



Southern Appalachian/Piedmont Fire Effects Monitoring Team

Fire Effects/Fire Ecology Annual Report Calendar Year 2009

A. Summary

2009 was another fascinating and productive year for the Southern Appalachian/Piedmont fire effects team. Work continued on short and long-term data collection at each of the six parks in our network (Table 1), as well as cooperative monitoring efforts with the US Forest Service in Tennessee and North Carolina. The crew also continued to play an important role in fire operations throughout the Southeast Region, supporting the completion of more than 24 prescribed burns at seven NPS units and providing leadership for wildfire management at the home park.

Table 1. Fire Effects Plot Workload 2009

Park	Monitoring Type	Type of Plot	Pre-burn	Immed. Post	Postburn (1-20 yrs)	Total Plots
Big South Fork (BISO)	Shortleaf Pine	FMH Forest plot	1	0	1	2
	White Oak	FMH Forest plot	6	4	4	11
Cumberland Gap (CUGA)	Scarlet Oak	FMH Forest plot	2	5	11	16
Congaree Swamp (COSW)	Longleaf Pine	FMH Forest plot	0	0	2	5
Great Smoky Mountains (GRSM)	Scarlet Oak	FMH Forest plot	1	2	5	13
	Black Oak	FMH Forest plot	0	0	4	4
	Yellow Pine	FMH Forest plot	0	0	9	26
Kings Mountain (KIMO)	Blackjack Oak	FMH Forest plot	0	0	3	8
	Chestnut Oak	FMH Forest plot	0	1	13	20
Cowpens (COWP)	Southern Red Oak	FMH Forest plot	0	0	2	2
Cherokee National Forest	High Elevation Oak	Modified FMH Forest			3	
Pisgah National Forest	Pine-oak-heath	Modified FMH Forest	2			
Total			12	12	57	107

As usual, there were some big changes in the team roster (Table 2). Most notably, longtime team member and Lead Monitor Nunally Benzing left the amazing world of fire to pursue work with

the Inventory and Monitoring program at Great Smoky Mountains NP (as of February 2010, Nunally resigned her position with the park). Many thanks and much credit go to Nunally for her contributions and dedication to excellent management of NPS resources.

Table 2. Fire Ecology Staffing 2009

Staff	Starting Date	Ending Date	# of Pay Periods	READ Qualified (Yes or No)	Training and Development
Rob Klein Ecologist	1/1/09	12/31/09	26	No	SER CBI training, AK fire detail, International Fire Ecology Congress
Wylie Paxton Lead Monitor (Former Assistant)	1/1/09	12/31/09	26	No	Attended S-271 HECM, completed ICT5 taskbook, Carolina Veg Survey, SER CBI training, Gramanoid Workshop, SAMAB Conference, International Fire Ecology Congress
Nunally Benzing Former Lead Monitor	1/1/09	3/28/09	6	No	Accepted field lead position working for GRSM Forest Ecologist
Bob Dellinger Crewmember	1/18/09	11/21/09	22	No	Continued work on CRWB and FIRB taskbooks, Carolina Veg Survey, SER CBI training, AK fire detail
Huma Alvarado Crewmember	3/29/09	10/24/09	15	No	Completed FEMO taskbook, Wilderness 1 st Responder Refresher, Carolina Veg Survey, SER CBI training, AK fire detail,
Matthew Wood Detailed Crewmember/ Assistant Lead Monitor	5/31/09 11/22/09	10/24/09 12/31/09	13	No	Detialed from GRSM WFM, later accepted assistant lead position, attended S-271 HECM, Carolina Veg Survey, AK fire detail, International Fire Ecology Congress
Eric Worthington Detailed Crewmember	8/2/09	8/29/09	2	No	Summer detail from GRSM Engine Crew to assist with long-term fire effects monitoring
Eddie Gambrell Cynthia Worthington KIMO Interns	May 09	June 09	2	No	Kings Mountains National Military Park student interns

The team was fortunate to promote Mr. Wylie Paxton into the role of Lead Monitor. Wylie has been with the crew for over six years now, and brings to this position an outstanding knowledge of our programs, ecology and people. The Assistant Lead Monitor position was recently filled by Mr. Matt Wood, who brings a broad range of knowledge and skills to our program.

Additional Fire Ecology/Fire Effects program highlights from Calendar Year 2009 include:

- Support for western fire season with fire assignment in Alaska
- Completion of a fire ecology assessment and 10-year treatment plan for Cades Cove
- Participation/Leadership in a site visit by a national burn-severity mapping team
- Service as Federal Cooperator on a new Joint-Fire Sciences research project to study the effects of fire on endangered Indiana bats
- Continued service as Federal Cooperator for ongoing region-wide fire history study
- Service on the steering team for the Southern Blue Ridge Fire Learning Network

- Presentation of fire effects on oak forests at International Fire Congress in Savanna, GA (with data from GRSM, KIMO, BISO, and CUGA).

Future Plans

In the coming year, our team will continue to provide short and long-term monitoring results as well as support for planning and operations at all of our parks. Some work is underway to incorporate the Blue Ridge Parkway into our prescribed fire/monitoring network, though this is not expected to impact our services to the existing network parks. In fact, it is expected that knowledge gained from work at additional parks will increase our ability to provide high quality resource information to managers.

The team is also exploring ways to provide additional monitoring products to managers and operations personnel. One of the most obvious findings that we have after 14 years of fire-effects monitoring is that each burn unit presents a unique combination of landscape, vegetation and fire effects – and understanding these unique features is essential to discussions about *how* to conduct future burns of a site in order to ensure that objectives are met. However, the long-term monitoring that makes up the lion's share of our work is more geared toward lumping all of a park's burn units into a basket and viewing a park as a whole. This is of course an appropriate course of action for the long-term, but fire managers/burn planners also have a need for short-term and site-specific data to base their more immediate actions on. To help meet this need, the team will attempt to develop maps for many of our upcoming units (FY2011) that detail unique characteristics and provide some recommendations, particularly for firing the unit. It is expected that such a product will provide valuable information for burn planning that will contribute to the achievement of resource objectives. We will be experimenting with the design/delivery of this product in the coming year, and we will be looking for your suggestions or comments along the way.

Finally, as all of our parks engage in the process of revising Fire Management Plans (FMP), we will be available to provide input and review to the parks. As you all know, the Fire Monitoring Plans that are meant to be an appendix to the FMPs remain largely unwritten. From a practical standpoint, good "plans" do exist, but a goal for this year will be to provide parks with organized documentation of these plans that they can add to the new FMPs. This process will undoubtedly be a year-long endeavor (at a minimum), and will be prioritized by the status of FMP revision.

B. Management Objectives and Monitoring Results 2009

The following sections are divided by park and contain a synopsis of prescribed fire projects from 2009 and data summaries from long-term fire-effects monitoring. *A new analysis of long-term monitoring results from each park has not been completed for 2009.* The annual report from 2008 contains extensive documentation of our most recent management objectives and analyses of those objective variables. Given the incremental change in the overall numbers, there was not enough post-burn data added to the databases in 2009 to justify a fresh (lengthy) analysis. Where additional pre-burn plots were established, I have added comments in the tables to indicate movement towards accomplishing our monitoring goals. The analyses will be revisited in the 2010 Annual Report. Meanwhile, pertinent analyses from individual parks will continue to be prepared and communicated to those parks. As always, park resource and fire managers are encouraged to address any specific fire-effects questions or needs to the Fire Ecologist or Lead Monitor.

The final section of this report contains a summary of the region-wide analysis of fire effects in oak forests that was completed for the 2009 Fire Ecology Congress in Savanna, Georgia. This analysis used data collected from four of our parks (KIMO, CUGA, BISO, GRSM) over the past 10 years, and resulted in more specific recommendations for using prescribed fire to manage oak woodlands in the Appalachian highlands. These recommendations deal with the creation and management of canopy gaps, and have been incorporated into the “Program Goals and Objectives” section (Section II) of reports from each of the included parks. Similar guidelines could be used at Cowpens as well.

Big South Fork National River Recreation Area (BISO): 2009 Fire Effects Monitoring Annual Report

I. Overview

The monitoring crew completed all scheduled plot reads in CY09, though only limited data were collected at oak plot #1 (Divide Road) due to hazards associated with snags. Three new plots were installed in 2009, all in the Gobblers Knob burn units just prior to burning in March. The vast majority of field work over the past year centered on the pre-burn, immediate post-burn, and year 1 post-burn monitoring of the five Gobblers Knob plots. The data from this burn are summarized and discussed in section III.

The park's work on the Gobblers Knob burn achieved regional and national attention when a visiting group of burn-severity mapping experts from around the country came to BISO in September. RM Division Chief Tom Blount and The Southern Appalachian Fire Effects Team helped lead the group in an effort to collect ground-truthing (or CBI, Composite Burn Index) data to support remote-sensing of burn severity (also known as dNBR, differenced Normalized Burn Ratio). The products of this remote-sensing are essentially maps that can show the severity of a wildfire or prescribed fire on forest fuels or vegetation at a 30meter pixel scale (Figure 1). Gobblers Knob was selected as a model because of its size and because it offered a great example of typical effects for fires in the eastern US.

Aside from completing short and long-term monitoring, Fire Ecology support for BISO centered on participation in the Gobblers Knob burn operations, and careful study of the area following the burn. Data from Gobblers Knob (and other BISO sites), were featured in presentations that were made at the International Fire Congress in November of 2009 (see section F. of this report), the NPS Fire and Aviation Management (FAM) meeting in February 2010, and in the annual fire effects reviews with the Cumberland Gap and Great Smokies Wildland Fire Modules. In particular, the presentation given at the NPS FAM meeting focused on the adaptive management process at BISO, touting the Gobblers Knob burn as an outstanding achievement. Any of these presentations is available upon request.

II. Program Goals and Objectives

The following goals and objectives remain very similar to what we've had in the past, with one notable exception: We've added as a burn objective to **limit the size of individual canopy gaps resulting from prescribed burning**. Similar language has also been added to the long-term objectives. This objective is being added to convey the importance of limiting the size of newly formed gaps, **particularly in the early stages of restoration (1st and 2nd entry burns)**. It should be noted that the creation of canopy gaps is one of the goals for the prescribed burning program, and such gaps will be necessary to truly restore oak and pine woodlands at BISO. However, we would like to avoid creating large or numerous gaps during first or second burns of a site and ultimately to limit the size of these individual gaps.

Monitoring and research suggest that opening large canopy gaps prior to establishment of desirable species in the understory (oak, pine, native herbs) can lead to a growth-release of

undesirable species (maple, black gum, sourwood, etc.) as well as invasion by non-native invasive species (princess tree, Chinese silvergrass, etc). In addition, with the loss of oak and pine litter, fuels in these gaps can actually restrict the effective spread of fire, further complicating efforts to meet objectives. We are just beginning to understand the dynamics in these gaps, and these objectives will undoubtedly need to be updated in the future.

Also, it should be stated that there are numerous large canopy gaps already existing at BISO, primarily as a result of pine mortality associated with the southern pine beetle attacks a decade ago. The still-young hardwood stands coming up in these gaps (which also have heavy fuel loads) are particularly susceptible to top-kill during burns. Additional monitoring will be required to help develop the best prescriptions for managing these gaps.

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

1. 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.
2. Restore and maintain structure, sustainability, and species diversity to oak and shortleaf pine woodlands.

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 typically oak and pine forests found on upper slopes and ridgetops.
- >30% topkill of saplings (<10cm dbh)
- **Limit individual canopy gaps (due to fire) to less than 1 acre in size**
- Fire Intensities do not exceed the following spatial proportions within targeted vegetation types:
 - <5% high intensity (FL >8')
 - 5-20% moderate intensity (FL 3-8')
 - 75-90% low intensity (FL 1-3')
- Burn is conducted with appropriate fuel conditions (i.e. KBDI) to achieve 15-45% total fuel reduction. KBDI <75 will typically produce this result on a first entry

burn at BISO. KBDI on first (or second?) entry burns should usually not exceed 200. The higher the KBDI, the less intensity is desired.

