National Park Service
Northeast Region
Fire Ecology Annual Report
2011

Monitoring

The fire effects monitoring team had a very efficient year servicing nearly 90 plots at five NPS units. Substantial progress was also made to other critical aspects of the program including protocol documentation, ArcGIS maps, database management and scanning historic program data.

Despite rain, fog, cold temperatures, bears, bees and the stomach flu, a highly successful fire ecology summit was held at Shenandoah National Park. Southeast and Northeast fire ecology staff came together in an effort to share ideas and resources across regional boundaries and complete pre-burn plot installations. The summit was viewed as a great success by all who participated. At the end of this year, lead fire effects monitor Tyler Schmitt transferred to the Sequoia Kings Canyon fire effects monitoring crew. While Tyler was only with the crew for a short time, he brought a tremendous amount of enthusiasm and dedication to his job that will surely be missed!

NER/SER Fire Ecology summit 2011.

Fire Management Planning

In an effort increase the amount of prescribed burning at Shenandoah, the fire ecology program collaborated with the Natural and Cultural Resources Division on several planning documents in 2011. A document prioritizing the use of prescribed fire by forest community type and Desired Future Conditions (DFC's) was completed. Through geospatial modeling and scientific research this document spatially depicts the forest community types in Shenandoah that will benefit from the application of prescribed fire (see Appendix A). In conjunction with this document, a spatially interactive fuel loading map was also completed as part of a 2010 Research Reserve request. These two products will serve as the foundation for the parks budding prescribed fire program and will ensure that fire management activities are informed and supported by the best available scientific information. Compliance planning and completing the park's five year plan will be the major focus for 2012 as the program.

READ

Shenandoah National Park had the privilege to host the first Resource Advisor Training (READ) in the Northeast Region. Fifty-three people were in attendance from eighteen NPS units and four Federal agencies. Moreover, fifteen employees were in attendance from the Shenandoah Natural and Cultural Resources Division! This timely training covered READ activities during wildfires, planned events, hurricanes and the Deepwater Horizon response. Following the training, the fire ecologist had the opportunity to serve as a READ for the Eastern Incident Management Team (EIMT) during hurricane Irene clean up at Cape Hatteras National Seashore.

2011 Northeast Region READ class.

Fire

It was a relatively quiet fire year, however fire ecology staff provided initial attack support on several small wildfires and one crew member participated on an engine assignment.

The fire ecologist provided WFDSS (Wildland Fire Decision Support Software) support on large and small fires throughout the year.

2012 Direction

A small group has come together from the NE, SE and National Office to discuss decreasing Federal budgets, increasing workloads and strategies to mitigate these challenges. One way the SHEN MTTS fire effects monitoring crew is adapting to shrinking budgets and changing National priorities is by modifying the frequency of data collection in our grassland parks. The percent change is not significant, usually only a few percentage points, and well within the standard error. Coupled with less money, positions and travel restrictions this intensive data collection is not cost effective or appropriate. We will collect grassland data every three to five years, especially in parks/units where we have good baseline data. As new projects come on board we will evaluate the level of monitoring needed. The 2012 season will have us focusing on larger forest projects at Shenandoah and new prescribed fire parks including New River Gorge and Catoctin Mountain Park. Below is a table of parks served tentative work plan for the next few years.

Parks monitored by the MTTS fire effects crew.

Park	Date of last Rx fire or mechanical treatment	Year Monitored Last	Planned Monitor 2012?	Next Scheduled Visit	New Project?	Current level of monitoring?
Acadia NP	2011	2007	No	unknown	No	Advisory
Antietam NBP (NCR)	2011	2005/2011	No	none	No	None
Appomattox Courthouse NBP	2010	2010	No	2013	Yes	Plots
Assateague Island NS	2010	2011	No	unknown	No	Assist with park plots
Cape Cod NS	2011	2010/2011	No	unknown	No	Assist with park plots
Catoctin Mountain Park (NCR)	Never	Never	Yes	2012	Yes	New plot installs
Delaware Water Gap NRA	2011	2011	No	2014	No	Plots
Fred. and Spot. NMP	2011	2011	No	2013	No	Plots
Gateway NRA	Never	Never	No	unknown	Yes	Advisory
Gettysburg NMP	Never	Never	Yes	2012	Yes	Advisory / may assist plots
George Washington Birthplace NBP	Never	Never	No	2013	Yes	Advisory
New River Gorge NRA	Never	Never	Yes	2012	Yes	New plot installs
Petersburg NBP	2011 (mech.)	Never	No	2014	Yes	Advisory
Richmond NBP	2010	2010	No	2013	No	Plots
Saratoga NHP	2011	2011	No	2014	No	Plots
Shenandoah NP	2010	2011	Yes	2012	Yes	Plots

Optional Information

FFI Suggestions

- A course/webinar that reviewed ways to export and analyze your data in useful ways using FFI.
- The query builder to be more user friendly. After years I still have to pull out my cheat sheets to remember if I need to select sum num subsample here or row count there. It is not intuitive and I know there is more I can do, it's just not easy to think your way through the process. Maybe it's just me.
- When you export and there was no hits on a transect, you have to go and put the zero's back in for the null transects. I export by macroplot anyway to calculate sd and se, but you couldn't group by "nothing" in query builder because all of your percentages would be overestimates. It takes a while to go back through and find all the transects that didn't have a hit and place a zero so you get accurate percent covers.
- The monitoring status assignment user interface sometimes leads to errors with people forgetting to assign a status or accidently changing the status. The interface would ideally be more intuitive.

Tables.

Table 1. Fire Effects Plot Workload (2011) and Total Plots Installed

Park	Monitoring Unit	Type of Plot (FMH, photo point, other)	Pre-burn 2011	Imm. Post 2011	Post-burn 2011	Annual Total (2011)	Total Plots
Acadia NP	Carriage Road Vistas	FMH Forest Plot (mod.)	0	0	0	0	8
Antietam NBP	Prye House Vista	non-FMH brush	0	0	0	0	1
	Snavely Ford Woods	non-FMH forest transect	0	0	0	0	6
	West Woods	non-FMH forest	0	0	0	0	5
	Sherrick Farm Woods	FMH Forest Plot	0	0	0	0	1
Appomattox Courthouse	Mixed Grassland	FMH Brush Plot	0	0	0	0	8
	NC Woodlot	FMH Forest Plot	0	0	0	0	3
Assateague Island NS	*Phragmites australis*	FMH Brush Plot	0	0	13	13	39
Cape Cod NS	Paradise Hollow Research Area	(Collaborative with Crary)	0	0	0	0	9
Delaware Water Gap NRA	Mixed Grassland	FMH Brush Plot	0	0	10	10	10
Fredericksburg and	Mixed Grassland	FMH Brush Plot	0	0	14	14	14
Richmond NBP		photo points	0	0	0	0	4
	Cold Harbor	FMH Forest Plot	0	0	0	0	2
	Malvern Hill	FMH Brush Plot	0	0	0	0	13
Saratoga NHP	Mixed Grassland	FMH Brush plots	0	0	9	9	24
Shenandoah NP	Pine-Oak	FMH Forest Plot	4	0	0	4	10
	Xeric Oak	FMH Forest Plot	4	0	0	4	7
	Mesic Oak	FMH Forest Plot	0	0	0	0	3
	Gray Birch	FMH Forest Plot	0	0	0	0	10
	Sawmill	Brown's lines	0	0	0	0	10
	Blackrock	CBI	-	-	0	0	14
	Fultz Run	CBI	-	-	0	0	20
	Lewis Mountain	CBI	-	-	0	0	16
	Rocky Top	CBI	-	-	0	0	19
	SHEN Complex	CBI	-	-	0	0	11
	Big Meadows	SNP prescribed fire brush transects	-	-	24	24	79
	SHEN LTEM Plots	LTEM Forest plots (Collaborative with	-	-	9	9	-
Total			**8**	**0**	**79**	**87**	**346**

Table 2. Fire Ecology Staffing 2011

	Starting Date	Ending Date	# of Pay Periods	READ Qualified (Yes or No)	Training and Development
Missy Forder **Ecologist**	12/31/2011	1/1/2011	26	Yes	Completed ICT5 taskbook, progress on CRWB(t) and FIRB(t), Rx-341 Burn Plan Preparation, First Responder certification, Hazwoper, READ assignment on Hurricane Irene, WFDSS on two Type 1 fires.
Tyler Schmitt **Lead Monitor**	2/13/2011	12/17/2011	22	Yes	S-271 (Helicopter Crew Member), First Responder, Leave No Trace master educator course training, Resource Advisor training (READ).
Monica Phillips **Crew Member**	5/22/2011	9/30/2011	9.5	Yes	S-290 (Intermediate Fire Behavior), S-271 (Helicopter Crew Member), Resource Advisor training (READ), Leave No Trace training.
Heather Dammayer **Crew Member**	5/22/2011	9/30/2011	9.5	Yes	Resource Advisor training (READ), Search and Rescue Training, Leave No Trace training.

Smith Run Fire, February 19, 2011.

Table 3. Management Objectives and Monitoring Results

Park	Monitoring Unit	Management Objective (80% C.I.) α .2	Monitoring Results	Objectives Achieved?	YR Last Analysis ?
Richmond National Battlefield Park	Malvern Hill	Maintain percent cover of woody species <25%	**Cool Season Grass Fields** Shrub Cover = 4% (± .2) Tree Cover = 16% (± 11)	**Yes**	2010
			Warm Season Grass Fields Shrub Cover = 0 Tree Cover = 2 (± .1)	**Yes**	
		Percent cover of non-natives grasses and forbs < 25%.	**Cool Season Grass Fields** Non-Native Grass Cover = 47 (± 12) Non-Native Forb Cover = 12(± 5)	**No**	2010
			Warm Season Grass Fields Non-Native Grass Cover = .3 (± .3) Non-Native Forb Cover = *10(± 10) *Plot 10 LESCUN	**Yes**	
		Percent cover of "meadow specialists" native grasses and forbs >75%.	**Cool Season Grass Fields** Native Grass Cover = 71(± 12) Native Forb Cover = 43(± 10)	**Yes**	2010
			Warm Season Grass Fields Native Grass Cover = 150(± 4) Native Forb Cover =13(± 3)	**Yes**	
	Cold Harbor	Decrease pole size trees by 50% after four burns.	**Pre:** 46 pole trees **03YR02:** 22 pole trees	**Yes**	2010
		Maintain an open forested stand as it appeared at the time of the battle.	Photopoints on going.	**Yes**	2010
		Increase relative percent cover of herbaceous species by 75%	**Pre:** 1.2% **03YR02:** 7%	**Yes**	2010

Appomattox Court House National Historical Park	Ferguson Field Mixed Grassland	Maintain percent cover of woody species <25%	Woody species= 9 (±3)	**Yes**	2010
		Percent cover of non-natives grasses and forbs < 25%.	Non-native grass = 38 (±7) Non-native forbs = 10(±4)	**Yes**	2010
		Percent cover of native grasses and forbs >75%.	Native grasses = 83 (±7) Native forbs = 13 (±4)	**Yes**	2010
	NC Woodlot	Short Term: Reduce Fuels: <1/4 inch diameter size class (litter) by 65 - 75%, ¼ to 1 inch diameter size class by 25% to 50%, 1in to 3 in diameter size class by 10%-25%	Preburn plots installed 2010	**N/A**	N/A
		Short Term: Reduce Density of pole-sized trees by at least 25% as measured within 1 year post burn.	Preburn plots installed 2010	**N/A**	N/A
		Short Term: Limit overstory mortality to <25% as measured 1 year post burn	Preburn plots installed 2010	**N/A**	N/A
Fredericksburg and Spotsylvania National Historical Park	Spotsylvania Mixed Grassland	Maintain woody species < 25%.	**Low Shrub Cover Fields** Shrubs=34 (±3) Trees=27 (±1) **High Shrub Cover Fields** Shrubs=50(±6) Trees=9 (±1)	**No**	2011
		Percent Cover on non-native grasses and forbs <25%.	**Low Shrub Cover Fields** Non-native grass = .8 (±.2) Non-native forbs = .6(±.2) **High Shrub Cover Fields** Non-native grass = 25(±4) Non-native forbs = .8(±.19)	**Yes**	2011
		Percent cover of native grasses and forbs >75%.	**Low Shrub Cover Fields** Native grass =122 (±4) Native forbs = 57 (±4) **High Shrub Cover Fields** Native grass = 108(±6) Native grass = 69(±5)	**Yes**	2011

Delaware Water Gap National Recreation Area	Darrones and Silver Spray Units	Percent cover of native grasses and herbs >75%.	**PRE** Native Grass = 11% (±2)		2011
			01YR01 Native Grass = 15% (±4)	**No**	
			01YR02 Native Grass = 22% (±1)		
			PRE Native Herb = 113% (±13)	**Yes**	
			01YR01 Native Herb = 95% (±12)		
			01YR02 Native Herb = 144% (±3)		
		Percent cover of woody species < 25%.	**PRE** Native Shrub = 17% (±2)	**No**	2011
			01YR01 Native Shrub = 15% (±3)		
			01YR02 Native Shrub= 10% (±1)		
			PRE Non Native Shrub = 0		
			01YR01 Non Native Shrub = 13% (±5)		
			01YR02 Non Native Shrub = 17% (±2)		
		Percent cover of non-natives grasses and forbs < 25%.	**PRE** Non-native Herbs = 43% (±8)	**No**	2011
			01YR01 Non-native Herbs = 42% (±8)		
			01YR02 Non-native Herbs = 25% (±2)		
			PRE Non-native Grass = 127% (±12)		
			01YR01 Non-native Grass = 94% (±12)		
			01YR02 Non-native Grass = 101% (±4)		
Assateague Island National Seashore	Phragmites	Remove dead biomass, particularly dead stems of Phragmites australis			2011
		Maintain species diversity of native species post burn			2011

Cape Cod National Seashore	Fire Cache *Corema* transplanting	Marconi WUI Broom Crowberry monitoring	Determine extent and time for colonization of burn pile footprints by Corema	**2011- no sampling completed . Ocular estimation that minimal mortality occurred**	on-going
	Lombard Paradise Hollow	Fire Cache Corema transplanting	Measure long term cover and health of 40 Corema plants prior to transplanting	**ocular estimate only, 50% mortality**	2010
		Lombard Paradise Hollow	Research, vegetation	**in prep year 24 (Patterson et. al.)**	2010
	Heathland Monitoring / Marconi Site Heathland restoration		Research, burning	**in prep year 24 (Patterson et. al.)**	2010
	Broom Crowberry burn	Heathland Monitoring / Marconi Site Heathland restoration	Establish pre-treatment baseline data for 35 area heathland restoration in the Marconi area	**on-going, Univ FLA (Von Holle, principle invest.)**	on-going
	Heathland /Hunting summers plots	Broom Crowberry burn	Determine if spring, summer or fall burning favors Corema conradii, three each 03 acres plots were burned (2.7 acres)	**in prep year 2 (Patterson et. al.)**	on-going

