[Extended Abstract]

USING THE ADAPTIVE MANAGEMENT PROCESS TO DEVELOP A MONITORING PROGRAM ON THE GEORGE WASHINGTON AND JEFFERSON NATIONAL FORESTS AND THE NATURE CONSERVANCY'S WARM SPRINGS MOUNTAIN PRESERVE

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Abstract—The George Washington and Jefferson National Forests (GWJNF) in collaboration with The Nature Conservancy began planning a monitoring program utilizing adaptive management methods to guide prescribed burning in 2008. The development of a successful monitoring program requires extensive research, planning, and cooperation between fire management officers and ecologists to establish measurable burn objectives. Working together, the GWJNF and The Nature Conservancy developed monitoring protocols then utilized the database Feat and Firemon Integrated (FFI), free software developed by the Forest Service, U.S. Department of Agriculture to promote data storage easily used and shared between multiple agencies. The data, once collected in the field and entered into the FFI database, is statistically analyzed, and those objectives identified in the burn plan are reviewed. Management action alteration is dependent upon the results generated from data collection. As management adapts, the cycle continues, allowing land managers to apply scientific principles and knowledge in restoring landscapes to historical fire regimes.

INTRODUCTION

The George Washington and Jefferson National Forests (GWJNF) span 1.8 million acres along the Appalachian and Blue Ridge Mountains, sharing a 13-mile long border with the Warm Springs Mountain Preserve owed by The Nature Conservancy (TNC) in Bath County, VA. The Forest Service, U.S. Department of Agriculture and TNC first came together in 2006 to develop a fire management program for the preserve. This collaboration helped spark the creation of the Alleghany Highlands Fire Learning Network (FLN). The FLN comprises several Federal and State cooperators from Virginia and West Virginia, allowing multiple agencies to meet and work together in achieving fire restoration and management goals. In 2008, the GWJNF and TNC joined forces again to create a monitoring protocol, Forest Composition and Structure Monitoring (FCS), for the prescribed burn programs on the forest and the preserve in an effort to establish land management activities implementing the adaptive management cycle.

An important element of decisionmaking in any land management program is the use of current and applicable scientific information. The adaptive management cycle is one process which continuously incorporates new information through the concept of "learning by doing" (Haney and Power 1996). Adaptive management comprises six steps: researching the system, developing objectives, planning and conducting monitoring, implementing management actions (burning), conducting post-burn monitoring, and analyzing results. As new information is gathered through monitoring, it is fed back into the system and the cycle repeats; managers can then change burn objectives to meet more realistic goals or may decide to change implementation techniques to achieve desired results on the landscape. Additionally, adaptive management benefits land managers by supporting National Environmental Policy Act, or NEPA, claims, proving especially useful if appeals are made to management actions. Those who question or doubt the use of fire in land management are provided with tangible numbers and photos of objective-driven changes taking place in the landscape.

THE ADAPTIVE MANAGEMENT CYCLE

Research the System

Successful land management cannot begin without a thorough understanding of the ecological systems and associated disturbance regimes found on the landscape. Fire management officers and ecologists must understand vegetation type and occurrence, terrain, climate and fire regimes to begin to understand how the landscape has deviated from pre-European settlement and even pre-

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fire suppression conditions. Fire regime comprises the general patterns of fire periodicity, seasonality, intensity, and size that emerge over time (Lafon and others 2005). This principle information serves as the foundation for management, giving insight to landscape conditions that will promote a healthy ecosystem.

As the monitoring program was being developed, the Forest Service and TNC cooperators shared their knowledge and expertise of the central Appalachian landscape, fire regimes and characteristics, and the diverse vegetation types found in the mountains. In order to more easily group and describe the ecological systems, the expansive landscape owned by the two agencies was condensed into ecological zones, units of land that can support a specific plant community or plant community group based on environmental factors (Simon 2011). The FLN combined and compared various ecological types using a crosswalk between Simon's Ecological Zone Modeling and the George Washington Forest Plan Systems, establishing three broad system types where fire typically has the greatest effect: mesic, dry-mesic and dry. Prescribed burning efforts on the forest and preserve focus on ecological zones where fire is beneficial to restoring the systems' ecological integrity or condition to their historic range of variability. Using Simon's model, the agencies began planning and prioritizing burn units in landscapes that would likely benefit from fire (table 1).