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-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 acre in size**
- Greater than 200 tall (>1meter) oak seedlings per acre
- Greater than 30% cover by native herbaceous species

III. 2008 Projects

Gobblers Knob A & B

The Gobblers Knob A and B prescribed burn units are located along Divide Road on the western side of the Big South Fork NRRA at the Kentucky/Tennessee state line. This landscape is primarily rolling/hilly with some steep, dissected terrain associated with No Business Creek. Elevations range from approximately 880-1620 feet, and all aspects are represented. Vegetation is dominated by mixed-oak and oak-pine forests, with mixed hardwoods and conifers in sheltered draws and low slopes. Prior to burning, most xeric to dry-mesic forests had been impacted by southern-pine beetle and there were substantial pockets with heavy mortality of Shortleaf and Virginia pines. Pre-burn fuels were primarily composed of oak leaf-litter, and woody fuels from pine were ubiquitous. Total combined size of the burn was around 5800 acres.

Overall, this was an outstanding first-entry burn across a significant landscape. Observations made during the burn (FEMO report available from fire ecologist), and throughout the year following the burn indicate that all of the short-term burn objectives were met (Table 1). Remote sensing of burn severity (Figure 1) confirms that the vast majority of this landscape burned in low to low-moderate severity, which is highly desirable for first-entry burns at BISO and will help insure that longer-term objectives are met on schedule. One area of concern that stands out from the burn severity image is the large patch of moderate severity (yellow) on the southern end of the unit. This was undoubtedly the result of rapid slope reversals that occurred following black-lining operations in this area. Such slope reversals resulted in higher intensity upslope runs on the day of the burn, and may contribute to formation of undesirably-large new canopy gaps (see section II. Goals and Objectives). In the future, such events could be mitigated by pre-planning the ignition patterns of the black-lining operation.

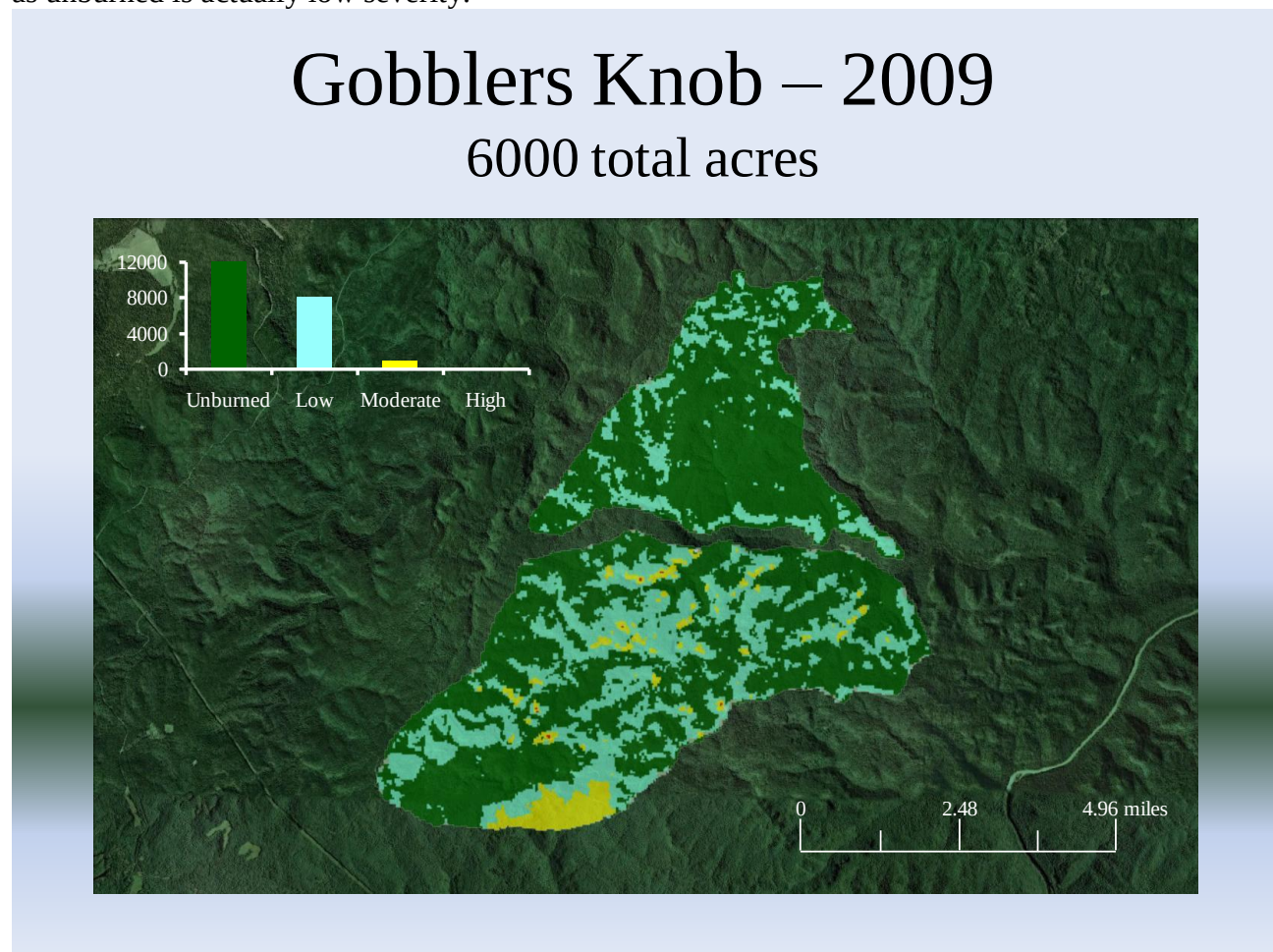
Table 1. Fire effects from Gobblers Knob A/B (n=4).

Burn Status	1000-hr load	Duff load	Litter load	Total load	Overstory trees	Pole trees
Preburn	4.9	16.5	10.7	33.5	313	1332
Postburn	4.4	10.8	0.4	17.3	313	980
% change	-10%	-35%	-96%	-48%	No Change	-26%

Fuel loads are tons/acre. Tree densities are stems/hectare.

Pine plot #2 was excluded from the analysis because it did not burn.

Figure 1. dNBR Extended Assessment image of Gobblers Knob A/B. In this image “Unburned” ranges from truly unburned to low severity. Undoubtedly, much of what is depicted as unburned is actually low severity.



IV. Long term Monitoring Results

The number of plots and prescribed burns at BISO remains insufficient to determine the effectiveness of the burn program with regard to the long term resource objectives. The data can, however, provide valuable insights into the effects and effectiveness of the early burns. Table 2 includes a listing of the

long-term restoration objectives along with a summary of the most pertinent data available to date. Again, there are obvious limits to the inferences that can be drawn from these data, and efforts are underway to continue building a more statistically meaningful dataset. Three plots were added to the BISO dataset in 2009: 2 in the oak woodland vegetation type and 1 in the shortleaf pine type.

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

Vegetation Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?
Shortleaf Pine Woodland (FPIEC1) 2 plots <i>Note: This vegetation type has been decimated at BISO and plots are very difficult to find.</i>	>60% Reduction in total fuel loading	Total fuel reduction = 32% (no CI) Preburn: 27.7 tons/ac After 2 burns: 18.8 tons/ac (n=1 plot, 1 burn unit)	Not Enough Plots – 1 plot added in '09
	>70% Reduction in pole-sized tree density (trees ≤ 15cm or 6")	Pole reduction = 67% (no CI) Preburn: 40 live trees After 2 burns: 13 live trees (n=1 plot, 1 burn unit)	Not Enough Plots – 1 plot added in '09
	25-50% Reduction in overstory tree density (trees ≥ 15cm or 6")	Overstory reduction = 20% (no CI) Preburn: 20 live trees After 2 burns: 16 live trees (n=1 plot, 1 burn unit)	Not Enough Plots – 1 plot added in '09
	>200 tall (>1m) Shortleaf Pine seedlings /ac	Preburn: 0 pine seedlings After 2 burns: 0 pine seedlings (n=1 plot, 1 burn unit)	Not Enough Plots – 1 plot added in '09
	>40% Cover by native herbs	No Preburn data 28.3 % cover of native herbs @ 01yr1	Not Enough Plots – 1 plot added in '09
Dry Oak Forest (FQUAL1) 11 plots	>50% Reduction in total fuel loading	Total fuel reduction = 46% (±2%) Preburn: 36.1 tons/ac After 1 burn: 19.6 tons/ac (n=4 plots, 3 burn units)	Not Enough Plots – 2 plots added in '09
	>70% Reduction in pole-sized tree density (trees ≤ 15cm or 6")	Pole reduction = 96 % (±3%) Preburn avg: 22 live trees After 1 burn: 1 live tree (n=3 plots, 2 burn units)	Not Enough Plots – 2 plots added in '09
	20-40% Reduction in overstory tree density (trees ≥ 15cm or 6")	Overstory Reduction = 9% (±5%) Preburn avg: 30 live trees After 1 burn: 27 live trees (n=4 plots, 3 burn units)	Not Enough Plots – 2 plots added in '09
	>200 tall (>1m) Oak seedlings /ac	Preburn avg: 0 After 1 burn: 54 tall oak seedlings/acre (n=3 plots, 2 burn units)	Not Enough Plots – 2 plots added in '09
	>30% Cover by native herbs	Preburn cover: 14.0% (±23.5) After 1 burn: 15.0% (±19.2) (n=3 plots, 2 burn units)	Not Enough Plots – 2 plots added in '09
Little Bluestem Sandstone Glade/Savanna (FSCSC1) 3 plots	>70% Reduction in pole-sized tree density	Pole-sized tree change: 16% (±19%) (n= 3 plots, 2 burn units)	Not Enough Plots
	>100% Cover by native herbs	Preburn cover: 103.3% (±27.4) After 1 burn: 144.7% (±32.7) (n= 3 plots, 2 burn units)	Not Enough Plots

V. Discussion and Comments

The process of restoring fire-adapted natural communities at BISO is still in its early stages, as is the fire-effects monitoring program. One of the limitations of the NPS sampling design is that it is not tailored to provide short-term results for individual burn units. Instead, it seeks to provide long-term information about the effectiveness of *burn programs*. With that said, extensive reconnaissance and comparisons with similar areas in the southeast should allow us to provide some interpretation of individual burns, which we have attempted to do in this report.

The findings discussed in this monitoring support the observation that the Gobblers Knob prescribed burns of 2009 represent a major step forward in our ability to apply fire appropriately to the BISO landscape. The park's burn program has undergone an impressive adaptive management process within a relatively short span of time (4 years), and has developed an effective approach to managing a difficult hazardous fuels situation. Some major challenges remain, and continued monitoring and engagement with all stakeholders will be vital to the success of restoring fire-adapted vegetation at BISO.

Congaree National Park (CONG): 2009 Fire Effects Monitoring Annual Report

I. Overview

There is very little new information to report for Congaree. No prescribed burns were conducted during 2009, and the only scheduled monitoring work was in the Harry Hampton unit (#1) and the RCW area (unit #4). Since only 2 of these 8 plots burned during the fall 2008 fire season, there was not much additional data, and a recalculation of objective variables was not warranted.

Efforts in the coming years will focus on continuing to sample all plots, and looking for opportunities to increase the number of plots. This will remain somewhat problematic due to the lack of additional longleaf sites and the lingering uncertainties about long term goals and objectives for the loblolly-dominated forests. Accordingly, other work will focus on helping to determine meaningful and achievable ecological objectives for these loblolly-dominated areas. The hope is that existing plots in the Red Bluff unit will receive a good hot burn in spring 2010, and generate some new information on managing the extensive loblolly pine forests of CONG.