Shenandoah National Park	Big Meadows Joint monitoring effort with SHEN Botany and Fire Effects.	Maintain the cultural open landscape.	Analysis in progress. Completed by SHEN Botany.	**Yes**	NCR 2008
		Examine changes in vegetation over time in response to management.	Analysis in progress. Completed by SHEN Botany.	**Yes**	NCR 2008
		Monitor Northern Blue ridge Mafic fen plant community which contains a significant amount of the parks rare plant species.	Analysis in progress. Completed by SHEN Botany.	**Yes**	NCR 2008
	Pine-Oak	> 50% reduction in fuel loading.	Pre-burn plots only.	**N/A**	N/A
		>70% reduction of mesic pole size trees (2.5 - 15 cm dbh) (i.e. red maple (Acer rubrum), blackgum (Nyssa sylvatica), sassafras (Sassafras albidum) and hickory (Carya spp.).	Pre-burn plots only.	**N/A**	N/A
		25 – 50% reduction in overstory tree density.	Pre-burn plots only.	**N/A**	N/A
		>200 tall (>60 cm in height) yellow pine seedlings (Pinus pungens, Pinus rigida, Pinus virginiana) per acre.	Pre-burn plots only.	**N/A**	N/A
		>40% cover of native herbs.	Pre-burn plots only.	**N/A**	N/A
		No net increase in invasive exotic species cover.	Pre-burn plots only.	**N/A**	N/A
		> 50% reduction in fuel loading.	Pre-burn plots only.	**N/A**	N/A
	Xeric Oak	>70% reduction of mesic pole size trees (2.5 - 15 cm dbh) (i.e. red maple (Acer rubrum), blackgum (Nyssa sylvatica), sassafras (Sassafras albidum) and hickory (Carya spp.).	Pre-burn plots only.	**N/A**	N/A
		15 – 30% reduction in overstory tree density.	Pre-burn plots only.	**N/A**	N/A
		>200 tall (>60 cm in height) Oak seedlings per acre.	Pre-burn plots only.	**N/A**	N/A
		>30% cover of native herbs.	Pre-burn plots only.	**N/A**	N/A
		No net increase in invasive exotic species cover.	Pre-burn plots only.	**N/A**	N/A

Mixed Grassland **Hillside Plots** n=5 (Plots 2,3,15,17,20)	Percent cover of native grasses and herbs >75%.	**2006** Native Grass = 84% (±11) **2010** Native Grass = 100% (±11) **2011** Native Grass = 110% (±4)	**YES**	2011
		2006 Native Herb = 132% (±19) **2010** Native Herb = 139% (±15) **2011** Native Herb = 169% (±7)	**YES**	
Plots burned 3-5 times. The area has been burned ~ 11 times.	Percent cover of woody species < 35%.	**2006** Native Shrub = 31% (±8) **2010** Native Shrub = 28% (±4) **2011** Native Shrub = 30% (±3)	**No**	2011
		2006 Non Native Shrub = 10% (±5) **2010** Non Native Shrub = 7% (±4) **2011** Non Native Shrub = 10% (±4)	**No**	
	Percent cover of non-natives grasses and forbs < 50%.	**2006** Non-native Herbs = 41% (±8) **2010** Non-native Herbs = 46% (±15) **2011** Non-native Herbs = 40% (±6)	**YES**	2011
		2006 Non-native Grass = .4% (±.2) **2010** Non-native Grass = 9% (±4) **2011** Non-native Grass = 22% (±3)	**YES**	
Mixed Grassland **Neilson Farm** 2008 n=3 (Plots 5,6,7)	Percent cover of native grasses and herbs >75%.	**2008** Native Grass = 95% (±16) **2010** Native Grass = 117% (±12) **2011** Native Grass = 132% (±5)	**YES**	2011
		2008 Native Herb = 24% (±14) **2010** Native Herb = 23% (±6) **2011** Native Herb =23% (±3)	**NO**	
2010 / 2011 n=6 (Plots 5,6,7,14,18,24) Plots burned 1 - 3 times. The area has been burned 3-7 times.	Percent cover of woody species < 35%.	**2008** Native Shrub = 18% (±5) **2010** Native Shrub = 21% (±4) **2011** Native Shrub = 27% (±3)	**YES**	2011
		2008 Non Native Shrub = 2% (±.3) **2010** Non Native Shrub = .5% (±.2) **2011** Non Native Shrub = .3% (±.08)	**YES**	
	Percent cover of non-natives grasses and forbs < 50%.	**2008** Non-native Herbs =150% (±21) **2010** Non-native Herbs = 127% (±22) **2011** Non-native Herbs = 119% (±10)	**NO**	2011
		2008 Non-native Grass = 5% (±3) **2010** Non-native Grass = 16% (±5) **2011** Non-native Grass = 15% (±2)	**YES**	

Mixed Grassland **Chatfield Farm** 2003 n=2 (Plots 11,12)	Percent cover of native grasses and herbs >75%.	**2003** Native Grass = 116% (±26) **2010** Native Grass = 101% (±13) **2011** Native Grass = =91% (±2)	**YES**	2011
		2003 Native Herb = 28% (±2) **2010** Native Herb = 19% (±7) **2011** Native Herb =18% (±3)	**NO**	
2010 n=3 (Plots 11,12,23) Plots have been burned 1-2 times. Summer burn 2003 and 2009.	Percent cover of woody species < 35%.	**2003** Native Shrub = 42% (±15) **2010** Native Shrub = 33% (±2) **2011** Native Shrub =37% (±3)	**NO**	2011
		2003 Non Native Shrub = 2% (±.3) **2010** Non Native Shrub = .3% (±.3) **2011** Non Native Shrub = 0% (±0)	**YES**	
	Percent cover of non-natives grasses and forbs < 50%.	**2003** Non-native Herbs = 74% (±27) **2010** Non-native Herbs = 74% (±13) **2011** Non-native Herbs = 92% (±16)	**NO**	2011
		2003 Non-native Grass = 7% (±5) **2010** Non-native Grass = 2% (±.3) **2011** Non-native Grass = 1% (±.1)	**YES**	

SE/NE Fire Ecology Summit - Solving all fire ecology problems.

Table 4. Fire Ecologist Accomplishments and Area of Focus		
Category	**Percent Time**	**Accomplishments and/or areas of activities**
Planning	**30%**	Completed the Prioritizing of the Use of Prescribed fire for Forest Community Management at Shenandoah National Park and Desired Future Condition document.
		Developed sound scientific objectives for prescribed fire projects and completed the NEPA process. (PEPC, section 7, 106, memo to file).
		NFPORS, PPS, WFDSS.
		Assisted with burn plan development, FMP re-write, ignition maps, IAP's.
Presentations	**5%**	Presentation at NER Fire Management Officer meeting.
		Served as the lead instructor for S190 and S131 classes at SHEN.
		Develop a fire podcast about prescribed fire in SHEN.
		Presentations to GETT and NERI managers.
		Annual report.
NPS meetings	**15%**	Coordinated NER READ training.
		Meetings with Natural and Cultural Resource Management division and a contracted university facilitator to develop Desired Future Conditions (DFC's) for SHEN.
		Attend SHEN Natural Resources monthly meetings.
		SHEN Fire Ecology Summit 2011
Interagency	**2%**	Appalachian Fire Learning Network meetings.
Wildfire	**5%**	CRWB(t) and FFT1 on two fires.
		READ assignment on EIMT Team at CAHA.
		WFDSS support on SHEN Smith Run Fire and Great Dismal Swamp (FWS) Lateral West Fire.
Prescribed Fire	**1%**	FIRB(t) on one Rx Fire.
Non-fire fuels	**1%**	Assist READ activities on SHEN Smith Run fire.
		VA Prescribed fire council.
Research	**10%**	Work with American Chestnut Foundation to establish monitoring plots in burn units.
		Completed the interactive fuel model and fuel loading web map for Shenandoah National Park as part of a Research Reserve Request
		Literature research for SHEN Desired Future Conditions.
		Coordinated SHEN fuels research request.
Data collection	**1%**	SHEN data collection.
Data entry	**<1%**	Assisted with very little data entry.
Data Analysis	**10%**	Completed data summaries and analysis for supported parks.
Supervision & Administration	**10%**	Hire seasonal crew.
		Developed performance standards for permanent and seasonal employees.
		Lead, Assistant and seasonal performance evaluations.
Training	**3%**	Rx-341 Prescribed fire Burn Plan preparation.
		Smoke management workshop.
		First Responder, Hazwoper, Fire Refresher, Defensive Driving.
Travel out of park for plot or project work	**2%**	Site visits to develop prescribed fire objectives to GETT and NERI.
Miscellaneous	**5%**	SHEN BAER plan preparation, READ SHEN 75th Anniversary Celebration, FMO delegated projects.

Table 5. Fire Effects Crew Accomplishments and Areas of Focus

Category	Percent Time	Accomplishments and/or areas of activities
FMH Plots	**55%**	5 NPS units serviced and/or supported.
		87 plots evaluated including 70 grass plots and 8 FMH forest plots and 9 LTEM I&M plots.
WUI Plots	**0%**	
CBI Plots	**0%**	
Other plot work	**5%**	Collaborate with I&M crew on LTEM plots to collect fuels data.
		Collaborate with I&M to read Big Meadows fire transects.
		ASIS prescribed fire plots.
Wildfire Assignments	**1%**	9 person days were completed on wildfire assignments on Appalachian Trail fire.
Prescribed Fire projects	**<1%**	FEMO on two prescribed burns.
Non-fire fuels project	**0%**	
Data entry	**30%**	100% of plot data has been entered into FFI and QA/QC for 2011.
Data Analysis	**0%**	
Supervision & Administration	**5%**	Lead supervised the crew of three and maintained time, travel and administrative paperwork.
Training	**2%**	S-290 (Intermediate Fire Behavior), S-271 (Helicopter Crew Member), Resource Advisor training (READ), Leave no trace training.
Miscellaneous	**2%**	SAR, 1-3 hours of physical training a week.

Table 6. Planning 2011

Park	Does Park have written DFCs? (yes or no)	Date Park-level Monitoring Plan completed (or revised)	Total # of Project or Community-level Monitoring Plans (not just 2011)	Assisted with how many BAER in 2011?
Assateague NS	No	none	1	0
Cape Cod NS	Yes	2005	5	0
Delaware Water Gap NRA	Yes	2008	1	0
Fredericksburg and Spotsylvania NMP	Yes	2010	1	0
Saratoga NHP	Yes	2007	1	0
Shenandoah NP	Yes	in progress 2011	1	1

Table 7. Monitoring 2011

Park	% 2011 Data Entered	% 2011 Data Quality Checked	# Prescribed Fires Monitored*	# Non-fire Fuels Treatments Monitored*	# Wildfires Monitored*	# BAER Treatments Monitored*
Assateague NS	**100%	**100%	1	0	0	0
Cape Cod NS (completed by CACO staff)	**100%	**100%	9	60	0	0
Delaware Water Gap NRA	100%	100%	1	0	0	0
Fredericksburg and Spotsylvania NMP	100%	100%	1	0	0	0
Saratoga NHP	100%	100%	1	0	0	0
Shenandoah NP	100%	100%	5	0	1	1

*Number of treatment units with treatment efforts monitoring conducted. Include pre-burn and post-burn monitoring but not burn-day monitoring

**Data entry and quality checking performed by the park and data is maintained by park staff.

Table 8. Communicating Results - 2011.

Park	# of Project Monitoring Reports completed in 2011	# of Annual meeting(s) with Park staff	# of Formal presentations of results	Do you use Minitab?
Assateague NS	1	0	0	no
Cape Cod NS (completed by CACO staff)	1	1	1	no
Delaware Water Gap NRA	1	1	0	no
Fredericksburg and Spotsylvania NMP	1	2	1	no
Saratoga NHP	1	1	0	no
Shenandoah NP	1	15	2	no

Table 9. Research- 2011.

Park	Are research needs identified in FMP or Monitoring Plan? (yes or no)	# of Proposals Submitted in 2011	# of Proposals Funded in 2011	# of Research Projects Supported in 2011*	Additional comments
Assateague NS	yes	0	0	1	Phrag. research
Cape Cod NS (completed by CACO staff)	yes	0	0	0	Research done in house as possible.
Delaware Water Gap NRA	yes	0	0	0	
Fredericksburg and Spotsylvania NMP	yes	0	0	0	
Saratoga NHP	yes	0	0	0	
Shenandoah NP	yes	0	0	2	Fuels map and American Chestnut Foundation.

Fredericksburg and Spotsylvania National Military Park (FRSP)
2011 Fire Effects Monitoring Annual Report

I. Program Overview

2011 Summary

Two fields were treated this spring in the Spotsylvania Courthouse prescribed burn unit and all plots were monitored. The last three years of data analysis continues to indicate no reduction of woody species. Current literature indicates a modification of timing in frequency will allow mangers to meet this objective. Moreover, a severe reduction of thatch combined with burning at the same time every year may have negative consequences on certain insects, birds and wildlife species. Fields should be burned in the late summer on a rotation (~3-5 years).

Future Plans

This project has moved from the restoration phase to the maintenance stage. With the onset of smaller travel budgets and increasing workloads the monitoring level and interval will be modified to every three years. This will continue to provide the necessary data to evaluate whether management goals and objectives are being met and whether undesired effects are occurring. Continued collection of monitoring data at current intensity level ***without*** altering burn timing and frequency will achieve the same results as in years past. Adaptive management needs to be embraced by managers (namely burning in the late summer) in order to achieve set objectives, maintain integrity and prove fiscally responsible.

II. Park Overview

Fredericksburg and Spotsylvania National Military Park is located approximately 50 miles south of Washington, D.C. The park is spread out over a 145-square mile area in the city of Fredericksburg, Virginia, at the junction of Interstate 95 and State Route 3, and in Caroline, Orange, Spotsylvania, and Stafford Counties. It is comprised of four separate Civil War battlefields: Fredericksburg, Spotsylvania Court House, Chancellorsville, and Wilderness, and four related sites: Salem Church, Chatham Manor, Jackson Shrine, and the Fredericksburg National Cemetery.

