
Bob Dellinger (STF Crewmember)	3/10/15	7/26/15	12	Yes	Participated in Prescribed fires at GRSM and KIMO. Disembarked for a new career as Lead Monitor at Big Thicket National Preserve
Cynthia Worthington (Seasonal Crewmember)	6/15/2015	10/16/15	9	Yes	READ assignment on the Sierra National Forest California

Research Update

Research partnerships continue to provide important data to fill in knowledge gaps and help guide our understanding of natural resources and fire management. 2015 saw the completion of three peer-reviewed scientific papers based on research done in Great Smoky Mountains NP (GRSM). In a paper that ranks in the top-tier of published work on Appalachian fire ecology, Dr. Will Flatley and his co-authors document the interplay between three centuries of fire history and forest succession in an old growth pine-oak stand of western GRSMNP. Two other papers were prepared and accepted for publication in 2015, and have just been published in early 2016. These papers analyzed 20-years' worth of NPS fire-effects monitoring plot data and dNBR burn severity data, and provide insights into fire restoration efforts that are applicable across a broad swath of the interior eastern U.S.

Additional research highlights from the past year include completion of "Historic Fire Regimes and Pre-European Settlement Vegetation of the Kings Mountain Region" by Cecil Frost. This was a project funded by NPS Fuels Reserve Research Funds, and marks the continuation of a strong research partnership between NPS and Dr. Frost. Since 2001, Dr. Frost has completed similar work on historic fire regimes and vegetation at Congaree NP, Big South Fork NRR, and Mammoth Cave NP. The reports and spatial data from his work provide invaluable insight into project prioritization and long-term fire restoration objectives.

These and other research partnerships are briefly described in the sections below. Facilitating great research and continued interest in the study of our National Parks is a key role for our Fire Ecology Program, and these activities are well-aligned with the mission and policies of the National Park Service and the goals of the NPS Centennial ***Call to Action***. Please contact Rob Klein with any research needs, ideas, or interested partners.

Regionwide Projects

There were no region-wide collaborations in 2015, but the groundwork was laid for some interesting work in the coming years. Several NPS Fire Ecologists were listed as Collaborators or Co-Principal Investigators for 2 Joint Fire Science Program (JFSP) proposals. Both projects, if funded, will seek to combine fire-effects data from multiple NPS units in the SER, NER, and MWR for major analyses:

- "Leveraging multiple data sets to guide effective timing of prescribed burns in Appalachian pine-oak forests" with Dr. Will Flatley, Northern Arizona University
- "Creation and validation of postfire mortality models across the southern United States" with Dr. Tara Keyser and Virginia McDaniel, USFS SRS.

These projects would add tremendous value to NPS monitoring efforts, both regionally and at the individual park level. Hopefully these projects will receive funding grants, and we will be hearing more about them in the coming year.

Great Smoky Mountains National Park

- **Southern Appalachian Dendrochronology/Fire History Study**

This project was originally funded by JFSP in 2006, and has produced a wealth of benefits for GRSM and the Southern Appalachian region. The third publication by Drs. Will Flatley, Charles Lafon, and co-workers was published in 2015:

Publication: Flatley, W.T., C.W. Lafon, H.D. Grissino-Mayer, L.B. LaForest. 2015. *Changing fire regimes and old-growth forest succession along a topographic gradient in the Great Smoky Mountains*. Forest Ecology and Management. Vol. 350: pp. 96-106.

This paper builds on the 300-year fire chronology for several Southern Appalachian sites that Flatley published in 2013. The current paper focuses on one of those locations: the Licklog Branch study site in GRSM. Here, the researchers inventoried and cored 1477 trees from 15 plots in five forest types. Tree composition and age data were then used to characterize tree establishment and stand dynamics in the different forest types during three distinct disturbance periods: 1) Frequent Fire Period 1700-1909, 2) Post-Fire Period 1910-1949, 3) Mesophication Period 1950-2000.

Results showed that xerophytic species (pines and oaks) dominated tree establishment during the frequent fire period, a mix of mesophytic and xerophytic species dominated establishment during the post-fire period, and mesophytic species have dominated establishment during the most recent mesophication period. The highly detailed, data-rich story contained in this paper provides an incredible example of how fire had an overriding effect on vegetation dynamics in several forest types for over 200 years prior to park establishment. Finally, it also clearly illustrates how landscape diversity has been dramatically reduced since the removal of fire nearly 100 years ago.

- **Multivariate Analysis of NPS Fire Effects Monitoring Data**

This work was part of Naomi Schwartz's M.S. thesis project at UNC Chapel Hill under Dr. Peter White. For the project, Naomi performed an original set of multivariate analyses on 20 years of fire-effects monitoring data collected by the staff at GRSM. The first publication of this work just came out in early 2016. The findings indicate that fire consistently reduces stand density and shifts plots towards lower shrub cover and higher herbaceous cover. However, this analysis indicated that compositional shifts were more variable, underscoring one of the challenges of restoring fire to long-unburned sites. Interestingly, fire severity (as measured by litter and duff reduction) was found to be important for predicting fire effects. These results are consistent with previous findings from our fire-effects monitoring, and seem to confirm that restoration of pine and oak systems is a multi-stage process that can be somewhat regulated by fire severity.

Publication: Schwartz, N.B., D.L. Urban, P.S. White, A. Moody, R.N. Klein. 2016. *Vegetation dynamics vary across topographic and fire severity gradients following prescribed burning in Great Smoky Mountains National Park*. Forest Ecology and Management. Vol. 365.

- **Using Burn Severity Maps to Understand Patterns of Bird Occurrence in GRSM**

For his M.S. thesis project, Eli Rose (North Carolina State under Ted Simons) collected three field seasons of new data on bird occurrence in recently-burned sites within GRSM. The first publication of Eli's work also just came out in early 2016. The main question addressed in this publication was: How useful are dNBR burn severity maps for explaining patterns of selected bird occurrence in burned sites? The park currently has such Landsat-based burn severity maps for over 30 fires that have occurred since the late 1980's, and continues to generate these maps for almost all new fires. This research is a major contribution in developing the potential uses of severity mapping, and addresses several major goals of the fire-effects monitoring program – including building knowledge of fire effects on non-vegetative species, and developing the use of severity maps to help quantify fire effects.

Publication: Rose, E.T., T.R. Simons, R. Klein, A.J McKerrow. 2016. *Normalized burn ratios link fire severity with patterns of avian occurrence*. Landscape Ecology. (DOI [10.1007/s10980-015-0334-x](https://doi.org/10.1007/s10980-015-0334-x))

- **Responses of Targeted Herpetological Communities to Fire Management Practices in Pine-Oak Forests of the Great Smoky Mountains National Park**

The field work for this project was conducted during the summers of 2012 and 2014 by students and staff of the University of Georgia, and the park received the final report in 2015. The study compared the results of salamander and reptile surveys in unburned and recently burned sites in the west end of GRSM. Surveys found that salamander habitat was not uniformly impacted by burning practices, and species respond differently to effects of burning. Some guilds of salamanders (large desmognathids) were more abundant in unburned sites, while all other groups studied (small desmognathids, large spelerpinids, small spelerpinids) were more abundant on burned sites. Reptile surveys found that commonly occurring species (northern fence lizards and skinks) were more abundant in burned sites. Further review of this recently received report is likely to uncover additional information that will be of value to fire managers at the park.

- **Landscape Conservation Forecasting for Fire-Maintained Forests of Great Smoky Mountains National Park**

This partnership with the Tennessee Chapter of The Nature Conservancy kicked off in 2015, and will be a focal point in the coming year. Landscape Conservation Forecasting is a set of tools and methods developed by members of The Nature Conservancy to assist federal land managers with development of landscape management plans. At the core of this process is the use of computer-based modeling to develop “reference conditions” for a given landscape. In the case of GRSM, this means using the best available science, data, and expert knowledge to describe the historic structure and composition of the park's fire-maintained forests. These reference conditions are then compared to current measurements of forest structure and composition to illustrate the current level of “departure,” and hence the greatest need for management. Perhaps more importantly, the reference conditions also provide metrics for the development of meaningful landscape management objectives. Finally, the process will result in a return-on-investment analysis that can inform the selection of various management alternatives.

This project has been well supported, receiving major funding from the Tallassee Fund, the NPS Fuels Research Reserve Fund, and the GRSM Fire Program. It is expected that this project will engage both Fire and non-fire Park staff, address the planning issues associated with the near-complete turnover of RMS staff since the original Fire Management Plan was published in 1996, and allow over a decade worth of new scientific information to be more effectively incorporated into Fire Management planning and the development of resource objectives.

- **Effects of Fire Severity on the Herbaceous Plant Species of Pine-Oak Forests in Great Smoky Mountains National Park. M.S. Thesis work, ongoing.**
Sean Binninger, Western Carolina University. (Dr. Laura DeWald, WCU)

The fieldwork for this interesting project was completed during the spring and summer of 2015, and Sean is currently conducting his analysis and writing up his thesis. We are looking forward to a presentation of the results at this year's GRSM Science Colloquium, and will reviewing those results in next year's annual report.

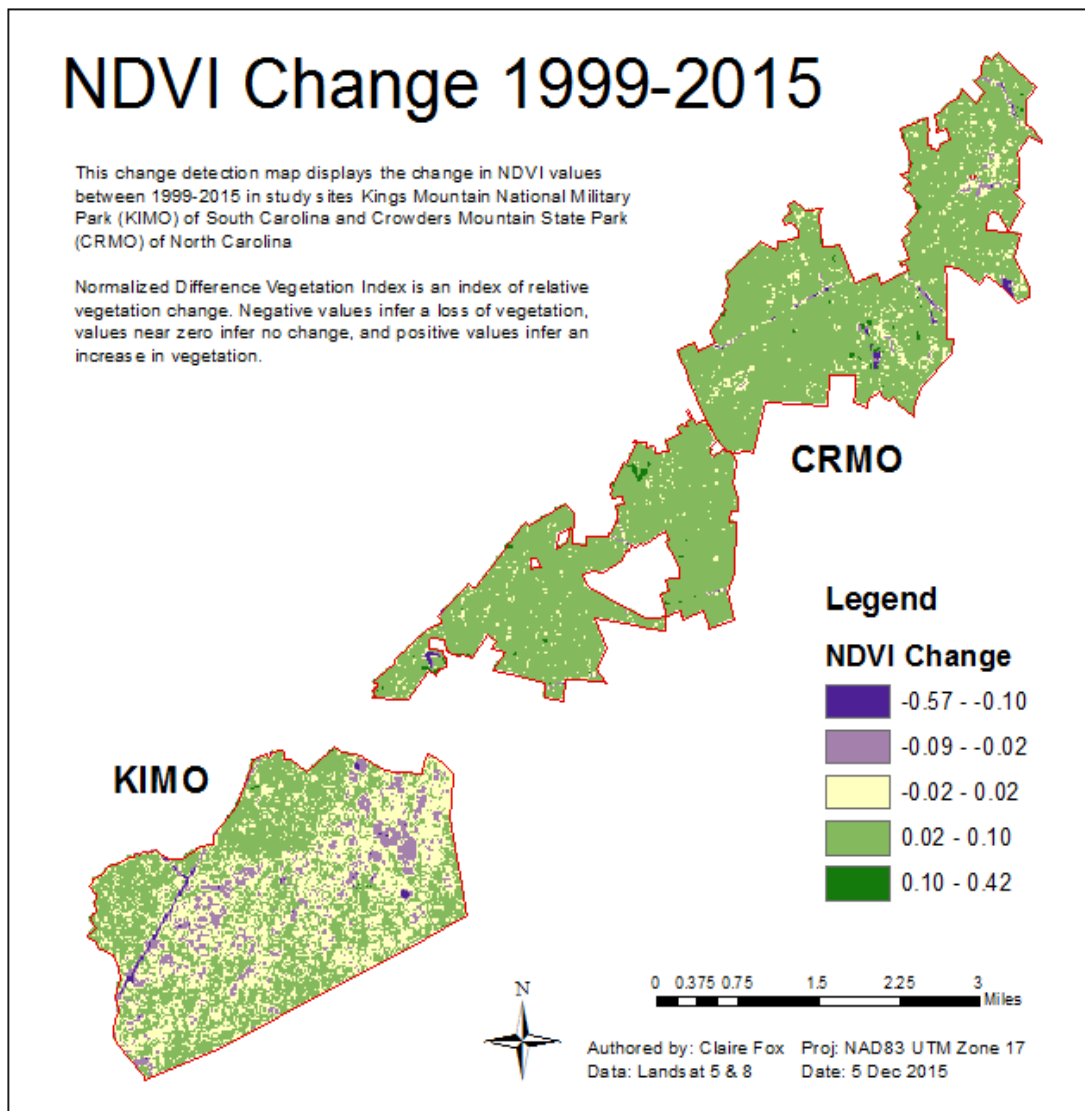
Kings Mountains National Military Park

- **Presettlement Vegetation and Fire Regimes of the Kings Mountain Region**
Dr. Cecil Frost, Landscape Fire Ecologist

This project was funded by the NPS Fuels Research Reserve in 2014, and the NPS received the final report at the end of 2015. The fire-effects program is still awaiting the spatial data products from the project, but we expect to have access to the data very soon. As expected, Dr. Frost's report offers a highly insightful historical perspective on the vegetation and fire regime of the region that includes Kings Mountain NMP, Kings Mountain State Park (SC), and Crowders Mountain State Park (NC). His research into the historical records paints a picture of open shortleaf pine and post oak woodlands with dense, grassy understories of black needle-grass, little bluestem, and silky oat-grass that were maintained by frequent, low-intensity fires. Dr. Frost suggests that such fires burned widely through this region about every 5-8 years until the time period just after the revolutionary war battle in 1781. One of the most compelling findings in the report is the extent to which grassy post oak woodlands have disappeared from this landscape over the past 150 years. This highlights the importance of continued monitoring of the few existing grassy post oak woodland remnants in the NMP, such as the one that was described in last year's annual report. There is also a need to continue locating, mapping and effectively managing these remnants with fire. This report, and the spatial products that accompany it, will be of central importance in the development of the multi-agency FMP that is currently in progress, and in the continuing efforts by each agency to restore the ecological/historical settings in the respective parks.

- Spatial Analysis of Parkwide Fire Regime Effects at Kings Mountain NMP**
Claire Fox, Duke University

This unique and informative study was the result of a quick-turnaround opportunity that was facilitated by the Cumberland-Piedmont Inventory and Monitoring Network. As part of a requirement for a graduate-level remote sensing class, Duke University student Claire Fox used Landsat and NAIP (aerial photo) imagery to examine changes in vegetation density and canopy gaps within the NMP over the past 15 years of extensive prescribed burning. This study is remarkable for several reasons: 1. it was completed over the course of just a couple of months, 2. it provides a unique, *park-wide* picture of the effects of an active prescribed-fire restoration program, and 3. it responds directly to information needs that were identified several years ago.



The excellent analysis provides many useful pieces of information, but none more interesting than the map depicting the change in NDVI (Normalized Difference Vegetation Index – based on Landsat imagery) from 1999 to 2015 (**see figure above**). Not only does this single map illustrate the large-scale effects of the entire 15-year burn program (approximately 85% of the 4000-acre

NMP has been prescribed-burned – much of it 2-3 times), it provides a “control” image of the nearby Crowder’s Mountain State Park (CRMO), which has had very little fire over the same time period. From a qualitative standpoint, this map appears to quite accurately depict the areas of the NMP that have had the greatest impacts of prescribed burning (personal observation, unpublished data). Though the map by itself doesn’t provide specific information about changes in forest structural or composition, fire effects monitoring plot data could be used to inform the map.

These exciting results suggest that comparisons of satellite data across relatively long time spans may provide a powerful monitoring tool to help assess landscape-scale fire effects. When coupled with field data, such information may be very useful for understanding the distribution of successional classes resulting from fire regimes, and should be used to guide future burning to best achieve long-term management objectives.

Introduction to Individual Park Reports

The following sections are divided alphabetically by park and each contains:

- an update on fire effects monitoring and fire ecology activities
- review of 2015 prescribed burns
- analysis of long-term fire-effects monitoring data

A new analysis of long-term monitoring results has only been completed when the past year's monitoring has added data that is directly relevant to the long-term analyses. A new column in the monitoring results table indicates when the latest analysis was completed. In some cases, the past year's data may not fit into the long-term analyses, but are summarized in the review of last's years prescribed burns. As always, park resource and fire managers are encouraged to address any additional fire-effects questions or needs to the Fire Ecologist or Lead Monitor.

For parks that don't have an updated analysis of long-term data, more attention has been given to the review of the past year's projects or additional data analyses. The information gained from the project reviews is often more valuable for making management decisions in the near term, and these reviews are the most valuable part of this annual report for stimulating adaptive management discussions. These reports may be of interest to a wide range of readers, and we encourage folks to read what is being learned in parks other than their own - most of these lessons are widely applicable. ***Highlights include:***

- ***Discussion of the implications of the new Southeast Region "Fire Management Zones" for fire effects monitoring at Big South Fork NRR and Cumberland Gap NHP (pp. 12 and 38)***
- ***Analysis of short-term vegetation and photopoint monitoring at Cape Hatteras (p 29-34)***
- ***Detailed discussions about third-entry burns at Arbutus and Wash Ridges, GRSN (P. 47-65)***
- ***Interesting discussion of Turkeybeard (*Xerophyllum asphodelioides*) at KIMO, along with park-wide changes in the Blackjack oak – Chestnut Oak Woodlands (p 72 -74)***

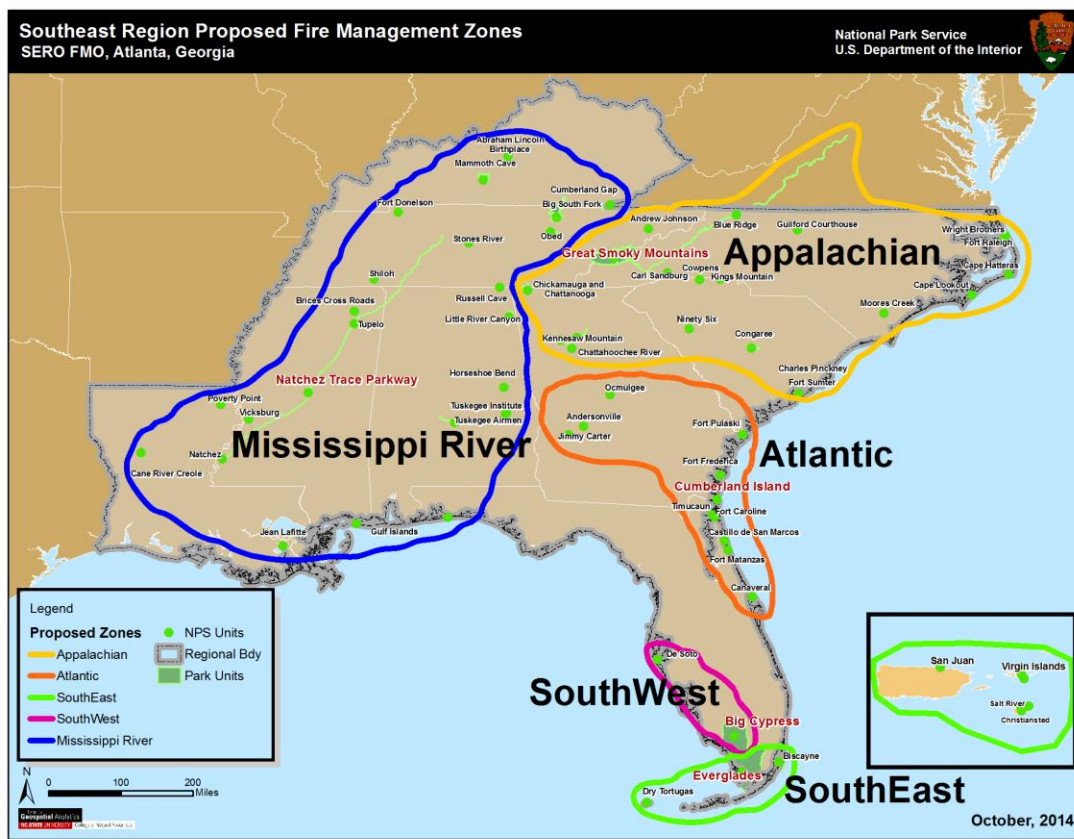
The fire effects team has spent a lot of time and effort over the past several years developing and implementing a variety of monitoring methods that have greatly enhanced our ability to provide more immediate and scientifically accurate feedback to managers about their prescribed burn programs and the most recent burns. Any comments, data requests, or feedback are always welcome.