II. Program Goals and Objectives

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

1. Restore and maintain all remaining remnants of longleaf pine woodland/savanna, using fire to reduce the density of hardwoods and loblolly pine. A related natural resource goal is to encourage/enhance herbaceous species abundance and diversity within these sites.
Note: This vegetation type is limited to around 70 acres within burn units 3 and 4, much of which has shared dominance by loblolly pine.
2. Restore the woody and herbaceous structure and composition within sites currently dominated by loblolly pine. An analysis of historical vegetation suggests that these areas were once dominated by a variety of longleaf pine natural communities.

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 longleaf pine remnants are -

- Reduce the 1-hour fuels between 50-85% over 75% of the unit measured immediately post burn.
- Reduce the density of pole and sapling-sized hardwoods and loblolly pines by 30-70% each burn as measured within 1 year post burn.

Burn objectives for loblolly pine-dominated forests are -

- Reduce the 1-hour fuels between 50-85% over 75% of the unit measured immediately post burn.
- Reduce the density of pole and sapling-sized hardwoods and loblolly pines by 30-

- 70% each burn as measured within 1 year post burn.
- *Induce over-story mortality*, where possible, to as much as 30% as measured 1 year post fire, per burn without compromising safety and/ or holding concerns.

Long term objectives – Long term objectives are typically expected to be achieved only after multiple prescribed burns. Please see Table 1 below for specific objectives and data.

III. 2008 Projects

There were no prescribed burns at Congaree during Calendar Year 2009.

IV. Long term Monitoring Results (repeated from 2008 annual Report)

As mentioned previously, long term fire effects monitoring has been ongoing at CONG for over 10 years now. Collection of meaningful fire effects data has been hampered somewhat by lack of an accurate baseline in the RCW unit and lack of clear management objectives for loblolly forests. Other major difficulties include the inability to build an adequate sample size for monitoring of the longleaf remnant. There is simply not enough of that vegetation type at the park to ever achieve a suitable number of plots using the existing NPS monitoring design. With that all said, there is a wealth of data available that can and should be used to help formulate a more meaningful set of management objectives for the use of fire at CONG. Once those objectives are developed, it should be possible to build upon the existing monitoring program to provide better information to park managers. Until such time, the following information provides a glimpse into the successes and shortfalls of the prescribed burning program at CONG. The data need to be viewed with the following caveats:

- The longleaf/loblolly plots included in this analysis are dominated by loblolly pine and are thus not representative of the restored longleaf remnant
- Neither vegetation type has enough plots to accurately describe the range of variability in the vegetation or the fire effects.

Table 1. Long term fire effects monitoring at Congaree Swamp NP

Vegetation Type	Management Objective Restoration Phase- After ?? burns	Monitoring Results (80% confidence intervals)	Objective Achieved?
Longleaf/ Loblolly Pine Woodland (FPIPA1) 5 plots	>50% Reduction in total fuel loading	Fuel reduction: 18% Preburn avg.: 21.1 tons/acre After 6 burns: 17.3 tons/acre (n=4 plots, 1 burn unit)	Not Enough Plots
	15-30% Reduction in overstory tree density	Overstory reduction = 4% ($\pm 16\%$) Preburn avg: 18.5 live trees After 5 burns: 17 live trees (n=4 plots, 1 burn unit)	Not Enough Plots
	>200 tall (>1m) Longleaf pine seedlings /ac	Preburn density: data not clean After 5 burns: 0 (n=4 plots, 1 burn unit)	Not Enough Plots

Vegetation Type	Management Objective Restoration Phase- After ?? burns	Monitoring Results (80% confidence intervals)	Objective Achieved?
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 (n=3 plots, 1 burn unit)	Not Enough Plots
	>70% Reduction in pole-sized tree density	Pole reduction: After 1 burn: 38% After 2 burns: 46% After 3 burn: 65% (n=3 plots, 1 burn unit)	Not Enough Plots
	25-50% Reduction in overstory tree density	Overstory reduction: After 1 burn: 3% After 2 burns: 3% After 3 burn: 8% (n=3 plots, 1 burn unit)	Not Enough Plots

V. Discussion and Comments (repeated from 2008 annual Report)

The park has been successful at meeting the primary goal of restoring the unique remnant of longleaf pine in the RCW unit. A quick walk through that site reveals a diverse and productive herb layer, healthy mature longleaf trees, and abundant regeneration of longleaf pine. Monitoring data from the recently established plot in this restored area can be used as an example of what the park hopes to achieve in other upland restoration projects.

Areas within the RCW site that are currently dominated by loblolly pine have even seen dramatic improvements in woodland structure and herbaceous abundance. These stands in Units 3 and 4 provide some indication that loblolly pine can serve as structural proxy for the longleaf pine community type in certain areas, though reestablishing longleaf pine in these areas will require substantially more time or a more aggressive restoration strategy. Still other stands that are closer to the bluff have developed such a dense midstory and understory that getting fire to spread into them has been problematic. Plots in this area indicate that new approaches are needed during prescribed burns: options might include fine-tuning the burn prescriptions or utilizing a helicopter for interior ignition.

It is doubtful that any change in prescribed burning prescriptions or tactics will allow the park to make appreciable progress in reducing the density or basal area of the loblolly pine that dominates most of the burn sites within CONG. As is repeated throughout this report, objectives and management strategies will need to be revised to reflect this reality. This process is underway and should be a focus of continued interaction between park managers and regional fire staff in the coming year.

An alarming trend that has been observed during fire effects monitoring over the past couple of years is the increase in wild hog activity in the RCW area. There are now many small and several large wallows and trails throughout even the best longleaf pine site in Unit #4. The effects of this wildlife activity ranges from damage to individual longleaf seedlings and saplings

to creation of bare patches that slow or stop the spread of fire during prescribed burns. A result of this kind of soil disturbance is a reduction in native herbaceous cover and diversity, and these areas may contribute to future spread of invasive exotic plants such as *Lespedeza cuneata*, which has been seen throughout the park. The fire effects crew can provide further information about specific hog sightings and large wallows within the RCW area.

Cowpens National Battlefield (COWP): 2009 Fire Effects Monitoring Annual Report

I. Overview

There is very little new information to report for Cowpens. No prescribed burns were conducted during 2009, and the only scheduled monitoring work was in the Hayes and Westside units. Since these were both year 2-postburn reads, there was little change in the data, and a recalculation of objective variables was not warranted.

Efforts in the coming years will focus on looking for opportunities to increase the number of forest plots and developing a monitoring protocol for units that do not have plots. The goal of this protocol will be to map vegetation of interest (high-quality remnants, invasive exotics, rare plants, etc.) and record qualitative notes on fire effects. Accordingly, other work will focus on helping to determine meaningful and achievable ecological objectives for these specific areas of interest.

II. Program Goals and Objectives

Goals – COWP is using prescribed fire to manage grasslands and forests throughout the park. The primary goals are:

1. Restore and maintain the historical battlefield landscape by using fire to reduce woody encroachment into fields. A related cultural and natural resource goal is to encourage/enhance native species within field sites.
2. Restore and maintain the historical structure and species diversity of oak and shortleaf pine woodlands.

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 -

- Reduce the 1-hour fuels between 50-85% over 75% of the unit measured immediately post burn
- Reduce the density of pole and sapling-sized hardwoods by 30-70% each burn as measured within 1 year post burn
- Maintain > 80% of existing mature oaks and pines.

Long term objectives – Long term objectives are typically expected to be achieved only after multiple prescribed burns. Please see Table 3 below for specific objectives and data.

III. 2008 Prescribed Burns

There were no prescribed burns at Congaree during Calendar Year 2009.

IV. Long term Monitoring Results (repeated from 2008 annual Report)

There is not much to say about long-term monitoring at COWP at this time. The prescribed fire program has been active for only a few years, and there remain only a small number of monitoring plots. Again, there was very little change observed in the data during 2009 monitoring, and the results in Table 1 were not recalculated for this report.

Table 1. Short term fire effects monitoring at Cowpens NB

Monitoring Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results	Objective Achieved?
Piedmont Dry Oak Forest (FQUFA1) 2 plots	>60% Reduction in total fuel loading	Total Fuel Reduction = 58% Preburn avg: 30.0 tons/ac Postburn avg: 12.7 tons/ac (n=2 plots, 2 burn units)	Not Enough Plots
	>70% Reduction in pole-sized tree density	Pole reduction = 75% Preburn avg: 16 live trees 01yr1 avg: 4 live trees (n=2 plots, 2 burn units)	Not Enough Plots
	>200 tall (>1m) Oak seedlings /ac	Preburn avg: not collected 01yr1 avg: 0.5 tall oak seedlings (41/ac) (n=2 plots, 2 burn units)	Not Enough Plots
	>20% Cover by native herbs	Preburn cover = not collected 01yr1 cover = <1% (n=2 plots, 2 burn units)	Not Enough Plots
	<20 Invasive Exotic plants/ac	Preburn avg: not collected 01yr1 avg: 0 (n=2 plots, 2 burn units)	Not Enough Plots

V. Discussion and Comments (repeated from 2008 annual Report with research update)

Given the fragmented and successional nature of the vegetation at COWP, it will be difficult to gain quantitative information about the impacts of prescribed burning to any single vegetation type. The decision was made to use a multi-pronged approach to monitoring at COWP, with a limited number of long term monitoring plots, cooperative research, and qualitative observations comprising the monitoring plan. Over time, it is hoped that this approach will yield information and insights that will contribute to the formation of more clearly defined desired future conditions for the fields and woodlands of this park. So far, the results from monitoring suggest three things:

1. Habitat for the Threatened plant *Hexastylis naniflora* **can** burn under prescription conditions – ongoing research should determine the relative harm or benefit to those populations and management decisions should be made accordingly

2. Stands of mature oak and shortleaf pine within the park are limited in size and number; these stands make up some of the best remnant vegetation in the park and efforts should be made to identify these areas and burn them with some care
3. The park likely contains every major invasive exotic plant in the southeast – burn sites will need to be surveyed regularly to ensure that prescribed burning is not exacerbating this problem.

Update: Early in 2009, the park received the final research report on fire effects on *Hexastylis naniflora* from the Southern Research Station of the US Forest Service. The findings of the study, in which NPS Fire Effects staff provided training and support, were that:

- Burns conducted during “typical” spring prescription conditions were successful at removing litter from the forest floor, but had little impact on the duff layer
- Such fire severity proved to have no effect on mortality or plant size of *H. naniflora*
- Burning during the flowering period (in this case, late April) resulted in loss of annual flower/fruit production for those populations – though the authors suggest that this should not have negative long-term impacts to the populations
- The results of this study should not be used to predict the impacts of repeated burning on these populations – additional monitoring will be needed.

Cumberland Gap National Historic Park (CUGA): 2009 Fire Effects Monitoring Annual Report

I. Overview

The monitoring crew completed all scheduled plot reads at CUGA for calendar year 2009, though full sampling at the two plots in Dark Ridge A & B could not be completed due to hazardous snags. A large amount of year-1 and year-2 post-burn data was collected and two new plots were installed in the Hoot Owl Hollow burn unit that is scheduled to be burned this spring. Monitoring results for the three units burned during 2009 are discussed in section III below.

Other efforts in 2009 centered around surveying/mapping exotics in the Dark Ridge A/B area, and producing a regional analysis of fire effects on oak woodlands using data from Cumberland Gap and several other parks. This analysis was featured in a presentation that was made at the International Fire Congress in November of 2009 (see section F. of this report) and in the annual fire-effects reviews with the Cumberland Gap and Great Smokies Wildland Fire Modules. Any of these presentations is available upon request.

Goals for future monitoring at CUGA remain to: 1) continue building the oak forest plot network to achieve the 80% confidence level for all variables, 2) expand efforts to monitor exotic plant encroachment into burned areas, and 3) provide the park with monitoring information for other vegetative communities of interest. As a bit of a side note, the SER Fire Office will be contracting with Dr. Cecil Frost in the coming year to produce highly site-specific fire history and fire ecology maps for Mammoth Cave NP, and an effort is being made to prioritize similar work at Cumberland Gap NHP.