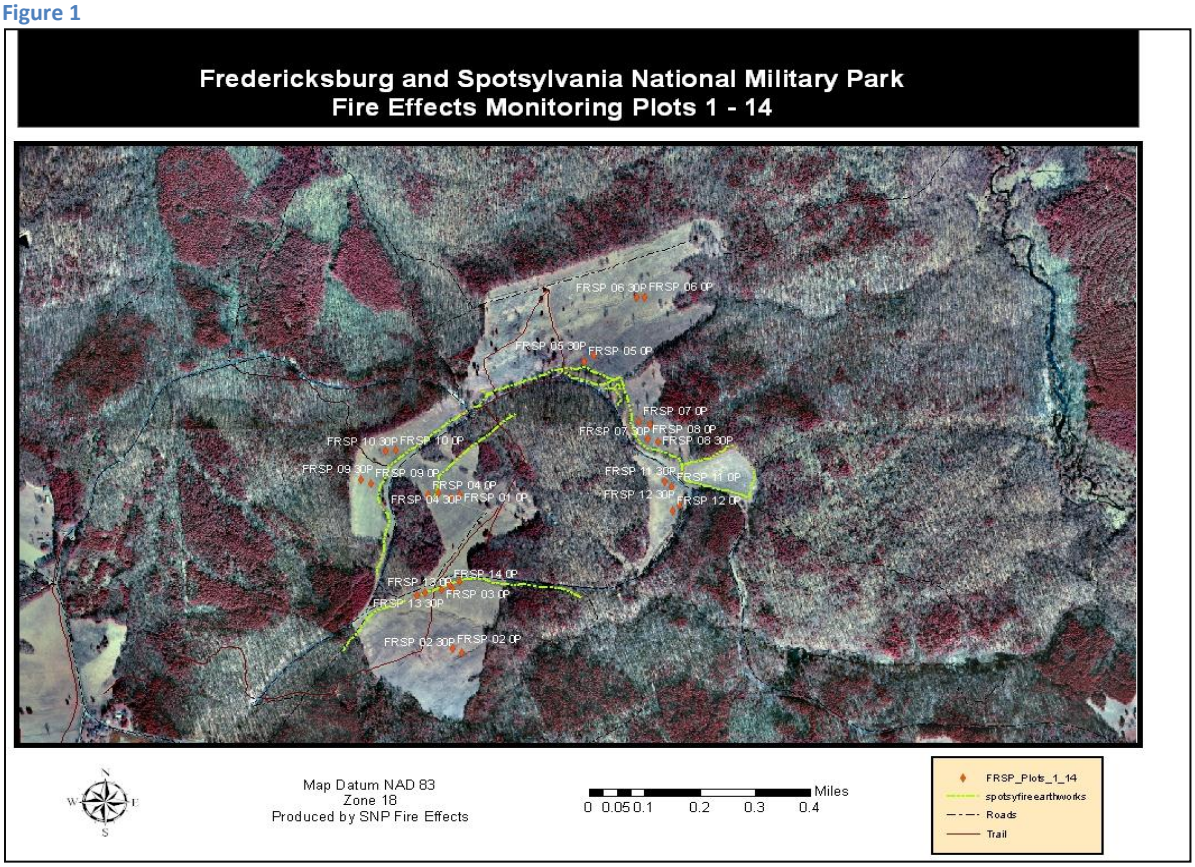
On four separate occasions, the main eastern armies of the United States and the Confederate States fought major battles in and around Fredericksburg, Virginia. The woods and fields of the battles are the primary resources of the park: federal lands encompass 1,200 ac of open fields, 6,000 ac of forest, 540 ac of wetlands, and 102 mi of boundary. In addition, the park has significant terrain features, historic roads and traces, structures, house sites, ruins, cemeteries, monuments, markers, and historic objects. A number of historic structures dating from the mid-19th century add to the park's significance, including more than 43 mi of earthworks built by the soldiers, Salem Church, the house where Stonewall Jackson died, Ellwood, Chatham Manor, and several other structures that were landmarks on the historic fields.

The Spotsy Fields Monitoring unit consists of open fields and earthworks. Open fields in Spotsylvania Court House Battlefield are considered cultural meadows. Cultural Meadow includes all mowed or maintained fields in the park, and are managed to maintain the open fields characteristic of Civil War battlefields. These meadows have a mix of native and exotic grasses and forbs with scattered shrubs. Dense stands of cool season grasses such as meadow fescue (*Schedonorus pratensis*) and orchard grass (*Dactylis glomerata*) typically occur.

Common vegetation encountered in fire monitoring plots include; native grasses and sedges such as, beaked panic grass (*Panicum anceps*), poverty oatgrass *(Danthonia spicata)*, rosette grass (*Dichanthelium dichotomum*), broomsedge (*Andropogon virginicus)*, little bluestem *(Schizachyrium scoparium)*, Indian grass (*Sorghastrum nutans)* and sedges *(Carex spp.)*. Shrubs include blackberry *(Rubus spp.)* and winged sumac *(Rhus copallinum)* and herbaceous plants include trailing bush clover *(Lespedeza procumbens)* yarrow *(Achillea millefolium)* and cinquefolia *(Potentilla spp.)* Tree seedlings include blackjack oak *(Quercus marilandica)*, sweet-gum *(Liquidambar styraciflua)* and locust *(Robinia pseudoacacia)*. Additionally, there are a few exotic species of concern found in the fields. Some of which include, but are not limited to, Japanese Honeysuckle *(Lonicera japonica)*, colonial bent grass *(Agrostis capillaris)*, sweet vernal grass *(Anthoxanthum odoratum)*, cat's ear *(Hypochaeris radicata)* and red sorrel *(Rumex acetosella)*.

The Northeast Region Fire Effects Monitoring Crew began monitoring fire effects at the park in 2004. Currently there are 14 FMH brush transect monitoring plots in a complex of seven fields for a total of 125 acres in size. Upton Field 11.8 ac, McCoull House Field 19.3 ac, Harrison House Field 29.7 ac, Crescent Field 5.3 ac, Native Grass Field 4.8 ac, Middle Field 7.2 ac, Landram House Field 46.4 ac.

Figure 1



III. Goals and Objectives

Goal

Open fields would preserve the historic scene as it appeared at the time of the battle while providing critical habitat for birds and small mammals. Native warm season grasses would dominate the vegetation cover while non-native cool season grass cover would be minimal.

Burn Objectives

- Provide for personnel safety.
- 90% - 100% of overall area to be burned as measured immediately post burn
- Limit mineral soil exposure to no more than 5% until greenup as measured immediately post burn.

Monitoring Objectives

- Maintain woody species < 25% as measured after four treatments.
- Percent cover on non-native grasses and forbs <25% as measured after four treatments.
- Percent cover of native grasses <75% as measured after four treatments.

Figure 2

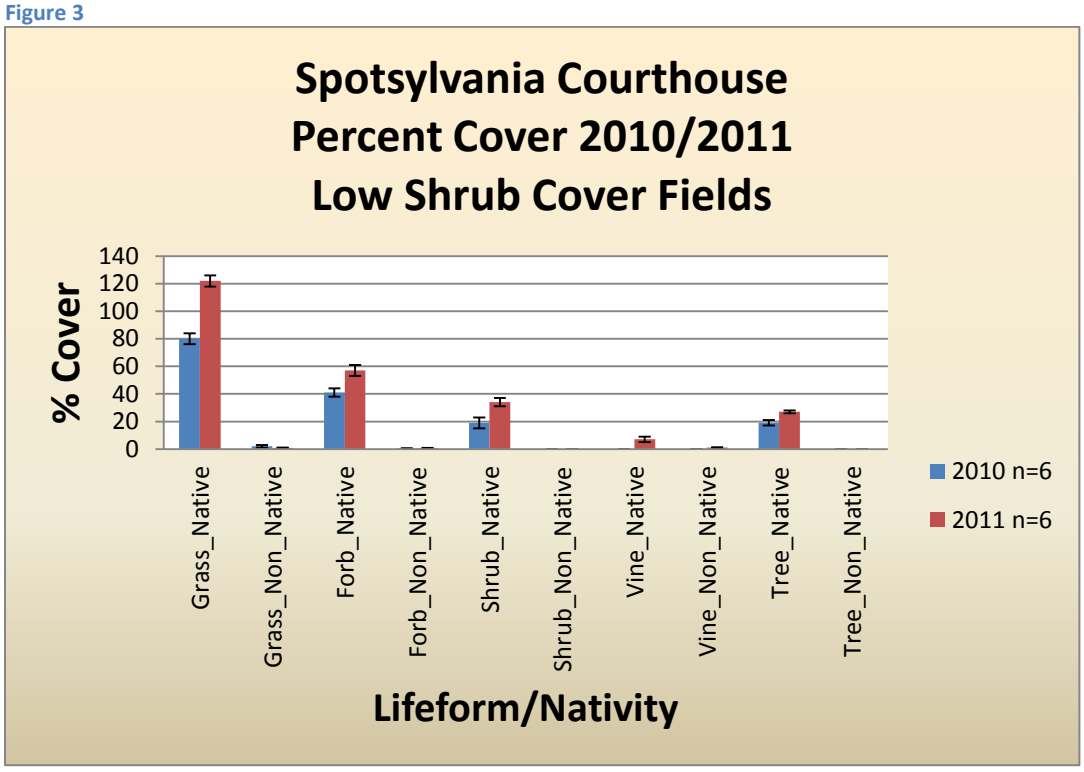
Spotsylvania Courthouse Burn History							11/29/11
Field	Upton Field	McCoull House	Harrison House	Crescent Field	Native Grass Field	Middle Field	Landrum House Field
Spring 2004	X		X	X	X	X	X
Summer 2004		X					
Spring 2005	X	X	X	X	X	X	X
Spring 2006	X	X			X		
Spring 2007			X		X	X	X
Spring 2008	X	X	X			X	X
Soring 2009	X	X	X	X	X	X	X
Spring 2010	X	X	X	X		X	X
Spring 2011	X		X				

Table of objectives, Spotsylvania Courthouse Unit.

Fredericksburg and Spotsylvania National Historical Park	Spotsylvania Mixed Grassland	Maintain woody species < 25%.	**Low Shrub Cover Fields** Shrubs=34 (±3) Trees=27 (±1) **High Shrub Cover Fields** Shrubs=50(±6) Trees=9 (±1)	**No**	2011
		Percent Cover on non-native grasses and forbs <25%.	**Low Shrub Cover Fields** Non-native grass = .8 (±.2) Non-native forbs = .6(±.2) **High Shrub Cover Fields** Non-native grass = 25(±4) Non-native forbs = .8(±.19)	**Yes**	2011
		Percent cover of native grasses and forbs >75%.	**Low Shrub Cover Fields** Native grass =122 (±4) Native forbs = 57 (±4) **High Shrub Cover Fields** Native grass = 108(±6) Native grass = 69(±5)	**Yes**	2011

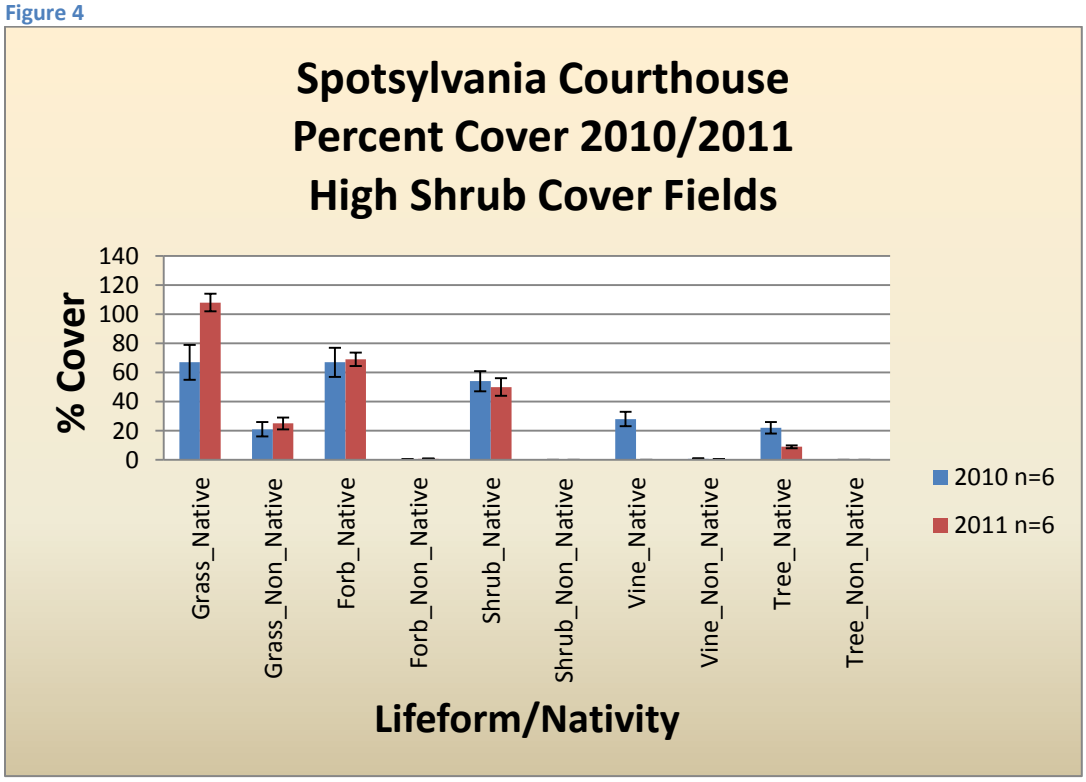
Upton, Harrison and Crescent fields (fields burned 4-7 times).

Figure 3



Landram, McCoull and Middle fields. (fields burned 4 -7 times).

Figure 4



IV. Results and Discussion

To meet the set objective of maintaining woody species <25% it is imperative that growing season burns be implemented. An analysis of our data shows an increase in the desired native warm season grasses and herbs, however no detectable decrease in woody vegetation. 2011 data results indicate the percent cover of trees and shrubs 50% (±6) and 9% (±1) respectively in the high shrub cover fields (Figure 4) and 34% (±3), 27% (±1) for the low shrub cover fields (Figure 3).

Growing season burning for the mid-Atlantic region would be August to early October when leaves and twigs are consumed and the temperature exceeds 145 degrees Fahrenheit and top kill is imminent. In late summer trees and shrubs prepare for fall senescence and transport carbohydrates, amino acids and other compounds down from the leaves and twigs to the roots. By burning at this critical time period, the plant does not have the nutrients to pass back down to the roots and its ability to start growing the following spring is greatly diminished (Harper *et al.* 2007). Carbohydrate reserves provide an energy source to support growth and respiration when plants are leafless (Loescher *et al.* 1990, Kozlowski 1992). The more reserves, the better an individual will be able to survive stress, whereas depleted reserves can lead to plant death (Kozlowski 1992, Johansson 1993). Late season defoliation causes a decrease in carbohydrate reserves and will impact the vigor of the plant the next growing season (Gregory *et al* .1986, Loescher *et al.* 1990).

A meeting was held in November of 2010 with the Parks Superintendent, Chief of maintenance and staff, Chief of natural resources and park FMO, cultural resources specialist, MTTS area FMO and Fire Ecologist, to discuss concerns of the visual appearance of the fields. The park had received a few complaints regarding overgrown vegetation impacting the historic vista. In past years, the park bush hogged all of the fields in this unit annually. However, when prescribed burning began in 2004 the amount of bush hogging was significantly scaled back. Small diameter shrubs and tree species appear to be top killed, however vigorously resprout. The reduction in bush hogging has also resulted in taller vegetation with the stems rarely consumed by the fire. As a result of this meeting, it was decided to re-implement bush hogging on a biennial (every other year) basis rotating throughout the fields. The fields were divided into two groups. The low shrub cover fields include; McCoull, Landram and Middle fields. The high shrub cover fields include; Harrison, Upton and Crescent fields. The fields with the highest percent of woody vegetation (high shrub cover fields) were scheduled to be treated with prescribed fire in summer of 2011, however this never occurred (Figure 4).

Mowing alone is an inadequate method to reduce woody encroachment because mowing woody saplings encourages multiple resprouting. A plants survival response after being cut is to resprout. The plant takes what energy it has remaining in the roots and pushes it above ground resprouts, grows leaves and begins to photosynthesize again. Timing of cutting can have a significant effect on sprout growth during the first 1-2 years following cutting (Kays 1991, Richburg *et al*. 2004). To have the greatest success reducing woody stems a treatment should be conducted during periods of low carbohydrate storage. This can be immediately after spring flush and followed up by another treatment before carbohydrate levels are replenished (Richburg 2003). Multiple treatments within a growing season can be effective so long as the time between treatments is long enough to allow sprouts to regrow and further depletes reserves (Richburg *et al.* 2004). An effective treatment to reduce woody species is a mechanical treatment following spring flush followed by a late growing season burn (Richburg 2004). This effectively depletes carbohydrate reserves and removes slash which inhibits wildlife mobility. Current literature supports multiple growing season treatments over multiple years.