Develop Objectives

Treating the landscape with prescribed fire requires each burn unit to have obtainable objectives outlined prior to ignition. These objectives guide ignition implementation and techniques, driving burn bosses to conduct firing in ways which achieve specific results on the unit. Additionally, objectives in a burn plan also relate directly to data collected during monitoring. Burn plans across the GWJNF and the preserve have incorporated specific, measurable, achievable, relevant, and timely (SMART) objectives. Specific infers that an objective should clearly define its purpose and subject. A measurable objective is one that can be quantitatively measured through data collection. Relevance ensures objectives are appropriate and feasible for the burn. Timely sets deadlines for results and data collection. For example, one burn objective may call for a 40-percent reduction in red maple (*Acer rubrum*) saplings less than 1 inch dbh within one year post burn. This objective specifically states species, size class, and percent reduction desired then can be measured using protocols developed for the monitoring program. It is relevant to a burn unit with the presence of shade-tolerant red maple and the mortality should be visible on the unit one year post burn. To achieve this objective, the burn boss would conduct firing on the unit with enough intensity to reduce the maple saplings.

Plan and Conduct Monitoring

Objectives cannot be measured in the field without consistent and quantitative data collection. A structured monitoring program is an essential component to the adaptive management cycle because it gives a way to measure changes seen on the landscape after fire. The FCS Protocol, first created in 2008, was revised in 2013. It includes guidelines for plot design, placement within burn units, and specific instructions for data collection. This guides consistent and accurate collection methods across the forest and preserve. The monitoring program uses randomly stratified, circular hundredth-acre plots across burn units to collect data in ecological systems of concern, such as Central Appalachian Dry Oak-Pine Forests (table 1). Each plot is visited before and after a burn at specific intervals to collect data (table 2). The plots are permanently retained through the use of visible paint markers, rebar stakes driven at plot center, and recorded GPS coordinates. Pre-burn or baseline data is collected prior to implementation of a burn to establish a "control" from which change following fire will be measured in the following visits.

Implement Monitoring Actions

Management actions are treatments applied to the landscape, such as timber harvesting, thinning, prescribed fire, or use of herbicides. Both the GWJNF and TNC utilize prescribed burns across large portions of the landscape and multiple ecosystems. Burns are typically conducted in the spring, dependent upon weather conditions, personnel availability, and ongoing wildfires in the area. Fire management officers, including burn bosses and firing bosses, work to burn the unit in a way that achieves desired objectives (fig. 1). Communication both pre-burn and throughout the burn is essential for firing the unit to meet objectives. The burn boss must explain the objectives during briefing, clearly outlining how those objectives should be met to all personnel on the fire, not simply firing bosses. This ensures all personnel have an understanding of why the burn is taking place and may better understand how certain techniques are used to create results. As the burn is conducted, the burn boss must ensure that firing is appropriate to meet objectives. This may include instructing firing bosses to increase or decrease intensity by using various firing methods.

Conduct Monitoring

As mentioned previously, FCS plots are permanent, allowing data to be recorded post burn at the same location. Within six months following a burn, each plot on the unit will be visited and immediate post-burn photos are taken to show immediate fire effects. A full visit is made after one full growing season post burn. Collected data includes photographs of north and south views from plot center, canopy cover measurements taken along four transects using a Densitometer, density quadrats to determine ground cover and seedling abundance, stem count and size of sapling tree/shrub species, and basal area of overstory trees using a Basal Area 10 prism (fig. 2). The plots are visited again five years post burn if the unit is not burned again within that time. If the unit is burned again within five years, immediate post-burn photos and a one-year post burn visit are made for the second entry. This process is continued for the duration the burn unit is treated. Data, once collected, is entered into Feat and Firemon Integrated (FFI). This database program acts to store data that can be shared between cooperators (including those outside Virginia) and performs statistical analyses.