II. Program Goals and Objectives

The following goals and objectives remain very similar to what we've had in the past, with one notable exception: We've added as a burn objective to **limit the size of individual canopy gaps resulting from prescribed burning**. Similar language has also been added to the long-term objectives. This objective is being added to convey the importance of limiting the size of newly formed gaps, **particularly in the early stages of restoration (1st and 2nd entry burns)**. It should be noted that the creation of canopy gaps is one of the goals for the prescribed burning program, and such gaps will be necessary to truly restore oak woodlands at CUGA. However, we would like to avoid creating large or numerous gaps during first or second burns of a site and ultimately to limit the size of these individual gaps.

Monitoring and research suggest that opening large canopy gaps prior to establishment of desirable species in the understory (oak, pine, native herbs) can lead to a growth-release of undesirable species (maple, black gum, sourwood, etc.) as well as invasion by non-native invasive species (princess tree, Chinese silvergrass, etc.). In addition, with the loss of oak and pine litter, fuels in these gaps can actually restrict the effective spread of fire, further complicating efforts to meet objectives. We are just beginning to understand the dynamics in these gaps, and these objectives will undoubtedly need to be updated in the future.

The creation of such large gaps hasn't been a huge problem at CUGA (see BISO), but similar dynamics have been observed in some of the smaller gaps in Dark Ridge A/B, and the potential certainly exists for the creation of medium-sized gaps, primarily in areas of pine mortality associated with the southern pine beetle attacks a decade ago. The still-young hardwood stands coming up in these gaps (which also have heavy fuel loads) are particularly susceptible to top-kill during burns. Additional monitoring will be required to help develop the best prescriptions for managing these gaps.

Goals – CUGA is using prescribed fire to manage upland forests, primarily those near developed areas or near the park boundary. The primary goals are to:

1. Reduce and manage fuels in the Wildland-Urban Interface to prevent the spread of unwanted fire off of or onto park lands
2. Restore and maintain natural and cultural landscapes using fire to manage fire-adapted oak and oak/pine forests throughout the park.

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 oak forests are -

- Consume >75% of surface litter (fine fuels) over >75% of the area occupied by target vegetation. Target vegetation is typically oak and pine forests found on upper slopes and ridgetops
- Reduce the density of pole and sapling-sized hardwoods by at least 30% each burn as measured within 1 year post burn
- Maintain > 80% of existing mature oaks and pines
- **Limit individual canopy gaps (due to fire) to less than 1/2 acre in size**
- Fire Intensities do not exceed the following spatial proportions within targeted vegetation types:
 - <5% high intensity (FL >8')
 - 5-20% moderate intensity (FL 3-8')
 - 75-90% low intensity (FL 1-3')

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-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 15-30% 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
- Less than 20 Invasive Exotic plants/ac

III. 2008 Prescribed Burns

Dark Ridge A & B

The second entry of prescribed fire into these units occurred on March 4, 2009. The initial burn of these units in 2005 resulted in several small to mid-sized canopy gaps, particularly in areas on steep slopes that had been impacted by southern pine beetle. Within the first year of that initial burn, these gaps were found to have modest numbers of invasive princess trees and tree-of-heaven. In the interim between that first year post-burn and the 2009 burn, most of these invasive exotics had been outcompeted by native woody vegetation, though small numbers of Chinese silvergrass (*Miscanthus*) persisted on the site. Thus, one goal for this operation was to burn the unit lightly to avoid creating additional canopy gaps.

Observations from the day of the burn and information from the Burn Boss Report indicate that this burn was generally low in intensity and low in severity, though there remain difficult challenges with completing this burn in one day while trying to minimize intensity on this steep slope. In the future, we may need to allow more time for the fire to truly back down the slope, or use aerial ignition to reduce the width of interior strip headfires on the southern end of the unit.

Post-burn reconnaissance and data from post-burn plot monitoring (Table 1) suggest that the burn objective for consumption of litter was achieved, and that progressive reduction of duff fuels is also being achieved. The increase in total fuels after the second burn reflects the large increase in woody fuels that occurred during the years after the first burn; as burned-out snags fell to the ground and became measureable fuel. This trend is to be expected in areas that have had high mortality due to hot fires, beetle-kill or other disturbances. Future burns will need to take this increase in woody fuels into account during the planning stages to ensure that the impacts of burning these high fuel loads are mitigated.

Table 1. Fire effects at Dark Ridge A & B (n=2).

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	22%	87%	-3%	-38%	-94%	-46%
After 2 burns	44%	Unknown, but likely 100%	+312%	-48%	-96%	+24%

All percentages are compared to preburn values.

I would add a note here that these plots occur on some of the most exposed (driest/sunniest) portions of these units, and while they serve to represent the effects on these dry parts of the unit, they are not particularly representative of much of the rest of the unit. As an additional note, no individuals of princess tree or tree of heaven were observed in the unit during the 2009 growing season. However, several populations of flowering Chinese silvergrass were observed and their locations were recorded. In almost all cases, the fire effects crew was able to remove the flowering heads and take them offsite. Undoubtedly we will need to continue to watch this

aggressive invader and provide additional (chemical) treatments. Locations for these populations are available from the Fire Ecologist or Lead Monitor.

Tiprell A, B & E

The combined Tiprell A,B & E units (385 acres) were burned on March 5, 2009. It was the second-entry of fire into units A and B, and the first-entry into unit E. The majority of the A/B units were burned with a low-intensity/low-severity fire during the initial burn, and the goal was to provide a similar second-entry burn and to burn the E unit in a like manner. The FEMO report and post-burn monitoring data (Table 2) indicate that the burn goals were achieved, though some concerns were raised about the ability of igniters to control fire intensity in isolated portions of the unit (near the “triangle”). Suggestions to deal with this are discussed in the FEMO report and have been the subject of discussion between fire effects and fire module staff. These issues notwithstanding, the Tiprell area is fast becoming a great demonstration area for the park’s attempts to manage hazard fuels and restore fire-adapted vegetation. Continued burning of the sites on schedule is highly recommended.

Table 2. Fire effects from Tiprell A, B, and E.

Burn Status	1000-hr load	Duff load	Litter load	Total load	Overstory trees	Pole trees
Preburn	5.4	10.3	8.2	25.6	303	1093
After 1 burn Tiprell A,B,E (n=3)	4.9	11.4	1.2	19.9	303	813
After 2 burns Tiprell A/B (n=2)	7.2	7.9	0.2	18.6	260	440
% change after 2 burns	+33%	-23%	-98%	-27%	-4%	-58%

Fuel loads are tons/acre. Trees are stems/hectare.

Lookout Tower

This small unit was burned on March 7, 2009. The primary goal was to restore the overgrown “field” around the old lookout tower site to a more open condition. The unit is also notable in that part of it occurred in a higher elevation oak-hickory forest than what is typically burned at CUGA. There are no plots within this unit, though an excellent FEMO report was completed that indicates a low intensity-low severity burn of most of the site. The lookout tower site was burned effectively, though rapid woody re-growth will require frequent burning and/or additional treatments if the goal of creating an open field is to be achieved. The northern (NW) side of the unit is dominated by a mature hemlock forest with a great rhododendron understory – this portion of the unit did not burn. Additional reconnaissance of the oak-hickory portion of the unit is recommended in the coming year. An interesting burn.

IV. Long term Monitoring Results

As stated in last year's report, the number of plots in dry oak forest at CUGA is now sufficient to make program-wide inferences (Confidence level = 80%) regarding the effectiveness of the burn program at reducing total fuel load and reducing density of overstory and pole trees. Five to six additional plots will be required to achieve a similar level of confidence in the results for oak seedlings and herbaceous cover (note: 2 additional plots were added in 2009)

Regardless of which variable is considered, the CUGA dataset is remarkably clean and has the advantage of having sampled the effects of seven first-entry burns. These data are a strong indicator of a program that is moving in a positive direction with respect to the long term objectives for most variables that are being measured.

Table 3. Results of long-term monitoring at Cumberland Gap NHP

Monitoring Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?
Dry Oak Forest (FQUCO1) 16 plots	>50% Reduction in total fuel loading	Total Fuel Reduction = 29% ($\pm 4\%$) Preburn avg: 24.7 tons/ac Postburn avg (1 burn): 17.5 tons/ac (n=12 plots, 6 burn units)	No. Not Enough Burns 2 plots added in 2009
	>70% Reduction in pole-sized tree density	Pole reduction = 29% ($\pm 6\%$) Preburn avg: 22 live trees 01yr1 avg: 15.6 live trees (n=13 plots, 6 burn units)	No. Not Enough Burns 2 plots added in 2009
	15-30% Reduction in overstory tree density	Overstory reduction = 2% ($\pm 1\%$) Preburn avg: 31 live trees 01yr1 avg: 30 live trees (n=13 plots, 6 burn units)	No. Not Enough Burns 2 plots added in 2009
	>200 tall (>1m) Oak seedlings /ac	Preburn avg: 0.3 tall oak seedlings (25/ac) 01yr1 avg: 0.5 tall oak seedlings (41/ac) (n=13 plots, 6 burn units)	Not Enough Plots Minimum plots = 19 2 plots added in 2009
	>30% Cover by native herbs	Preburn cover = 2% ($\pm 1\%$) 01yr1 cover = 3% ($\pm 2\%$) (n=13 plots, 6 burn units)	Not Enough Plots Minimum plots = 20 2 plots added in 2009
	<20 Invasive Exotic plants/ac	Preburn avg: 0/acre *(Multiflora rose present in plot 9 Preburn) 01yr1 avg: 1.7 exotic plants (68/acre) (n=13 plots, 6 burn units)	Not Enough Plots 2 plots added in 2009

VI. Discussion and Comments (repeated from 2008 Annual Report with update)

The process of restoring fire-adapted natural communities at CUGA is still in its early stages, as is the fire-effects monitoring program. One of the limitations of the NPS sampling design is that it is not tailored to provide short-term results for individual burn units. Instead, it seeks to provide long-term information about the effectiveness of *burn programs*. With that said,

extensive reconnaissance and comparisons with similar areas in the southeast should allow us to provide some interpretation of individual burns, which we have attempted to do in this report.

With regard to achieving long-term objectives, the park's fire program has been very successful at moderating expectations for first-entry burns in order to achieve the long-term objectives. As evidenced in Table 3, above, the park is making solid moves forward toward achieving those goals. A hallmark of the prescribed fire program at CUGA has been its responsiveness to fire effects monitoring information. One of the first prescribed burns of the modern program was Dark Ridge A/B, which was generally a fine burn, but which killed some larger oaks and increased the size of canopy gaps where southern-pine beetle had killed the overstory pines. One of the results of this burn that was picked up by monitoring was a modest invasion by exotic trees. Since that time, the fire effects staff has worked with the CUGA Fire Use Module to develop more sensitive ignition strategies for the park's burns. The results from prescribed burns of 2008 are strong evidence that this strategy is moving the park in the right direction.

Despite this more moderate approach to burning, it is possible that exotic plants could find their way into these burned areas following future burns. Most of the burns units thus far occur directly on the park's boundary, near disturbed sites that are a haven for a number of invasive species. While good data is collected for exotics that happen to occur in plots, the sampling design that is currently being used at CUGA is not going to be an effective way to monitor the frequency of exotics in these areas. The fire effects staff is currently looking at some new methods to survey and monitor burn units for these occurrences.