Percent cover of non-native grasses and forbs still remain below the 25% threshold for both the low shrub cover fields (Figure 3) and the high shrub cover fields (Figure 4). Non native herbs are barely detectable at less than 1% (Figure 3 and 4) in both groups of fields. In contrast, the high shrub cover fields have a much larger proportion of non native grasses 25% (±4) (Figure 4) than the low shrub cover fields .8% (±.2) (Figure 3). A decrease in woody vegetation in the high shrub cover fields would likely allow for the germination of the desired native warm season grasses and a reduction in some of the more shade tolerant non native grasses. The percent cover of native grasses and forbs is excellent with the low shrub cover field having 122% (±4) and 57% (±4) (Figure 3) respectively and 108% (±6), 69% (±5) for the high shrub cover fields (Figure 4).

In addition to focusing on growing season burns, it is strongly recommended that the fields be placed on a set rotation allowing for fallow years. Fields have been burned in the spring repetitively since 2004 (Figure 2) with between 4 – 7 treatments. A change in timing and frequency will allow for the achievement of objectives while maintaining the ecological structure and diversity of the fields.

Spotsylvania Courthouse percent cover by lifeform of 13 plots 2008-2011. (shrubs and trees are all native)

Figure 5

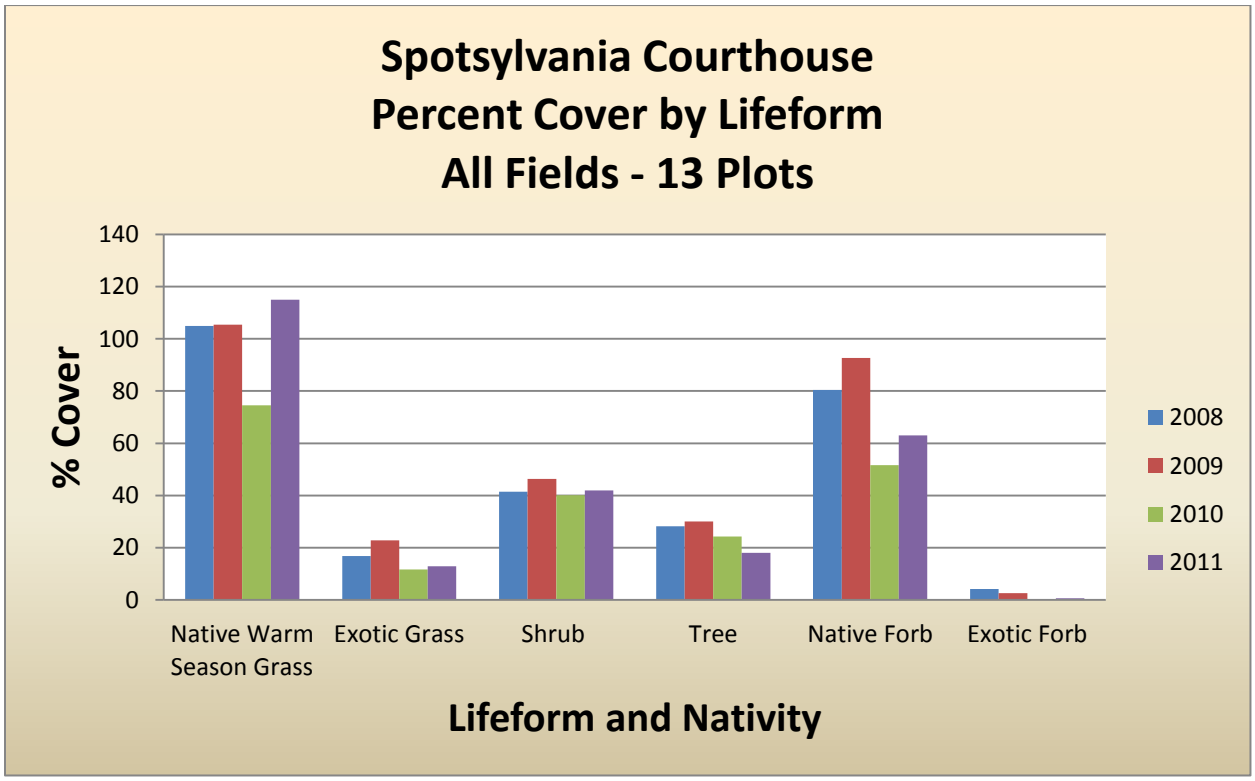


Figure 6

Spotsylvania Courthouse treatment schedule from the November 2010 Spotsylvania field management plan. Summer 2011 prescribed fires were not conducted. Harrison field was burned in spring 2011.

Tentative Cutting / Summer - Spring Prescribed Burning Schedule for 2011 - 2016						
	2011	2012	2013	2014	2015	2016
Upton Field	Summer RX	Bush - hog	Summer RX	Bush - hog	Spring RX	Bush - hog
Landram Field	Spring RX	Spring RX	Bush - hog	Spring RX	Bush - hog	Summer RX
Harrison Field	Summer RX	Bush - hog	Summer RX	Bush - hog	Spring RX	Bush - hog
McCoull Field	Spring RX	Spring RX	Bush - hog	Spring RX	Bush - hog	Summer RX
Middle Field	Spring RX	Spring RX	Bush - hog	Spring RX	Bush - hog	Summer RX
Crescent Field	Summer RX	Bush - hog	Summer RX	Bush - hog	Spring RX	Bush - hog
Native Grass Field	Spring RX	Spring RX	Bush - hog	Spring RX	Bush - hog	Summer RX

Delaware Water Gap National Recreation Area (DEWA)
2011 Effects Monitoring Annual Report

I. Program Overview

2011 Summary
All 10 grass plots were monitored in 2011. Preburn, post burn year 1 and 2 data has been collected and provides a baseline to refine initial objectives. Monitoring data indicates a positive move towards the achievement of set objectives; however multiple treatments will be required.

Future Plans
With the onset of smaller travel budgets and increasing workloads, the monitoring interval will be modified to every three to five years. This will continue to provide the necessary data to evaluate if management goals and objectives are being met and whether undesired effects are occurring.

II. Park Overview

Delaware Water Gap National Recreation Area is the largest natural area in the entire National Park System between Virginia and Maine and one of the largest protected natural areas in the metropolitan corridor extending from Washington, D.C., to Boston, Massachusetts. The recreation area encompasses 67,000 acres of mountain ridge, forest, and floodplain on both sides of the Delaware River in the states of New Jersey and Pennsylvania. Forty miles of the Middle Delaware River are within the park unit. The park is the tenth most visited area in the National Park System with almost 5 million recreational visits each year.
The mission of the park is to provide outdoor recreation opportunities while conserving the natural, cultural and scenic resources of the recreation area. The park has a significant number of threatened species including 49 plant, 9 fish, 13 mammals, 7 reptiles and 10 amphibians.

Agriculture, forested areas and suburban development have replaced open fields with Native Warm Season Grasses (NWSGs). Native grasslands with scattered trees and shrub cover, maintained by fire, have also been replaced with non-native grasses such as smooth brome (*Bromus inermis)* and Kentucky bluegrass (*Poa pratensis)*. Native warm season grass fields provide critical habitat for numerous songbirds and wildlife species.
Resource management staff has identified the use of prescribed fire as a viable management technique to aid in achieving the open space goals and objectives listed in the park's General Management Plan and Resource Management Plan. An open space prescribed fire plan was completed in 2007 which describes many units that can be treated with prescribed fire.

III. Goals and Objective

Goal
The overall objectives of these burns are to perpetuate the native species, perpetuate the open space character of the landscape, maintain wildlife habitat, control invasive exotic species, maintain fire dependent ecosystems, and reduce hazard fuel concentrations by disrupting fuel continuity.
New Objectives – (Revised after initial monitoring. Old objectives in the Open Space Fire Management Plan are below).

- Reduce 1-hour, dead and down fuels by ≥ 75% as determined immediately post burn.
- Percent cover of native grasses and herbs >75% as measured after four treatments.
- Percent cover of woody species < 25% as measured after four treatments.
- Percent cover of non-natives grasses and forbs < 25% as measured after four treatments.

Objectives stated in the DEWA Open Space Prescribed Fire Plan.
Revised after initial monitoring. See above.

Goal Number 1: Safety. Provide for safety of fire personnel and the public.
• **Objective 1: Ensure the public experience no injuries.**
• **Objective 2: Ensure fire personnel receive no lost time injuries.**
Goal Number 2: Perpetuate native plant species
• **Objective 3: Maintain native grass cover by ≥ 75% as determined one year post burn.**
• **Objective 4: Maintain native herbaceous cover by ≥ 75% as determined one year post burn.**
Goal Number 3: Perpetuate open space landscape Goal Number 4: Maintain wildlife habitat
• **Objective 4: Reduce available10-hour fuels ≥ 75% as determined immediately post burn.**
• **Objective 5: Reduce shrub and brush cover by ≥10% as determined one year post burn.**
• **Objective 5: Minimum overstory mortality (all species) of ≥10% as determined one year post burn.**
Goal Number 5: Control invasive exotic plant species
• **Objective 7: Reduce exotic invasive cover by ≥ 25% as determined one year post burn**
Goal Number 6: Hazard Fuels Management - minimize fire risk to park infrastructure, adjacent non federal land and the wildland urban interface/intermix.
• **Objective 8: Reduce 1-hour, dead and down fuels by ≥ 75% as determined immediately post burn.**
• **Objective 9: Minimum overstory mortality (pine/cedar species) of ≥25% as determined one year post burn.**

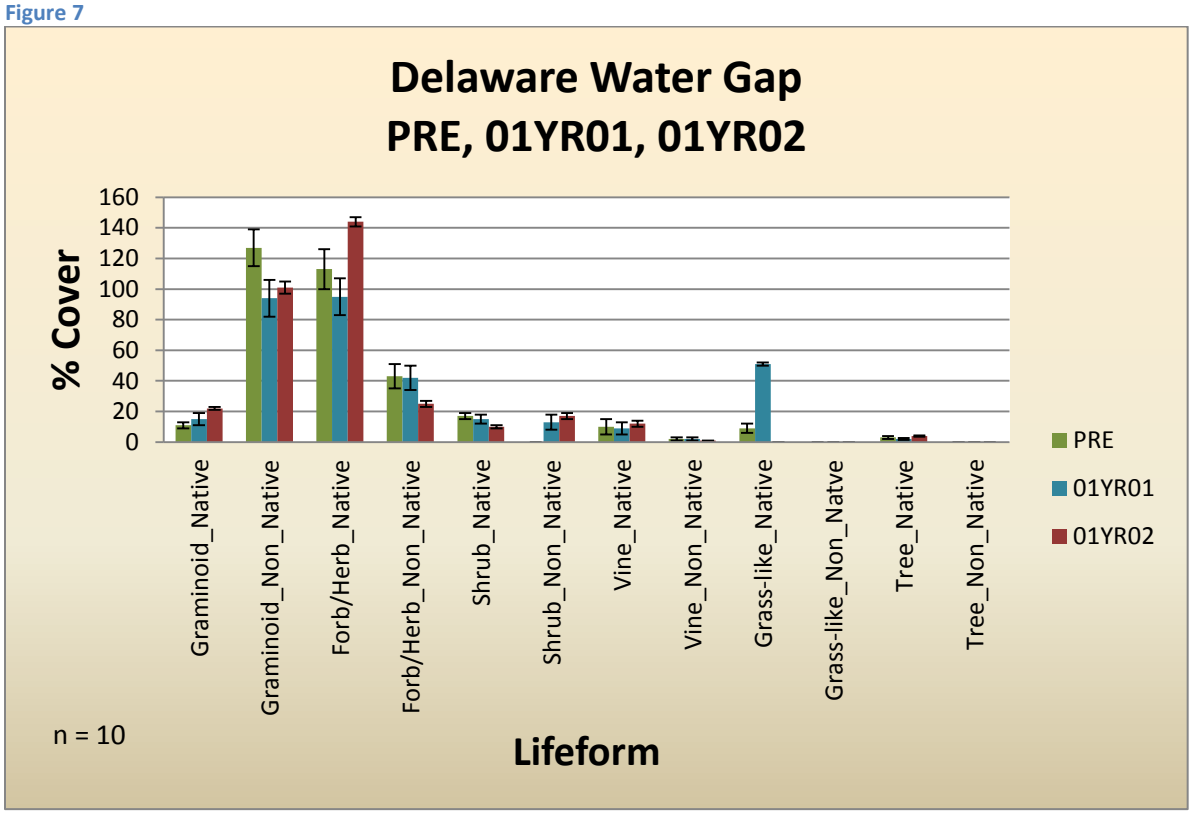
Table of Objectives for Delaware Water Gap, Darrones and Silver Spray.

Darrones and Silver Spray Units	Percent cover of native grasses and herbs >75%.	**PRE** Native Grass = 11% (±2)		2011
		01YR01 Native Grass = 15% (±4)	**No**	
		01YR02 Native Grass = 22% (±1)		
		PRE Native Herb = 113% (±13)		
		01YR01 Native Herb = 95% (±12)	**Yes**	
		01YR02 Native Herb = 144% (±3)		
	Percent cover of woody species < 25%.	**PRE** Native Shrub = 17% (±2)	**No**	2011
		01YR01 Native Shrub = 15% (±3)		
		01YR02 Native Shrub= 10% (±1)		
		PRE Non Native Shrub = 0		
		01YR01 Non Native Shrub = 13% (±5)		
		01YR02 Non Native Shrub = 17% (±2)		
	Percent cover of non-natives grasses and forbs < 25%.	**PRE** Non-native Herbs = 43% (±8)	**No**	2011
		01YR01 Non-native Herbs = 42% (±8)		
		01YR02 Non-native Herbs = 25% (±2)		
		PRE Non-native Grass = 127% (±12)		
		01YR01 Non-native Grass = 94% (±12)		
		01YR02 Non-native Grass = 101% (±4		

Fire backing in the snow along Skyline Drive, Smith Run Fire 2/19/2011

Preburn, postburn year one and two percent cover by lifeform.

Figure 7



IV. Results and Discussion – Darronnes and Silver Spray

Native herbaceous cover is excellent at 144% (±3) (Figure 7). This exceeds the objective of maintaining percent cover of native herbaceous plants greater than 75%. However, native grass cover is low at 22% (±1) after one burn. One of the reasons for this lack of native grasses is due to the prevalence of non-native grass cover. Preburn cover for non-native grass was 127% (±12) and post burn 94% (±12) and 101% (±4) (Figure 7). This indicates a small decrease in cover, however, non-native grasses clearly still dominate the fields. Of particular concern is smooth brome (*Bromus inermis)* and Kentucky bluegrass (*Poa pratensis)*. These non-native grass species frequently co-occur together. There is a difference in the timing of the most susceptible phonological stages of the two species. However, there is a small window of overlap when both of the species are vulnerable to fire. The optimal time to burn Kentucky Bluegrass is in *early spring* before flower and smooth brome while still in the boot stage (i.e. the flowering head is still enclosed within the sheath) or *late spring*. Prescribed burning may reduce smooth brome if repeated annually in mid to late spring. As noted earlier, this is later than would be recommended for control of Kentucky bluegrass. Smooth brome is a good target for selective control by timed close mowing or use of herbicides. One close mowing when the plants are 18-24 inches tall, or treatment with glyphosate at 0.5 to 1.1 kg/ha before flowering, may improve chances of selectively controlling this species. The literature supports, prescribed burns need to be repeated for several consecutive years because a single burn would allow smooth brome to recover the following year. A multifaceted approach will be needed to control these two species. There are pockets of native warm season grasses such as little blue stem (*Schizachyrium scoparium)* which responds positively to fire and should continue to increase as non-native grasses are controlled. Non-native herbaceous cover level decreased in the second year from preburn to postburn levels 43% (±8) and 25% (±2) respectively. However, as noted earlier, the fields still remain surprisingly diverse with native herbaceous cover at 144% (±3). Goldenrods are particularly diverse in the Silver Spray field. Shrub cover has remained the same with 10% (±1) native shrubs and 17% (±2) non-native shrubs after one treatment. These fields would benefit by repeated spring burns to encourage native warm season grasses, selectively applying herbicides and planting native warm season grasses if possible.