Analyze Results

The analysis and informed use of monitoring data ultimately feeds back into the adaptive management cycle. As new information becomes available, managers and ecologists continue to revise and implement objectives in prescribed burns, using the monitoring program to study future burns. Using Forest Service-developed FFI or other programs, such as Microsoft Excel®, the data can be analyzed on large or small scales. The questions posed by burn objectives (e.g., did we kill 40 percent of red maple saplings under one inch dbh?) are answered. The analyzed data can be easily used by fire management officers to read results of their burn treatments, enabling them to make informed decisions for future burns. New burn objectives may be developed with the new information and/or firing techniques may be altered to achieve different results in the future. For example, if only 20 percent of red maple saplings were killed after one year, fire management officers may decide to burn the unit with more intensity in the next entry and will alter the firing plan to achieve those results. Alternatively, the data may show managers that the burn objectives are unobtainable, prompting them to revise them to more accurately reflect changes that occur on the landscape after a burn.

CONCLUSION

The adaptive management process has become a major focus of the prescribed burn program on the GWJNF and TNC's Warm Springs Mountain Preserve. Through the development of a monitoring program, both the forest and TNC have the ability to use relevant research and data to modify burn plans and firing techniques to best meet predetermined burn objectives. The use of a monitoring program not only provides feedback to fire management officers, but has also established a close working relationship between the Forest Service and TNC. It further supports NEPA claims and provides the public with quantitative evidence of how prescribed burning influences the landscape by improving ecological integrity in different community types.

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Table 1—Plant community groups used to describe changes from a narrow to broad range of ecological communities across the landscape at the introduction and use of prescribed fire[a]

Simon's Ecological Zones	George Washington systems (Forest Plan)	Fire Learning Network systems
Spruce	Spruce Forest	Mesic
Northern Hardwood Slope	Northern Hardwood Forest	
Northern Hardwood Cove	Cove Forest	
Acidic Cove		
Spicebush Cove		
Rich Cove		
Alluvial Forest	Floodplains, Wetlands, and Riparian Areas	
Floodplain Forest		
High Elevation Red Oak	Oak Forests and Woodlands	Dry-Mesic
Montane Oak Rich		
Montane Oak Slope		
Montane Oak Cove		
Colluvial Forest		
Dry Mesic Oak		
Dry Mesic Calcareous Forest		
Dry Oak Evergreen Heath		
Dry Oak Deciduous Heath		
Low Elevation Pine	Pine Forests and Woodlands	Dry
Pine-Oak Heath (eastside ridge)		
Pine-Oak Heath (westside ridge)		
Pine-Oak Heath (ridgetop)		
Pine-Oak Shale Woodlands		
Shale Barren	Cliff, Talus and Shale Barrens	
Alkaline Woodland	Mafic Glade and Barrens and Alkaline Glades & Woodlands	Dry-Mesic
Mafic Glade and Barren		