Big South Fork National River and Recreation Area (BISO): 2015 Fire Effects Monitoring Annual Report

Activity Summary

The Fire-Effects team made two trips to Big South Fork during 2015, both times to monitor the short and long-term effects of prescribed burning at Darrow Ridge. Some of the early findings from this work are discussed in the “Review of 2015 Projects” section of this report.

Other work that occurred during 2015 included discussions about roles and responsibilities for fire ecology and fire-effects monitoring support under the new “Fire Management Zone” model. Early in 2015, the SER Director officially established five Fire Management Zones within the region (see Map). This major realignment resulted in BISO, OBRI, and CUGA being placed in



the Mississippi River Zone, which serves the fire ecology and fire monitoring needs through the Natchez Trace Parkway Fire Ecology program. However, this arrangement is problematic because the Appalachian (Great Smokies) Fire Ecology program has provided these services for those parks since at least 2004. Through several separate discussions, it appeared that the parks, the Mississippi River Zone staff, and the Appalachian Zone Fire Ecology staff all agreed that the park’s needs would be best served by having the Appalachian Zone continue to provide ecology

and monitoring services to BISO, OBRI, and CUGA. So far, there is general agreement about the following points:

- Fire effects monitoring field work will be conducted principally by the Appalachian Zone, but the preferred action will be for the crews to collaborate whenever feasible
- Ecology support will be provided principally by the Appalachian Zone Fire Ecologist
- Costs for monitoring and ecology activities will be paid principally by the Mississippi River Zone (*this is captured in the Interpark Agreement between the MS River Zone and the park*)
- Coordination of fuels projects and monitoring needs will require good communication between the Zone Fire Ecologists and with the park staff
- For adaptive management to be successful, plans, recommendations, and objectives will need to be openly communicated between all parties involved in fuels management activities at these parks.

Clearly, one of the most important tasks in the coming year will be to develop effective communication channels that ensure coordination between resources from both Zones and the staff at Big South Fork NRR.

Program Goals and Objectives

One of the successes of our fire-effects monitoring program has been its contribution to the development of short and long-term objectives for the prescribed fire program. Monitoring data have been continually used to evaluate and improve objectives, and this is indicative of major advances in understanding Appalachian fire ecology over the past 15 years.

The following goals and objectives constitute the general aims of the BISO prescribed fire program. There are also broad guidelines for achieving restoration over multiple burns, and single-burn objectives that are complementary to achieving the long-term goals. It is important to emphasize that these objectives (especially the single-burn objectives) may need to be adapted or otherwise changed to meet the needs of a particular burn. The process of adapting burn objectives involves using whatever site-specific data we have at our disposal in conjunction with on-the-ground reconnaissance and discussion of site conditions. Whatever the means, developing and communicating good site-specific objectives will be critical to our success on every burn, especially as sites that have been burned one or more times may have experienced vastly different fire effects.

Goals – BISO is currently using fire to manage grasslands and upland forests. The primary goals are as follows:

1. *Restore and maintain structure, sustainability, and species diversity of oak and shortleaf pine woodlands.*
2. *Effectively manage and reduce large fuels loads resulting from years of fire exclusion and southern pine-beetle damage.*
3. *Restore and maintain cultural and natural landscapes using fire to reduce woody encroachment into fields. A related cultural and natural resource goal is to encourage/enhance native species within field sites.*

Strategy - Use a series (3-5) of low to low-moderate severity prescribed burns to *gradually* reduce woody stem densities in all strata and reduce total fuel loading (see long term objectives); producing the variety of conditions that are favorable for regeneration of yellow pines, dry-site oaks, native herbaceous species and low-growing shrubs. **Minimize initial mortality** of mature yellow pines and oaks and prevent exotic plant invasions during first and second-entry burns by utilizing low-intensity/low-severity fires. Subsequent burns may increasingly use variable intensity and seasonality to achieve desired structure, fuel reduction, and composition. Fire-effects monitoring will be the basis for an adaptive-management approach to restoration. Monitoring can include simple visual assessments, burn severity maps, or various types of plots.

Single - Burn Objectives – Objectives for individual burns will, of course, vary according to fuel type, burn purpose (hazard fuels vs. WUI), or number of burns into the restoration cycle. But in general:

Burn objectives for **fields** are -

- *> 80% consumption of fine fuels (=stand replacement) over 90% of unit*
- *> 70% topkill of woody stems (all size classes)*

Burn objectives for **forests** are -

- *Consume >75% of surface litter (fine fuels) over >75% of the area occupied by target vegetation. Target vegetation is oak and pine forests found on upper slopes and ridges.*
- *>30% topkill of saplings (<10cm dbh)*
- *Limit individual canopy gaps (due to fire) to less than 1/2 acre in size*
- *Use a range of low-intensity ignition (<4' flame length). In general, fire intensities should not exceed the following spatial proportions:*
 - *<5% should burn in high intensity (FL >8')*
 - *5-20% should burn in moderate intensity (FL 3-8')*
 - *75-90% should burn in low intensity (FL 1-3')*
- *Preferred timing is the dormant season (mid-February through early April). This is especially important during first and second-entry burns. If burning occurs after green-up, it is desirable to have less intensity (lower flame lengths, slower moving fires), and not to burn during a pronounced drought.*

Long term objectives – Also called “Restoration-Phase” objectives. These objectives vary by vegetation type and are typically expected to be achieved only after 3-5 prescribed burns. It is estimated that such a restoration cycle will take approximately 20 years. At the completion of this restoration phase *in the oak-woodland vegetation type*, we would like to see:

- *At least a 50% reduction in total fuel loading*
- *Greater than 70% reduction in pole-sized tree density*
- *A 20-40% reduction in overstory tree density, achieved with newly-formed gaps of less than 1/2 acre in size*
- *Greater than 200 tall (>1meter) oak seedlings per acre*
- *Greater than 30% cover by native herbaceous species*

Review of 2015 Projects

Darrow Ridge Prescribed Burn:



Figure 1. View south from center of Shortleaf Pine stand at Darrow Ridge

Background:

The Cumberland Gap Wildland Fire Module (WFM), GRSM WFM, and BISO staff completed the 3rd entry of prescribed fire into the Darrow Ridge burn unit. Darrow Ridge is located in the South-west corner of the Recreation Area. It is bordered by a silt/gravel road that runs from the Northwest tip of the unit continuing below the entire South portion of the unit. The North portion of the unit is bordered by Laurel Fork Creek and Cumberland plateau-gorge type vegetation that is typically mesic in nature.

The Darrow Ridge unit has burned three times previously: in a 2001 wildfire, and in 2005 and 2010 prescribed burns. The size of the unit is 600 acres. The unit is composed of mostly forests dominated by white oak (*Quercus alba*), scarlet oak (*Quercus coccinea*) and black oak (*Quercus velutina*). Most of the pine in this unit has been decimated by the 2000-2001 southern pine beetle infestation. Occasional glade-type vegetation occurs on the broad, flat ridges that this unit encompasses as well as on rock outcrops. Species that dominate these areas are Post oak (*Quercus stellata*), Pig-nut hickory (*Carya glabra*), black needle grass (*Piptochaetium avenaceum*), mountain oat-grass *Danthonia compressa*, various Goldenrod (*Solidago*) and Aster species as seen in [Figure 5](#).

Since the wildfire and previous prescribed fires, this unit has seen a sizeable total acreage of overstory mortality in the areas that occupy the broad flat ridges closest to the road. Usually the areas with the most mortality remain approximately within 100-200 feet of the road or at the northern tips of the broad ridges and no one patch is larger than 2 acres. These open stands

remain a thicket of hardwood re-sprouts between 1-3 meters tall (some areas have shortleaf pine saplings) with a border of more intact, quality oak that has benefitted from previous fires.

Also, the discovery of a mature, in-tact Shortleaf Pine (*Pinus echinata*) stand located mid –slope off the rim with acreage of approximately ¼ acre in size is a notable discovery for the parks restoration objectives (Figure 1).

2015 Prescribed Burn

With one failed attempt due to winds being out of prescription, a second attempt was successful. No GRSM Fire Effects Monitors were requested for the second attempt and only limited monitoring data are available for the day of the burn.

The firing of the unit occurred mostly along the road and the Darrow Ridge Horse Trail. It was reported that” wind carried the fire into the unit at a rapid pace as the day progressed” from Cumberland Gap Wildland Fire Module. Operations and firing may have continued on the following day, although the specifics have not been confirmed.

Fire Effects notes and post-burn field data were collected a couple of weeks following the burn. The following three different techniques were used to initially describe the fire effects; severity imagery, post burn FMH plots and post burn assessment points. The most telling observations seen in **Figure 2** below based on severity imagery collected immediately post-burn. Simply looking at the map and noticing the coverage of the burn (light blue/yellow polygons) and the green polygon being unburned indicate that the treatment had covered the majority of the target vegetation within the unit.

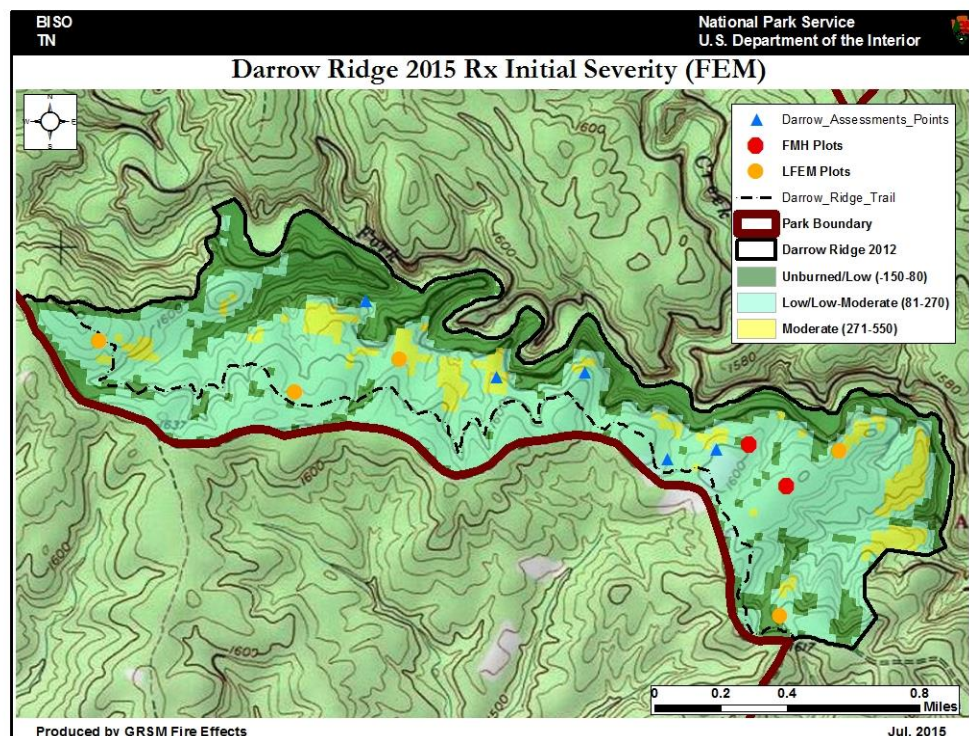


Figure 2. Initial Severity using averaged thresholds

Fire Effects:

The following photos are based on 03Post and 03yr01 Assessments points shown in **Figure 2**. The qualitative assessments points showed a mix of severity on fuels and vegetation. In **Figure 3**, some potential high severity along trailside associated with firing on codominant oaks was noted, most likely as ignition progressed west. Elsewhere on the landscape, there were areas of similar topography where fire backed slowly and extinguished quickly (**Figure 4**).



Pole is used as a height reference. Approximately 1.3 meters at the top of char

Figure 3. Scarlet Oak char heights and maple resprouts



Litter reduction and mosaic of severity

Figure 4. Severity and litter reduction

The initial post burn assessment and the growing season monitoring indicated as in [Figure 2](#) that most of the unit did burn with light intensity overall, with the fire extinguishing itself in unpredictable locations.

Another unique feature that had mixed results as seen from Post Burn Assessment points is the sandstone glade vegetation type. In the top photo severity may be delayed, but effects can be seen with the thinning of the mid-story (Bottom Photo).



Scorched white pine mid-story on an east facing slope

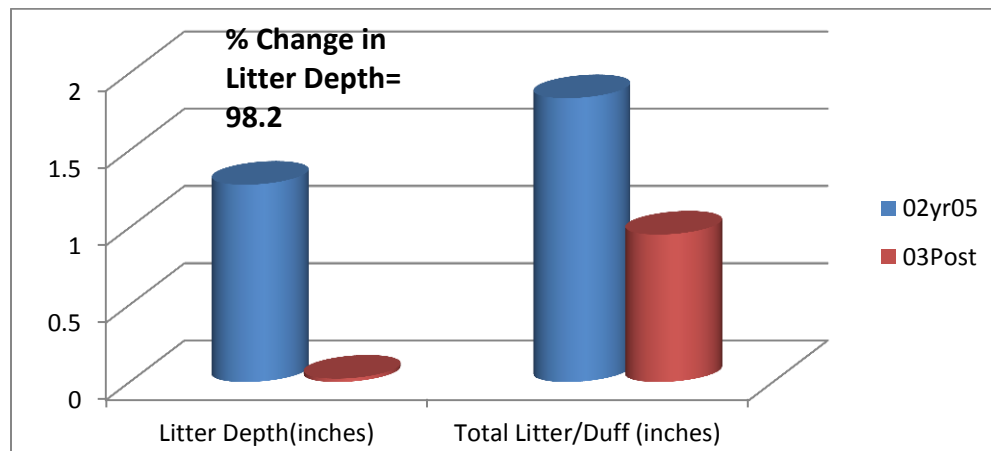


Photo depicts herb response following 03 Burn and limbed mid-story

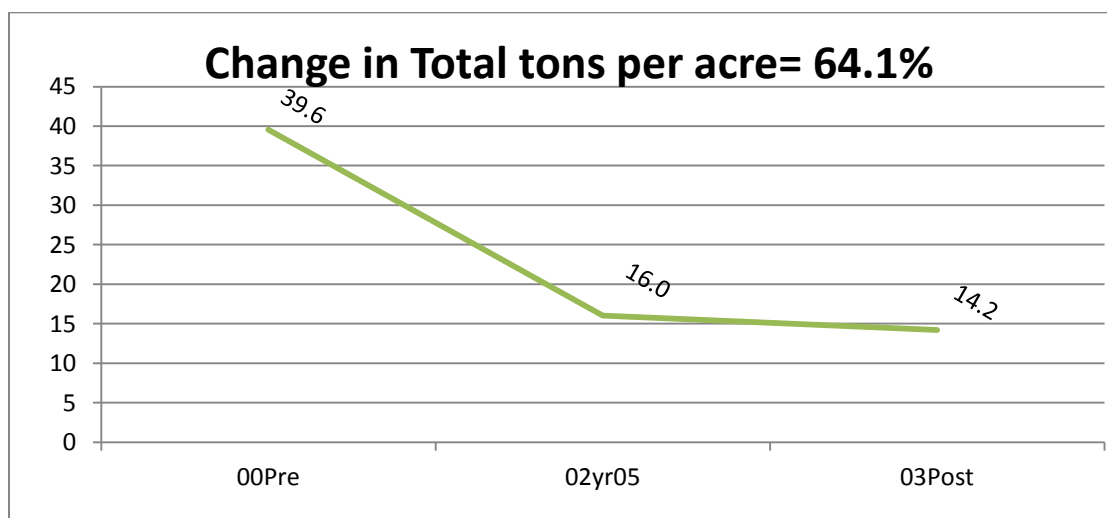
Figure 5 Near Fiddlers Arch/ Same general locations

Fire Effects data for fuel reduction (single plot):

It is advised that the following data is from only 1 NPS FMH plot. Given the context of the plot location and the surrounding canopy remaining intact, the information that the data provides can only be viewed within that landscape context. Effects from a single plot location cannot be inferred in other areas of the landscape, or in other community types such as the glade or canopy gaps. The fuels are significantly different in each of those areas and would need to be measured accordingly. With 3 treatments of fire at Darrow ridge over 10 years' time, the reduction in fuels seems the most significant sign of success for the park. Although statistically invalid to use 1 plot to determine if objectives were met, field reconnaissance indicated a consistency of similar effects across similar stands.



The long term objective for total fuel reduction greater than 50% has currently been achieved (at least in our single plot) as seen by comparing pre-burn data to the current post-burn fuels data (n=1). One point not readily seen in the data is that Litter makes up a little over 1/3 of the total fuel load, and there will be some recovery with annual leaf fall, although fuel loading will take several years to return to pre-burn levels.



Long Term Monitoring Results

There are no new data to add to the long-term monitoring results. The most up-to-date analysis of monitoring results is provided in **Table 1**.

Table 1. Objectives and long-term monitoring results for BISO

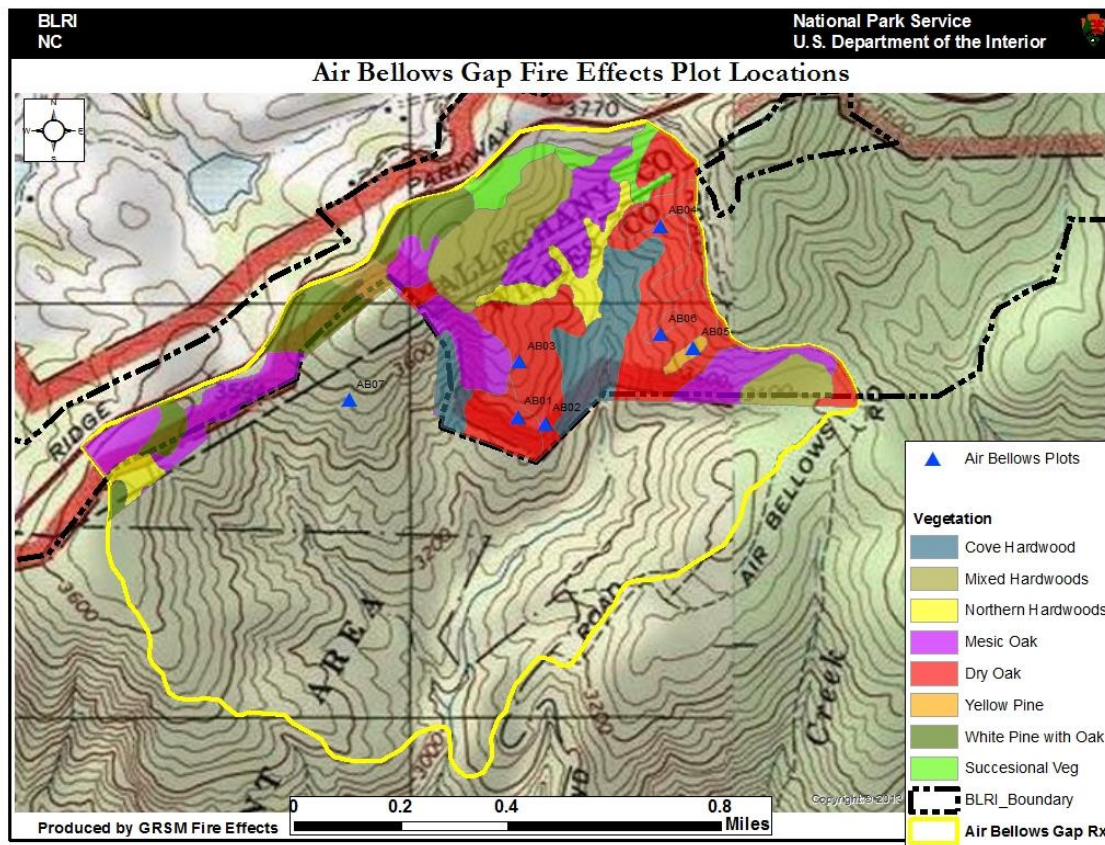
Vegetation Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?	Year Last Analysis Completed
Dry Oak Forest (FQUAL1) 14 plots	>50% Reduction in total fuel loading	Total fuel reduction After one burn = 52% ($\pm 2\%$) ($n = \underline{10}$ plots)	Yes, but will require more time to assess.	2012
	>70% Reduction in pole-sized tree density (≤ 15 cm dbh)	Pole reduction After one burn = 58% ($\pm 7\%$) ($n = \underline{10}$ plots)	Not yet, but on course.	2012
	20-40% Reduction in overstory tree density (> 15 cm dbh)	Overstory reduction After one burn = 4% ($\pm 2\%$) ($n = \underline{11}$ plots)	Not yet, but this is a long-term objective	2012
	>200 tall (> 1 m) Oak seedlings /ac	Preburn mean: 96/acre (± 43) Post-burn mean: 103/acre (± 35) ($n = \underline{11}$ plots)	Not after a single burn.	2012
	>30% Cover by native herbs	After 1 burn: 14% (± 5) ($n = \underline{11}$ plots)	Not after a single burn.	2012
Little Bluestem Sandstone Glade/Savanna (FSCSC1) 3 plots	>70% Reduction in pole-sized tree density	Pole reduction: After one burn = 16% ($\pm 11\%$) After two burns = 30% ($\pm 14\%$) ($n = \underline{3}$ plots)	Not yet, but on course.	2011
	>100% Cover by native herbs	Preburn cover: 98% (± 26) After 1 burn: 123% (± 28) After 2 burns: 133% (30) ($n = \underline{3}$ plots)	Yes, but not with 80% confidence	2011

Note: Underscored sample size indicates that minimum plot numbers exist for $\alpha = 0.20$

Blue Ridge Parkway (BLRI): 2015 Fire Effects Monitoring Annual Report

Activity Summary

The fire effects crew made one week-long trip to BLRI during 2015 to install seven new fire-effects monitoring plots in the Air Bellows Gap prescribed burn site ([see Map](#)). This unit is located just north of Doughton Park picnic area, and it represents a cooperative burning effort between the NPS, North Carolina Wildlife Resources Commission, and North Carolina State Parks. This project is also within the “Northern Escarpment Landscape” of the Southern Blue Ridge Fire Learning Network (or FLN), and it is set to be the first multi-agency burn within this landscape.