Saratoga National Historical Park
2011 Fire Effects Monitoring Annual Report

I. Program Overview

2011 Summary

The park has an extremely complex history of mowing, burning and chemically treating vegetation over the last 20 years. The prescribed fire program dates back to the early 1990's. Fire effects monitoring data has been collected at Saratoga for 11 years (2001), with nine plots read in 2011. Objectives were modified in winter of 2011 following the last report. Further meetings will be held in the spring of 2012 to discuss objectives, frequency and timing of prescribed fires.

Future Plans

With the onset of smaller travel budgets and increasing workloads the monitoring interval will be modified to every three to five years. This will continue to provide the necessary data to evaluate if management goals and objectives are being met and whether undesired effects are occurring.

II. Park Overview

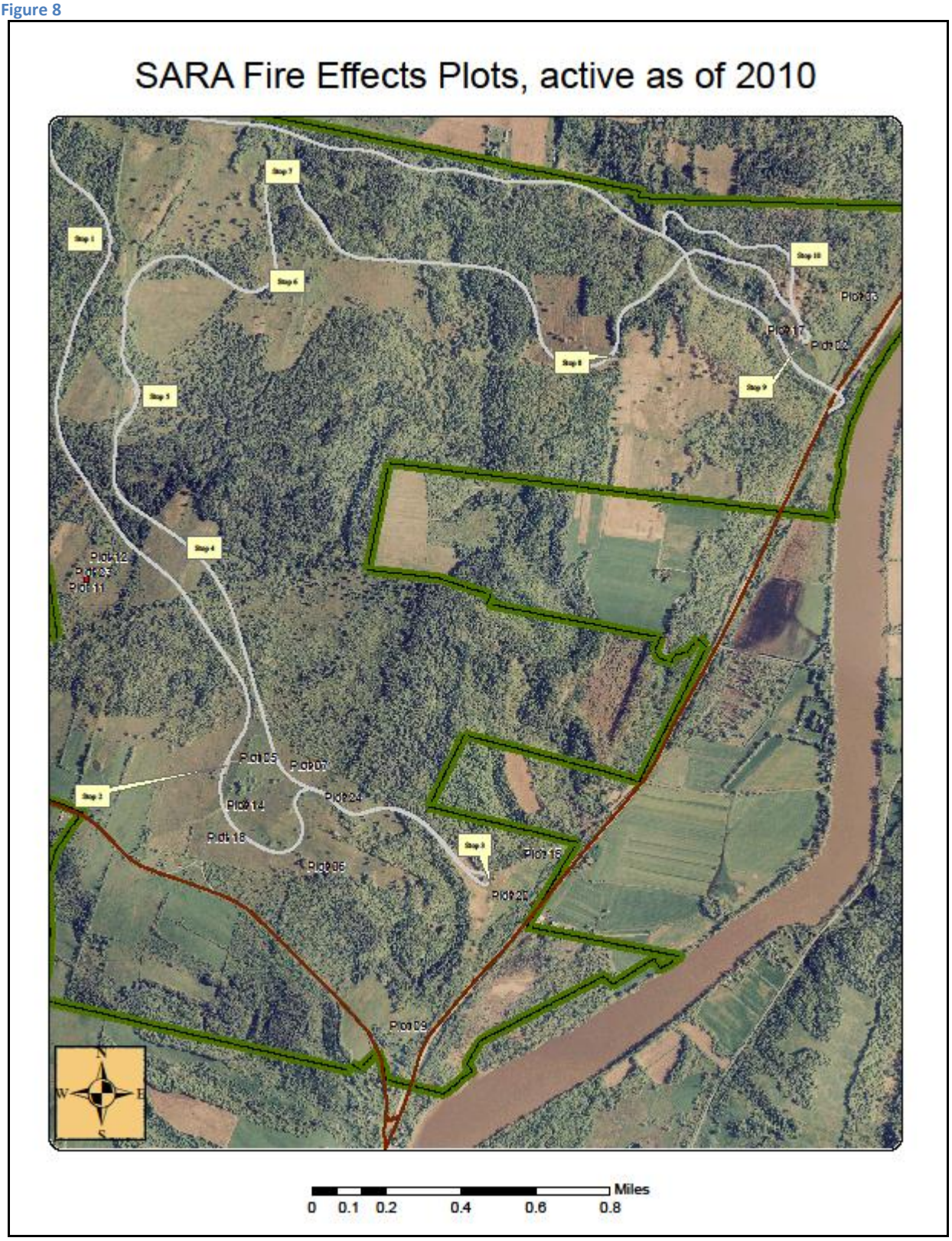
Saratoga National Historical Park is located in the towns of Stillwater and Saratoga, in Saratoga County in upstate New York, about 30 north of the state capital at Albany. Although a neighbor to the highly urbanized "Capital District," the park is rural in character and farming is the major use of adjacent lands. The park comprises 2,912 acres preserving the sites associated with a significant American military victory during the Revolution. In 1777 American forces met, defeated, and forced a major British army to surrender, an event which led France to recognize the independence of the United States and enter the war as a decisive military ally of the struggling Americans. The Battlefield Unit, 2,843 acres, was made part of the national park system in 1938 when Saratoga National Historical Park was authorized by the United States Congress. Prior to 1760's the predominant vegetative cover was forest with perhaps some meadow/field areas along the river floodplain. Settlement and agriculture brought about great change. By the mid 1800's the forests had been cut leaving only small wood lots, orchards, and forested ravines. Many of the cultivated fields have persisted to present day. There were really no native grasslands comprising the battlefield. Continued agriculture (mostly for forage with agriculture leases), deer browsing, mowing by park staff, and using prescribed fire have helped to maintain these fields. Over the years a few native warm season grasses (predominantly Little Bluestem-*Schizachyrium scoparium*) have been populating these clearings, particularly in the sandy soil areas. Recently Big Bluestem-*Andropogon gerardi*, has appeared, most likely attributed to one of the farmers with the agricultural lease. While native warm season grasses do provide habitat for a suite of grassland birds, the majority of these species are in the fields dominated by non-native grasses and forbs which comprise The Important Bird Area.

Grasslands are comprised of vegetation dominated by bluestem (*Schizachyrium scoparium*), sedge (*Carex* spp.), panic-grass (*Dichanthelium* spp.), fescue (*Festuca* spp., *Schedonorus pratensis*) and Reed Canary Grass - *Phalaris arundinacea*, an invasive exotic. Common forbs include yarrow (*Achillea millefolium*), knapweed (*Centaurea jacea and biebersteinii* - an invasive exotic), bedstraw (*Galium* spp.), cinquefoil (*Potentilla* spp.), goldenrod (*Solidago* spp.), and thyme (*Thymus* spp.). Woody species including dogwood (*Cornus racemosa*), black cherry (*Prunus serotina*), buckthorn (*Rhamnus cathartica* – an invasive exotic.), sumac (*Rhus* spp.), brambles (*Rubus* spp.), poison ivy (*Toxicodendron radicans*), viburnum (*Viburnum* spp.), and grape (*Vitis* spp.). Ferns are common to dominant in one field (Field 37, called The Fern Field) and include lady-fern (*Athyrium filix-femina*), sensitive fern (*Onoclea sensibilis*), and royal fern (*Osmunda regalis*).

The Northeast Region Fire Effects Monitoring Crew began monitoring fire effects at the park in 2001. There are 24 plots installed throughout the park, all in fields. In 2010, it was decided to retire 9 of the plots that were primarily located in mown areas. Fifteen plots still remain active as of 2011. Due to varying location, topography and treatments, plots were broken up into three analysis groups. The first group, the *hillside plots*, are located on steep slopes and are maintained with fire to reduce woody vegetation. Steep slopes are a safety issue and pose a safety hazard when mowing. The second group, *Neilson Farm plots*, are maintained with fire to reduce woody vegetation and also reduce invasive exotic knapweeds. The third group, *Chatfield Farm*, are maintained with fire to reduce woody vegetation and control knapweed. The Chatfield Farm fields have been experimentally burned in the summer of 2003 and 2009 to eliminate woody vegetation.

Map of active Saratoga fire effects plots in 2011.

Figure 8



III. Goals and Objective

The Saratoga NHP Fire Management Plan states the objective to, "Maintain and rehabilitate park fields, meadows, and historic landscapes through the application of prescribed fire and other techniques.
Old Monitoring Objectives (2001 – 2010)

- Reduce the density of woody stems by 70% to 90%.
- Reduce the cover of nonnative herbaceous species, expressed as a percent of the total cover of herbaceous species, by 20% to 40%.
- Increase the cover of native herbaceous species, expressed as a percent of the total cover of herbaceous species, by 20% to 40%.

New Proposed Monitoring Objectives 2011*(with input from Linda White on 10/31/2011)*

- Reduce 1 and 10 hour, dead and down fuels by ≥ 75% as determined immediately post burn.
- Percent cover of woody species < 35% as measured following two growing season burns.
- Percent cover of non-natives grasses and forbs < 50% as measured after 5-7 burns.
- Percent cover of native grasses and forbs >75% as measured after 5-7 burns.
- Maintain Knapweed species at ?? % cover as measured after 5-7 burns.

IV. Hillside Plots

Discussion – Hillside Plots

Native grass and herb cover is excellent with Native Herb 169% (±7) and Native Grass 110% (±4) (Figure 9) respectively. Percent cover of shrubs has remained the consistently the same throughout the data set. The current percent cover is near the new desired threshold of < 35%. This threshold was raised after re-evaluating the objectives in 2010. Recent literature supports burning during the late summer-early fall to achieve a higher mortality of woody species. An analysis of our data shows an increase in the desired native warm season grasses and herbs, however no detectable decrease in woody vegetation. If a further reduction of woody species is desired by park managers, multiple growing season burns are recommended to achieve this objective.
Growing season burning would be August to early October when leaves and twigs are consumed and the temperature exceeds 145 degrees Fahrenheit and top kill is imminent. In late summer trees and shrubs prepare for fall senescence and transport carbohydrates, amino acids and other compounds down from the leaves and twigs to the roots. By burning at this critical time period, the plant does not have the nutrients to pass back down to the roots and its ability to start growing the following spring is greatly diminished (Harper *et al.* 2007). Carbohydrate reserves provide an energy source to support growth and respiration when plants are leafless (Loescher *et al.* 1990, Kozlowski 1992). The more reserves, the better an individual will be able to survive stress, whereas depleted reserves can lead to plant death (Kozlowski 1992, Johansson 1993). Late season defoliation causes a decrease in carbohydrate reserves and will impact the vigor of the plant the next growing season (Gregory *et al* .1986, Loescher *et al.* 1990).

Mowing alone is an inadequate method to reduce woody encroachment because mowing woody saplings encourages multiple resprouting. A plants survival response after being cut is to resprout. The plant takes what energy it has remaining in the roots and pushes it above ground resprouts, grows leaves and begins to photosynthesize again. Timing of cutting can have a significant effect on sprout growth during the first 1-2 years following cutting (Kays 1991, Richburg *et al*. 2004). To have the greatest success reducing woody stems a treatment should be conducted during periods of low carbohydrate storage. This can be immediately after spring flush and followed up by another treatment before carbohydrate levels are replenished (Richburg 2003). Multiple treatments within a growing season can be effective so long as the time between treatments is long enough to allow sprouts to regrow and further depletes reserves (Richburg *et al.* 2004). An effective treatment to reduce woody species is a mechanical treatment following spring flush followed by a late growing season burn (Richburg 2004). This effectively depletes carbohydrate reserves and removes slash which inhibits wildlife mobility. Current literature supports multiple growing season treatments over multiple years.

Cover of non-native grass is still low at 22% (±3) (Figure 9) in 2011, it did however increase from 9% measured in 2010. However, non-native herbs are below the desired threshold of <50% with 41% (±8) (Figure 9) in 2011. Plots 2 and 3 at Stop 10 have high concentrations of knapweeds which influence the high amounts of cover. This condition objective threshold was raised in 2010 from <25% to <50%.
The hillside area has been burned approximately 11 times since the start of the prescribed fire program in the early 1990's. Plots have been burned 3-5 times after installation.

Figure 9

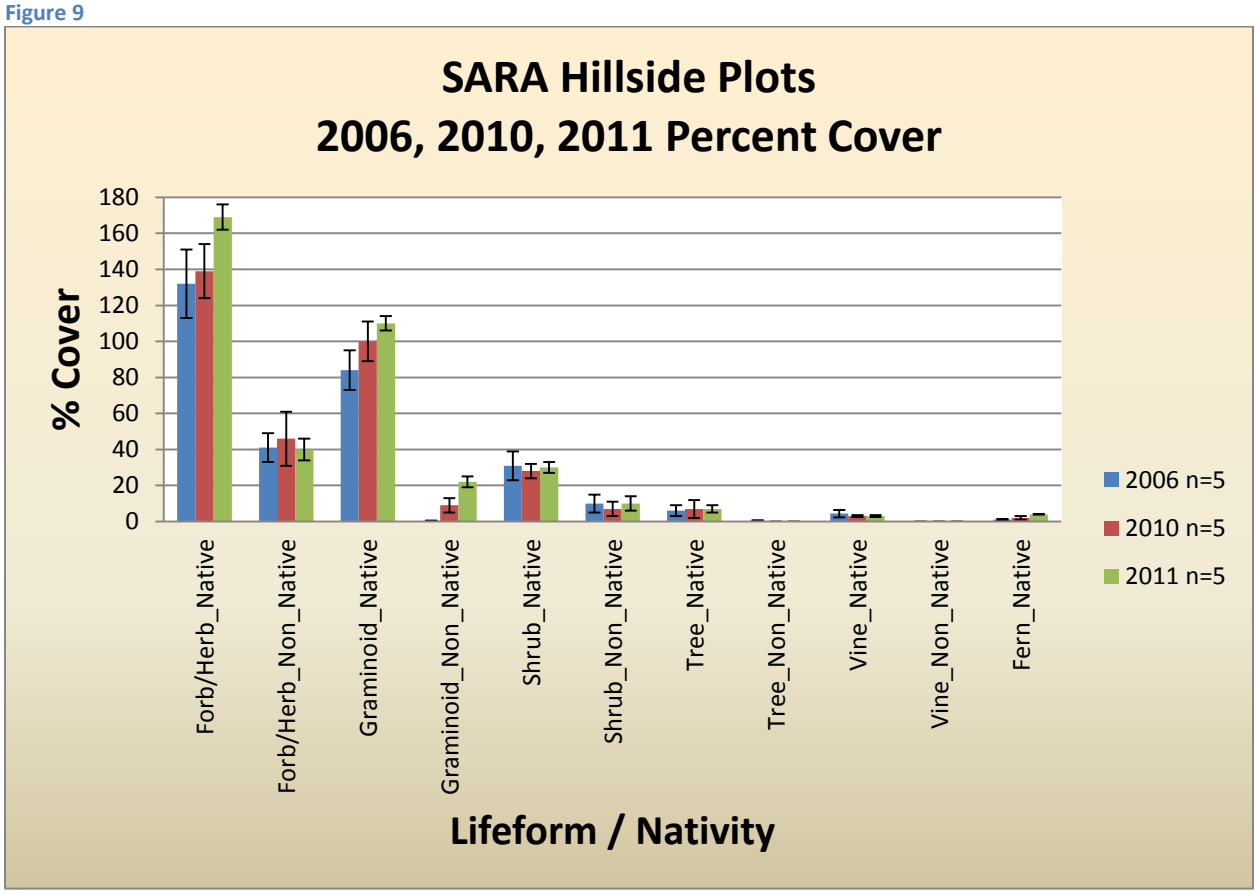

SARA Hillside Plots
2006, 2010, 2011 Percent Cover
% Cover
180
160
140
120
100
80
60
40
20
0
Forb/Herb_Native
Forb/Herb_Non_Native
Graminoid_Native
Graminoid_Non_Native
Shrub_Native
Shrub_Non_Native
Tree_Native
Tree_Non_Native
Vine_Native
Vine_Non_Native
Fern_Native
Lifeform / Nativity
2006 n=5
2010 n=5
2011 n=5

Table of objectives for Saratoga - Hillside Plots.