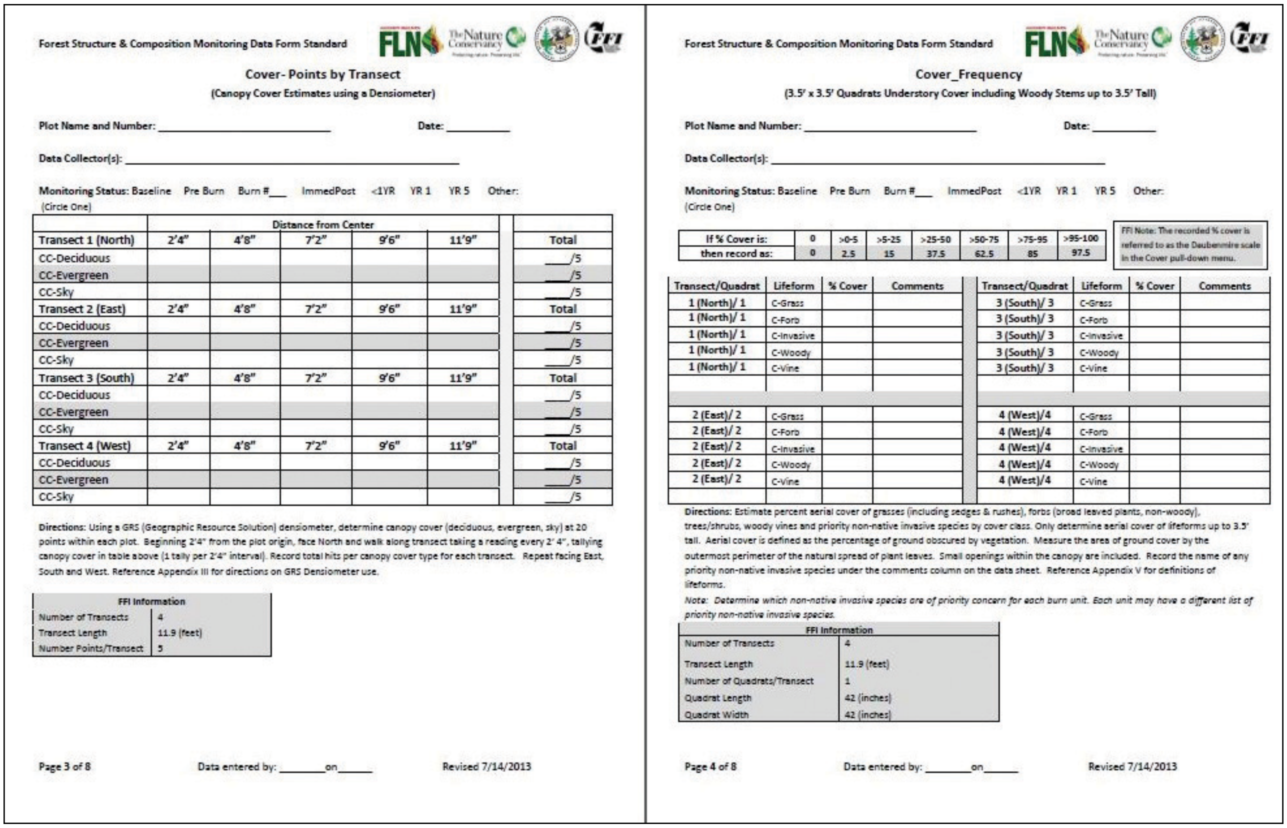
[a] Plant community groups are defined by Simon (2011), the George Washington National Forest Plan, and the Alleghany Highlands Fire Learning Network.

Table 2—Monitoring statuses with descriptions of appropriate use in the Forest Composition and Structure Monitoring Program[a]

Monitoring status	Comment (description and appropriate use)
Pre Burn01	Most appropriately used when unit has not burned in (recent) past. Will be "baseline" data, collected before the first burn.
Baseline	Used in situations where the first data collected is not collected at the beginning of fire reintroduction. Used in lieu of "Pre Burn" data, since it is not technically "pre" burn.
Burn01ImmedPost	Data collected immediately after the 1st burn. Usually is limited to fuels, severity and photos, unless dictated by additional objectives.
Burn01 Year 1	Data collected one full year after the 1st burn, preferably during growing season (which may be 2nd growing season post-burn). Overstory and midstory tree diameters do not need to be re-collected at this time, unless dictated by objectives.
Burn01 Year 5	Data collected 5 full years after the 1st burn. If unit is re-burned before this time, start monitoring sequence over (for example, Burn02 Year1, Burn02ImmedPost) without using this status.
Burn02ImmedPost	Data collected immediately after the 2nd burn. Usually is limited to fuels, severity and photos, unless dictated by additional objectives.
Burn02 Year 1	Data collected one full year after the 2nd burn, preferably during growing season (which may be 2nd growing season post-burn). Overstory and midstory tree diameters do not need to be re-collected at this time, unless dictated by objectives.
Burn02 Year 5	Data collected 5 full years after the 2nd burn. If unit is re-burned before this time, start monitoring sequence over (for example, Burn03 Year1, Burn03ImmedPost) without using this status.

[a] These statuses are also used in FFI to separate and compare data taken at different times on plots.

Figure 1—Implementation of prescribed burn on the Warm Springs Ranger District on the Hidden Valley burn unit. The burn was conducted alongside of personnel from The Nature Conservancy in the Alleghany Highlands Fire Learning Network.