Update Comments:

- Chinese silvergrass (*Miscanthus sinensis*) has been observed at several burned and unburned areas within the western end of the park. This species needs to be closely monitored and may require aggressive control measures. Coordination with the Regional Exotic Plants Team is recommended.
- A field trip to Tiprell with fire and resource staff may be beneficial to illustrating the desired approach to oak woodland restoration at CUGA, and a successful example of that approach.
- There has been much discussion over that past 2-3 years about expanding the prescribed fire program at CUGA, and an important theme to these discussions has been that managers would like to see *some* expansion of burning, with limitations to the amount of proposed wilderness being burned. With an upcoming rewrite of the Fire Management Plan, and a September 2010 deadline for 3 years worth of projects to be entered into NFPORS, this summer may be a good time to convene a small workshop to discuss potential future burn sites, and to lay out a vision for the next 3-5 years. The fire ecologist would be available to help organize such a meeting.

Great Smoky Mountains National Park (GRSM): 2009 Fire Effects Monitoring Annual Report

I. Overview

The monitoring crew completed all of the scheduled plot reads at GRSM for calendar year 2008. Some of the more interesting data now available include the following:

- Year 10 reads at Lynn Hollow
- Year 5 reads at Hatcher Mountain
- 2nd year after the 2nd burn at Wedge Ridge (originally burned hot in 1998).

Additional short-term fire-effects data for oak woodlands was collected at Beard Cane and Wear Cove Gap, and burn severity data (CBI) were collected from the Laurel Falls II wildfire.

Aside from completing challenging reads from a large number of remote plots, fire effects/fire ecology support for GRSM in 2009 included preparation of a detailed fire ecology assessment and 10-year burn schedule for the grass fields of Cades Cove. The team collected and compiled photos and information on dominant species, woody invasion, wetlands, and avifauna for nearly all grass-dominated parts of the Cove. The team then collaborated with the GRSM fire crew to synthesize ecological and operational factors into a map of appropriate burn units and a 10-year burn schedule.

Goals for future monitoring at GRSM remain to: 1) complete all scheduled reads of existing plots while providing for safety first, 2) continue to expand the dry oak forest plot network in future burn units, and 3) continue to build a burn severity (CBI) dataset that can be used in conjunction with spatial data (dNBR) to monitor large scale fire effects from wildland fires.

Other highlights for the year included being part of a successful Joint Fire Sciences grant to study fire effects on Indiana bats in the Southern Appalachians. This research will facilitate the restoration of fire-adapted communities in GRSM, while providing accurate information about the protection of these Federally Endangered bats. Final pieces of field work were completed on the ongoing GRSM fire history research, and the researchers have now turned to compiling and analyzing the data and writing the scientific papers. Finally, data from 10 years of fire effects monitoring at GRSM were included in a regional analysis of the effects of prescribed burning on oak woodlands that was presented at the International Fire Ecology Congress in Savanna, GA (please see section F. of this report). GRSM data were also used to prepare briefings for the Wildland Fire Modules in an effort to enhance the process of adaptive management of NPS natural resources.

II. Program Goals and Objectives

The following goals and objectives remain very similar to what we've had in the past, with one notable exception: We've added as a burn objective to **limit the size of individual canopy gaps resulting from prescribed burning**. Similar language has also been added to the long-term objectives. This objective is being added to convey the importance of limiting the size of newly formed gaps, **particularly in the early stages of restoration (1st and 2nd entry burns)**. It should be noted that the creation of canopy gaps is one of the goals for the prescribed burning program,

and such gaps will be necessary to truly restore oak and pine woodlands at GRSM. However, we would like to avoid creating large or numerous gaps during first or second burns of a site and ultimately to limit the size of these individual gaps.

Monitoring and research suggest that opening large canopy gaps prior to establishment of desirable species in the understory (oak, pine, native herbs) can lead to a growth-release of undesirable species (maple, black gum, sourwood, etc.) as well as invasion by non-native invasive species (princess tree, colt's foot, etc). In addition, with the loss of oak and pine litter, fuels in these gaps can actually restrict the effective spread of fire, further complicating efforts to meet objectives. We are just beginning to understand the dynamics in these gaps, and these objectives will undoubtedly need to be updated in the future.

Also, it should be stated that there are numerous large canopy gaps already existing at GRSM, primarily as a result of pine mortality associated with the southern pine beetle attacks a decade ago. The still-young hardwood stands coming up in these gaps (which also have heavy fuel loads) are particularly susceptible to top-kill during burns. Additional monitoring will be required to help develop the best prescriptions for managing these gaps, though frequent burning during the restoration period is considered essential.

Goals – GRSM 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 to pine and oak woodlands
2. 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
3. Reduce and manage fuels in the Wildland-Urban Interface to prevent the spread of unwanted fire off of or onto park lands.

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 typically oak and pine forests found on upper slopes and ridgetops.

- Fire Intensities do not exceed the following spatial proportions within targeted vegetation types:
 - <5% high intensity (FL >8')
 - 5-20% moderate intensity (FL 3-8')
 - 75-90% low intensity (FL 1-3')
- **Limit individual canopy gaps (due to fire) to less than 2 acres in size**
- Burn is conducted with appropriate fuel conditions (i.e. KBDI) to achieve 15-45% total fuel reduction. KBDI 35-100 will typically produce this result on a first entry burn at GRSM. KBDI on first entry burns should usually not exceed 200. The higher the KBDI, the less intensity is desired.

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 2 acres 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.

III. 2009 Prescribed Burns

Wear Cove Gap

Wear Cove Gap is a 200 acre unit centrally located just west of Gatlinburg, TN, along the northern boundary area of the park bordered by several large upper scale homes. The unit is comprised of a main north-south ridge with several spur ridges to the south east. The ridgeline forest is comprised of oak and yellow pine with several patches of southern pine beetle killed pine and laurel occasionally present in the understory across the ridgeline.

Ignition was carried out on April 17, 2009, and, overall, fire intensity observed on the burn day was desirable for a first entry burn. After black-lining along the park boundary behind the homes, primary ignition of the unit was along the main ridge by helicopter. Fire was then allowed to back down or carried from the ridge down with hand ignition. On April 26, 2009, an area on the north end of the unit near the home interface area began to re-burn and was put out

and mopped-up over the next few days, resulting in <1acre re-burned.

Generally, fire behavior ranged from very low to moderate intensity across the unit, and post-burn reconnaissance and data from post-burn monitoring (Table 1) suggests that most of the impact was on the understory laurel shrub layer and the pole sized trees, with a very limited amount of overstory tree mortality. Also, approximately 90-95% of the target area burned in a uniform manner, with most of the litter layer removed and the duff layer only slightly reduced. Overall, this burn was very successful as a first step in reducing hazardous fuels from the park's Wildland-Urban Interface.

Table 1. Fire Effects at Wear Cove Gap (n=2).

Burn Status	1-100 hr load	1000-hr load	Duff load	Litter load	Total load	Avg # of live overstory	Avg # of live poles
Preburn avg	2.3	1.5	24.4	10.7	40.5	41	33
Postburn avg	2.3	1.4	24.1	0.2	29.5	41	27
Average % change	No change	-6%	No change	-98 %	-27%	No change	-18%

Fuel loads are tons/acre.

Cades Cove

Cades Cove is located in the northwest end of the Great Smoky Mountains National Park. It is one of the few open grassland areas in the park and is also one of the most heavily visited sections of the park. A seven mile loop road encompasses most of the Cades Cove valley passing by several historic structures. Much of this area was heavily disturbed through conversion of fields to non-native grasses for grazing, drainage of wetland areas, and channelization of streams. Because of high visitation Cades Cove receives high priority concerning resource management, and significant time was invested this year in updating and improving the management objectives and plan for this area with regard to prescribed fire.

Spring Burns

The Cades Cove spring prescribed burns were carried out in late March and included fields in two areas: in the west end area, the Old field along with the fields directly north and south, and the Abrams Falls Trailhead and Cable House fields, and in north central area, the fields encircled by Hyatt Lane, Feezel Branch, and the Loop Road around the Methodist Church. The Old Field area experienced a very effective burn with significant impact to the woody encroachment, and post burn a patch of river cane was observed to be flowering, a rare and noteworthy event. The adjacent Abrams Falls Trailhead and Cable House fields were both burned on the same day with some patchy consumption, particularly in Cable House, due to overcast skies, higher humidity, and a brief period of light precipitation. The Hyatt-Feezel area burn had fairly continuous consumption of fine fuels with moderate to high severity impacts to smaller woody encroachment and low to moderate severity impacts to larger pine encroachment.

Fall Burns

Due to expected road closures, the fields scheduled for the spring 2010 rotation were burned in November of 2009. These fields included 2 large adjacent units, Sparks Lane and Maple Branch, centrally located in the interior of the Cades Cove Loop road, Martha's Branch located north central, Tater Branch located to the northwest, Elijah Oliver on the west end, and Pumphouse Marsh to the southwest off Forge Creek Road. Tater Branch had continuous consumption of finer fuels with high severity to pole size trees and low to moderate severity impacts to larger tree size encroachment. Consumption in the Elijah Oliver unit was continuous but limited to upland half of the field as the lower half transitioned into a wetland with standing water and meandering streams, reducing the impact to some of the woody encroachment. Martha's Branch was a patchy burn due to early ignition time and shading from adjacent woodlots resulting in half the unit burning and overall low to moderate severity impacts to the woody encroachment. Sparks Lane was a very uniform and continuous burn with little woody encroachment present prior to the burn. Maple, the largest of the units, was burned under gusty and partly rainy conditions with the passage of a front, which surprisingly resulted in very good consumptions to the point of removing all standing grass and forb structure down to short charred stubs in some areas. Pumphouse Marsh was not burned due to time constraints, however in an effort to control some of the woody encroachment several small pine trees were felled and many larger pines were limbed up 4-6ft from the ground. Overall, the post-burn overwintering vegetative structure was patchy throughout all the units with very few areas of dense cover or structure remaining in terms of wildlife usage. While fall field burning is a viable option for future burns, it is advisable to separate large adjacent units, like Sparks and Maple, between fall and spring burn seasons to avoid removing too much contiguous wildlife cover in one season.

IV. Long term Monitoring Results (repeated from 2008 Annual Report)

As mentioned previously, the number of plots in yellow pine woodlands at GRSM is now sufficient to make program-wide inferences (Confidence level = 80%) regarding the effectiveness of the burn program at reducing total fuel load and reducing the density of pole trees. Due to high variability in overstory mortality between plots, five additional plots will be required to achieve the desired confidence level for overstory mortality. Additional burns will be required to adequately assess pine seedling and herbaceous cover increases, though outstanding results for these variables have been achieved in individual plots.

There have not been enough burns of dry-oak forest plots to make any strong statements about the relative success of achieving management objectives in this type. In general, the existing data show moderate impacts that are complementary to achieving the long-term objectives in this vegetation type.