The monitoring approach for Air Bellows represents a bit of a departure from the traditional sampling design that has been used by our monitoring program at other sites in the Southern Appalachians. The Air Bellows monitoring design is a prototype for future fire-effects monitoring efforts in distant or remote locations, and it has been under development for the past several years in parks throughout our monitoring network. This approach is built on lessons that have been learned from years of fire effects monitoring in the region, and is specifically designed

to meet the monitoring and adaptive management goals of the Parkway, the Appalachian Fire Management Zone, and the NPS in a meaningful and cost-effective manner.

The central idea behind this approach is to combine plot-based data with remote sensing to accomplish two things:

1. Provide project-specific fire effects information for natural communities of interest
2. Provide data for modelling that will allow inferences to be made across other burns (or wildfires) in similar natural communities.

The field plots are randomly located within vegetation types identified by the park's vegetation map. Plots are 20m x 20m (400m²), marked with averaged GPS locations, and permanently monumented with 5 rebar. Data are collected on customized datasheets, and data includes: site information, photopoints, forest fuels ("Brown's" transects), and vegetation cover by species/stratum. Plots are established and sampled prior to burning, and will be resampled during the first growing season following the burn. Subsequent sampling will occur at least once between years 2-5 post burn. Burn severity mapping will be requested from USGS EROS data center or created in-house for each burn. At minimum, an extended assessment burn severity map will be acquired, and initial assessment mapping may be requested/developed on a case-by-case basis.

Plots in the Air Bellows burn unit were established in Dry Oak and Montane Yellow Pine forest types. Six plots were established on BLRI land, while a single plot was located in NC State Game Land. Planned analysis and reporting will include photopoint comparison, change in fuel loading by time-lag fuel moisture classes, short-term change in vegetation structure and composition, and burn severity (plot-based observation and remote-sensing). The permanent plots will also allow analysis of long-term change, aggregation with similar plots from other sites, and modelling the relationship between on the ground effects and remote-sensed burn severity.

Program Goals and Objectives

The following goals and objectives constitute the general aims for the BLRI prescribed fire program. They provide broad guidelines for achieving restoration over multiple burns, and single-burn objectives that are complementary to achieving the long-term goals. As the prescribed burning program begins at BLRI, it is a great time to review the goals and restoration strategy, as well as the short-term and long-term objectives that will help to achieve those goals.

It is crucial for Park managers and SER Fire Staff to understand that these goals, strategies, and objectives, while not perfect, have been developed over many years with the benefit of abundant experience and monitoring data from similar forest types in several different NPS units. It is important to note that there remain some inconsistencies between the objectives listed below and those found in the *Doughton Park Prescribed Burn Plan*, particularly with respect to desired mortality of overstory trees following first-entry burns. Specific burn objectives should be reviewed and approved by park Resource Managers before each burn.

It is also important to realize that these objectives (especially the single-burn objectives) may need to be adapted or otherwise changed to meet the needs of a particular burn. This process involves using whatever site-specific data we have at our disposal in conjunction with on-the-ground reconnaissance and discussion of site conditions. Whatever the means, developing and communicating good site-specific objectives will be critical to our success, especially as sites that have been burned one or more times may have experienced vastly different fire effects.

Goals – BLRI is currently using fire to manage upland forests. The primary goals are as follows:

1. *Effectively manage and reduce large fuel loads resulting from years of fire exclusion, especially in the wildland-urban interface*
2. *Restore and maintain structure, sustainability, and native species diversity to pine and oak forests.*

Strategy - Use a series (3-5) of low to low-moderate severity prescribed burns to **gradually** reduce woody stem densities in all strata and reduce total fuel loading (see long term objectives); producing the variety of conditions that are favorable for regeneration of yellow pines, dry-site oaks, native herbaceous species and low-growing shrubs. **Minimize initial mortality** of mature yellow pines and oaks and prevent exotic plant invasions during first and second-entry burns by utilizing low-intensity/low-severity fires. Subsequent burns may increasingly use variable intensity and seasonality to achieve desired structure, fuel reduction, and composition. Fire-effects monitoring will be the basis for an adaptive-management approach to restoration. Monitoring can include simple visual assessments, burn severity maps, or various types of plots.

Single - Burn Objectives – Objectives for individual burns will, of course, vary according to fuel type, burn purpose (hazard fuels vs. WUI), or number of burns into the restoration cycle. But in general, we want to:

- *Consume >75% of surface litter (fine fuels) over >50% of the area occupied by target vegetation. Target vegetation is oak and pine forests found on upper slopes and ridges.*
- *Top-kill >30% of saplings (<10cm dbh)*
- *Limit individual canopy gaps (due to fire) to less than 1/2 acre in size*
- *Limit the mortality of mature oak and yellow pine to <10%*
- *Use a range of low-intensity ignition (<4' flame length). In general, fire intensities should not exceed the following spatial proportions:*
 - *<5% should burn in high intensity (FL >8')*
 - *5-20% should burn in moderate intensity (FL 3-8')*
 - *75-90% should burn in low intensity (FL 1-3')*
- *Preferred timing is the dormant season (mid-March through late April). This is especially important during first and second-entry burns. If burning occurs after green-up, it is desirable to have less intensity (lower flame lengths, slower moving fires), and not to burn during a pronounced drought.*

Long term objectives – Also called “Restoration-Phase” objectives. These objectives vary by vegetation type and are typically expected to be achieved only after 3-5 prescribed burns. It is estimated that such a restoration cycle will take approximately 20 years. At the completion of this restoration phase *in the montane oak-pine forest vegetation type*, we would like to see:

- *At least a 50% reduction in total fuel loading*
- *Greater than 70% reduction in pole-sized tree or tall shrub density*
- *A 20-40% reduction in overstory tree density, achieved with newly-formed gaps of less than 1/2 acre in size*
- *Greater than 200 tall (>1meter) oak or combined oak and yellow pine seedlings per acre*
- *Greater than 30% cover by native herbaceous species.*

Long Term Monitoring Results

No long-term data are available.

Conclusion

2015 was an exciting year for fire management at BLRI. Tremendous progress was made in the development and planning of a prescribed burn that will serve as a model for cooperative ecological burning in an important mountain landscape. This progress includes the establishment of seven permanent monitoring plots that will be used to monitor short and long-term fire effects, and contribute to the development of landscape-scale fire monitoring that combines plot-based data collection with remote sensing.

Goals for BLRI fire effects monitoring in 2016 are to: participate in the prescribed burn of Air Bellows, re-sample all field plots within that unit during the summer of 2016, acquire a burn severity map for that burn, and continue to establish new field plots as future burn units are identified.

Cape Hatteras National Seashore (CAHA): 2015 Fire Effects Monitoring Annual Report

Activity Summary

Fire effects program staff made two trips to CAHA during 2015. The fire ecologist accompanied the Fire Management Officer in March for a meeting with the Superintendent and management staff. That trip also included an extensive field survey of WUI areas, proposed burn areas, previously burned areas, and an informal review of Fire equipment and infrastructure at the Seashore.

During September, the ecologist and fire-effects crew made a trip to CAHA to conduct fire-effects monitoring in the Bodie Island 1.3 burn site. That trip also included a meeting with CAHA Resource Management and Resource/Visitor Protection leadership, a meeting with Fire Management staff from USFWS, and a field assessment of the 2015 Little Kinnakeet Wildfire. Some of the findings from the Bodie Island 1.3 monitoring and a brief assessment of the Little Kinnakeet fire are included in this report.

Program Goals and Objectives

The following goals and objectives were taken from the 2012 Bodie Island Prescribed Burn Plan. As always, it is important for Resource Managers and Fire staff to critically review existing objectives for consistency with current management direction, and make adjustments as needed. For example, the current objectives do not specifically address the response of common reed (*Phragmites australis*) to prescribed burning activities, though this a species of tremendous management concern. The fire-effects monitoring data described in this report provide *one* source of information to aid in evaluating the objectives.

Resource Goals

1. Reduce encroaching brush species from marsh habitats.
2. Reduce dead vegetation content of marsh grasses to improve marsh habitat for waterfowl and wading birds.
3. Maintain or improve herbaceous species diversity and cover in marsh and forested plant communities.
4. Maintain or improve shrub scrub habitat for resident and migratory avian species.
5. Maintain Mixed Maritime Forest to provide for quality wildlife habitat and visitor experiences.

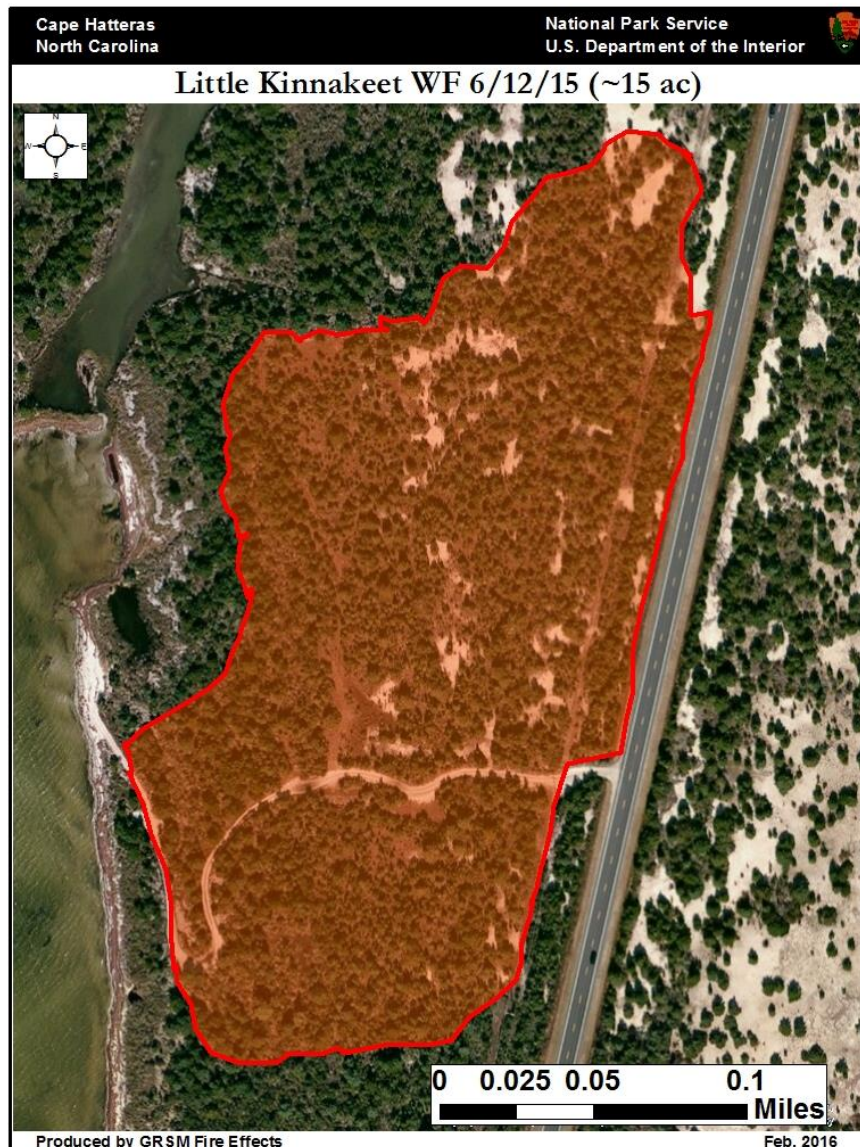
Prescribed Fire Objectives

1. Reduce hazardous fuel loading thru consumption of >70% of 1 hour fuels and >60% of 10 hour fuels within each burn unit.
2. Reintroduce fire disturbance regime into all appropriate vegetative communities in the park.
3. Top kill 50-75% woody brush vegetation in marsh habitats.
4. Reduce live and dead fuel loading by 50-80% in the shrub-scrub habitat.

Review of 2014 Field Work:

Little Kinnakeet Fire:

This fire occurred on June 12, 2015 on Hatteras Island just north of the town of Avon. It was a relatively intense fire, burning in a mix of cedar-shrubland, marsh, and dry grassland. Flame lengths of 30-40' were reported during initial attack. The fire was ultimately contained/controlled by USFWS, NC State Forestry, and the local VFD, using a tractor-plow line and engines. The final extent of the fire was 15 acres (**see map**), and footprint of the fire lies entirely within a State-Registered Natural Heritage Area.



During our September 2015 monitoring trip, we had a chance to map the wildfire site, and observe some of the fire effects and suppression effects. The map was submitted to the SER Fire GIS contractor for inclusion into the NPS National Fire Database. Not only is this important for

long-term NPS records, but good mapping and documentation about wildfire occurrence is crucial for determination of fire-related funding.

The photos below record a few of the sights we observed while we were mapping. A large portion of the burn is covered by red-cedar scrub, and we repeatedly saw evidence of a hot fire that scorched and killed entire patches of trees (**photo 1**). Within these patches, we also saw frequent examples of small (and some large) cedars that had partial or total consumption of the needles – again, indicative of a very high intensity fire. The occurrence of this kind of fire points to the need to better understand the availability of this fuel type and identify areas where the fuel type can threaten public or private values.



**Photo 1. Heavy scorching and kill of eastern red cedar.
Note the strong response of saltmeadow cordgrass (*Spartina patens*).**

We also observed the effects of heavy equipment use during fire suppression, which included soil displacement, berm formation, piling of uprooted woody material, and proliferation of weedy species (**photos 2 and 3**). No significant occurrences of non-native species were observed, but given the Natural Heritage Area status of the area, it should continue to be monitored for exotic plant invasions.

Given the fuel types and intensity of the fires, our cooperators often rely on mechanical means and heavy equipment to effectively suppress fires, so this kind of damage is somewhat unavoidable. However, through better communication with cooperators we should be able to ensure that fire-suppression-related resource damage is minimized and/or repaired in the future. If repair work can't be completed by on-site resources immediately after the fire is out, then the

Zone Fire Ecologist and SER BAER (Burned Area Emergency Rehabilitation) Coordinator may be able to assist CAHA in securing funding to have the work done in the future.



Photo 2. Formation of a berm following tractor plow use.



Photo 3. Piled woody debris and growth of weeds (native *Cyperus* in this case).

Monitoring Results

Bodie Island 1.3 Monitoring:

Fire-effects monitoring at CAHA features 5m-radius permanent plots, each with four photo-points and dominant-species cover estimates. In October of 2012, the fire effects crew and CAHA staff installed 12 of these plots in the Bodie Island 1.3 burn unit (**see map**). Plots were



subjectively placed across the burn unit, with the goals of providing representation of the major vegetation types, visual information on impacts to woody species (shrubs), and information on the response of *Phragmites* to the burning treatment. The area was prescribed-burned in 2014, and the plots were revisited in 2014 (photos only) and 2015 (photos and species cover). While the results are very qualitative and preliminary in nature, they offer an opportunity to assess

short-term fire effects and evaluate the type of information that this monitoring can provide. The results are discussed within the framework of the existing resource goals from the burn plan.

Goal: Reduce encroaching brush species from marsh habitats

Again, the plots were located in areas so as to provide visual information on impacts to brush species, so this goal is best evaluated by comparing photos repeated before and after the burn. Such a comparison was included in last year's annual report, and the reader should refer to that report for examples of repeated photos that show clear impacts to shrub hammocks. The cover of this annual report also provides a clear example of these impacts. Anecdotally, the majority of shrub hammocks observed during fieldwork had "heavy" impacts (i.e. greater than 50% top-kill), and this is pretty well supported by an analysis of photos taken at the monitoring plots (**Table 1**).

Table 1. Number of plots with varying levels of impacts to shrubs, as determined through photo-series.

No Impacts	Light Impacts	Heavy Impacts
2	4	6

Additional information about effects to shrubs can also be gained by reviewing the photos. The most important point here is that prolific resprouting can be observed in nearly all photos (**see photo below**). This is a common response of many woody species to being top-killed by fire, and it underscores the need for repeated treatments to achieve true shrub reduction.



**September 2015 Photo showing top-kill of shrubs in BI 1.3.
Note the prolific resprouting that is typical of most shrub species.**

Goal: Reduce dead vegetation content of marsh grasses to improve marsh habitat for waterfowl and wading birds

Achievement of this goal is best assessed by simple visual observations of burn cover and thatch consumption made immediately following the burn. For this burn these observations were made during an immediate post-burn survey, and at each plot within 2 months of the burn. The post-burn survey was discussed in last year's annual report, and it describes the burn coverage as a mosaic of burned and unburned marsh and shrub hammocks. Over 50% of the unit burned, and greater than 70% of dead grass material (thatch) was consumed. Field notes from the summer 2014 plot reads indicate that 75% of the plots burned, providing further evidence that this goal was achieved, though we have no data on waterfowl and wading bird usage.

Goal: Maintain or improve herbaceous species diversity and cover in marsh and forested plant communities

The vegetation monitoring component was not designed to specifically answer questions about changes in species diversity, because we only collect cover information for species that have greater than 5% cover (due to time constraints and species ID skills). That said, we can use the data to look at changes in the number of species that have over 5% cover. There did appear to be a small increase in the average number of species with high cover, with one plot (#21) showing the largest single increase (**Table 2**). This plot is interesting in that it lies right on the edge of a shrub hammock. Even though only about half of the plot burned, it provides a good illustration of a fire effect that was repeatedly observed throughout the burn site and in the Little Kinnakeet wildfire site: areas of heavy (and even light) impacts to shrubs consistently show clear increases in herbaceous cover. This effect will be reduced as resprouting shrubs achieve a stature similar to the preburn condition (4 years?).

Table 2. Summaries of selected plot data for vegetation.

	Average Number of Species (n=12)	Number of Species – Plot 21 only	Average Herbaceous Cover (n=12)	Average Cover <i>Spartina patens</i> (n=12)
Preburn	2.7	3	79%	17%
Year 2 Post-Burn	4.3	10	151%	43%

Our monitoring data also provides information about total herbaceous cover. Increases in cover were observed in all but one plot, driving a large increase in average cover (**Table 2**). The largest contributor to this increase in cover was saltmeadow cordgrass (*Spartina patens*), which occurred in every plot. Bulrush (*Schoenoplectus spp.*), saltgrass (*Distichlis spicata*), and cattail (*Typha spp.*) also showed consistent increases in cover, though they were observed in fewer plots (6, 7, and 5 respectively).

Goal: Maintain or improve shrub scrub habitat for resident and migratory avian species

Achievement of this goal was not assessed.

Note: This goal seems to be in opposition to Goal #1. Given the strong impacts to shrub hammocks during this burn, we recommend that any areas of shrub/scrub that need to be maintained be identified so fire can be excluded from them.

Goal: Maintain Mixed Maritime Forest to provide for quality wildlife habitat and visitor experiences

Achievement of this goal was not assessed, and there are few instances of maritime forest within this burn site. However, observations of a burned pine forest during the September monitoring trip suggest that any forests that the Seashore desires to maintain need to be pre-identified and excluded from high-intensity burning (**see photo**).



September 2015 photo showing impacts to pine forest. This is simply for example purposes - Most of this forest stand experienced less impact.