Mixed Grassland **Hillside Plots** n=5 (Plots 2,3,15,17,20)	Percent cover of native grasses and herbs >75%.	**2006** Native Grass = 84% (±11)		2011
		2010 Native Grass = 100% (±11)	**YES**	
		2011 Native Grass = 110% (±4)		
		2006 Native Herb = 132% (±19)		
		2010 Native Herb = 139% (±15)	**YES**	
		2011 Native Herb = 169% (±7)		
Plots burned 3-5 times. The area has been burned ~ 11 times.	Percent cover of woody species < 35%.	**2006** Native Shrub = 31% (±8)		2011
		2010 Native Shrub = 28% (±4)	**No**	
		2011 Native Shrub = 30% (±3)		
		2006 Non Native Shrub = 10% (±5)		
		2010 Non Native Shrub = 7% (±4)	**No**	
		2011 Non Native Shrub = 10% (±4)		
	Percent cover of non-natives grasses and forbs < 50%.	**2006** Non-native Herbs = 41% (±8)	**YES**	2011
		2010 Non-native Herbs = 46% (±15)		
		2011 Non-native Herbs = 40% (±6)		
		2006 Non-native Grass = .4% (±.2)		
		2010 Non-native Grass = 9% (±4)	**YES**	
		2011 Non-native Grass = 22% (±3)		

V. Neilson Farm

Discussion – Neilson Farm

Native grass cover is excellent with Native Grass at 132% (±5) (Figure 10). In contrast, native herbaceous cover is very low with 23% (±3) (Figure 10) in 2011. This low native herb cover is likely the result of an extremely high percentage of non native herbs 119% (±10) (Figure 10), mostly the invasive exotic herb spotted knapweed. Non native grass cover still remains below the <50% threshold at 15% (±2) (Figure 10). Native and Non-native shrub cover were below the <25% threshold with 27% (±3) and .3% (±.08) (Figure 10) respectively. Stinger herbicide has been experimentally introduced into some of the areas infested by brown and spotted knapweed.

Neilson farm percent cover by lifeform and nativity. Three plots in 2008 and six plots in 2010 and 2011.

Figure 10

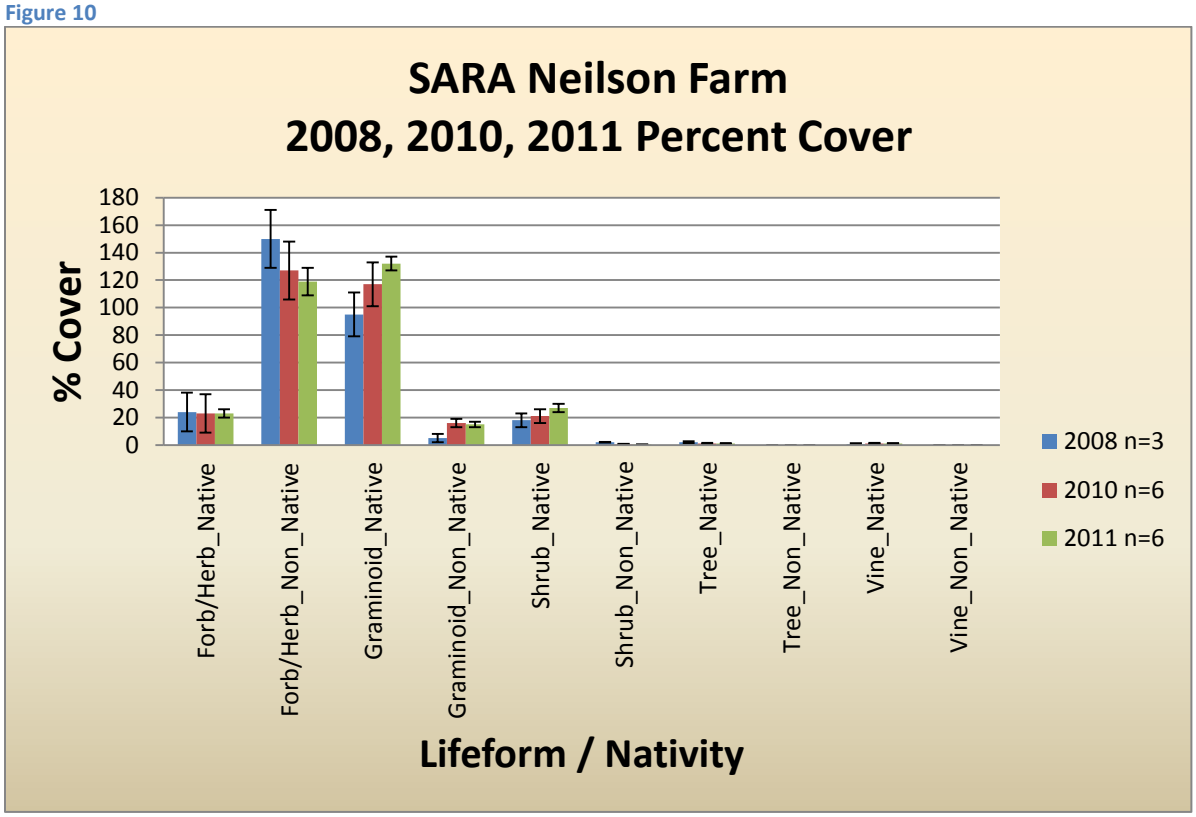


Table of objectives for Saratoga - Neilson Farm.

Mixed Grassland **Neilson Farm** 2008 n=3 (Plots 5,6,7) 2010 / 2011 n=6 (Plots 5,6,7,14,18,24) Plots burned 1 - 3 times. The area has been burned 3-7 times.	Percent cover of native grasses and herbs >75%.	**2008** Native Grass = 95% (±16)		2011
		2010 Native Grass = 117% (±12)	**YES**	
		2011 Native Grass = 132% (±5)		
		2008 Native Herb = 24% (±14)		
		2010 Native Herb = 23% (±6)	**NO**	
		2011 Native Herb =23% (±3)		
	Percent cover of woody species < 35%.	**2008** Native Shrub = 18% (±5)		2011
		2010 Native Shrub = 21% (±4)	**YES**	
		2011 Native Shrub = 27% (±3)		
		2008 Non Native Shrub = 2% (±.3)		
		2010 Non Native Shrub = .5% (±.2)	**YES**	
		2011 Non Native Shrub = .3% (±.08)		
	Percent cover of non-natives grasses and forbs < 50%.	**2008** Non-native Herbs =150% (±21)		2011
		2010 Non-native Herbs = 127% (±22)	**NO**	
		2011 Non-native Herbs = 119% (±10)		
		2008 Non-native Grass = 5% (±3)		
		2010 Non-native Grass = 16% (±5)	**YES**	
		2011 Non-native Grass = 15% (±2)		

VI. Chatfield Farm

Discussion – Chatfield Farm

Native grass cover remains high with 91% (±2) and non-native grass is low with 1% (±.1) (Figure 11) in 2011. Similar to the Nielson Farm area, non-native herbaceous plants remain high with 92% (±16) (Figure 11) measured in 2011. This area appears to have less knapweed then the Neilson Farm, however, native herbs are still outnumbered almost 3:1 by non-native herbs. In 2011, native herbs were measured at 18% (±3) (Figure 11). Woody vegetation remains above the 35% threshold in 2011 (37% (±3) (Figure 11). There has been approximately a 10% decrease since the "preburn" measure in 2003 (42% (±15). The area was burned experimentally in the summer 2003 and 2009. Additional growing season burns are recommended along with the application of herbicide to control the knapweed species.

Percent cover by lifeform and nativity from Chatfield farm plots. Sample size in 2003 two plots and three plots in 2010 and 2011.

Figure 11

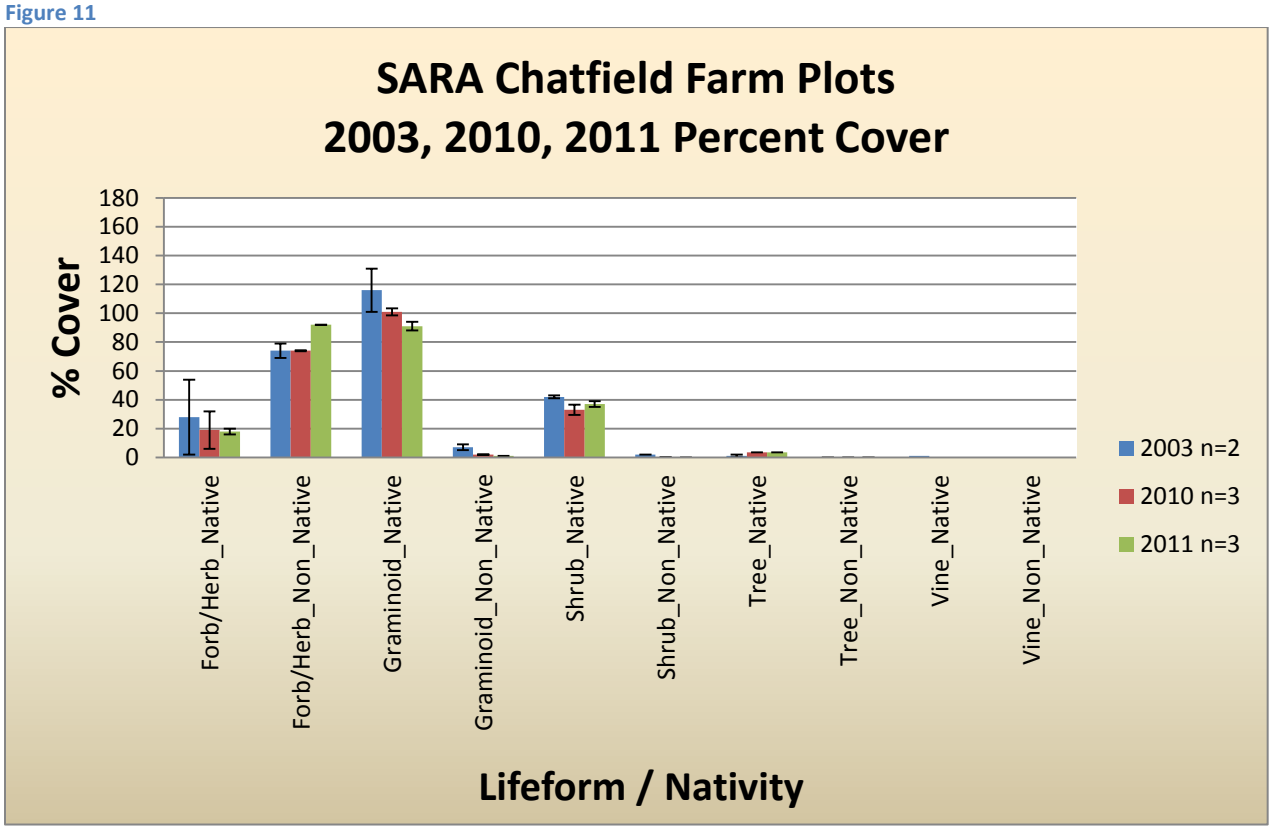


Table of objectives for Saratoga - Chatfield Farm.

Mixed Grassland **Chatfield Farm** 2003 n=2 (Plots 11,12)	Percent cover of native grasses and herbs >75%.	**2003** Native Grass = 116% (±26) **2010** Native Grass = 101% (±13) **2011** Native Grass = =91% (±2)	**YES**	2011
		2003 Native Herb = 28% (±2) **2010** Native Herb = 19% (±7) **2011** Native Herb =18% (±3)	**NO**	
2010 n=3 (Plots 11,12,23) Plots have been burned 1-2 times. Summer burn 2003 and 2009.	Percent cover of woody species < 35%.	**2003** Native Shrub = 42% (±15) **2010** Native Shrub = 33% (±2) **2011** Native Shrub =37% (±3)	**NO**	2011
		2003 Non Native Shrub = 2% (±.3) **2010** Non Native Shrub = .3% (±.3) **2011** Non Native Shrub = 0% (±0)	**YES**	
	Percent cover of non-natives grasses and forbs < 50%.	**2003** Non-native Herbs = 74% (±27) **2010** Non-native Herbs = 74% (±13) **2011** Non-native Herbs = 92% (±16)	**NO**	2011
		2003 Non-native Grass = 7% (±5) **2010** Non-native Grass = 2% (±.3) **2011** Non-native Grass = 1% (±.1)	**YES**	

Cape Cod National Seashore (CACO)
2011 Fire Effects Monitoring Annual Report

(Prepared by David Crary)

I. Program Overview

Fire is a natural and integral part of the ecosystem encompassing Cape Cod National Seashore (CACO). The natural communities and historic cultural landscapes occurring on the Seashore reflect the influence of naturally ignited fires, fires ignited by Native Americans prior to the arrival of European settlers (Dunwiddie and Adams 1995), and fires ignited by European settlers themselves. Fire acts as a significant force of change to the resources of the Seashore and surrounding non-federal lands. The potential for wildland fire to impact life and property is substantial. Under certain weather conditions, the wildland fuels of southeastern Massachusetts are as explosively flammable as the fuels found in California chaparral.
This fire management plan (FMP) is a strategic document that defines a program for fire management in the wildland fuels of Cape Cod National Seashore. The reasons for developing this FMP are:

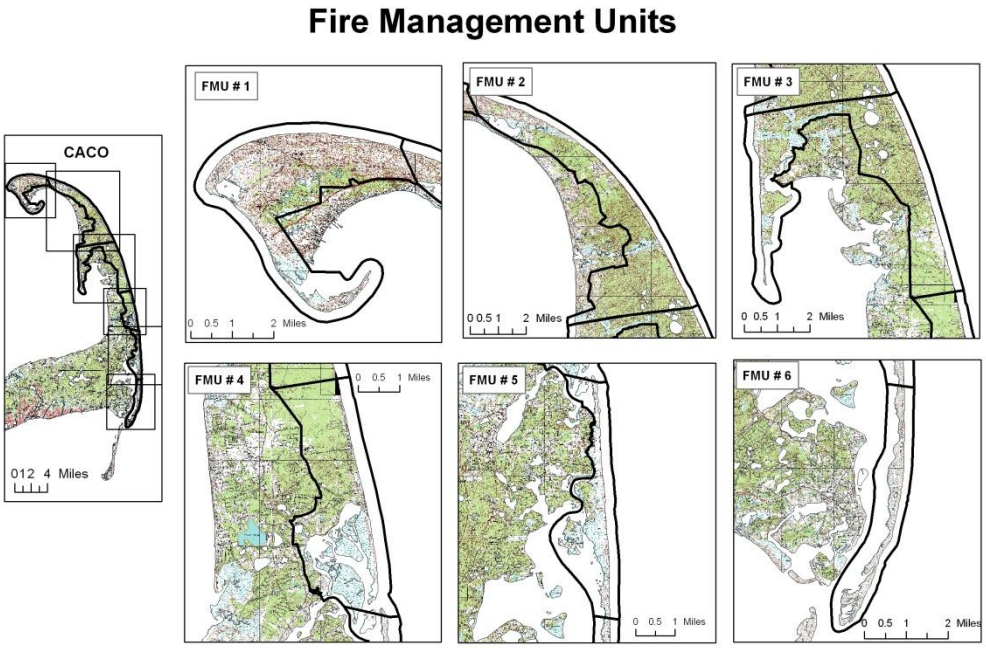
(1) to protect life, structures, natural resources, and cultural resources from harmful effects of wildland fire;
(2) to restore fire as an ecological process on the landscape, returning the Seashore to a diverse, mosaic of fire-influenced natural communities through the use of prescribed burning.
(3) to restore, maintain, or protect rare, threatened, and endangered species and significant natural communities;
(4) to investigate the effects of fire on natural resources of the Seashore;
(5) to reduce the accumulation of hazardous wildland fuels using prescribed burning and mechanical treatments; and
(6) to comply with the National Park Service (NPS) Director's Order #18: Wildland Fire Management (NPS 1998A), which requires that all areas of NPS units containing vegetation capable of sustaining fire develop a FMP.