Table 2. Long-term fire effects monitoring at Great Smoky Mountains NP

Monitoring Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?
Yellow Pine Woodland (FPIR11) 26 plots	>50% Reduction in total fuel loading	Total fuel reduction = 36% ($\pm 5\%$) Preburn mean = 43 tons/ac 01 Post mean = 28 tons/ac ($n=23$, 6 burn units)	No, but not enough burns to evaluate
	>70% Reduction in pole-sized tree density	Pole reduction = 75% ($\pm 7\%$) Preburn avg: 37.6 live trees 02yr1 avg: 7.9 live trees ($n=11$, 3 burn units) Reduction after 1 burn ($n=25$): 54% ($\pm 5\%$)	Yes
	25-50% Reduction in overstory tree density	Overstory reduction = 41% ($\pm 9\%$) Preburn avg: 47.7 live trees 02yr1 avg: 27.5 live trees ($n=11$, 3 burn units) Reduction after 1 burn ($n=25$): 20% ($\pm 5\%$)	Yes, but not enough plots Minimum plots =31
	>200 tall (>1m) Yellow Pine seedlings /ac	Preburn avg: 0 tall pine seedlings Avg. After 1 burn ($n=25$): 97/ac (± 49) Avg. After 2 burns ($n=11$): 49/ac (± 40)	No, but not enough burns to evaluate
	>40% Cover by native herbs/subshrubs	Preburn cover = 3% ($\pm 1\%$) Avg. After 1 burn ($n=23$): 11% ($\pm 4\%$) Avg. After 2 burns ($n=9$): 10% ($\pm 6\%$)	No, but not enough burns to evaluate
Dry Oak Forest (FQUCO1) 12 plots	>50% Reduction in total fuel loading	Total fuel reduction = 30% ($\pm 4\%$) Preburn mean = 34 tons/ac 01 Post mean = 24 tons/ac ($n=8$, 3 burn units)	No, but not enough burns to evaluate
	>70% Reduction in pole-sized tree density	Pole reduction = 22% ($\pm 7\%$) Preburn avg: 28.9 live trees 01yr1 avg: 23.1 live trees ($n=8$, 3 burn units)	No, but not enough burns to evaluate
	15-30% Reduction in overstory tree density	Overstory reduction = 2% ($\pm 1\%$) Preburn avg: 41.5 live trees 01yr1 avg: 40.5 live trees ($n=8$, 3 burn units)	No, but not enough burns to evaluate
	>200 tall (>1m) Oak seedlings /ac	Preburn avg: 0.4 tall oak seedlings (33/ac) 01yr1 avg: 0 tall oak seedlings ($n=8$, 3 burn units)	No, but not enough burns to evaluate
	>30% Cover by native herbs/subshrubs	Preburn cover = 4% 01yr2 cover = 2% ($n=8$, 3 burn units)	No, but not enough burns to evaluate

V. Discussion and Comments (repeated from 2008 Annual Report without update)

Fire-effects monitoring has been in place at GRSM for well over ten years now, and much knowledge has been gained about the effects of prescribed burning on pine and oak forests in the southern Appalachians. Monitoring data has continually provided information that can be used to refine long-term objectives as well as prescriptions and tactics for individual burns. That being said, the process of restoring fire-adapted natural communities at GRSM is still in its

early stages. It is estimated that a minimum of 3-5 burns (20+ years) will be required to meet the restoration objectives laid out in Table 3. With this in mind, it is critical to also use monitoring data to examine individual burns and ensure that short term objectives and effects are supportive of the longer term goals. The brief analysis of the Beard Cane prescribed burn represents an attempt to use limited monitoring data and more extensive post-burn reconnaissance for this purpose.

With regard to long-term objectives, the park's prescribed fire program has been successful at reducing hazardous fuels and creating a range of structural and compositional effects across the landscape. The mean values for most of the objective variables in pine and oak systems indicate progress in a positive direction, while low overall values for pine/oak regeneration and herbaceous cover illustrate the long-term challenges of restoring these communities. Viewing the pooled data from multiple burns, however, misses the important point that effects vary dramatically from burn to burn and even plot to plot. For example, early burns at GRSM were successful at creating conditions for regeneration of yellow pines, while more recent burns have not yet created these conditions. This is largely a result of altering the seasonality of burning, but it underscores the need to examine fire effects at a range of scales. Such a process will be critical for developing more site-specific prescriptions in the coming years.

Kings Mountain National Military Park (KIMO): 2009 Fire Effects Monitoring Annual Report

I. Overview

The monitoring crew completed all scheduled plot reads at KIMO for calendar year 2009. No new plots were installed. Immediate post-burn data was collected from 1 plot out of the 3 burn units that were treated this spring. Monitoring results from this burn (Piedmont) are discussed below in section III.

Fire-effects monitoring at KIMO started in 2004. There are now 28 long term monitoring plots in two different vegetation types, with the primary focus on the dry oak woodlands that represent the dominant vegetation of the prescribed burn sites. The small number of plots in the blackjack-chestnut oak woodland reflects the scarcity of this vegetation type within burn areas, and it is doubtful that additional plots of this type will be added. To date, all of these plots have been burned, many of them two or even three times. Updated results from the long-term monitoring of these plots are provided in section IV (Table 2). The sample size in the dry-oak forest type is now adequate to make program-wide inferences about fuel load reduction and overstory and pole tree changes at the 80% confidence level, but results from additional burns will be needed to achieve that same confidence level for oak seedling and herbaceous cover variables.

Goals for future monitoring at KIMO are to: 1) complete all scheduled reads of existing plots, 2) communicate results to park managers, 3) provide the park with monitoring information for other vegetative communities or species of interest and 4) adapt sampling techniques to provide managers with new and more comprehensive data using a variety of monitoring techniques.

Fire ecology support for KIMO during CY09 centered on data analysis and participation in prescribed burns and monitoring efforts. Fire effects data from KIMO were incorporated into a regional analysis of fire effects on oak woodlands that was presented at the International Fire Ecology Congress in Savanna, GA.

II. Program Goals and Objectives

The following goals and objectives remain very similar to what we've had in the past, with one notable exception: We've added as a burn objective to **limit the size of individual canopy gaps resulting from prescribed burning**. Similar language has also been added to the long-term objectives. This objective is being added to convey the importance of limiting the size of newly formed gaps, **particularly in the early stages of restoration (1st and 2nd entry burns)**. It should be noted that the creation of canopy gaps is one of the goals for the prescribed burning program, and such gaps will be necessary to truly restore oak and pine woodlands at KIMO. However, we would like to avoid creating large or numerous gaps during first or second burns of a site and ultimately to limit the size of these individual gaps.

Monitoring and research suggest that opening large canopy gaps prior to establishment of desirable species in the understory (oak, pine, native herbs) can lead to a growth-release of undesirable species (maple, black gum, sourwood, etc.) as well as invasion by non-native

invasive species (princess tree, Chinese silvergrass, etc). In addition, with the loss of oak and pine litter, fuels in these gaps can actually restrict the effective spread of fire, further complicating efforts to meet objectives. We are just beginning to understand the dynamics in these gaps, and these objectives will undoubtedly need to be updated in the future.

The creation of such large gaps poses a modest problem at KIMO (see BISO), with the biggest issue being existing large gaps that have resulted from seasonality of burns and ignition intensity, in conjunction with drought conditions. The issue at KIMO is thus more an issue of managing existing gaps than preventing new ones, but care should be taken not to create additional large, unplanned openings. Continued monitoring and learning will be required to help develop the best prescriptions for managing these gaps.

Goals – KIMO is using prescribed fire to manage oak and pine forests and woodlands. The primary goals are to:

1. Restore and maintain cultural and natural landscapes using fire to manage fire-adapted oak and oak/pine forests throughout the park
2. Reduce and manage fuels to prevent the spread of unwanted fire off of or onto park lands.

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 oak forests are -

- Reduce the 1-hour fuels by at least 50% over 75% of the unit as measured immediately post burn
- Reduce the density of pole and sapling-sized hardwoods by at least 30% each burn as measured within 1 year post burn
- **Limit individual canopy gaps (due to fire) to less than 1 acre in size**
- Maintain > 70% of existing mature oaks and pines.

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-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 15-30% reduction in overstory tree density, **achieved with newly-formed gaps of less than 1 acre in size**
- Greater than 200 tall (>1meter) oak seedlings per acre
- Greater than 15% cover by native herbaceous species

III. 2009 Prescribed Burns

Colonial Rd.

This was a first entry burn for this unit. The burn was conducted on April 07, 2009 using hand ignition techniques only. In terms of vegetation communities of the entire park, this unit contained more than average *Pinus echinata* (shortleaf pine) stands and mixed *Quercus montana* (chestnut oak) and *Quercus marilandica* (black-jack oak) typical in the Piedmont Rock Chestnut oak-Blackjack oak woodland community. The unit also contained a moderately dense *Kalmia latifolia* (Mountain laurel) thicket on North and East sides of the slope typical of the Piedmont Chestnut Oak-Heath Bluff community type.

This burn was considered very successful for a first entry burn due to low intensity fire behavior, decisive and thoughtful ignition patterns and cloud cover remaining most of the day. Very little char or overstory mortality was observed. Fine fuels were reduced upon immediate observation but no data were collected for this unit. Other observations taken from the FEMO report that are notable are the 70% scorch on dense stands of Mountain laurel. The reduction of Laurel from upland sites is considered a goal by most Fire Programs and has been very apparent in this unit.

Note: The technique of “bone piling” was employed in this burn along riparian habitats. These streamside areas do not generally contain hazardous fuels; in fact the woody debris in these sites constitutes important habitat for amphibians, reptiles and small mammals. Reduction of this important habitat as well as soil sterilization can be a problem without thoughtful consideration and placement of piles. The issue was addressed during AAR and noted in the FEMO report. There were no FMH plots in this unit.

Piedmont Road

The Piedmont Rd Unit was treated on April 8, 2009. The unit remains one of the last units not to have had any application fire to it under the current program. The unit is such that it is bounded by a road on the North, trails on the West and East and a hand line along the south.

The topography of the unit is one with multiple broad flat ridges divided by creek drainage in the center draining North to South. The ridges are typically dominated by *Quercus coccinea* (Scarlet oak), *Quercus montana* (Chestnut oak) and *Quercus alba* (white oak) amongst the typical cohort of smaller, fire-intolerant hardwoods. An old road occurred on the east side but remained interior for a good portion of the unit. Other features to note were a significant patch of *Quercus stellata* (Post oak) with *Piptochaetium avenaceum* (black-seeded spear grass) dominating the herbaceous portion of the patch located approximately halfway through the unit on the Eastern side. There were small thickets of *Kalmia latifolia* (Mountain laurel) at the south end of the unit, remaining mostly near the creek and the lower 1/3 of the slope and protected slopes. Also at this end of the unit, large shortleaf pine snags remained on the ridge top but were reminiscent of a former Southern Pine Beetle infestation. Some evidence of past fire and logging were seen on reconnaissance of the unit. According to the vegetation map, the majority of the ridges are Southern red oak/ white oak mix (Dry-mesic oak). There is one portion of the southwest corner that is Piedmont dry mesic oak hickory.

Typical methods of Black-lining the perimeter and igniting the interior with a helicopter were the norm on this day. A few spot-fires happened as the day progressed along the Southeast corner of the unit due to erratic winds. Helicopter ignition reported the difficulty of seeing

the unit and keeping the lines of ignition tight enough to mitigate intensity of fire behavior. The West side of the unit had little problem in regards to spotting or slop-over because of a strong West wind. The dilemma for the West side was that not enough fire could be applied to keep intensity down, even on a relatively flat surface. In the southwest corner, which was fired around 1530, head fire with 5-10 flame lengths were the norm.

Immediate post fire observations showed the average of 3' char heights with oaks sustaining strong basal heating and likely to suffer some mortality in the near future. Other issues on this particular side to note were the prolific stand of *Eupatorium capillifolium* (Dog-fennel) observed 6 months after the burn. The size of the area that these colonizers occupied was approximately 1-2 acres. The patch is discontinuous, relegating the colonizers to the flat, broad ridge tops and totaling 2-3 acres of canopy gaps with early-successional vegetation.

The first entry of fire for this particular unit was successful in post burn observations with regards to categories such as: fine fuel reduction and %pole mortality. It is questionable to state the success at this time in regards to %overstory mortality due to the recent nature of the burn, and uncertainties about delayed oak mortality.

Table 1. Fire effects at Piedmont Rd. (n=1).

Burn Status	% Overstory tree mortality	Avg Char Ht (feet)	% Pole tree mortality	Duff fuel load change	Litter fuel load change	Total fuel load change
After 1 burn	-4%	4.5 ft	-81%	-6%	-100%	-51%

All percentages are compared to preburn values.*

Aster:

This unit was attempted on April 9, 2009 and the weather conditions did not meet the Prescription requirements for the burn plan. The burn was attempted again April 22nd and dismissed due to a state burn ban and unfavorable conditions. There were no more attempts to treat this unit in 2009.