Response of *Phragmites australis*

Phragmites is a clonal, non-native grass that can spread rapidly following disturbances, and crowds out native species in both freshwater and brackish wetlands. Large populations of *Phragmites* already exist in the marshlands of CAHA, and there is substantial management concern that prescribed burning may encourage the spread of this species. Burning without subsequent herbicide treatment has been observed to stimulate the growth and spread of the species in other sites. For this reason, one of the goals for our fire-effects monitoring is to gain more information on the response of *Phragmites* to prescribed burning at CAHA. To do this, we subjectively placed several of our permanent plots in areas that either contained *Phragmites* or were on the edge of an existing patch. This approach should allow for photo-series comparison of spread, and comparison of abundance within our vegetation plots.

Four of the monitoring plots contained relatively low levels of *Phragmites* prior to burning, and two of those plots showed increases in cover by the second year post-burn (**Table 3**). The data

Table 3. *Phragmites australis* cover in BI 1.3 monitoring plots.

	<i>Pre-Burn Cover (%)</i>	<i>Year 2 Post-Burn Cover (%)</i>
Plot 17	15	15
Plot 20	15	15
Plot 21	2.5	15
Plot 26	2.5	37.5

from Plot 26, in particular, showed a substantial increase in cover, and this is confirmed by the photo series from that plot (**see photos**). Here, we should emphasize caution when interpreting



**Photo comparison of plot 26 preburn (top) and year 2 post-burn (bottom).
Note the increased band of green *Phragmites* in the lower photo.**

these results. First, the monitoring design that we've employed at CAHA does not allow any level of statistical certainty to be applied to the results. Second, a reliable amount of change was only observed within a single plot (#26), and several other marsh species showed much higher increases in cover across wider portions of the burn. The final point to make is that we are only looking at very short-term effects from a single burn. These data tell us very little about how *Phragmites* might respond to multiple burns over longer periods of time. That all said, the modest increase observed in our data, coupled with known ability of this species to spread following fire, indicates that this monitoring needs to continue, and that additional management actions (such as herbicide) should be considered for use in conjunction with future burning.

Conclusion

Vegetation and photo-point monitoring efforts that began in 2012 are beginning to provide good information about the effects of prescribed burning on the marshes and shrub hammocks on Bodie Island. Coupled with existing research, this information can be useful for adaptive management, and for making decisions about future prescribed burning objectives at Cape Hatteras. Monitoring of existing sites will continue, and additional monitoring plots can be added if new prescribed burns are identified. Goals for the coming year include continued analysis and evaluation of monitoring results, continued review of pertinent ecology and fire effects literature to help inform management objectives, and a trip to conduct monitoring within planned project areas.

Congaree National Park (CONG): 2015 Fire Effects Monitoring Annual Report

Summary

The Fire Ecology/Fire Effects Monitoring team made a combined three trips to Congaree during 2015. The Ecologist accompanied the Appalachian Zone FMO to attend the Congaree NP Fire Education Workshop, and also attended the internal scoping meeting for the Fire Management Plan rewrite. The Fire Effects crew visited during the summer of 2015 to install new plots that will monitor the effects of mechanical fuel reduction at Congaree. This work involved the development of a unique monitoring protocol, which is described later in this report.

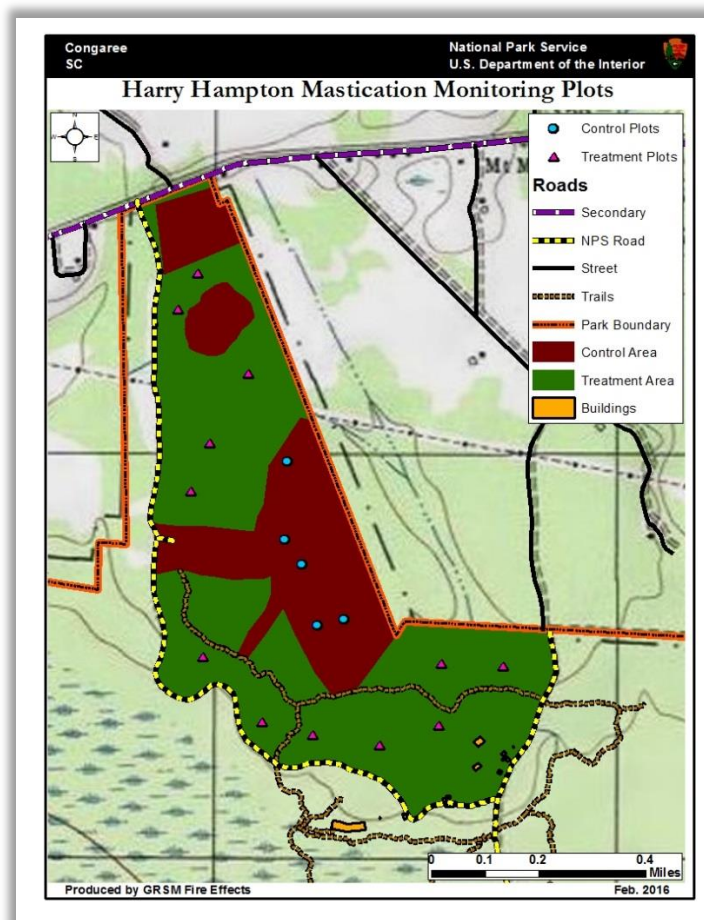


Figure 1. Map of monitoring plots within Harry Hampton mastication project area.

The mechanical fuel reduction project (aka NPS – PMIS Project #194397) was funded for Fiscal Year 2016. The intent of the project is to use mechanical means for restoration of upland forest structure in a 100 acre block adjacent to the Congaree NP Visitor Center and along the Park entrance road. This area, referred to as the “Harry Hampton burn unit”, has been repeatedly prescribed-burned since 2002, and contains 3 long-term fire effects monitoring plots.

The objectives for this project are as follows (from PMIS Project Proposal):

- Thin brush and pole-sized trees over 100 acres of upland pine forest
- Immediate 50% reduction in pole-sized tree basal area
- 25% increase in grass/forb cover within 5 years
- Long term goal for tree basal area is 40-70 ft²/acre
- Conduct monitoring before the treatment and over a 5 year period following treatment.

The Harry Hampton unit was surveyed during the summer of 2014 and divided into treatment and control areas based on ease of access for mastication equipment and ecological value. Subsequently, during the summer of 2015, 12 monitoring plots were established in the treatment area and 5 in the control area. Plot layout was 20m x 20m in an “H” shape with 2 outer parallel 20m lines connected by a perpendicular 20m centerline and monumented with a single rebar and high visibility cap at plot center. Within each plot species composition data were collected by strata, counts of pole-sized trees were collected in half the plot, basal area was determined at plot center using a 10 BAF prism, and 2 photo were taken, one from each end of the plot centerline looking at plot center. **Figure 1** shows the distribution of plots within Harry Hampton burn unit.

The Harry Hampton unit is slated to be prescribed-burned during the spring of 2016 and mastication should be implemented during the summer of 2016. All plots will be resampled 1-2 years following mechanical treatment using the same protocols outlined above. Also, rebar will be added to better monument the corners of the plot and fuel bed depth measurements will be collected along each of the two 20m outer plot lines. One additional resampling will also occur 5 years post-treatment. Results of the treatment should be forthcoming in the 2017-2018 annual report.

Long Term Monitoring Results

There has been no update to the long-term monitoring results table for Congaree. The most recent table of results is included below for the reader's reference (**Table 1**). An update to this table should be completed for next year's annual report.

Table 1. Objectives and long-term monitoring results for CONG

Vegetation Type	Management Objective Restoration Phase- After ?? burns	Monitoring Results (80% confidence intervals)	Objective Achieved?	Year Last Analysis Completed
Longleaf/ Loblolly Pine Woodland (FPIPA1) 5 plots	>50% Reduction in total fuel loading	Fuel reduction after 6 burns: 18% (<i>n=4 plots, 1 burn unit</i>)	No	2008
	15-30% Reduction in overstory tree density	Overstory reduction after 5 burns: 4% (<i>n=4 plots, 1 burn unit</i>)	No	2008
	>200 tall (>1m) Longleaf pine seedlings /ac	Preburn density: data not clean After 5 burns: 0 (<i>n=4 plots, 1 burn unit</i>)	No*	2008
Loblolly Pine Forest (FPITA1) 5 plots	>50% Reduction in total fuel loading	Total fuel reduction = 38% Preburn avg.: 33.0 tons/acre After 3 burns: 20.6 tons/acre (<i>n=3 plots, 1 burn unit</i>)	No	2008
	>70% Reduction in pole-sized tree density	Pole reduction: After 1 burn: 38% After 2 burns: 46% After 3 burns: 65% (<i>n=3 plots, 1 burn unit</i>)	No	2008
	25-50% Reduction in overstory tree density	Overstory reduction: After 1 burn: 3% After 2 burns: 3% After 3 burns: 8% (<i>n=3 plots, 1 burn unit</i>)	No	2008

* There are numerous longleaf seedlings within the core longleaf area and some additional seedlings near the Bluff Campground.

Conclusion

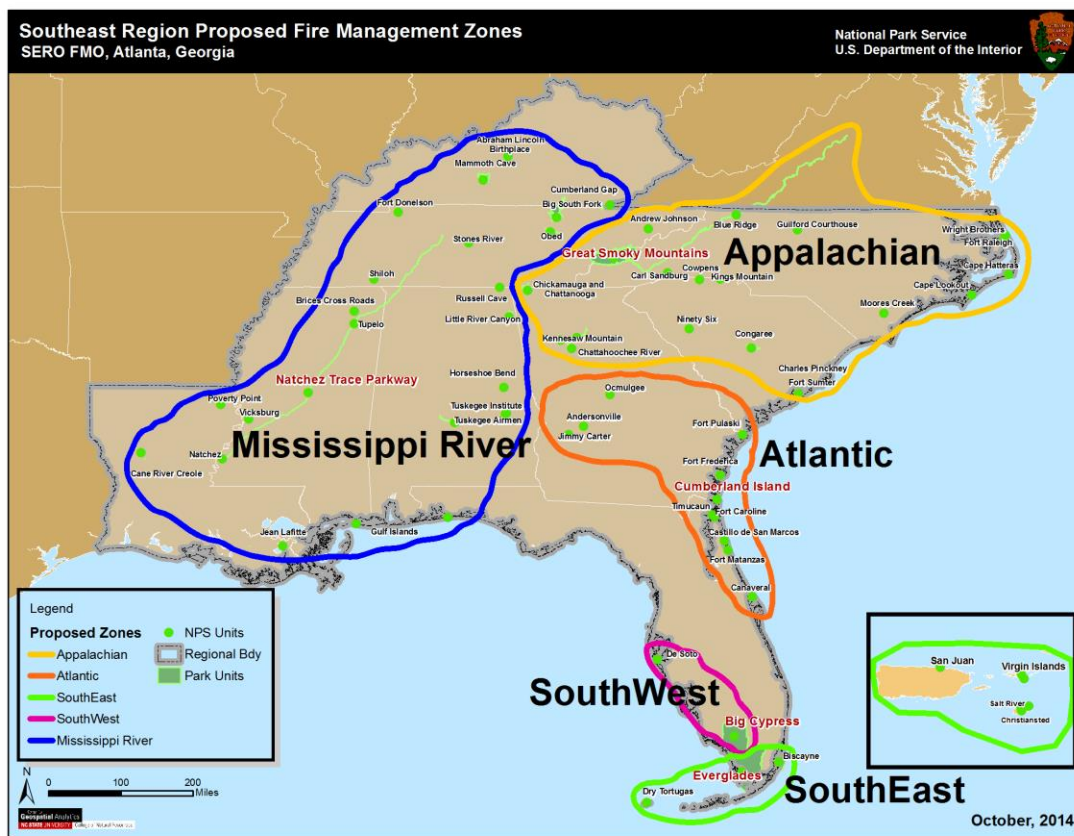
Monitoring work during the 2015 field season focused on the installation of pre-treatment monitoring plots for the upcoming Harry Hampton mechanical thinning project. This marks the first time that we will be monitoring the effects of mechanical fuel mastication, and we hope to gain knowledge that can help guide future work at Congaree or other SER parks. A new protocol was developed for this monitoring, and a total of 17 plots (12 treatment/5 control) were installed within the 100-acre project site. Plans for the coming year include participating in the re-burn of the RCW unit, coordinating monitoring efforts with the mastication project, and re-sampling long term fire-effects monitoring plots.

Cumberland Gap National Historic Park (CUGA): 2015 Fire Effects Monitoring Annual Report

Activity Summary

The Fire Effects monitoring crew made 2 visits to Cumberland Gap during 2015. The first visit was in March to assist with the Hoot Owl Hollow Rx burn and complete the post-burn reads for those 2 plots. An additional trip was made in August to complete the 02yr01 plot reads for the Hoot Owl Hollow burn unit. Additional data collected during that visit included gps locations of the invasive plant *Miscanthus sinensis* within the Hoot Owl Hollow and Dark Ridge C burn units. Other reconnaissance data was collected from Sugar Run and Dark Ridge C with regards to fuel loading in advance of the prescribed burn scheduled for spring of 2016.

Other work that occurred during 2015 included discussions about roles and responsibilities for fire ecology and fire-effects monitoring support under the new “Fire Management Zone” model. Early in 2015, the SER Director officially established five Fire Management Zones within the region (see Map). This major realignment resulted in BISO, OBRI, and CUGA being placed in



the Mississippi River Zone, which serves the fire ecology and fire monitoring needs through the Natchez Trace Parkway Fire Ecology program. However, this arrangement is problematic

because the Appalachian (Great Smokies) Fire Ecology program has provided these services for those parks since at least 2004. Through several separate discussions, it appeared that the parks, the Mississippi River Zone staff, and the Appalachian Zone Fire Ecology staff all agreed that the park's needs would be best served by having the Appalachian Zone continue to provide ecology and monitoring services to BISO, OBRI, and CUGA. So far, there is general agreement about the following points:

- Fire effects monitoring field work will be conducted principally by the Appalachian Zone, but the preferred action will be for the crews to collaborate whenever feasible
- Ecology support will be provided principally by the Appalachian Zone Fire Ecologist
- Costs for monitoring and ecology activities will be paid principally by the Mississippi River Zone (*this is captured in the Interpark Agreement between the MS River Zone and the park*)
- Coordination of fuels projects and monitoring needs will require good communication between both Zone Fire Ecologists and the park staff
- For adaptive management to be successful, plans, recommendations, and objectives will need to be openly communicated between all parties involved in fuels management activities at these parks.

Clearly, one of the most important tasks in the coming year will be to develop effective communication channels that ensure coordination between resources from both Zones and the staff at Cumberland Gap NHP.

Review of 2015 Projects

Hoot Owl Hollow Rx Burn:



Figure 1. Structure of forest vegetation Hoot Owl Hollow main ridge after two burns

Overview:

Hoot Owl Hollow is a 105 ac unit located along the southwest boundary of the park near the Town of Harrogate, Tennessee. This is the second entry of fire for this unit. The unit is primarily bordered by undeveloped private property and a couple of small homes with outbuildings. The topography of the unit is a west-northwest facing slope off a main ridge with a single spur ridge linking the main ridge to a distinct knob in the northwest corner of the unit. The park boundary runs along the main ridgeline on the south side of the unit and a stream runs along the base of the slope on the north side. The ridgeline and upper slopes are composed of dry oak forest, mostly dominated by chestnut and scarlet oak (*Quercus montana* and *Q. coccinea*), with occasional scattered pitch pine (*Pinus rigida*). The mid-slope areas contained more of a mix of dry-mesic oak, commonly including white and black oak (*Q. alba* and *Q. velutina*) mixed with occasional scarlet and chestnut oak. Lower slopes had more mesic mixed hardwoods with some areas of significant rhododendron (*Rhododendron maximum*) understory. Additionally, a notable limestone woodland area with shagbark hickory (*Carya ovata*), chinquapin oak (*Q. muehlenbergii*) and richer herbaceous diversity occurs along steep slopes on the southwest corner of the unit.

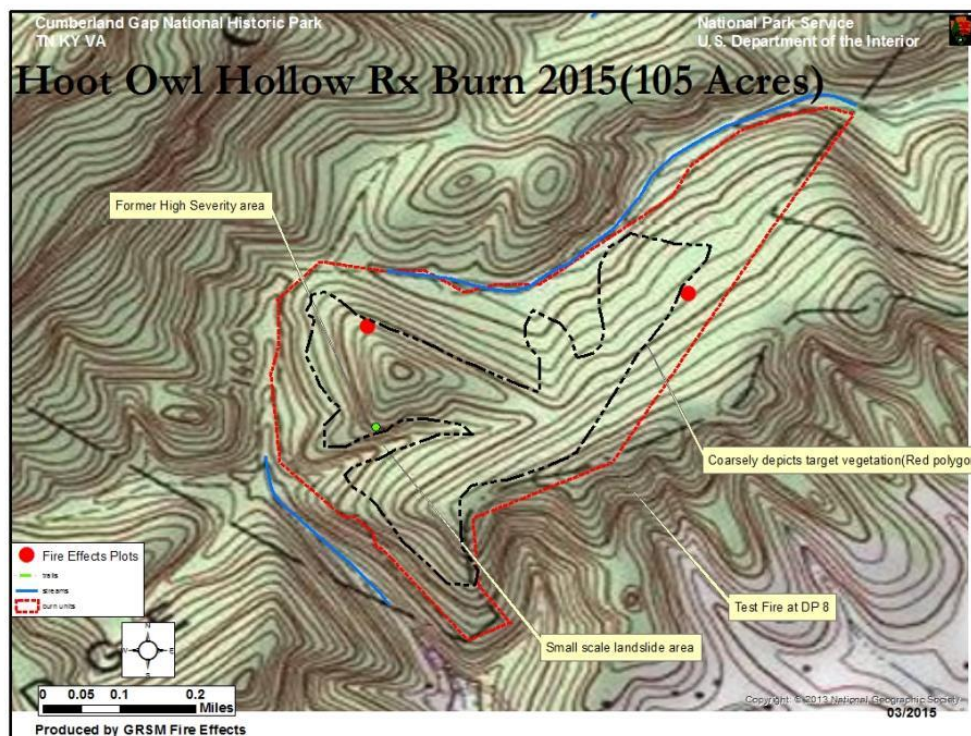


Figure 2. Map and Features of Rx CUGA unit

The burn day weather was not as predicted. The cloud cover was high aloft and almost 100% whereas predictions were only supposed to be 65% cloud cover from National Weather Service. The temperatures were lower (53F as opposed to predicted 65F) and RH approximately in line with NWS spot forecast.

These factors helped mitigate intensity and severity in large canopy openings while achieving most of the Resource Objectives as they relate to fuels. Firing was straightforward in beginning at the highest ridge and working a black-line down both flanks of the unit. Fire was mostly allowed to back into the unit on its own, although slow (1/2-1 ch/hr) for most of the day. Interior ignition was targeted to fill in the unburned areas with dot ignition using a firing device. Very low intensity, short head fires were a result of the technique and remaining fire was backing and flanking. [Figure 3](#) is an example of the fire behavior after using dot ignition pyro-shot to expand burn coverage and the observed fire behavior across the unit. The NW corner of the main ridge had the highest severity seen all day, though even that was fairly light.