Forest Structure & Composition Monitoring Data Form Standard

Cover- Points by Transect

(Canopy Cover Estimates using a Densiometer)

Plot Name and Number: ____________________ **Date:** __________

Data Collector(s): ______________________________

Monitoring Status: Baseline Pre Burn Burn #___ ImmedPost <1YR YR 1 YR 5 Other:
(Circle One)

	Distance from Center						Total
Transect 1 (North)	**2'4"**	**4'8"**	**7'2"**	**9'6"**	**11'9"**		**Total**
CC-Deciduous							___/5
CC-Evergreen							___/5
CC-Sky							___/5
Transect 2 (East)	**2'4"**	**4'8"**	**7'2"**	**9'6"**	**11'9"**		**Total**
CC-Deciduous							___/5
CC-Evergreen							___/5
CC-Sky							___/5
Transect 3 (South)	**2'4"**	**4'8"**	**7'2"**	**9'6"**	**11'9"**		**Total**
CC-Deciduous							___/5
CC-Evergreen							___/5
CC-Sky							___/5
Transect 4 (West)	**2'4"**	**4'8"**	**7'2"**	**9'6"**	**11'9"**		**Total**
CC-Deciduous							___/5
CC-Evergreen							___/5
CC-Sky							___/5

Directions: Using a GRS (Geographic Resource Solution) densiometer, determine canopy cover (deciduous, evergreen, sky) at 20 points within each plot. Beginning 2'4" from the plot origin, face North and walk along transect taking a reading every 2' 4", tallying canopy cover in table above (1 tally per 2'4" interval). Record total hits per canopy cover type for each transect. Repeat facing East, South and West. Reference Appendix III for directions on GRS Densiometer use.

FFI Information	
Number of Transects	4
Transect Length	11.9 (feet)
Number Points/Transect	5

Page 3 of 8 Data entered by: ________on______ Revised 7/14/2013

Forest Structure & Composition Monitoring Data Form Standard

Cover_Frequency

(3.5' x 3.5' Quadrats Understory Cover including Woody Stems up to 3.5' Tall)

Plot Name and Number: ____________________ **Date:** __________

Data Collector(s): ______________________________

Monitoring Status: Baseline Pre Burn Burn #___ ImmedPost <1YR YR 1 YR 5 Other:
(Circle One)

If % Cover is:	0	>0-5	>5-25	>25-50	>50-75	>75-95	>95-100
then record as:	0	2.5	15	37.5	62.5	85	97.5

FFI Note: The recorded % cover is referred to as the Daubenmire scale in the Cover pull-down menu.

Transect/Quadrat	Lifeform	% Cover	Comments		Transect/Quadrat	Lifeform	% Cover	Comments
1 (North)/ 1	C-Grass				3 (South)/ 3	C-Grass		
1 (North)/ 1	C-Forb				3 (South)/ 3	C-Forb		
1 (North)/ 1	C-Invasive				3 (South)/ 3	C-Invasive		
1 (North)/ 1	C-Woody				3 (South)/ 3	C-Woody		
1 (North)/ 1	C-Vine				3 (South)/ 3	C-Vine		
2 (East)/ 2	C-Grass				4 (West)/4	C-Grass		
2 (East)/ 2	C-Forb				4 (West)/4	C-Forb		
2 (East)/ 2	C-Invasive				4 (West)/4	C-Invasive		
2 (East)/ 2	C-Woody				4 (West)/4	C-Woody		
2 (East)/ 2	C-Vine				4 (West)/4	C-Vine		

Directions: Estimate percent aerial cover of grasses (including sedges & rushes), forbs (broad leaved plants, non-woody), trees/shrubs, woody vines and priority non-native invasive species by cover class. Only determine aerial cover of lifeforms up to 3.5' tall. Aerial cover is defined as the percentage of ground obscured by vegetation. Measure the area of ground cover by the outermost perimeter of the natural spread of plant leaves. Small openings within the canopy are included. Record the name of any priority non-native invasive species under the comments column on the data sheet. Reference Appendix V for definitions of lifeforms.

Note: Determine which non-native invasive species are of priority concern for each burn unit. Each unit may have a different list of priority non-native invasive species.

FFI Information	
Number of Transects	4
Transect Length	11.9 (feet)
Number of Quadrats/Transect	1
Quadrat Length	42 (inches)
Quadrat Width	42 (inches)

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Figure 2—Datasheets used in Forest Composition and Structure monitoring. Data is transferred into FFI after collection in the field.