IV. Long term Monitoring Results (repeated from 2008 Annual Report)

As mentioned previously, the number of plots in dry oak forest at KIMO is now sufficient to make program-wide inferences (Confidence level = 80%) regarding the effectiveness of the burn program at reducing total fuel load and reducing density of overstory and pole trees. Though none of those objectives have yet been achieved, the data indicate that the burn program is on target to achieve them within the restoration period. It is less certain whether objectives for oak/pine regeneration and herbaceous cover will be achieved on a program-wide basis. As an interesting sidebar, plot QUMO12 in the Y/S Road unit was resampled this year (5 years after the 2nd burn), and provides an interesting glimpse of some of the more advanced restoration in the park. This plot is literally full of shortleaf pine regeneration that is 5-10' tall and has an impressive herbaceous cover that is unlike other burned areas in the park.

The number of plots in the blackjack oak type is more limited by the scarcity of this vegetation type, though data from plots also indicate good progress toward achievement of restoration objectives.

Regardless of which vegetation type or which variable is considered, the KIMO dataset is remarkably clean and has the advantage of having sampled the effects of six first-entry burns as well as multiple second and third entry burns. These data are a strong indicator of a program that is moving in a positive direction with respect to the long term objectives for most variables that are being measured.

Table 2. Results of long-term monitoring at King's Mountain NMP

Monitoring Type	Management Objective Restoration Phase- (After 4 burns)	Monitoring Results (80% confidence intervals)	Objective Achieved?
Chestnut Oak- Blackjack Oak Woodland (FQUMA1) <i>8 plots</i>	>50% Reduction in total fuel loading	Total fuel reduction = 47% ($\pm 4\%$) Preburn mean = 34 tons/ac 01 Post mean = 17 tons/ac ($n=7$, 4 burn units)	No, but not enough burns to evaluate
	>70% Reduction in pole-sized tree density	Pole reduction (1 burn): 45% ($\pm 12\%$) Pole reduction (2 burns): 62% ($\pm 12\%$) ($n=8$ for 1 burn, $n=4$ for 2 burns)	No, but not enough burns to evaluate
	15-30% Reduction in overstory tree density	Overstory reduction (1 burn): 30% ($\pm 11\%$) ($n=8$, 5 burn units)	Yes, but not enough plots
	>30% Cover by native herbs	Preburn cover: 6% Cover after 1 burn: 9% ($n=7$, 4 burn units)	No, but not enough burns to evaluate
Dry Oak Forest (FQUMO1) <i>20 plots</i>	>50% Reduction in total fuel loading	Total fuel reduction = 41% ($\pm 5\%$) Preburn mean = 33 tons/ac 02 Post mean = 18 tons/ac ($n=19$, 6 burn units)	No, but not enough burns to evaluate
	>70% Reduction in pole-sized tree density	Pole reduction (1 burn): 43% ($\pm 2\%$) Pole reduction (2 burns): 58% ($\pm 5\%$) ($n=19$, 6 burn units)	No, but not enough burns to evaluate
	15-30% Reduction in overstory tree density	Overstory reduction (1 burn): 7% ($\pm 3\%$) Overstory reduction (2 burns): 12% ($\pm 3\%$) ($n=19$, 6 burn units)	No, but not enough burns to evaluate
	>200 tall (>1m) Oak or shortleaf pine seedlings/acre	Preburn density: 85 stems/ac (± 49) Density after 1 burn: 55 stems/ac (± 34) Density after 2 burns: 55 stems/ac (± 32) ($n=19$, 6 burn units)	No, but not enough burns to evaluate
	>15% Cover by native herbs/subshrubs	Preburn cover: <1% Cover after 1 burn: 1% Cover after 2 burns: 1-2% ($n=19$, 6 burn units)	No, but not enough burns to evaluate

V. Discussion and Comments

All parks should take heed to the approach and fortitude with which Kings Mountain National Military Park is progressing with their burn program. KIMO is steadfast in its desire to leave no patch of land unburned.

In the past and in my opinion, currently little weight is given to the long-term effects of a more moderate intensity fire on the canopy. If one looks at Piedmont Road as just a separate unit and not a snapshot of the larger landscape, objectives were achieved. Yes, only a small percentage of the entire canopy is removed (the edge and ridge-top pockets), which is within the acceptable limit, but a larger fuel problem now occurs. Not only will those larger, now dead, oaks fall and create more fuel, but they will not re-sprout as fervently as the maple, sourwood and black-gum (unwanted mesic species). There-in lies a problem with regards to creating a fuel bed to carry the next prescribed fire. The scenario is set-up where a longer fire return interval will have to be instituted with regards to what will carry fire. The other disturbing point is the amount of heavy oak fuel piled underneath the remaining live oaks that are standing.

Again, first (and second?) entry burns should pay particular notice to burning conditions and firing technique to resolve issues such as those stated above.

In the future a more comprehensive monitoring strategy with more burn unit-specific information and more visual products can provide Fire Use Modules more useful information to complete the projects and meet park objectives.

C. Staff accomplishments and areas of focus

Table 4. Fire Ecologist Accomplishments/Focus Areas

Category	Percent Time	Accomplishments and/or areas of activities
Planning	20%	GRSM FMP & EA, section 7 consultation for GRSM and CUGA, long-range burn planning for Cades Cove. Involved in out-year and long-range burn planning at all parks in network.
Presentations	8%	Oral and poster presentations at Fire Ecology Congress in Savanna, GA Adaptive Management presentations to CUGA and GRSM fire modules. Annual Report
NPS Meetings/ task groups	2%	Strong involvement in GRSM Inventory and Monitoring workshops.
Interagency work	5%	Steering team for Southern Blue Ridge FLN, Annual FLN Workshop, Cooperative interagency monitoring, participation in LANDFIRE fuels recalibration.
Fire Assignments	8%	Lots of prescribed fire throughout SER, wildfire at GRSM, Assignment in Alaska.
Research	5%	Played central role in successful JFSP proposal to study fire effects on Indiana bats; Continued as Federal cooperator on regional JFSP dendrochronology project; various roles interacting with researchers
Data Collection	20%	Some fieldwork at all parks, including 2 weeks of “emergency” plot installations at BISO prior to the 6000ac Gobblers Knob burn (February) CBI work at GRSM and with National dNBR/CBI cadre
Data entry	1%	Estimated amount of time spent entering data from paper to PC
Data analysis	15%	Estimated amount of time spent performing analyses, including data summaries and statistical tests.
Supervision/Admin	10%	Hiring, supervision, travel, payroll, crew support, purchasing etc.
Training	1%	OTJ CBI training
Miscellaneous	5%	Mostly communication

Table 5. Fire Effects Crew Accomplishments/Focus Areas

Category	Percent Time	Notes
FMH plots	55%	Plot data collecting and preparing plot folders and equipment for field.
WUI plots	0	
CBI plots	2%	Laurel Fall II (GRSM), National Mapping Team site visit
Other plot work	5%	Nested subplots data collection in each FMH plot, assisting dendrochronology/fire history project, assisting USFS NC & TN
Fire Assignments	13%	Crew assisted with 24 prescribed burns, 1 suppression Two members completed helitack details. Two members completed 1 week Alaska detail with the GRSM module
Fuels Project work	0	
Data entry	20%	80% of plot data has been entered for 2008
Data analysis	1%	Some analysis was completed on fuel loading for FEMO reports
Supervision/Admin	2%	Lead monitor supervised crew of three most of season and maintained misc travel, time and purchasing paperwork
Training	2%	Refresher Training 1-3 hours of physical training a week was completed for each employee. Wilderness First Responder Refreshers

**F. Synopsis of a Presentation Made at the 4th International Fire Ecology Congress
Savanna, Georgia
December 1, 2009**

**Restoration of Oak Ecosystems Using Prescribed Fire:
A Regional Look at Fire Effects Monitoring in the Southeast Region of the
National Park Service**

Introduction:

Oak (genus *Quercus*) forests and woodlands represent the dominant vegetation throughout substantial portions of the central and eastern United States. The failure of oaks to regenerate has been widely reported throughout this region, and has been repeatedly linked to the cessation of widespread fires during the 20th century. National Park Service (NPS) units in the southeastern U.S. use prescribed fire as the principal tool to restore and maintain natural communities dominated by oak. These efforts to restore attributes of a sustainable ecosystem have been documented for the past ten years using standard NPS fire-effects monitoring methods.

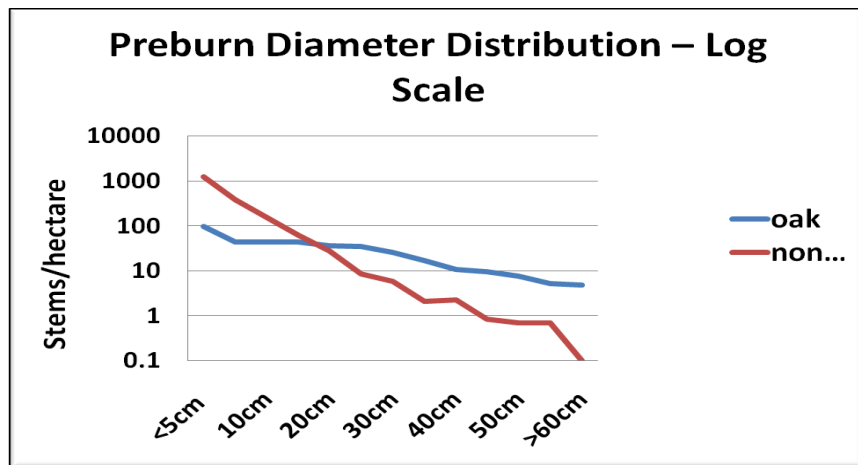
We used data pooled from NPS units across the Appalachian Highlands physiographic province (GRSM, KIMO, BISO, CUGA) to answer the following questions:

- What are the short-term effects of repeated prescribed burning on various size classes of both oak and non-oak trees?
- What are the trends in abundance of oak and non-oak seedlings? Specifically, are we seeing an increase in the abundance of oak seedlings with repeated burns?
- Are there differences in post-fire effects on oak that correspond to fire intensity, fire severity, or pre-burn site conditions?

Finally, we also wanted to generate recommendations for using fire to restore oak-dominated ecosystems in the Appalachian highlands based upon our data.

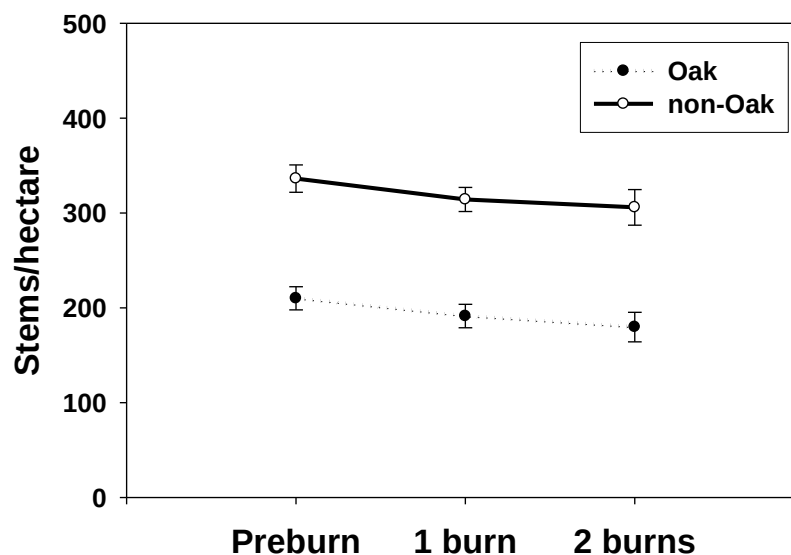
Results:

Pooled tree data from 72 *pre-burn* plots at four different parks provide strong support for the idea that oaks are being vastly outcompeted in the smaller diameter classes by more shade-tolerant species (red maple, black gum, white pine, etc) and are in danger of being replaced as the dominant species over time. The following chart is a diameter distribution with diameter size-class on the x-axis and tree density on the y-axis. You can clearly see the dominance of oak (blue line) in the larger classes and the significantly greater numbers of non-oak trees (red line) in the sapling and small-pole size classes. This is not new information, but it highlights the current conditions at our parks; notably, this is the same pattern observed in each park individually, representing a fairly broad geographic range.