Figure 3. Fire Behavior on NW corner of main ridge

Objectives:

Resource objectives (short term):

Reduce the 1-hour fuels by at least 50% over 75% of the target landscape as measured immediately post burn. **Yes**

Reduce 10 and 100 hour fuels by 20-80% **Yes**

Induce mortality of pole size trees (less than 6" diameter) by 20-80% **Yes, but this is mostly limited to stems less than 2" diameter**

Limit overstory mortality to <20% as measured 1 year post burn. **Yes. Qualitatively assessed**

Long term restoration objectives (4 burns or 20 years):

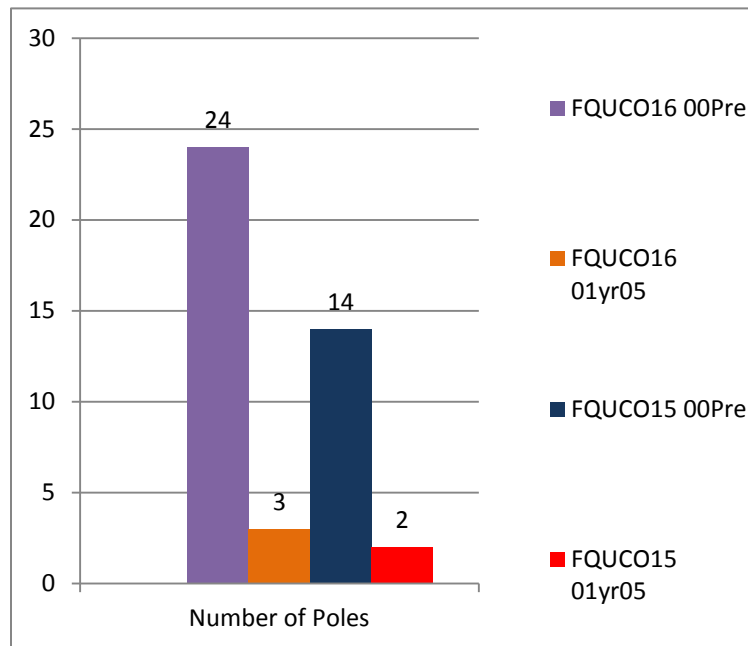
Reduce total fuel loading by >50%. **TBD**

Reduce pole-size tree density by >70%. **Mostly done in first burn- See Graph below**

Maintain >70% of overstory trees. **TBD**

Minimize exotic plant densities (<20 plants/acre) **this may need reassessment on an annual basis and treatment due to outside seed sources.**

Graph 1: Total of Pole-sized Trees (2.5 cm-15cm DBH) within 2 FMH Plots (Hoot Owl Hollow)



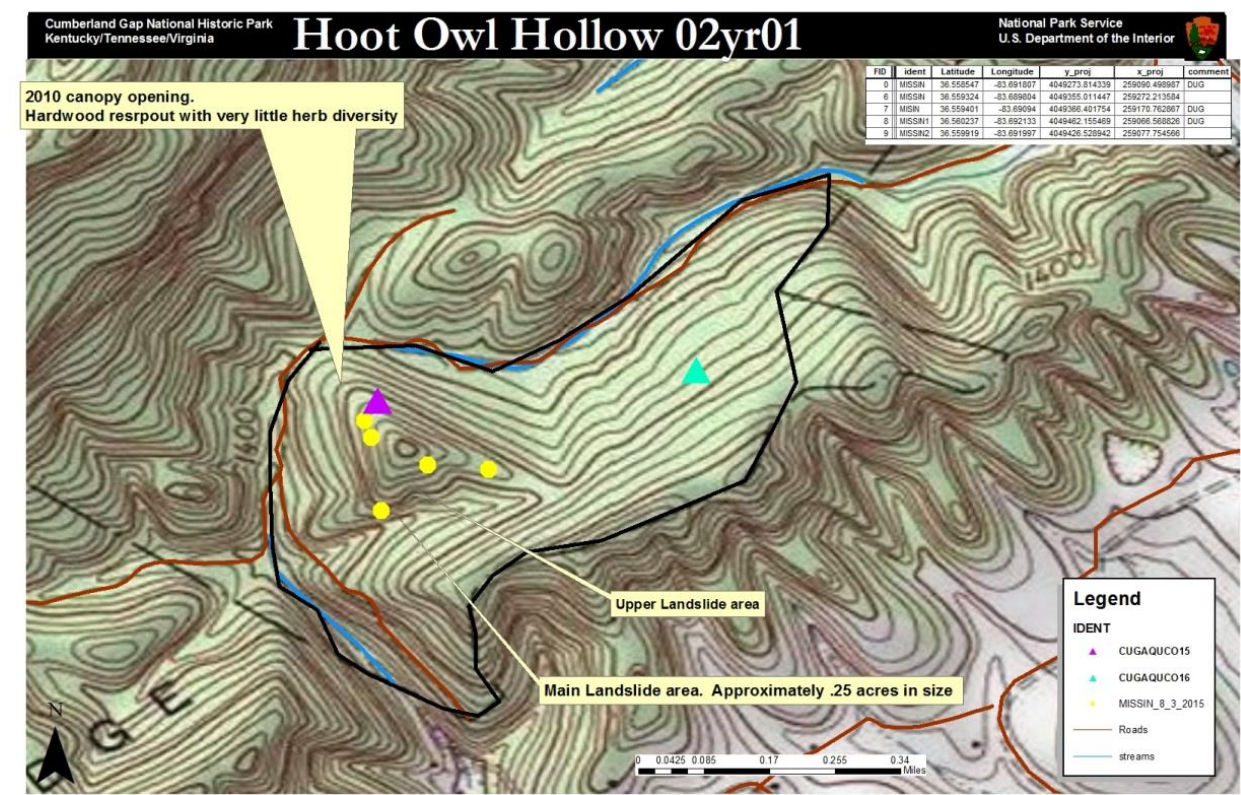
Discussion:

The emphasis for the Hoot Owl Hollow burn can be noted from the [Figure 1](#) and [Graph 1](#). The photo depicts an open midstory and slightly open overstory with a flush of herbaceous perennials following fire treatment. The suite of herbaceous species were on site prior to burning and are too numerous to name but showing vigor following a moderate severity first burn and a light second burn.

Graph 1 indicates a reduction in pole sized trees by 86.6% from 2 FMH plots. This data can be extrapolated to nearly the entire 100 acres based on qualitative assessments. The difficult part of the restoration phase is allowing regeneration of oak seedlings to establish while maintaining 70% overstory and limiting the growing exotics dilemma associated with outside seed sources.

Monitoring for *Miscanthus sinensis* in Hoot Owl Hollow and Dark Ridge C:

A qualitative assessment for severity and exotics invasive plants was done following plot work to understand coverage and impact of 2 burns across the entire unit. Several new locations of exotic invasive plant *Miscanthus sinensis* were found since the last visit to survey the unit in 2010. On a positive note, no new or existing stems of *Paulownia tomentosa* were found in 2015. This is an example of how early and vigorous treatment removed the infestation before they became established. Maps of the new and existing locations of *Miscanthus sinensis* found in the Hoot Owl Hollow and Dark Ridge C units can be found below.



Long Term Monitoring Results

There has been no update to the standard analysis of long-term monitoring results. Consequently, **Table 1** has not been updated for this report, though we include it below as a reference point for reviewing the progress toward achieving program objectives.

Table 1. Results of long-term fire effects monitoring at Cumberland Gap NHP.

Vegetation Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?	Year Last Analysis Completed
Dry Oak Forest (FQUCO1) 16 plots	>50% Reduction in total fuel loading	Total Fuel Reduction: After 1 burn = 29% (± 3) (n = <u>16</u> plots) After 2 burns = 26% (± 2) (n = <u>11</u> plots)	Not yet, but on course	2013
	>70% Reduction in pole-sized tree density (≤ 15 cm dbh)	Pole Reduction: After 1 burn = 39% (± 5) (n = <u>16</u> plots) After 2 Burns = 67% (± 3) (n = <u>11</u> plots)	Not yet, but close	2013
	15-30% Reduction in overstory tree density (>15cm dbh)	Overstory Tree Reduction: After 1 burn = 5% (± 5) (n = <u>16</u> plots) After 2 Burns = 8% (± 1) (n = <u>11</u> plots)	Not yet, but on course	2013
	>200 tall (>1m) Oak seedlings /acre	Preburn mean: 101/acre (± 12) After 1 burn: 91/acre (± 6) (n=16 plots)	Not yet.	2011
	>30% Cover by native herbs	Mean preburn cover = 2% ($\pm 1\%$) Mean after 1 burn = 4% ($\pm 2\%$) (n=14 plots)	No, but more burns are needed.	2011
	< 20 Invasive exotic plants/acre	Preburn avg: 0/acre Post burn mean: 20/acre (± 14) (n=16 plots)	Unclear due to high variability.	2011

Note: An underlined sample size number indicates minimum plots exist for 80% Confidence Level.

Great Smoky Mountains National Park (GRSM): 2015 Fire Effects Monitoring Annual Report

Activity Summary

The Fire Ecology/Fire Effects team continued to support the goals of the NPS and Great Smoky Mountains NP in 2015 by conducting short and long-term fire effects monitoring, helping to lead prescribed burning efforts, analyzing long-term datasets, supporting numerous research efforts, providing educational outreach services, and continuing to build strong relationships with many different partners and collaborators. Fire-effects plot monitoring was concentrated in Arbutus and Wash Ridges, both areas which received interesting third-entry burns in the spring of 2015. More detailed information and monitoring results for those two burns can be found in the “Review of 2015 Projects” section of this report. Additional field work was completed at the Lynn Hollow burn site.

It was another notable year for contributions to Southern Appalachian fire science, with three major publications of data collected in the Great Smoky Mountains NP, and a final report of another study completed in the park. Each of these projects was successful due to strong involvement by every member of our Fire Ecology/Fire Effects staff, as well as the park’s Vegetation Management Team. The papers are listed and briefly discussed in the “Research Update” section, found near the beginning of this Annual Report. Our staff also provided educational outreach in the form of guest lectures, a campfire talk, and field trips for visiting students and managers. A highlight of the year was a large, multi-agency field trip to look at the old-growth shortleaf pine trees at Lynn Hollow, which allowed us to showcase some of the work that GRSM is doing with hazard fuel reduction and ecological restoration.

Program Goals and Objectives

One of the successes of our fire-effects monitoring program has been its contribution to the development of short and long-term objectives for the prescribed fire program. Monitoring data have been continually used to evaluate and improve objectives, and this is indicative of major advances in understanding Appalachian fire ecology over the past 15 years.

The following goals and objectives constitute the general aims of the GRSM prescribed fire program, broad guidelines for achieving restoration over multiple burns, and single-burn objectives that are complementary to achieving the long-term goals. It is important to realize that these objectives (especially the single-burn objectives) may need to be adapted or even changed to meet the needs of a particular burn. This process involves using whatever site-specific data we have at our disposal in conjunction with on-the-ground reconnaissance and discussion of site conditions. Whatever the means, developing and communicating good site-specific objectives will be critical to our success, especially as sites that have been burned one or more times may have experienced vastly different fire effects.

Goals – GRSM is currently using fire to manage upland forests and grasslands. The primary goals are as follows:

1. Restore and maintain structure, sustainability, and species diversity to pine and oak woodlands
2. Reduce and manage fuels in the Wildland-Urban Interface to prevent the spread of unwanted fire off of or onto park lands.
3. Restore and maintain cultural and natural landscapes using fire to reduce woody encroachment into fields. A related cultural and natural resource goal is to encourage/enhance native species within field sites

Strategy - Use a series (3-5) of low to low-moderate severity prescribed burns to *gradually* reduce woody stem densities in all strata and reduce total fuel loading (see long term objectives); producing the variety of conditions that are favorable for regeneration of yellow pines, dry-site oaks, native herbaceous species and low-growing shrubs. **Minimize initial mortality** of mature yellow pines and oaks and prevent exotic plant invasions during first and second-entry burns by utilizing low-intensity/low-severity fires. Subsequent burns may increasingly use variable intensity and seasonality to achieve desired structure, fuel reduction, and composition. Fire-effects monitoring will be the basis for an adaptive-management approach to restoration. Monitoring can include simple visual assessments, burn severity maps, or various types of plots.

Burn Objectives – Objectives for individual burns will, of course, vary according to fuel type, burn purpose (hazard fuels vs. WUI), or number of burns into the restoration cycle, but in general:

Burn objectives for fields are -

- > 80% consumption of fine fuels (=stand replacement) over 90% of unit
- > 70% topkill of woody stems (all size classes)

Burn objectives for forests are -

- Consume >75% of surface litter (fine fuels) over >75% of the area occupied by target vegetation. Target vegetation is oak and pine forests found on upper slopes and ridges.
- Reduce the density of pole and sapling-sized hardwoods by at least 30%
- Maintain > 80% of existing mature oaks and pines
- Use a range of low-intensity fires (flame length <4'). Fire intensities should not exceed the following spatial proportions within targeted vegetation types:
 - <5% should burn in high intensity (FL >8')
 - 5-20% should burn in moderate intensity (FL 3-8')
 - 75-90% should burn in low intensity (FL 1-3')
- Limit individual canopy gaps (due to fire) to less than 1/2 acre in size
- Preferred timing is the dormant season (early March through mid April). This is especially important during first and second-entry burns. If burning occurs after green-up, it is desirable to have less intensity (lower flame lengths, slower moving fires), and not to burn during a pronounced drought.

Long term objectives – Also called “Restoration-Phase” objectives. These objectives vary by vegetation type and are typically expected to be achieved only after 3-5 prescribed burns. It is estimated that such a restoration cycle will take approximately 20 years. After this restoration phase *in the oak-pine woodland vegetation type*, we would like to see:

- At least a 50% reduction in total fuel loading
- Greater than 70% reduction in pole-sized tree density
- A 20-40% reduction in overstory tree density, achieved with newly-formed gaps of less than 1/2 acre in size
- Greater than 200 tall (>1meter) oak or yellow pine seedlings per acre
- Greater than 30% cover by native herbaceous species

Please see Table 2 below for more information on objectives and long-term monitoring data. Note that the objectives above are a bit of a hybrid from our separate oak and pine types.

Review of 2015 Projects

North Arbutus and Arbutus Ridge Prescribed Burn:

North Arbutus and Arbutus Ridge (850 acres) were burned on March 8, 2015 (**Figure 1**). This burn consisted of parts of two units identified in the *North of Abrams Burn Plan*: North Arbutus and Arbutus Ridge. The North Arbutus unit had not been previously burned, while the central ridge of Arbutus (see **Figure 1**) was burned in 2003 and again in 2007.

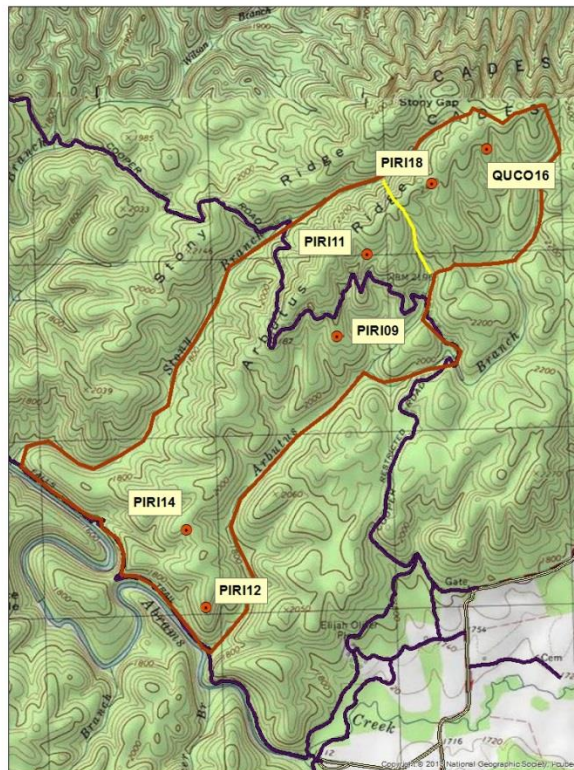


Figure 1. Arbutus Central Burn Area with plots. The yellow line depicts the split between Arbutus North and previously burned section of Arbutus Ridge.

The overall goals for this prescribed burn are to restore and maintain fire and drought-adapted species on xeric to dry-mesic sites on the landscape. Long-term objectives include a fuels management component and a vegetation management component. To achieve the long-term goals and objectives, the burn-day objectives for this event were as follows:

- Reduce total fuel load in target areas by 15-35% (i.e. >80% litter reduction)
- Top-kill 30-60% of fire-sensitive midstory trees and shrubs
- Limit mortality of mature yellow pines and oaks to < 20%.

Fire Behavior/Immediate Fire Effects Observations

The FEMO report filed immediately after the burn contains fire behavior observations and notes from the day of the burn. The test fire occurred at 1045 at the northern end of the unit. Litter fuels were noticeably drier than the day before, evidence of significant drying overnight (see weather discussion). However, oak litter fuels were not burning effectively for the first hour following the test fire, particularly in areas with evergreen understory. Though the surface of the litter was dry enough to burn, moisture just below the surface was still high enough to limit spread and consumption. The decision was made to call the test fire a success based upon general expectations that burning conditions would improve through the day.



Figure 2. Fire Behavior at 1145 near the test fire site

Ignition proceeded along the main ridge toward Cooper Road, while igniters continued to apply fire to the spur ridges in the northern portion of the unit. The North Arbutus section (which was receiving a first-entry burn) burned in a very light, patchy manner. Reduction of pole-sized trees in two monitoring plots averaged about 3%, which is indicative of a very light burn. However, data from those same two plots indicated an average litter consumption of 85%, and total fuel consumption of 29% - which are well within the stated objectives.

By 1300, the igniters south of Cooper Road began to move south along the main ridge, reporting limited fire activity. Back on the main ridge north of Cooper Road, organized lines of fire were observed on open slopes and ridges shortly after 1300, and most fire activity was limited to low-intensity backing and flanking fires. In those areas that burned, the objectives for litter consumption (>80%) were likely met (**Figure 3**).



Figure 3. Evenly burned landscape on Southeast-facing slopes off the main ridge; 1340.

The most active fires of the day were observed along the Cooper Road Trail between 1430 and 1530. The exposed slopes, mixed brushy/litter fuels, and ignition intensity from multiple igniters resulted in very effective burning in both forested and open brushy areas. It is very likely that all objectives were met in this part of the unit. **Figure 4** is an image of fire backing down the slopes just below Cooper Road. The pictured low-intensity behavior was very typical of most of the fire observed throughout the day, though higher intensity fire was observed in more open, brushy areas.



Figure 4. Backing fire just below Cooper Road Trail: 1515.

Continuing south along the main ridge, much of the fire lit by igniters earlier in the day was observed to have produced patchy results with limited consumption (**Figure 5**). Much of this fire went out close to the edge of the ridge, though it was continuing to back down in fingers along spur ridges and exposed slopes. Approximately 50% of the target vegetation is estimated to have burned. It should be noted that fire was purposely excluded from the eastern-most lobe of the North unit as well as the oxbow on the southern end of the unit.



Figure 5. Patchy burn with limited consumption on ridgetop south of Cooper Road.
Note the lack of scorch on small white pine seedlings.

Effects of Restoration Fire Regime

With this burn, Arbutus Ridge proper became the first prescribed-burn unit in the Great Smokies to reach three burns, giving us a unique opportunity to examine the effects of three closely-spaced burns. This opportunity is invaluable for developing our understanding of ecological restoration of fire-maintained natural communities, and can be used to reassess existing strategies and objectives. Information to support this evaluation comes from several sources. Long term monitoring plots were established in 2001-2002, prior to the onset of the restoration fire regime. Remote-sensing burn severity maps provide snapshots of the landscape effects of each burn; when put together and informed by ground-based sampling, these maps illustrate cumulative impacts of the frequent fire regime. Finally, simple qualitative field surveys can enhance the interpretation of the data and help to tell the story.

Monitoring data from 4 permanent plots on Arbutus Ridge provide a picture of trends in major fire effects on structure and fuels (**Table 1**). Lots of information can be gleaned from these data, but the major things to point out are:

- The extremely light impacts of the 2003 first-entry burn
- Modest changes in duff fuels are indicative of successful implementation of a strategy for gradual reduction of these fuels

- Increases in woody fuels are typical of restoration-phase burning, as initial mortality of small to medium-sized trees results in accumulation of dead wood
- There is steady progress towards achievement of the restoration-phase objectives

Table 1. Fire effects on fuels and forest structure at Arbutus Ridge (n=4).

Burn Status	% Overstory tree mortality	% Pole tree mortality	Woody fuel load change	Duff fuel load change	Litter fuel load change	Total fuel load change
After 1 burn (2003)	1%	18%	+22%	No Change	-18%	-0.4%
After 2 burns (2007)	5%	61%	+64%	-21%	-89%	-23%
After 3 burns (2015)	15%	54%	+195%	-34%	-59%	-17%
Goal: After 4 Burns	25-50%	>70%				>-50%

Note: All percentages are compared to preburn values.

During the early stages of prescribed fire restoration, fire effects data on fuels and forest structure are paramount to understanding slower ecological responses such as species composition dynamics: this is particularly true of tree sapling and herb layer dynamics. Given the relatively light impacts on fuels and forest structure of the Arbutus plots, sapling and herb variables need to be monitored for several more years before any conclusions can be drawn about compositional trends. It is likely that additional burning will be necessary before objectives for tree sapling composition and herb cover will be achieved within our plots.