II. Park Overview

Fire Management Units at CACO

A Fire Management Unit (FMU) is any land management area definable by objectives, topographic features, access, values to be protected, political boundaries, fuel types, or major fire regimes that sets it apart from an adjacent unit. Cape Cod National Seashore has six FMU's (Figure 5). For largely administrative purposes, the FMU's are delimited by town boundaries. The Seashore often cooperates with town fire departments to suppress wildland fires, and maintains inter-agency agreements with each of the town fire departments for wildland fire suppression. Furthermore, prescribed burns are ignited after concurrence is obtained from the fire department chief of the respective town. Community involvement with wildland fire and prescribed fire issues is often handled at the town government level (*e.g.*, via public town meetings, presentations at schools, fire department membership meetings). Some general fuel type differences exist among the towns on NPS-owned property. For these reasons, the Seashore is divided into fire management units according to the political boundaries of the towns of Provincetown (FMU 1), Truro (FMU 2), Wellfleet (FMU 3), Eastham (FMU 4), Orleans (FMU 5), and Chatham (FMU 6). Each FMU is discussed in some detail below. Note that fire weather cycles are similar for all FMU's and is described in detail in the Seashore Fire Management Plan it the *Wildland Fire Management Situation* section.

Figure 12



Goals and Objectives for Fire Management Units

(1) Coordinate fire suppression and prescribed burning activities with the Community and Town Fire Department
(2) Aggressively suppress all wildland fires in the FMU.
(3) Conduct prescribed burning and mechanical treatments in the FMU to reduce hazardous fuel loadings, restore and maintain heathlands and rare species habitat, and maintain cultural landscapes.

Management Constraints

(1) Do not violate national ambient air quality standards or cause unacceptable smoke hazards/nuisance with prescribed burning.
(2) Do not negatively affect cultural resources or rare, threatened, or endangered species with fire management activities except under wildland fire situations where lives or structures are in imminent danger.
(3) Do not jeopardize positive public relations with the FMU community; keep the affected community adequately informed as to fire management activities planned and in progress.
(4) Do not allow structures or their occupants to be placed at risk during prescribed fires; make all reasonable efforts to protect structures from wildland fires.

III. 2011 Results and Discussion

- Marconi WUI Broom Crowberry monitoring: On-going, no formal sampling completed in 2011, however ocular estimation is that minimal to no recruitment of new Corema seedlings became established. This contradicts findings by Schall (2005) who observed up to 2,000 seedlings in similar burn pile footprints on sites 0.5 miles south of the Marconi WUI.

- Fire Cache Corema transplanting. On-going, no formal sampling completed in 2011, however ocular estimation is that minimal mortality of transplants occurred during 2011(three years after transplanting). About half of the transplants (15 of 30) died during the first two years following transplanting.

- Lombard Paradise Hollow (veg and burning): no sampling took place in 2011 although treatments (burn and mow) continued (and are expected to continue thru 2022 (year 36 of the experiment). Intensive pre and post burn monitoring is expected in years 35 and 36 which will be the fourth time in history (yr 0, 12, 24, and 36) when all plots of the 1-4 years intervals will be treated in the same year. A contract employee (Motzkin) has been hired by PI W. A. Patterson to summarized and document the first 24 years of the experiment.

- Heathland Monitoring / Marconi Site Heathland restoration: Update: Heathland Monitoring / Marconi Site Heathland restoration: Dr. Von Holle had a graduate student and an undergraduate technician establish and sample vegetation on 90 plots in two distinct sample areas at Marconi during the summer of 2011. Standing trees were removed from plots and treatment plots were scarified, seeded, and burned (summer treatment). Spring treatment (burning) is planned for March 2012.

- Broom Crowberry burn: Sampling did not occur during 2011, however is expected to in 2012. Visual estimates and photo documentation in the spring of 2011 show up to a thousand Corema seedlings on the spring treatments (after two growing seasons), hundreds of seedlings on the summer treatment plots (after two growing seasons) and only tens on the fall treatment plots (after one growing season). One meter grid point intercept monitoring is expected to occur during the summer of 2012 by contact employee hired by W. A. Patterson.

Broom Crowberry Rx Fire at Marconi site, April 27, 2009.

Table of Objectives for CACO.

Cape Cod National Seashore	Fire Cache *Corema* transplanting	Marconi WUI Broom Crowberry monitoring	Determine extent and time for colonization of burn pile footprints by Corema	**2011- no sampling completed . Ocular estimation that minimal mortality occurred**	on-going
	Lombard Paradise Hollow	Fire Cache Corema transplanting	Measure long term cover and health of 40 Corema plants prior to transplanting	**ocular estimate only, 50% mortality**	2010
		Lombard Paradise Hollow	Research, vegetation	**in prep year 24 (Patterson et. al.)**	2010
	Heathland Monitoring / Marconi Site Heathland restoration		Research, burning	**in prep year 24 (Patterson et. al.)**	2010
	Broom Crowberry burn	Heathland Monitoring / Marconi Site Heathland restoration	Establish pre-treatment baseline data for 35 area heathland restoration in the Marconi area	**on-going, Univ FLA (Von Holle, principle invest.)**	on-going
	Heathland /Hunting summers plots	Broom Crowberry burn	Determine if spring, summer or fall burning favors Corema conradii, three each 03 acres plots were burned (2.7 acres)	**in prep year 2 (Patterson et. al.)**	on-going

Richmond National Battlefield Park (RICH)
2011 Fire Effects Monitoring Annual Report

I. Program Overview

2011 Summary

No prescribed burns or monitoring took place at Richmond this year (2011), therefore additional data analysis was not completed. Two prescribed burns are planned for 2012 including a portion of the Malvern Hill grass unit and the Cold Harbor oak-pine unit.

Future Plans

The Cold Harbor and Malvern Hill unit will be monitored in 2013. 2010 data analysis indicate the achievement of all but one objective. Recent data analysis indicates that both of these projects have moved from the restoration phase to the maintenance stage. With the onset of smaller travel budgets and increasing workloads the monitoring interval will be modified to every three years. This will continue to provide the necessary data to evaluate whether management goals and objectives are being met and whether undesired effects are occurring.

II. Park Overview

Richmond National Battlefield Park is located 110 miles south of Washington, D.C., in and near the city of Richmond, Virginia. The park manages approximately 1200 acres in 13 individual units spread over a 132-square mile area. Established as part of the National Park System in 1936, the park protects Civil War battle sites where in 1862 and 1864-65 the Union Army attempted to take the city of Richmond, the capital of the Confederacy, and to destroy the Army of Northern Virginia.

III. Malvern Hill Unit Overview

The Malvern Hill consists of approximately 1,040 acres of agricultural crop fields, mixed oak and hardwood-conifer woodlands, hedgerows, mown grass fields, lawn, and an interpretive facility.

The field burn unit is partially surrounded by blacktop road and is fuel model 1 and 3. The area consists of warm season native grasses, cool season exotic grasses, and patchy shrub species to a height of 1- 3 meters. Prescribed fire is being used to reduce brushy fuels to open up the historic scene, maintain vistas, reduce invasive non-native species and promote the growth of native warm season grasses, so that park maintenance will no longer need to use time, equipment, and fuel to maintain these open fields, so that park visitors can get a feeling for the battlefield as it was during the Civil War, and to create grassland habitats suitable for a diversity of birds, herps and small mammals.

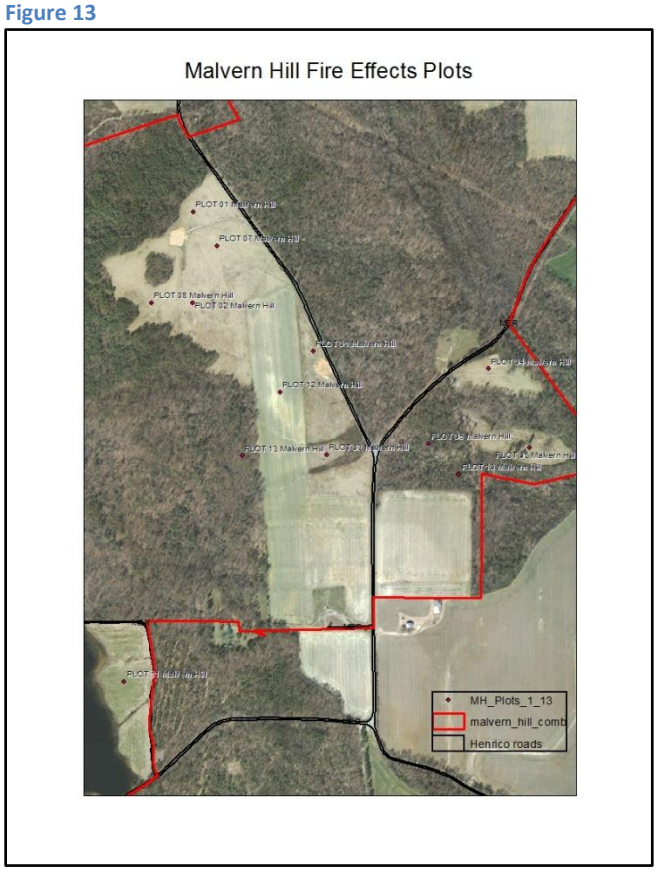
The Mid-South historically contained vast acreages of native grassland and savannas with scattered trees and shrub cover, which was maintained by fire. Through the years, these have been replaced with non-native grasses such as meadow fescue (*Schedonorus pratensis*). Agriculture, trees and suburban development have also replaced open fields with Native Warm Season Grasses (NWSGs). Native warm season grasses provide critical habitat for numerous songbirds and wildlife species. These native grasslands are the most endangered ecosystems in the Mid-South and as a result of their loss numerous wildlife and grassland bird species have experienced steep, long term declines.

The unit contains several invasive species of concern including Johnson grass (*Sorghum halepense*), Chinese bush clover (*Lespedeza cuneata*) and Japanese Honeysuckle (*Lonicera japonica*). These exotics are actively being treated with herbicide. Dense patches of meadow fescue (*Schedonorus pratensis*), an exotic cool season grass, are also being sprayed. This grass forms a dense carpet and prevents the establishment of desired native warm season grasses. Common native grasses include Broomsedge (*Andropogon virginicus*), purpletop (*Tridens flavus*), little bluestem **(***Schizachyrium scoparium) and* Indian grass *(Sorghastrum nutans).* The shrub layer is dominated by winged sumac (*Rhus copallinum*) and blackberry (*Rubus* spp.). Common native forbs include ragweed (*Ambrosia artemisiifolia*) and gypsyweed (*Veronica officinalis*).

The crew began monitoring the Malvern Hill grassland unit in 2005. Currently, there are 13 FMH brush monitoring plots located in a complex of seven fields. In 2008 it was decided to analyze the fields in two separate groups relating to their management history. The first group, referred to as the cool season grass fields were planted with meadow fescue (*Schedonorus pratensis*) prior to the establishment of the current natural resource program. An objective for these fields is to remove the carpet of fescue and allow the NWSGs to re-establish. These fields include 29 acre North, Parsonage North and South and the 12 acre South field (not planted with fescue). The warm season grass fields have been planted with NWSGs and include Parsonage West and the Crewes Channel field. The objective for this group of fields is to maintain the planted NWSGs (Figure 1). In the future the 12 acre South field will be lumped with the warm season grass fields or they may be analyzed together.

Map of fire effects plots Malvern Hill.

Figure 13



IV. Goals and Objective – Malvern Hill

Goal

The primary goal is to restore and maintain the historic scene of July 1, 1862 and perpetuate native grassland species. This will be accomplished through mechanically removing trees, herbicide treatment of exotic vegetation, bushogging, and the use of prescribed fire.

Burn Objectives

- >90% consumption of fine fuels as measured immediately post burn.
- < 5% mineral soil exposure prior to green up as measured immediately post burn.