As shown in the following graph, the effects of two prescribed burns are very similar on oak and non-oak overstory trees (> 6" dbh). Means for overstory tree density from preburn, 1 burn, and 2 burns are from 55, 55, and 29 plots, respectively. The numbers give an average overstory mortality rate of 10% after 2 burns, with a 14% reduction of oak stems only, and a 9% reduction of non-oaks. This difference in mortality rate between oaks and non oaks is actually pretty small, given the variability in the data, but we should watch this trend in future burns. Among the overstory trees, the oaks make up most of the older trees in these stands, and ironically, it could be that they are *more* likely to succumb to the combined effects of fire and drought, especially following higher intensity burns.

Relative Effects on Overstory Trees



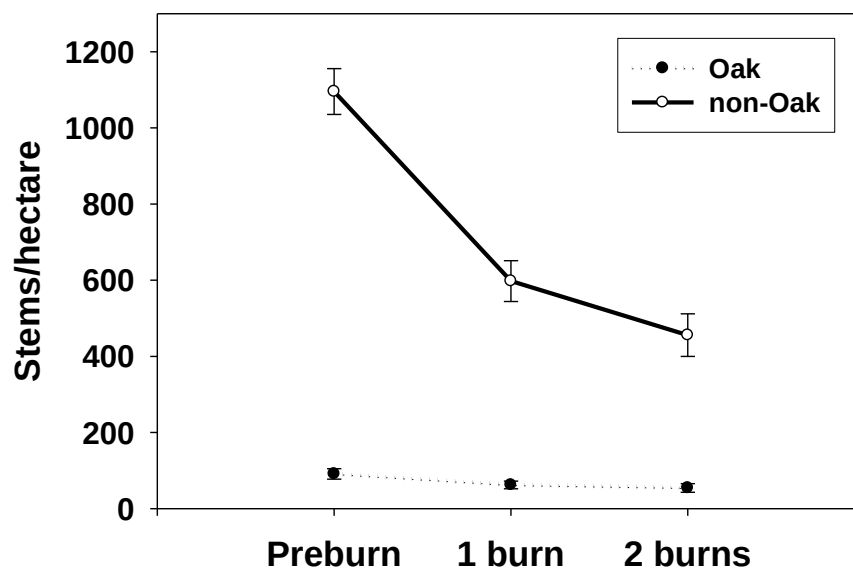
The graph of fire effects on pole-tree (1"-6") density paints a somewhat different picture than that for the overstory. Two things jump out immediately from this graphic:

1. There are very few oak poles in these stands. This reflects the same dynamic that we saw in the diameter distribution (graph #1)
2. The mortality rate for non-oaks is higher than that for oaks.

The average mortality of all pole-sized trees following two burns was 57%, with oak-only mortality of 41% and non-oak mortality at 58%. The higher rate of mortality among non-oak species is to be expected, due to the greater average diameter of the oaks, as well as the greater adaptation of oaks to fire (eg. thicker bark).

An additional point to be made about fire effects on poles is that the majority of these midstory and understory trees are observed to re-sprout from the base following initial top-kill. In most cases, this re-sprouting leads to an actual *increase* in the density of undesirable woody stems in the understory. The composition and intensity of this re-sprouting is one of the primary factors that determines the frequency of prescribed burns during the restoration phase, as repeated top-killing of non-oak sprouts will be necessary for the eventual re-establishment of oak regeneration.

Relative Effects on Pole Trees



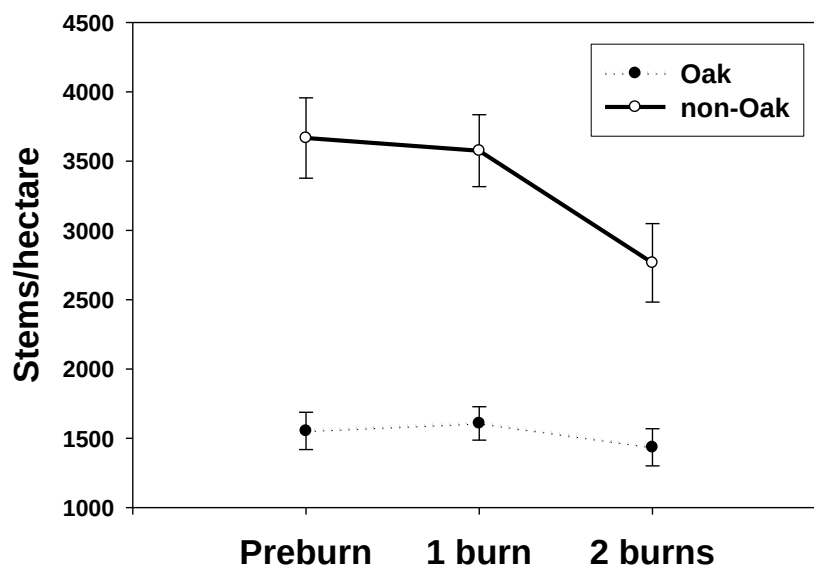
One of the questions of greatest interest concerning these oak-restoration burns is: Do we see evidence for increasing oak regeneration after a couple of burns? As seen in the following graph, the short answer region-wide is no, and there are probably a couple of reasons for this:

- There are relatively few oak seedlings in these stands prior to burning
- Oak regeneration is reliant upon oak reproduction, which is a complex process involving bumper acorn crops, good environmental conditions, and escape from herbivory – this process is not unrelated to fire, but neither is it driven solely by fire
- Even after a couple of burns, most of our stands still have too little light penetration and too much shade-tolerant competition for oaks to establish.

Thus, restoration of oak and oak regeneration will require the creation of conditions that are conducive to oak germination and seedling establishment, as well as a reduction in the density of competitors in the understory. Perhaps more importantly, it will require patience for habitat and oak seedling production to align, and monitoring to observe when that occurs.

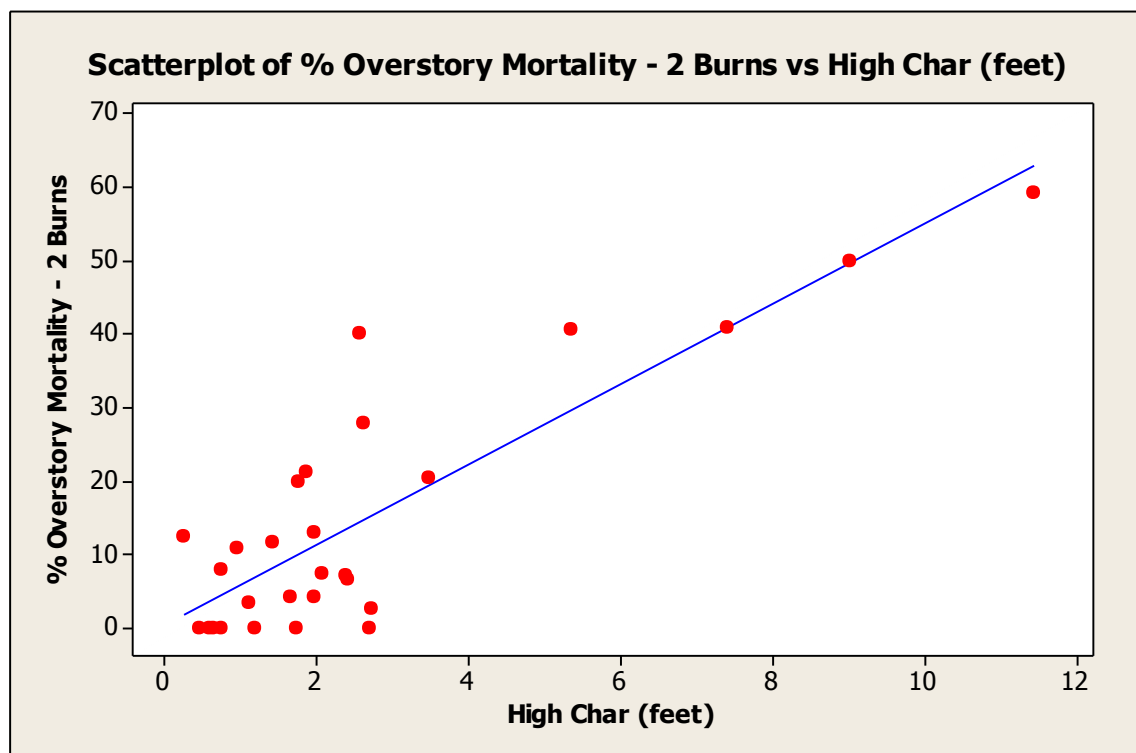
Anecdotally, there are a small number of individual plots that have seen increases in the density of oak seedlings. For the most part, these are plots in the Dark Ridge A/B units at CUGA, and the Divide Road unit at BISO, and it is important to note that the increases in oaks are part of a large increase in overall seedlings associated with the creation of canopy gaps. In fact, the number of oak seedlings in these sites is still low compared to the number of non-oaks, and it is unclear how well the oaks will be able to compete in the absence of additional fires.

Relative Effects on Tree Seedlings



Examination of the relationship between post-fire effects on oak and fire intensity, fire severity, and pre-burn site conditions yielded an important (and intuitive) finding: The percent of overstory trees that died in each plot after 2 burns had a strong correlation to the highest average char height recorded for that plot. Statistically, the Pearson Correlation Coefficient is +0.85, with 1.0 being a perfect correlation. In other words, the higher the average char height on overstory trees following a burn, the greater the mortality of overstory trees (see scatterplot below).

What's really valuable is that the data tell us at what char heights we can expect to see elevated mortality. This is, of course, valuable information as we seek to manage the structure of our forests. At average char heights of less than about 2', there was little effect on mortality, and average mortality remained below 15%. Above 2-3', however, there is an increased likelihood that overstory mortality will rise above 20%. Char heights greater than 5' (indicative of a moderately-intense head fire) have been associated with high levels of tree mortality (40-60%).



Summary and Conclusions:

The key findings and implications from this analysis can be summarized as follows:

- There is currently little oak regeneration in dry-oak forests of NPS units in the Appalachian Highlands physiographic province
- Prescribed burning offers an ecologically and historically appropriate tool to restore sustainability to these oak forests
- Fire-effects monitoring indicates that post-burn char height is strongly correlated with overstory mortality and that a subset of our plots have had fairly high mortality
- Data suggest the possibility that mature oaks are killed at a higher rate than other overstory trees (they are at least killed at the same rate)
- Removal of mast-producing oaks before establishment of regeneration will make long-term restoration of oak woodlands much more difficult (loss of seed-source, changing fuels, release of competitors, invasive plants, etc.)
- We have more control over char height (fire intensity = flame length) than many variables in the restoration process.

The broad recommendation that comes out of this work is to limit the overstory mortality in our oak forests, especially before during first- and second-entry burning. Monitoring will tell us when oaks are regenerating. In the long-term, we will need to reduce the density of overstory trees and create gaps (which may require head fires), but we should attempt to do this in a deliberate fashion to the extent possible. Specifically, we have added objectives for limiting the size of canopy gaps for all of our oak-dominated parks, and have taken a stab at guidelines for fire intensity (see GRSM “Goals”). These objectives represent a first cut at incorporating the oak monitoring data into objectives for burning, and they will need to be reviewed by all and revised as necessary.

One final note to be added here is that the majority of our plots (and burn units) burn in low intensity fires, and experience overstory mortality of less than 15%. These are good examples of the kind of effects that we should look for in our first and second entry burns, and we are achieving our overall objectives. The caution here is to avoid large patches of intense head-fire that may lead to unacceptably high amounts of oak mortality and/or large canopy gaps, especially during early burns when oak regeneration has not yet been established.