However, trends in effects on trees by species can provide a meaningful picture of restoration progress (**Figure 6**). There is a lot going on in this graph, but the major things to point out are:

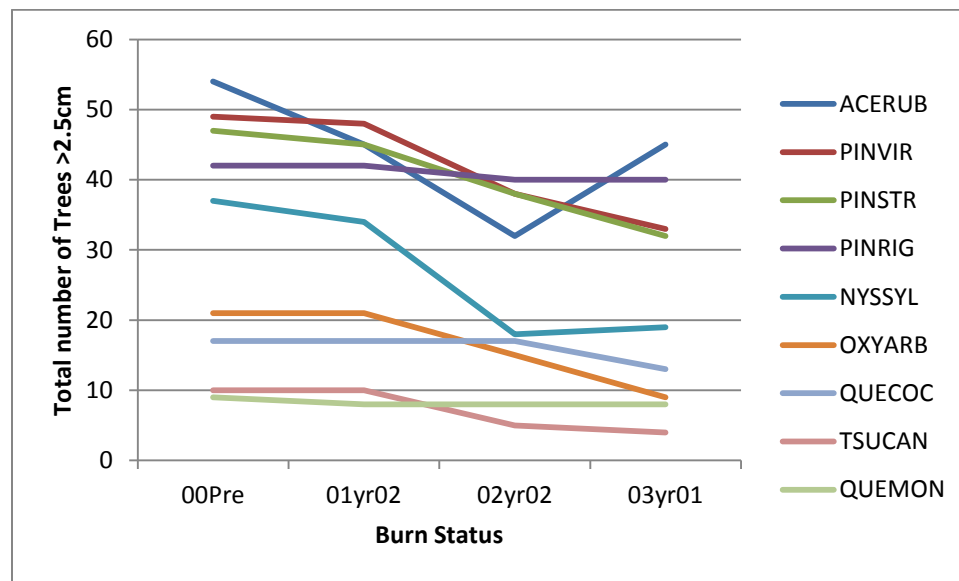


Figure 6. Total number of trees: change over time for 9 most abundant species. (n=4)

- Density of pitch pine, chestnut oak, and scarlet oak have remained pretty steady
- Density of all other species has markedly decreased, particularly following the second burn in 2007, which was the hottest burn to date
- Red maple, and to a lesser degree black gum, have shown marked initial decreases followed by an uptick in density – this represents the ability of these trees to resprout following initial top-kill. This is an important and common trend during restoration, and indicates a need to continue burning on a relatively frequent basis.

Finally, one of the most exciting pieces of data that can be used to evaluate the effects of a restoration fire regime is unit-wide burn severity mapping. **Figure 7** is a map depicting the cumulative burn severity of the section of Arbutus Ridge that has now been burned three times.

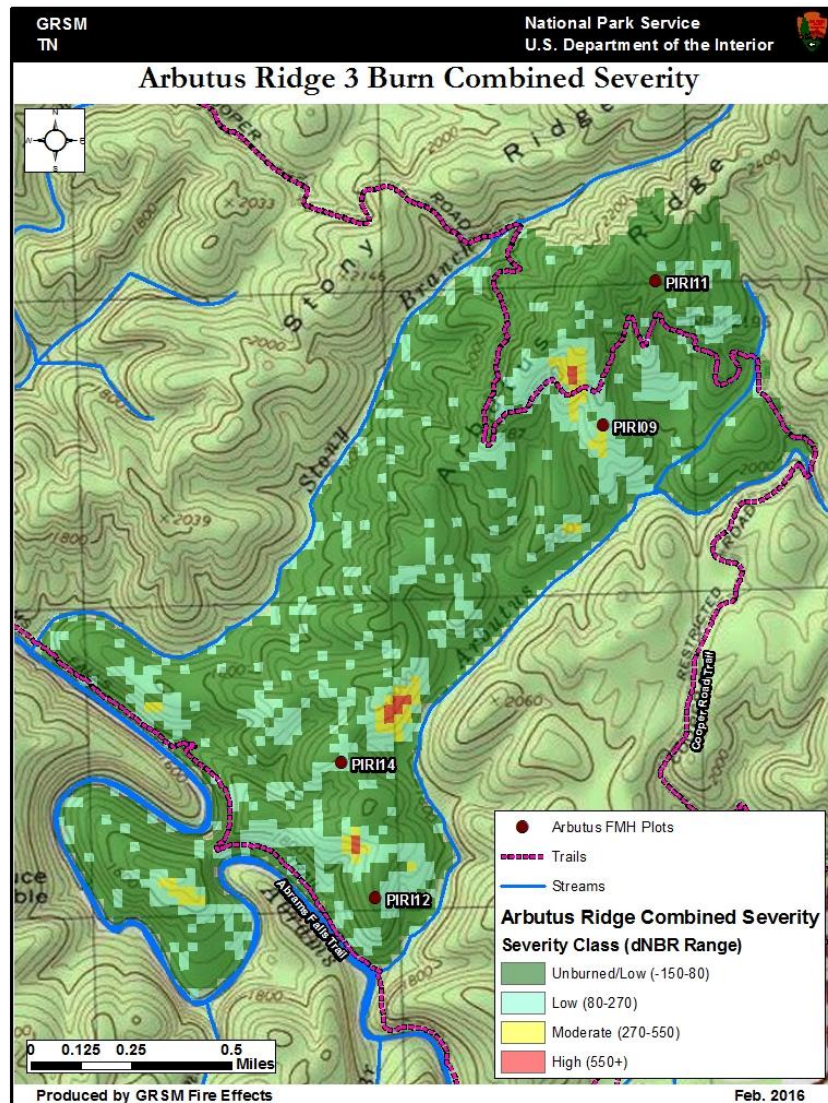


Figure 7.

This map provides a way to visualize the effects of multiple burns over the entire treatment landscape, and places individual plots into a broader context. The scientific rigor of this monitoring approach (Landscape Fire Effects Mapping) is still under development, but the data can already provide valuable insights. A series of photos (**Figures 8-10**) were taken during a June 2015 field survey of Arbutus Ridge. All of these photos were taken in the vicinity of Cooper Road and have corresponding GPS locations that (unfortunately) were not included on the map. However, they still provide a great way to view specific effects of burning as they relate to severity levels depicted on the map.



Figure 8. Mixed low elevation pine and oak stand after 3 burns. Note the woody regrowth in the medium sized canopy gap. This area is located in a low severity (blue) polygon just below Plot PIRI11.



Figure 9. Example of herb layer development after 3 burns in a Low severity (blue) polygon. Indian grass, Little bluestem, and rattlesnake weed are among the herb species. This area lies just north of Cooper Rd, west of the High severity patch.



Figure 10. Hardwood resprout thicket with yellow pine regeneration in the Moderate-High severity (red-yellow) area just north of Cooper Rd. This patch has a high cover of native herbaceous species.

Discussion

Overall, this was an interesting burn, and an important return to the previously-burned portions of Arbutus Ridge. Burning in the North Arbutus unit was minimal, limited by fuel moisture and shading. As a first-entry burn, this could be considered an acceptable result. While acknowledging that objectives were only partially met there, this unit is just now entering a long-term restoration process that will take several more burns. As such, the most important things are that the operation itself was a success and it was not burned too severely.

The results from the previously-burned portion are more mixed. Much of the area that burned very likely met our objectives, particularly in the vicinity of Cooper Road. The ridges south of Cooper Road were more of a disappointment, and it is possible that results could have been improved with additional igniters that could have worked in tandem with the two that were assigned. Extra folks may have been able to work directly with those two to generate more intensity during primary ignition, or indirectly by reigniting unburned areas later in the day when fuels were more receptive.

To summarize the actual burn event, though the conditions turned out to be subpar, GRSM fire staff achieved a significant amount of quality burning and perhaps most importantly, demonstrated that ridgetop prescribed burning of nearly 1000 acres of rugged landscape can be achieved in a single day. It is also worth pointing out that even a single additional day to followup this burn could have easily resulted in much higher achievement of objectives. Much was accomplished in a single day.

Looking at the bigger picture of ecological restoration, the fire effects team is combining long-term plot monitoring, remote sensing of burn severity, and qualitative surveys to understand how the current fire regime is affecting fuels, vegetation structure, and species composition. The Arbutus burn site offers an opportunity to showcase how this approach can provide managers with a picture of how fire restoration looks after 13 years and 3 low-to-low-moderate severity burns. The information that is being collected will help guide future management actions at this site and others like it.

Wash Ridge Prescribed Burn:

Wash Ridge is a 560 acre burn unit located in Cataloochee Valley, an area positioned in the southeast corner of the Great Smoky Mountains National Park (GRSM). It is primarily bounded by streams, trails, and roads along with a short section of handline on the northwest flank. Wash Ridge is higher in elevation, ranging 2900'-3700', compared to the majority of GRSM's legacy burn units which are located in the western portion of the park and are typically less than 2000' in elevation. Target overstory vegetation is composed of dry-mesic oak species versus the drier yellow pine and xeric oak communities found in the park's west end.

This unit has the distinction of being one of the few areas that has received 3 burn treatments since the beginning of the park's prescribed fire program in the late 1990's. The reintroduction of

elk to the Cataloochee Valley in 2001 fueled interest in using prescribed fire as a management tool to improve habit/increase forage for elk on the forested slopes and ridgetops surrounding the open grassy fields of the Cataloochee Valley. The initial burns occurred on 4/7/04 and 3/24/07 followed by the most recent burn on 3/18/15. Prior to burning, much of the unit had a tall and decadent understory evergreen shrub layer comprised of mountain Laurel (*Kalmia latifolia*) and rosebay rhododendron (*Rhododendron maximum*) along with a closed canopy oak overstory and dense mixed hardwood midstory, allowing for little or no herbaceous layer (**Photo 1** and **2**).



Photo 1 (Left) and **Photo 2 (Right)** show pre-burn shrub density. Photo 1 was taken on Wash Ridge proper and Photo 2 was taken immediately following the 2004 burn along the northwest handline. Notice the basal char and heavy leaf scorch on the mountain laurel shrub layer, which resulted significant top-kill of these shrubs.

The reduction of the shrub layer has been one of the most notable accomplishments of the first 2 burn entries. **Photos 3** and **4** roughly show the difference in shrub height and density between the burn and the unburned area adjacent to the unit along the northwest handline.



Photo 3 (Left) and **Photo 4 (Right)** show the 2015 ignition along the northwest handline close to the general area of Photo 2. Notice the tall dense shrub layer just outside the unit compared to the shorter layer inside the unit.

The on-going goal for the target vegetation at Wash Ridge is to thin pole-size trees and continue to top-kill resprouting shrubs and hardwood tree seedlings to create and maintain a more open understory and mid-story while retaining overstory oak as a seed source. Ultimately, the desire is to establish and maintain oak regeneration and increase herbaceous species richness and relative abundance. The initial 2 burns made significant strides toward removing >25% of the midstory along the main ridge as well as top-killing much of the tall decadent shrub layer. However, the lapse between 2007 and 2015 allowed much of the shrub layer and tree seedlings to reassert themselves via vigorous resprouts. So, one of the most critical goals for the 2015 burn was to, at a minimum, top-kill these resprouts with the hope that future burns could be conducted with greater frequency in order to maintain and build upon past progress.

The ignition strategy of the 2015 burn included securing the critical holding lines (northwest handline and southeast field) and igniting the ridgelines and spurs, allowing fire to back downslope to the unit boundaries. Day of burn observations indicated that fire generally carried well through the target areas and burned with reasonable intensity (1-2 cph ROS and 0.5' to 1' FL) under much of the mountain laurel and rhododendron resprouts and hardwood tree seedlings (**Photo 5**).



Photo 5. Example of typical fire behavior along the upper slope of Wash Ridge. Notice drab olive colored mountain laurel shrub in the upper middle portion of the photo indicating almost 100% scorch.

Post-burn reconnaissance in combination with USGS burn severity imagery indicates excellent burn coverage of target vegetation (**Figure 1**).

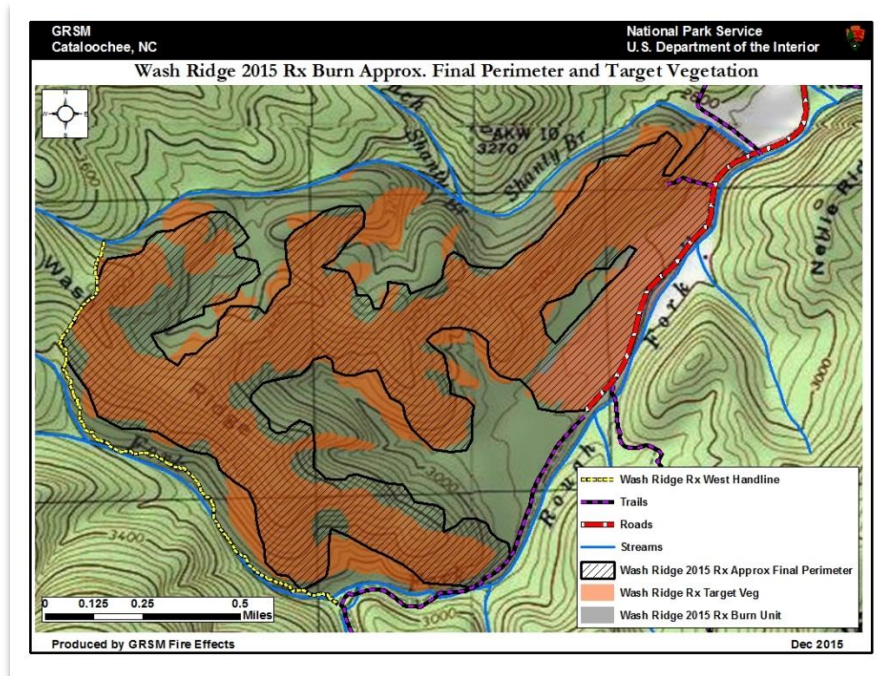


Figure 1. Approximate final perimeter for the 2015 Wash Ridge prescribed burn overlaid on target vegetation.

Severity data calculated from pre and post Landsat imagery shows burn severity was low across the unit with small areas of higher severity located in hot spots and canopy gaps from prior burns (Figure 2).

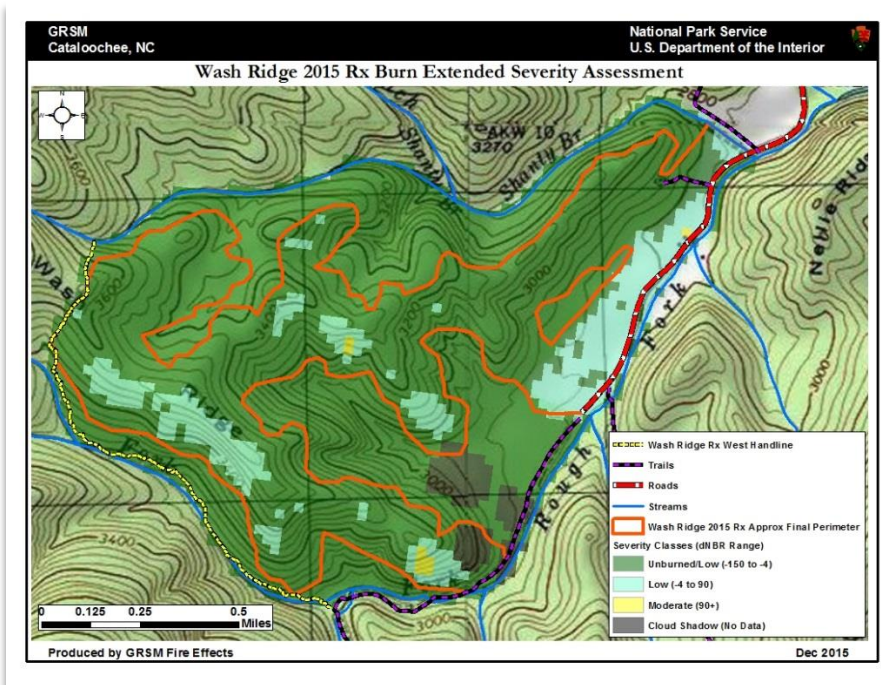


Figure 2. USGS extended burn severity image for 2015 Wash Ridge prescribed burn. Note that the threshold ranges were lowered to better highlight areas of slightly increased severity, when in reality no moderate severity was indicated based on calculated dNBR values.

Post burn scouting and FMH plot data collection agree with the severity map, indicating little to no significant impacts to overstory trees. The primary impact appears to be limited to the understory, specifically the seedling and shrub layer. **Photo 6** and **7** illustrate this impact as seen along the main ridgeline.



Photo 6 (Left) and **Photo 7 (Right)** were taken on Wash Ridge proper post burn during the late growing season. Note the numerous dead stems of tree seedlings and shrubs in the understory, both of which are resprouting. Photo 6 also shows some of the heavier midstory thinning that has occurred during prior burns.

Wash Ridge Long Term Monitoring

The Wash Ridge unit has 4 FMH forest plots located along the prominent east spur. Long term monitoring of fuels data indicates a steady and promising trend toward reducing total fuel loading (**Table 1**). The bulk of fuel loading in this system is comprised of duff, 1000-hr fuels, and litter, generally in that order, and as seen in **Table 1**, duff load has been decreasing with each burn, while woody fuels have shown an increase compared to pre-burn, and litter reduction has remained roughly constant. The steady decrease in duff load is exactly the type of trend that is desired to meet objectives in this forest type because initial duff depth was significant enough that rapid removal would likely result in high overstory mortality, hence, the gradual but steady trend that has occurred over the last 3 burns is excellent progress. The increase in woody fuel load post burn is a frequently observed occurrence in the early stages of reintroducing fire to this system, because the objectives are to thin the understory and midstory, which pre-burn are often very dense. In the case of Wash Ridge, there has been widespread top-kill of understory shrubs and tree seedlings in addition to moderate thinning of the midstory, all of which has added to the woody fuel load. However, another important caveat is the decline of eastern hemlock (*Tsuga canadensis*) via a non-native insect pest. Hemlock is a fire intolerant species that normally occurs in wet drainages and moist northern slopes, but which had heavily encroached upon the drier upper slopes and ridges of Wash Ridge prior to the first burn. While repeated burns would likely have removed much of these off-site trees from the target burn areas, the concurrent rapid decline from the insect pest has possibly sped this process compared to the effects of fire alone, especially in the larger midstory tree size class, thereby artificially inflating the increase in woody fuels post burn. Leaf litter generally recovers to near pre burn depth within 3-5 yrs post

burn if the overstory is retained, so the litter reduction pattern observed in **Table 1** is typical of low intensity burns that effectively remove the litter but result in low overstory impacts.

Burn Status	% Woody Fuel Load Change	% Duff Fuel Load Change	% Litter Fuel Load Change	% Total Fuel Load Change
After 1 Burn (2004)	+59.6%	-15.2%	-94.7%	-22.3%
After 2 Burns (2007)	+40.1%	-20.9%	-93.1%	-28.2%
After 3 Burns (2015)	+47.8%	-39.6%	-89.5%	-38.7%

Table 1. Wash Ridge long term fuels analysis showing percent change in tons/acre of fuel loading (n=4). Note that all percentages are compared to 2001 pre burn data.

For the purposes of evaluating overstory change following 3 burns, trees were grouped into 6 categories: **oaks**, especially chestnut oak (*Quercus montana*), which almost exclusively comprise the older remnant overstory canopy and represent the majority of the fire adapted stems on wash ridge, **yellow pine** a notable but infrequently occurring fire adapted sub-genus on Wash Ridge, **hickory** a drought tolerant genus that is adapted to low intensity burns but is easily damaged and/or killed by hotter burns, **mixed hardwoods** which include a mix of deciduous hardwood species, most notably sourwood (*Oxydendrum arboreum*) and red maple (*Acer rubrum*), that are generally fire intolerant and prior to reintroducing fire, heavily invaded the seedlings, poles, and overstory, **white pine** (*Pinus strobus*), another prolific invader of drier sites in the absence of fire, is a fast growing species that typically inhabits acidic coves, drainages and northern slopes and is fire intolerant when young, becoming more resistant to low intensity fire as it matures and develops rougher bark, and finally **hemlock** which, as mentioned above, is another encroaching off-site species that is typically limited to moist drainages and north slopes by fire. **Figures 3 and 4** show the proportion of the total overstory stem count that each of these groups comprised pre-burn and following 3 burns respectively. The key points from comparing these 2 figures include:

- Younger oaks are not replacing the current overstory of aging oaks that stand as a remnant of the former American chestnut (*Castanea dentata*) and oak forest that dominated the ridgetops and upper slopes of Wash Ridge prior to the loss of chestnut as an overstory tree species in the 1920's due to chestnut blight, a devastating non-native bark disease.
- Mixed hardwoods, especially sourwood and red maple, have continued to move into the overstory size class, and comprise the bulk of the stem count, although they may not yet exceed oak in terms of basal area.
- Similarly, though in fewer numbers, white pine has also continued to encroach on the overstory
- Hemlock has shown a marked decline, which as discussed above, is mostly attributable to mortality from a non-native insect pest, devastating hemlock throughout its range in GRSM.

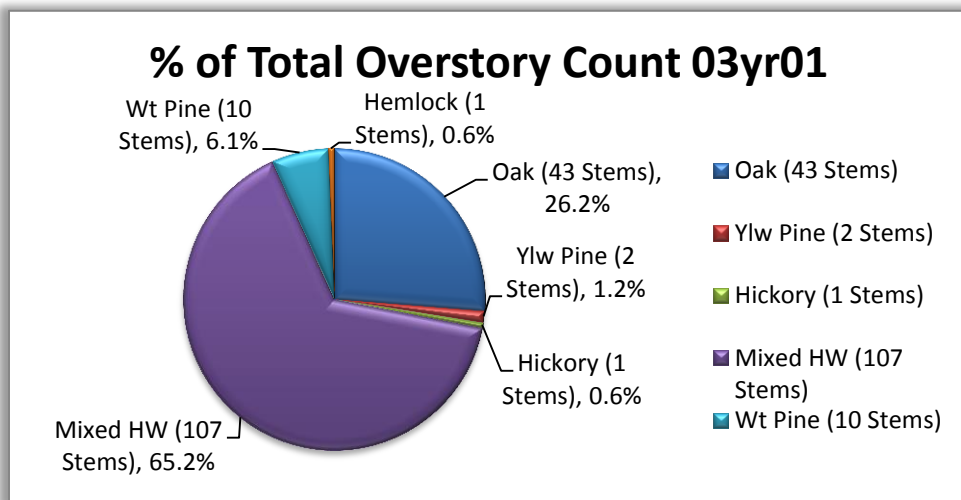
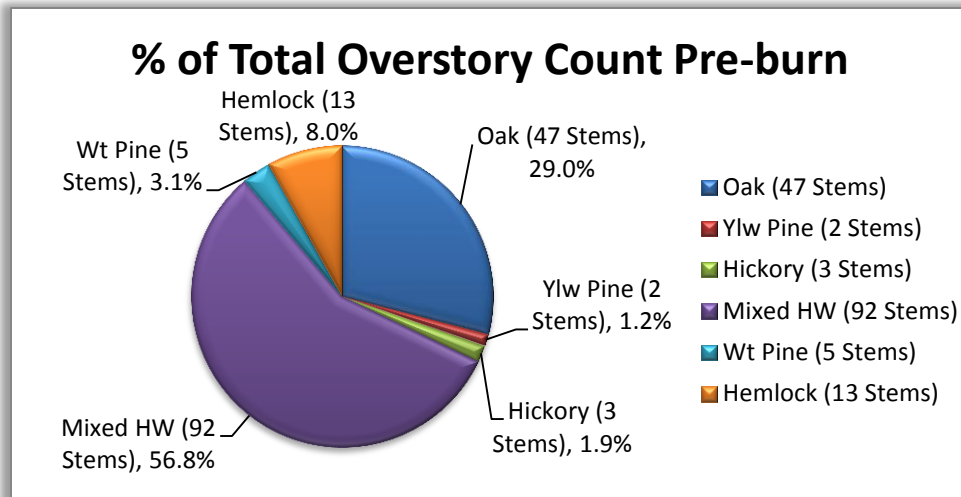


Figure 3(Top) shows the pre-burn percent of total overstory stem count by species combined across all 4 Wash Ridge FMH plots. **Figure 4(Bottom)** shows the same information collected the first growing season following the 3rd burn. Note the decline of eastern hemlock and increase in mixed hardwoods.

Poles were likewise divided into the same groups and included oaks, mixed hardwoods, white pine, and hemlock. **Figures 5 and 6**, like the above figures, show proportions for each of these groups pre-burn and following 3 burns respectively. Key points include:

- The total number of poles has been reduced across all groups, partly indicating thinning of the understory and midstory, but also due to mixed hardwood and white pine recruitment into the overstory
- The total pole size class stem counts continue to be dominated by mixed hardwoods
- There was almost no oak pre-burn and no additional recruitment after 3 burns
- Hemlock again shows a significant decrease in numbers

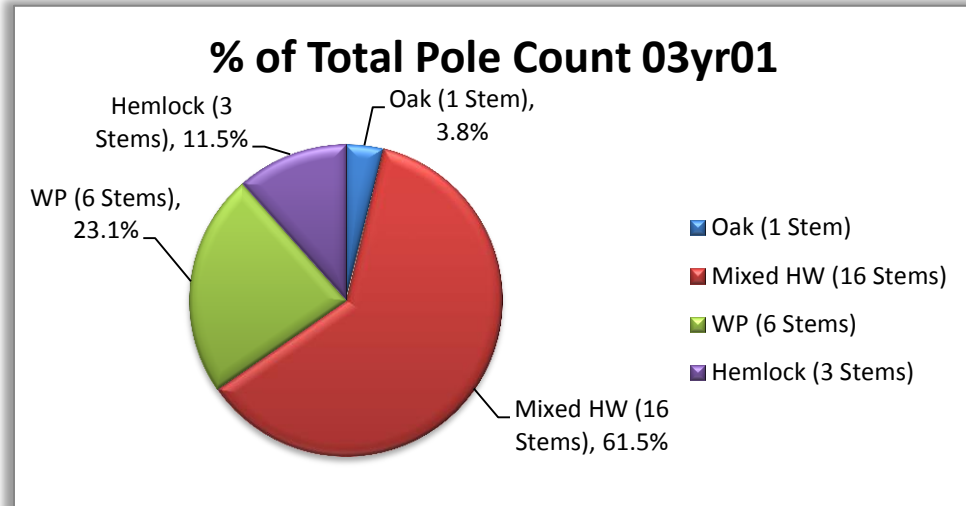
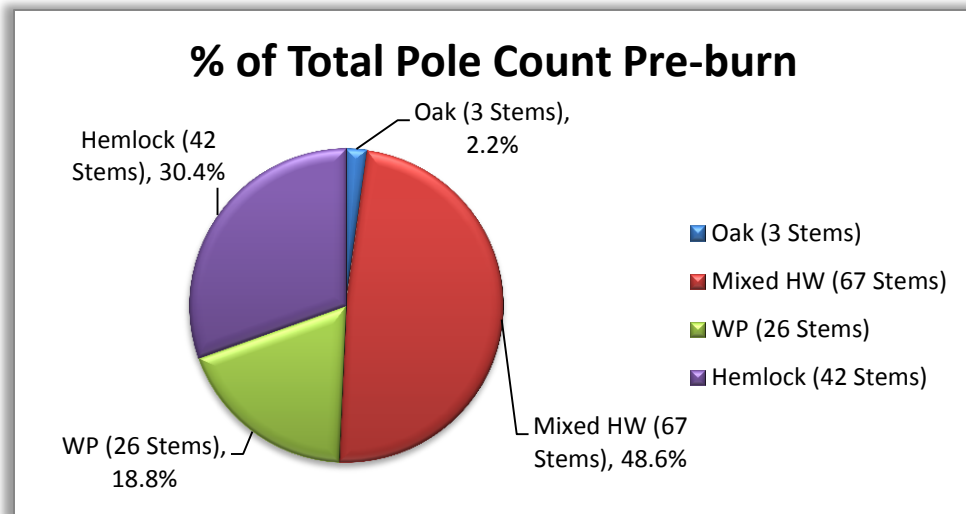


Figure 5(Top) shows the pre-burn percent of the total pole stem count by species combined across all 4 Wash Ridge FMH plots and **Figure 6(Bottom)** shows the same information collected the first growing season following the 3rd burn. Note the decline of eastern hemlock and relative dominance of mixed hardwoods.

Seedlings were also divided into the same groups as described above along with the addition of **chestnut**, formerly a key component of the ridgetop overstory 80-90 years ago but now relegated to a common resprout in the understory by the chestnut blight disease. **Figure 7** is a graph showing total seedling counts for each group combined across all 4 FMH plots and broken down by monitoring status (Note: that only stems > 0.6m tall were included in the counts in an attempt focus on the most vigorous individuals). Key points include:

- The first growing season following a burn is a poor indicator of long term changes in species abundance but it does give an indication of burn severity
- Oak and chestnut counts remain low but fairly constant over the long term
- Mixed hardwoods have become more numerous over time, primarily due to vigorous resprouts from top-killed sourwood poles

- White pine and hemlock, neither of which have the ability to resprout if top-killed, were absent from the seedling size class the 2nd growing season after the 1st burn.
- The 2007 burn was the most severe of the 3 burns with only a single red maple resprout exceeding 0.6m in height the first growing season following the burn, although it should also be noted that 2007 was a record drought year for the park so post fire recovery was delayed.

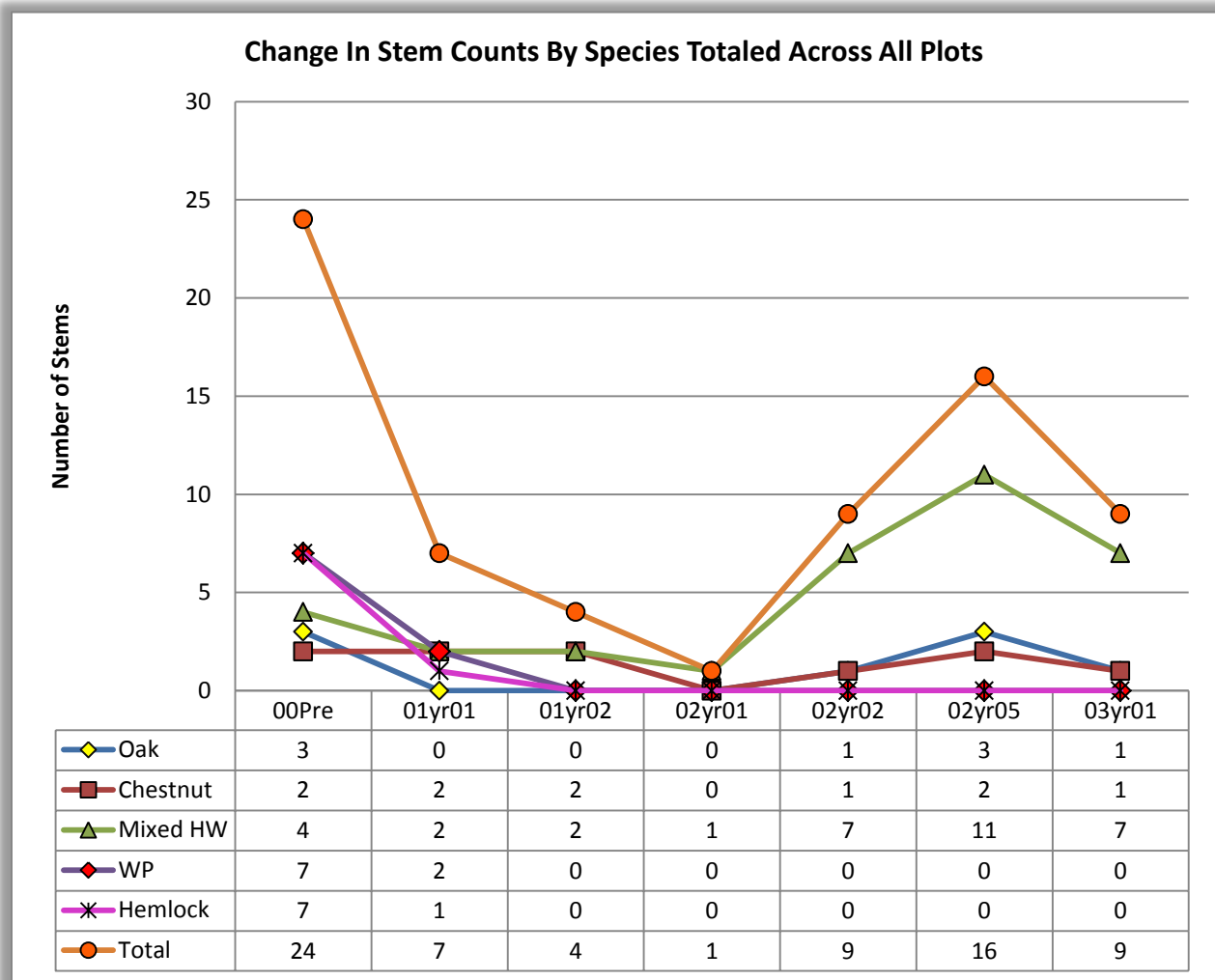


Figure 7. Graph showing the total stem count combined across all 4 FMH plots for each species group by monitoring status. Note that stem counts only included tree seedlings >0.6m tall.

In addition to analyzing FMH data we have been experimenting with methods to combine multiple dNBR severity images to create a single composite image that approximates the total effect of multiple burns for a single unit. **Figure 8** shows the results of such an effort for Wash Ridge, derived by using the ‘raster calculator’ tool in ArcMap to perform a simple addition of the dNBR values for all 3 burns. Obviously there are several caveats and problems with using this method, however as a coarse tool it does a reasonable job highlighting the areas of greatest severity. One of the key things to consider from this figure is the placement of our FMH plots in

comparison to the areas of higher severity. The calculated dNBR score for any point on the map is largely driven by change in overstory canopy cover, and our plots tend to represent the areas of lowest severity indicating the canopy has generally remained intact over the 3 burns. One example of how the FMH plots do not fully capture the variability in the severity is seen on the long southwest facing slope of Wash Ridge proper, which based on field observation, has experienced significant removal of the midstory and scattered single tree and small group removal of overstory trees. We have also observed some indications of oak regeneration in these areas that may prove significant in the years to come. One additional important observation from **Figure 8** is the increased severity on the moist north facing slopes above the stream that forms the northern unit boundary. This area comprises much of the former hemlock dominated forest with a heavy rhododendron understory shrub layer, which generally has not burned during any of the 3 prescribed burns due to fuel type, fuel moisture and shading. The composite image does partially pick up the loss of overstory hemlock on this northern extent of the unit but the timing of the Landsat images used were selected to best show burn severity and therefore underestimate the overstory impacts from Hemlock Woolly Adelgid in this area.

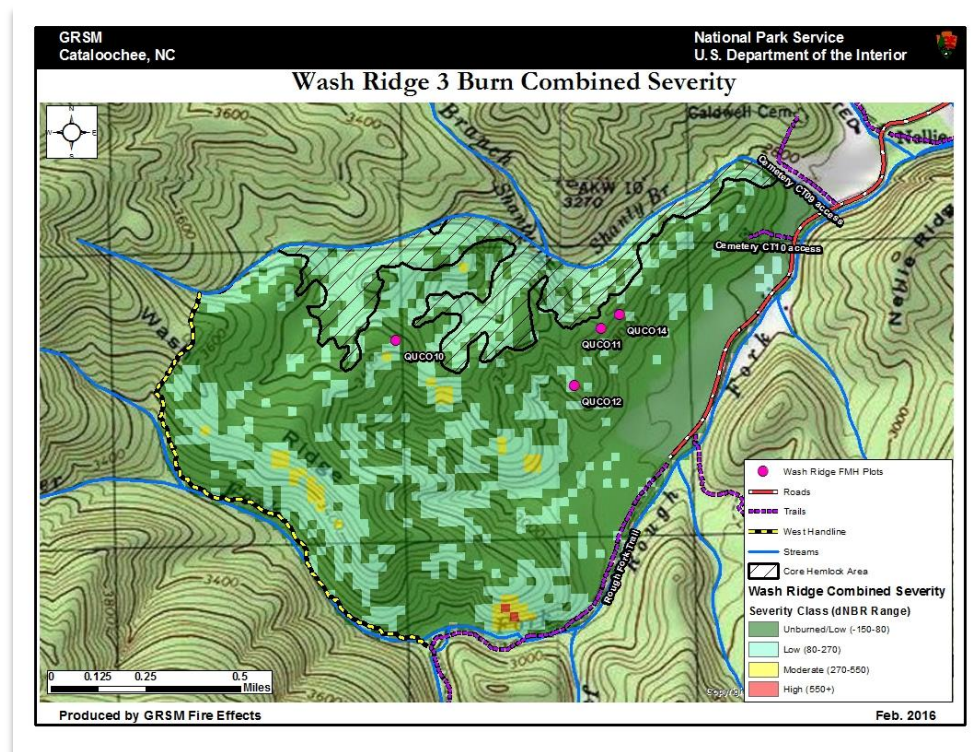


Figure 8. Composite of severity images from 2004, 2007, and 2015 extended burn severity assessments. Note the hatched area displays former eastern hemlock dominated forest which was in heavy decline from a non-native insect pest during the first and second burns, and which is partially represented in the severity image.

Wash Ridge Summary

- Based on field observations and the USGS severity map, there was good burn coverage of the target vegetation across the unit for the 3rd burn entry.
- FMH plots and field scouting indicate good top-kill of the dense resprouting mountain laurel and rhododendron understory shrub layer and hardwood tree seedling resprouts within the target vegetation.
- FMH plots indicate no significant recruitment of oak in any of the tree size classes while fire intolerant mixed hardwoods and white pine continue to encroach on the midstory and overstory. However, plot placement is not capturing the full range of effects observed in areas of higher severity. Future scouting of these areas and alternative monitoring protocols should provide better insight into the variation of long term fire effects.
- FMH plot data and field observation both agree that there has been significant thinning of the midstory across much of the target vegetation.
- Field observations also indicate little increase in herbaceous species richness or abundance due to heavy shrub and hardwood tree resprouts.

Long Term Monitoring Results

No new analysis of long-term monitoring results is available for this report. **Table 2** contains the most up-to-date analysis of long-term monitoring objectives that is available for GRSM.

Table 2. Objectives and long-term monitoring results for GRSM

Monitoring Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?	Year Last Analysis Completed
Yellow Pine Woodland (FPIR11) 27 plots	>50% Reduction in total fuel loading	Total fuel reduction: After one burn = 36% ($\pm 5\%$) (n=23) After two burns = 37% ($\pm 4\%$) (n=16)	Not yet, but on course.	2011
	>70% Reduction in pole-sized tree density	Pole reduction: After one burn = 54% ($\pm 5\%$) (n=25) After two burns = 75% ($\pm 7\%$) (n=11)	Yes	2009
	25-50% Reduction in overstory tree density	Overstory reduction: After one burn = 20% ($\pm 5\%$) (n=25) After two burns = 41% ($\pm 9\%$) (n=11)	Yes, but more burns are needed before drawing conclusions.	2009
	>200 tall (>1m) Yellow Pine seedlings /ac	Preburn density: 0 (n=25) After 1 burn: 97/ac (± 49) (n=25) After 2 burns 49/ac (± 40) (n=11)	No, but more burns are needed.	2009
	>40% Cover by native herbs/subshrubs	Preburn cover: 3% ($\pm 1\%$) (n=23) After 1 burn: 11% ($\pm 4\%$) (n=23) After 2 burns 10% ($\pm 6\%$) (n=9)	No, but more burns are needed.	2009
Dry Oak Forest (FQUCO1) 15 plots	>50% Reduction in total fuel loading	Total fuel reduction: After one burn = 29% ($\pm 3\%$) (n=11)	Not yet, but on course.	2011
	>70% Reduction in pole-sized tree density	Pole reduction: After one burn = 34% ($\pm 7\%$) (n=11)	Not yet, but on course.	2011
	15-30% Reduction in overstory tree density	Overstory reduction: After one burn = 5% ($\pm 2\%$) (n=11)	Not yet, but good gradual movement.	2011
	>200 tall (>1m) Oak seedlings /ac	Preburn density: 20/acre (± 23) (n=10) After 1 burn: 4/ac (± 6) (n=10)	No, but more burns are needed.	2011
	>30% Cover by native herbs/subshrubs	Preburn cover: 4% ($\pm 2\%$) (n=9) After 1 burn: 4% ($\pm 2\%$) (n=9)	No, but more burns are needed.	2011

Kings Mountain National Military Park (KIMO): 2015 Fire Effects Monitoring Annual Report

Activity Summary

The monitoring crew made two trips to KIMO during 2015. The crew participated in the Turkeybeard/Garner Creek prescribed burn, and conducted immediate post-burn plot monitoring during that same trip. The crew returned in late summer to complete short and long-term monitoring in Turkeybeard, East Garner, and Saddleback burn units. A summary of the prescribed burn/fire effects monitoring for Turkeybeard and East Garner can be found in the “Review of 2014 Projects” section of this report.

Program Goals and Objectives

One of the successes of our fire-effects monitoring program has been its contribution to the development of short and long-term objectives for the prescribed fire program. Monitoring data have been continually used to evaluate and improve objectives, and this is indicative of major advances in understanding Appalachian and Piedmont fire ecology over the past 15 years.

In past years’ reports, we’ve used this space to communicate existing goals and objectives and to improve the objectives as new data have become available. There are no significant changes in goals and objectives for KIMO, so in the interest of reducing the length of this report, the reader is referred to the 2011 Annual Report.

Review of 2015 Projects

Turkeybeard /East Garner Prescribed Burn:



Figure 1. View East towards Lookout Tower

The Turkeybeard and Garner units are located in the Southwest corner of the park. Together they occupy approximately 400 acres in what can be considered as the harshest, driest part of the park's landscape. Among the units is unique geology called Kings Mountain quartzite and a globally rare vegetation community type Piedmont Rock Chestnut oak- Blackjack Oak woodland (Total acres=15.1). The community is sparse to moderate coverage with Chestnut Oak, Blackjack Oak and shortleaf pine in the overstory. The herb layer is diverse and patchy including species such as sparkleberry (*Vaccinium arboreum*), downy Danthonia (*Danthonia sericea*), Anise scented goldenrod (*Solidago odora*), bracken fern, little bluestem (*Schizacharium scoparium*) and eastern turkeybeard (*Xerophyllum asphodeloides*) in one location of the park. Although the majority of the unit is comprised of Scarlet oak (*Quercus coccinea*), chestnut oak (*Quercus montana*), shortleaf pine (*Pinus echinata*) and mixed fire intolerant hardwoods associated with the Interior Southern Red Oak-White Oak forest community type. The type is typical of King Mountain NMP indicated by poor soils, low herb diversity and mostly second growth forest.

Turkeybeard unit was treated in 2001, 2005 as an individual unit and combined with the east half of the Garner unit in 2015. Garner was treated in 2006 and split into an East and West half in 2013. For 2015, the combination of Turkeybeard and Garner East for 267 acres made for easier operation on the South and West side of the units with regards to holding concerns (Figure 2). The Turkeybeard 2005 and Garner 2006 Rx burns resulted in several large canopy openings and a conversion from Forest fuel type to grass fuel type and hardwood resprout thickets.

The burn operation, after an initial false start on 4/24/2015 relating to weather and prescription parameters, resumed with completion on 4/26-27/2015. The operation started on the Eastern peak of Browns Mountain with ignition splitting into two groups working opposite direction until fire was tied into southern holding line and creeks.

Fire behavior was within acceptable range depending on slope, aspect and arrangement of fuels. Obviously the west side of Turkeybeard had a larger buildup of fuels and xeric vegetation, so more intense fire behavior was observed here. Coverage was a mosaic, but consistent consumption especially where mid-elevation forests with closed canopies existed. The Blackjack Oak community type had mixed fire intensity and severity, especially when fuels were sparse or canopies were open. Turkeybeard unit had mostly backing and flanking fire except the occasional torching due to mountain laurel/leaf litter pockets. There were also areas that remained unburned in that particular vegetation community type across both units. Several large open-canopies with hardwood re-sprout thickets had minimal fire spread into them due to lack of fuels and the compressed nature of leaf litter.



Garner/Turkeybeard Unit 2015

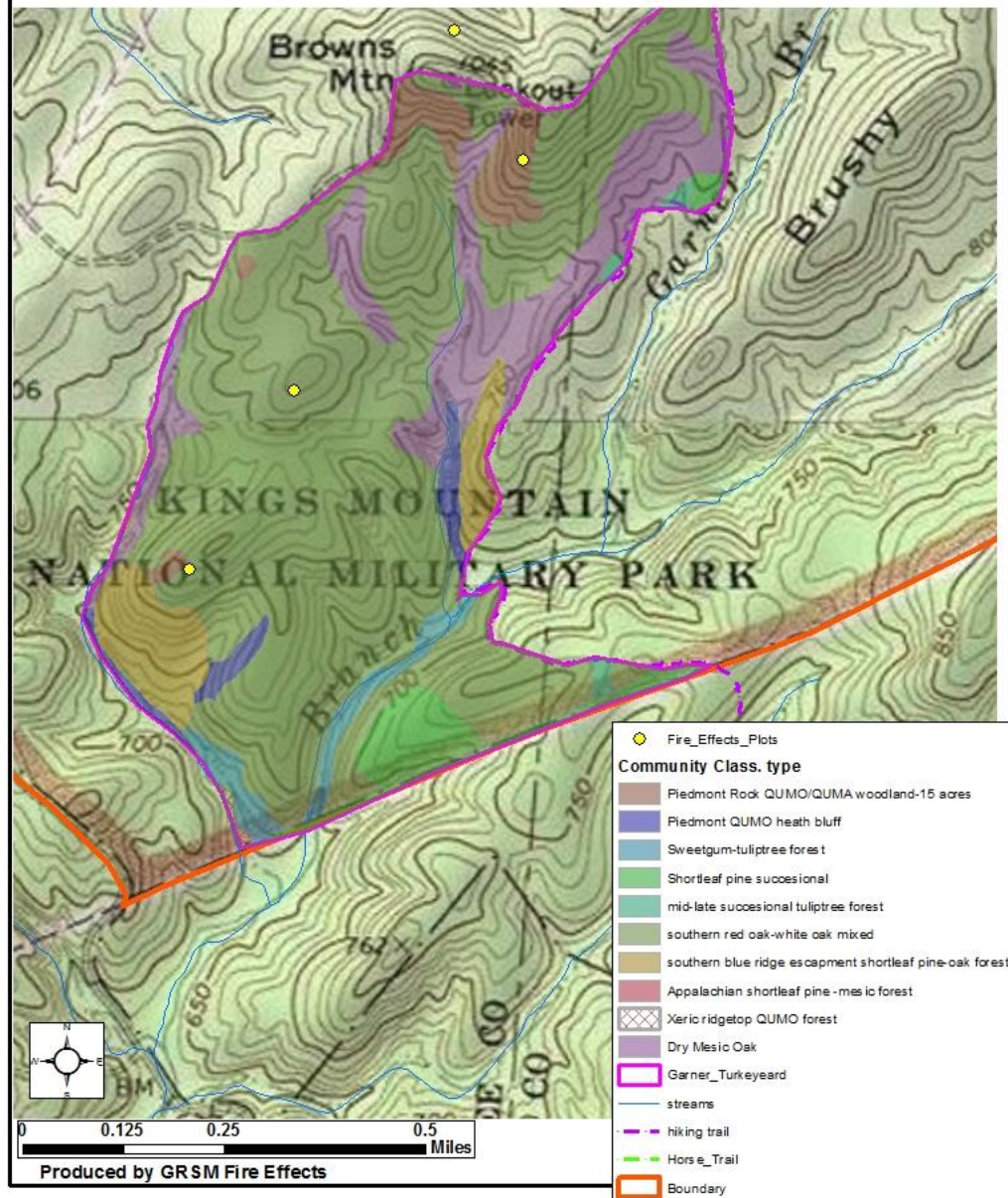


Figure 2. Map of Vegetation and combined 2015 unit

Examples of typical fire behavior in the xeric forest type (Figure 3.) As a side note, one particular feature to notice in the photo is the consumption of litter beneath the shortleaf pine seedlings. Through Qualitative monitoring and a few FMH plots, we've observed seedlings of shortleaf pine transitioning to the midstory, especially within the xeric vegetation types in the Garner/Turkeybeard unit.

Additional ignition followed on day 2 in what appeared to be securing holding lines along the southern perimeter although no official statement was made during briefing. Litter and small fuel consumption was uniform over the entire unit where appropriate ([Figure 3](#)), as well as numerous 1000 hour fuels being consumed well into the second and third day. Very minimal damage was done to the remaining overstory, and excellent top-kill of fire sensitive sprouts less than 1-2" in diameter was observed during the growing season post burn.



Figure 3. Fire Behavior - Day 1



Figure 4. Fire behavior - day 2

Goals and Objectives taken from Fire Effects Monitoring Report:¹

- Consume >75% of surface litter (fine fuels) over >70% of the area occupied by target vegetation. Target vegetation is typically oak and pine forests found on slopes and ridge tops, but also include large areas of 5'-10' tall hardwood regeneration with sparse overstory.
- Use low-intensity backing fires to protect mature oak and pine stands and individuals, while utilizing a range of fire behaviors to control (top-kill) non-oak hardwood regeneration.
- Top kill 30-60% of the mid-story (non-oak or pine) trees and shrubs as measured 1 year post burn. Again, this is for target areas described above.
- Limit mortality of mature oaks to <10% as measured 2 years post burn.
- Prevent the creation of additional canopy gaps in areas of mature forest by using low-intensity fire in these areas.

Most likely met; some of these will require more time to assess, although observations on burn day and the following day indicate very high probability of meeting fuel reduction, and overstory goals, while possibly meeting midstory goals.

Restore and Maintain structure and composition to accurately portray the landscape of 1780, including fire and drought-adapted vegetation on dry sites (i.e. Eastern Turkeybeard).

One more step forward towards restoration of more historically accurate vegetation structure and composition.

The Turkeybeard (*Xerophyllum asphodeloides*) population in the park associated with the sparse fuels of the Blackjack community type had mixed burn coverage. The state of South Carolina conservation ranking status for Turkeybeard as S2 or State imperiled (6-20 populations)². Kings Mountain National Military Parks population is furthest Southeast in the U.S. After surveying the population following the burn, 2 of the 5 remaining clumps remained unburned with one of those flowering at the time of the burn.

For the past 15 years, the fire effects crew has monitored a FMH plot adjacent to the Turkeybeard population and informally kept a record of the population and number of clumps. Figure 5 is a table of number of clumps and indicates the population numbers over the past 15 years.

¹ Robert Dellinger – Garner Creek East/Turkey Beard Rx Burn FEMO Report
Kings Mountain National Military Park, SC

² <http://www.centerforplantconservation.org/>

<u>Dates</u>	<u>Number of XERASP clumps</u>
2000	6
2001	8
2003	8
2005	7
2006	4
2009	3
2014	4
2015	5(1 of these clumps was previously uncounted in total counts)

Figure 5. Turkeybeard clumps tracked over 15 years

Although the monitoring of this population has been informal, the numbers appear to show a drop in population by almost half following the 2005 Rx treatment. (There were visibly dead plants noted within the data). The cause for the population decline is unclear and needs further research. Some topics to research are: what is the ideal canopy structure for turkeybeard to flourish?; Did the population decline due to excessive removal of duff and moisture holding soil structure following the 2005 Rx burn and ensuing drought?; What are the germination requirements for this species?: Are seeds from this small population viable?

The other interesting area of the parks vegetation communities is Piedmont rock Chestnut Oak-Blackjack Oak woodland, which is listed by NatureServe as Globally rare. Several Fire Effects FMH plots occur in this community throughout the park and 3 of those plots lie within the Garner/Turkeybeard unit.

Since 2000, photo documentation of plots has occurred in what is titled QUMA(*Quercus marlandica*) forest plot type which amounts to an enormous amount of data that can be used compare visual changes from various stages of the restoration process. The following photo series is from a plot QUMA05 from the installation prior to any treatment (00Pre) through the first burn (01 post), year 2 after the first burn, year 5 after the first burn, and the first growing season following the second burn (02).

The series indicates a snapshot of what the 15.1 acres of Piedmont Rock-Chestnut Oak-Blackjack Oak woodland community type looks like. In places where the canopy was removed following the 01 burn, the increase in sunlight and thus herbaceous flush of colonizers to high quality native grass and herbs as well as establishment of shortleaf pine seedlings. Following the 02Burn and growing season is the top kill of fire sensitive sprouts, decrease in native grass cover, increase in native herbaceous cover and promotion of shortleaf pine into the pole-sized category.



00 PRE



01 Post burn



01yr02



01yr05



02yr01

Long Term Monitoring Results

2009 was the last time that long-term monitoring results for KIMO were updated (**Table 1**), but there was not enough data collected during 2015 to improve the current analysis. As noted before, the results indicate that KIMO is on track toward achievement of its management objectives. Despite the large number of plots at KIMO, however, there are significant trends in fire effects that are not being captured in the plot data. These trends are still being explored, and have been discussed in previous reports and presentations.

Table 1. Objectives and long-term monitoring results for KIMO

Monitoring Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?	Year Last Analysis Completed
Chestnut Oak-Blackjack Oak Woodland (FQUMA1) <i>8 plots</i>	>50% Reduction in total fuel loading	Total fuel reduction: After one burn = 47% ($\pm 4\%$) ($n=7$)	Not yet, but on course.	2009
	>70% Reduction in pole-sized tree density	Pole reduction: After one burn = 45% ($\pm 12\%$) ($n=8$) After two burns = 62% ($\pm 12\%$) ($n=4$)	Not yet, but on course.	2009
	15-30% Reduction in overstory tree density	Overstory reduction: After one burn = 30% ($\pm 11\%$) ($n=8$)	Yes	2009
	>30% Cover by native herbs	Preburn cover: 6% Cover after 1 burn: 9% ($n=7$)	No, but more burns are needed.	2009
Dry Oak Forest (FQUM01) <i>21 plots</i>	>50% Reduction in total fuel loading	Total fuel reduction: After two burns = 41% ($\pm 5\%$) ($n=19$)	Not yet, but on course.	2009
	>70% Reduction in pole-sized tree density	Pole reduction: After one burn = 43% ($\pm 2\%$) After two burns = 58% ($\pm 5\%$) ($n=19$)	Not yet, but on course.	2009
	15-30% Reduction in overstory tree density	Overstory reduction: After one burn = 7% ($\pm 3\%$) After two burns = 12% ($\pm 3\%$) ($n=19$)	Not yet, but on course.	2009
	>200 tall (>1m) Oak or shortleaf pine seedlings/acre	Preburn density = 85/ac (± 49) After one burn = 55/ac (± 34) After two burns = 55 stems/ac (± 32) ($n=19$)	No, but more burns are needed.	2009
	>15% Cover by native herbs/subshrubs	Preburn cover: <1% After 1 burn: 1% After 2 burns: 1-2% ($n=19$)	No, but more burns are needed.	2009

Additional Program Information

Table 1. Planning - 2015

Park	Does Park have written DFCs? (yes or no)	Date Park-level Monitoring Plan completed (or revised)	Total # of Project- or Community- level Monitoring Plans (not just 2015)	Assisted with how many BAER plans in 2015?
BISO	yes	n/a	0	0
BLRI	yes	n/a	0	0
CAHA	no	n/a	0	0
CONG	yes	n/a	0	0
COWP	no	n/a	0	0
CUGA	yes	n/a	0	0
GRSM	yes	n/a	0	0
KIMO	yes	n/a	0	0
MOCR	no	n/a	0	0

Table 2. Monitoring - 2015

Park	% 2015 Data entered	%2015 Data Quality Checked	# of Prescribed Fires Monitored	# Non-Fire Fuels Treatments Monitored	#Wildfires Monitored	#BAER Treatments Monitored
BISO	50	50	1	0	0	0
BLRI	0	0	1	0	0	0
CAHA	100	100	2	0	1	0
CONG	0	0	0	1	0	0
COWP	-	-	0	0	0	0
CUGA	50	50	1	0	0	0
GRSM	75	25	3	0	0	0
KIMO	50	50	4	0	0	0
MOCR	-	-	0	0	0	0

Table 3. Communicating Results - 2015

Park	# of Project Monitoring Reports completed in 2015	# of Annual meeting(s) with Park staff	# of Formal presentations of results	Do you use Minitab?*
BISO	1	1	0	Yes
BLRI	0	0	0	Yes
CAHA	1	1	0	No
CONG	0	1	0	Yes
COWP	0	0	0	No
CUGA	1	1	0	Yes
GRSM	2	1	0	Yes
KIMO	0	1	0	Yes
MOCR	0	1	0	No

Table 4. Research - 2015

Park	Are research needs identified in FMP or Monitoring Plan? (yes or no)	# of Proposals Submitted in 2015	# of Proposals Funded in 2015	# of Research Projects Supported in 2015*	Additional Comments
BISO	yes	0	0	1	
BLRI	yes	0	0	0	
CONG	yes	0	0	0	
COWP	yes	0	0	0	
CUGA	yes	0	0	0	
GRSM	yes	2	2	5	Heavy support
KIMO	yes	1	1	2	
MOCR	yes	0	0	0	

*Number of funded research projects, new or ongoing, supported by the fire ecology program including logistical info or support, staffing, etc.

Fire Ecologist and Fire Effects Crew Accomplishments and Areas of Focus

Table 1. Fire Ecologist 2015 Accomplishments/Focus Areas

Category	Percent Time	Accomplishments and/or areas of activities
Detail /Acting Role	15%	30-days of a 90-day detail as SERO Fire Ecologist (January 2015); 90 day stint as Acting-FMO of Appalachian/Piedmont that included implementation of the Phase 2 Medical Standards/FFT Physical process with multiple Risk Mitigation/Waiver cases.
Data Collection	8%	Field work at GRSM, BLRI, and CAHA. FMH plots, LFEM plots, and qualitative surveys.
Planning	15%	Fire Realignment planning ; Realignment meetings with management staff at CAHA and CONG ; FMP scoping/ecological support for KIMO, CONG, CUGA, CHCH ; Fire effects monitoring budget and workload planning ; Site-specific prescribed burn planning (esp. firing planning) ;
Data analysis	7%	Estimated amount of time spent performing analyses, including data summaries and statistical tests. Tabular and spatial data.
Data management	5%	Routine data management tasks
Supervision/Admin	10%	Budget/Realignment issues. Hiring, Supervision, Performance evaluations, IDPs, travel, payroll, crew support, purchasing etc.
Fire Operations	8%	Prescribed burns at GRSM; Wildfire on Cherokee BIA; 2 week assignment as Engine Crew in OR.
Writing	7%	Work on monitoring plans; Proposal writing. Annual report. Detailed correspondence.
Educational Outreach	5%	Participation in Congaree NP Fire Education Workshop, Guest lecture at Western Carolina University, Campfire program for visiting college Honors group, Field trip with class from Highlands Biological Station, Field trip with large multi-agency group to view fire restoration at GRSM
Partnerships	5%	Build strong partnership with TNC –TN chapter and NPCA to advocate for continued prescribed fire restoration in GRSM; Met with USFS – Cherokee NF to build burning capacity
Research/ Publications	10%	Involvement with several research projects at GRSM, and KIMO (see Research Update); Co-author on two refereed publications; Heavy involvement in GRSM Landscape Conservation Forecasting project; Co-PI on two JFSP proposals; Data support, field support, support letters.
Miscellaneous	5%	Mostly communication; E-mails, phone calls, informal planning discussions.
Training	0	Identify training needs

Table 2. Fire Effects Crew 2015 Accomplishments/Focus Areas

Category	Percent Time	Notes
Planning	15%	Primarily related to prescribed fire and includes participating in planning meetings, extensive pre-burn scouting of project units, providing feedback to operations personnel via maps and oral or written communication, and assisting with the development of formal firing plans based on knowledge of on-site conditions and burn objectives. Also includes routine coordination with the Fire Ecologist to plan and schedule general fire effects monitoring field work
FMH plots	20%	Primarily GRSM along with a few plots at CUGA, BISO, and KIMO. Also assisted NATR Fire Effects Team with plots at LIRI and HOBE
Qualitative Monitoring	5%	Completed for burn units at GRSM, BISO, CUGA, KIMO
CBI/ Landscape Fire Effects Monitoring (LFEM) Plots	5%	LFEM plots combine species composition data with a streamlined CBI data collection process. Resampled plots at CAHA and installed 7 permanent LFEM plots at BLRI prior to planned 2016 burn.
Wildfire assignments	5%	Lead work as a HECM on a Texas fire assignment and Seasonal Crewmember worked as a READ on the Sierra National Forest California. Crew assisted with in-park (GRSM) fires and local response on Cherokee BIA land
Prescribed fire projects	10%	Assisted with prep, implementation, and mop-up of burns at CUGA, GRSM, and KIMO
Non-fire fuels projects	<5%	Crew installed 17 new species composition plots at CONG prior to 2016 mastication project
Travel out-of-park for plot or project work	5%	
GIS	10%	Primarily map making for field work and as a communication tool used in reports, meetings, and presentations, but also includes data management such as FMH and CBI plots databases and Fire History/Fire Occurrence database.
Data entry	10%	Approx. 70% entered
Data analysis	<5%	Mostly summary tables for various reports but also includes some work with CBI dataset
Supervision/Admin	5%	Supervision of crew in completing field and office work, and time, travel, and purchasing paperwork
Training	<5%	Lead Attended NCTC wetland plant identification training. Crew had fire refresher training and misc. on the job training
Miscellaneous	<5%	

The End.