Monitoring Objectives

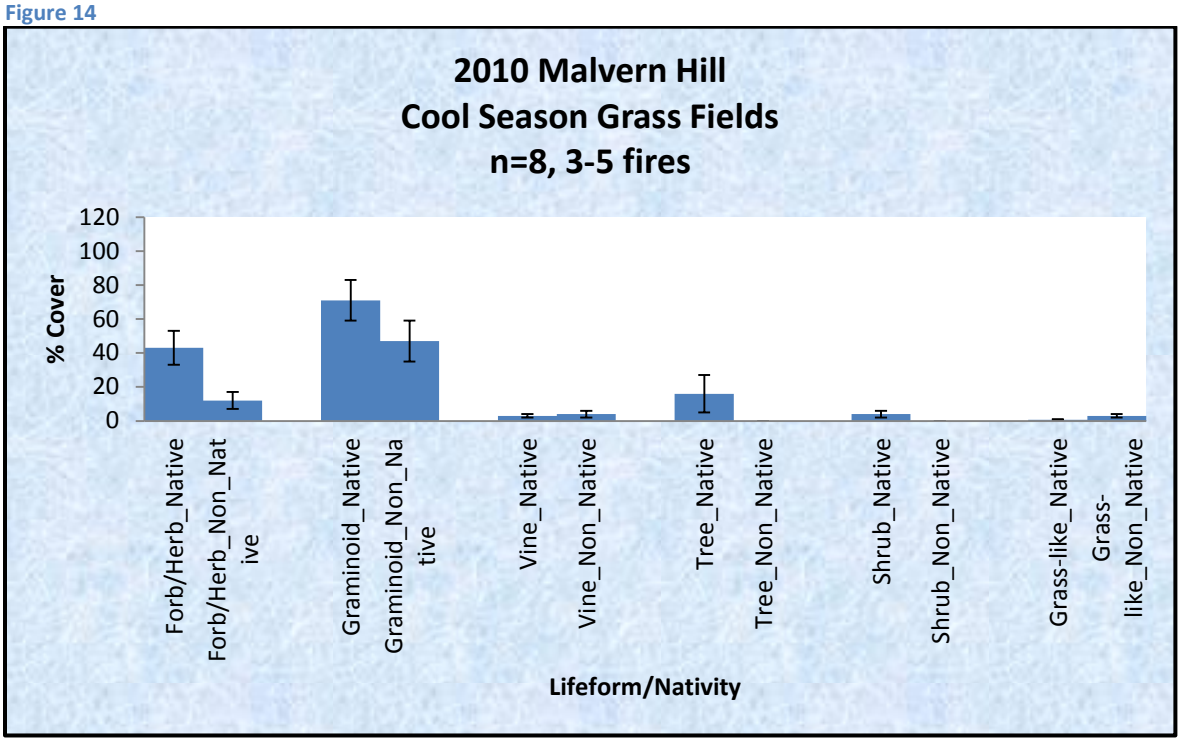
- Percent cover of woody species < 25% as measured after four treatments.
- Percent cover of non-natives grasses and forbs < 25% as measured after four treatments.
    - Resource Management staff measures from NRCA:
        - proportion of plot cover in "non-natives"
        - number of species per plot of "non-natives"
        - proportion of total species "non-natives"
- Percent cover of “meadow specialists” native grasses and forbs >75% as measured after four treatments.
    - Resource Management staff measures from NRCA:
        - proportion of plot cover in "meadow specialists"
        - number of species per plot of "meadow specialists"
        - proportion of total species in "meadow specialists”

Table of objectives for the Malvern Hill burn unit.

Malvern Hill	Maintain percent cover of woody species <25%	**Cool Season Grass Fields** Shrub Cover = 4% (± .2) Tree Cover = 16% (± 11)	**Yes**	2010
		Warm Season Grass Fields Shrub Cover = 0 Tree Cover = 2 (± .1)	**Yes**	
	Percent cover of non-natives grasses and forbs < 25%.	**Cool Season Grass Fields** Non-Native Grass Cover = 47 (± 12) Non-Native Forb Cover = 12(± 5)	**No**	2010
		Warm Season Grass Fields Non-Native Grass Cover = .3 (± .3) Non-Native Forb Cover = *10(± 10) *Plot 10 LESCUN	**Yes**	
	Percent cover of "meadow specialists" native grasses and forbs >75%.	**Cool Season Grass Fields** Native Grass Cover = 71(± 12) Native Forb Cover = 43(± 10)	**Yes**	2010
		Warm Season Grass Fields Native Grass Cover = 150(± 4) Native Forb Cover =13(± 3)	**Yes**	

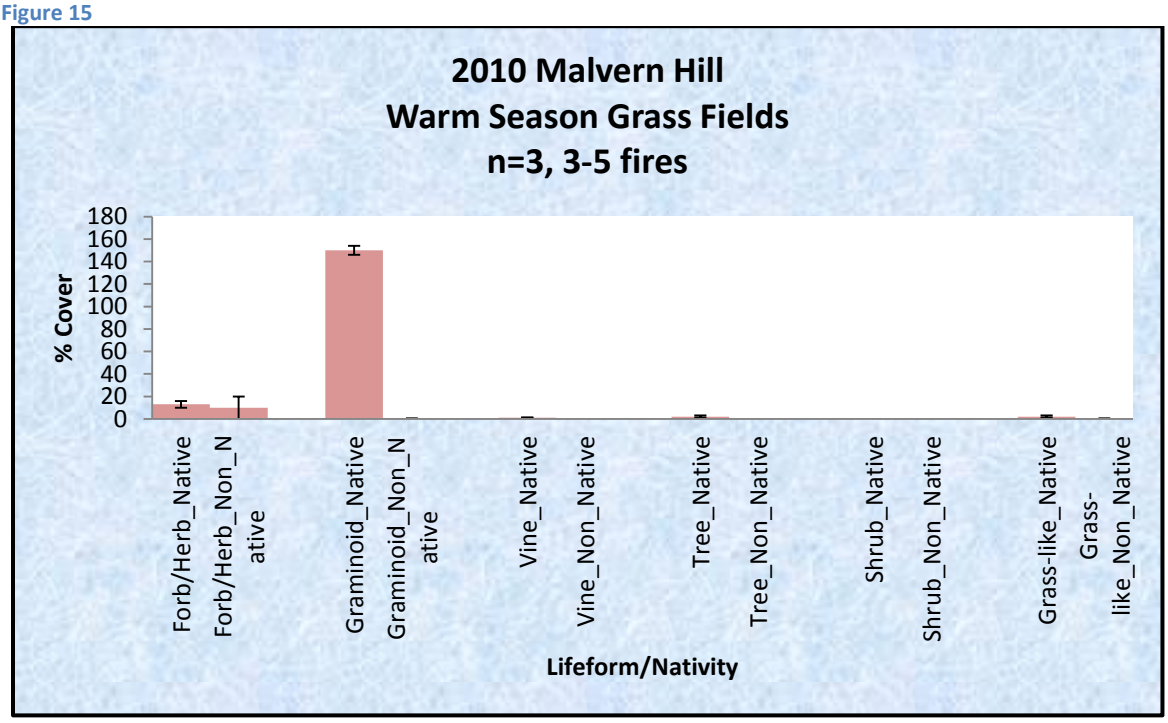
2010 graph of percent cover by lifeform and nativity cool season grass fields.

Figure 14



2010 graph of percent cover by lifeform and nativity in the warm season grass fields.

Figure 15



V. 2010 Results and Discussion – Malvern Hill

All objectives are being met with the exception of maintaining non native grass cover below 25 percent in the cool season grass fields. In the fall of 2010, 18 acres of meadow fescue (*Schedonorus pratensis*) in the largest cool season grass field, along with woody species throughout all of the fields were contracted and sprayed with herbicide. The non native honeysuckle (*Lespedeza cuneata)* will be treated during the summer of 2011. This year's prescribed fire had a very positive impact with a noted reduction of non native grass from 72% (±16) in 2009 pre- treatment to 47% (± 12) in 2010 after treatment (Figure 14). The burn day weather conditions (low RH, high temp.) allowed the fire to carry continuously through the fields. In the last three years native grass cover in the cool season grass fields has remained approximately the same. Hopefully, the spraying will provide more bare ground and allow native warm season grasses to germinate. The 12 acre south field, which is currently grouped in with the cool season grass fields, continues increase with NWSGs. The two plots in this field had 84% and 116% native grass cover, with only 2% and 0% non native grass cover. This field should be moved in with the warm season grass group and burn rotation. The Native warm season grass fields continue to have exceptional native grass cover at 150% (± 4) and .3% (± .3) (Figure 15) non native grass percent cover. Native forbs also continue to increase from 5% (± 3) in 2008 to 13% (± 3) (Figure 15). Current research supports biannual spring burning and should allow for more native forbs to germinate. Plot 10 in the Parsonage West field was noted to have an increase in the non native invasive honeysuckle (*Lespedeza cuneata).* This should be treated as there are not many other native forbs in this field and it will likely quickly spread.

VI. Cold Harbor Overview

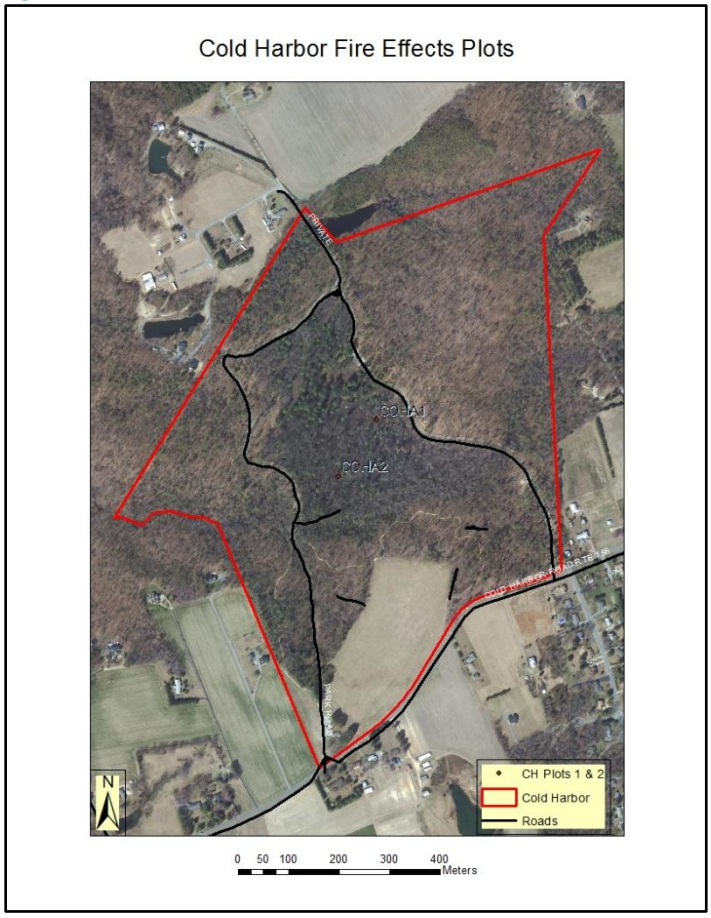
Cold Harbor Unit is predominately composed of a Coastal Plain Oak Heath Forest, with a Coastal Plain Acidic Seepage Swamp community bisecting the unit and running along Bloody Run Creek. Historically, Bloody Run Creek looked much like it does now, with deciduous trees in the overstory and thick underbrush, spreading up the hill and eventually mixing with the pine community on the uplands. The majority of the forest is 70-80 years in age and in fair health. During the Civil War most of the ridge areas were open farmland, and the slopes and streams were covered by woods; however, many of these fields have since been allowed to become mixed hardwood and coniferous forests. The understory vegetation along the drainage is an acidic seepage swamp community characterized by an extremely dense and brushy shrub layer.

The community that runs along the creek has an overstory dominated by blackgum and American holly, with an understory of sweet pepperbush, wild azalea and blueberry. The oak heath forest community is dominated by loblolly pine and black oak,white oak, northern red oak and American holly The understory of these communities consists of saplings of tree species that dominate the overstory, with the addition of hickory, sassafras and blueberry. The herbaceous layer is sparse and dominated by muscadine, Virginia creeper and Japanese honeysuckle (*Lonicera japonica*

This burn unit comprises an area of approximately 30 acres, which is in the central portion of the Cold Harbor Unit and is surrounded by a blacktop road Anderson and Wright Drive. The unit was first burned in 1997 before the establishment of monitoring plots. FMH forest plots were installed in 2003, and have been treated in 2004, 2005 and 2009. Plot design is consistent with the specifications for forest plots found in the NPS Fire Monitoring Handbook. Mechanical (lopping and chain sawing) and chemical treatments have also take place in the unit. A tropical storm impacted the area in 2005, falling numerous large trees.

Map of Cold Harbor fire effects plots. Sample size is 2.

Figure 16



VII. Goals and Objectives - Cold Harbor

Goal

The desired future condition for the Cold Harbor Unit is to maintain a “park-like” atmosphere for visitors, keeping the earthworks exposed for viewing and interpretation, and creating a more natural community that may have existed at this site before the suppression of fires.

- Reduce hazard fuels thereby minimizing the threat of a wildfire.
- Reduce understory fuels to open up the historic scene.
- Open up and maintain vistas.
- Maintain and promote native warm season grasses.
- Minimize tall woody/shrubby vegetation from growing in the burn area
- Restore fire as a natural process.
- Reduce the amount of fuel used in tractors for mowing the area.

Burn Objectives

- < 10% mineral soil exposure prior to green up as measured immediately post burn.
- Limit flame height to be not more than 3 feet on average as measured during the burn.

Monitoring Objectives

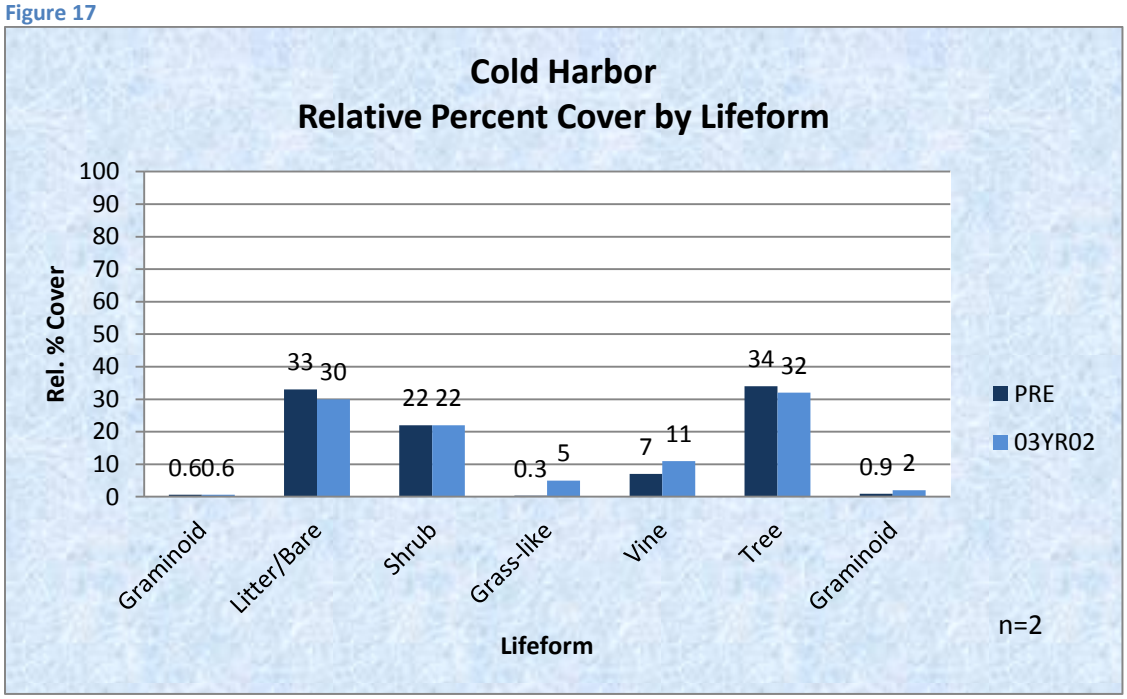
- >50% Reduction in pole size tree density after four burns.
- Increase native grasses by >75% after four burns.
- Maintain an open forested stand as it appeared at the time of the battle.

Table of objectives for the Cold Harbor Unit.

Cold Harbor	Decrease pole size trees by 50% after four burns.	**Pre:** 46 pole trees **03YR02:** 22 pole trees	**Yes**	2010
	Maintain an open forested stand as it appeared at the time of the battle.	Photopoints on going.	**Yes**	2010
	Increase relative percent cover of herbaceous species by 75%	**Pre:** 1.2% **03YR02:** 7%	**Yes**	2010

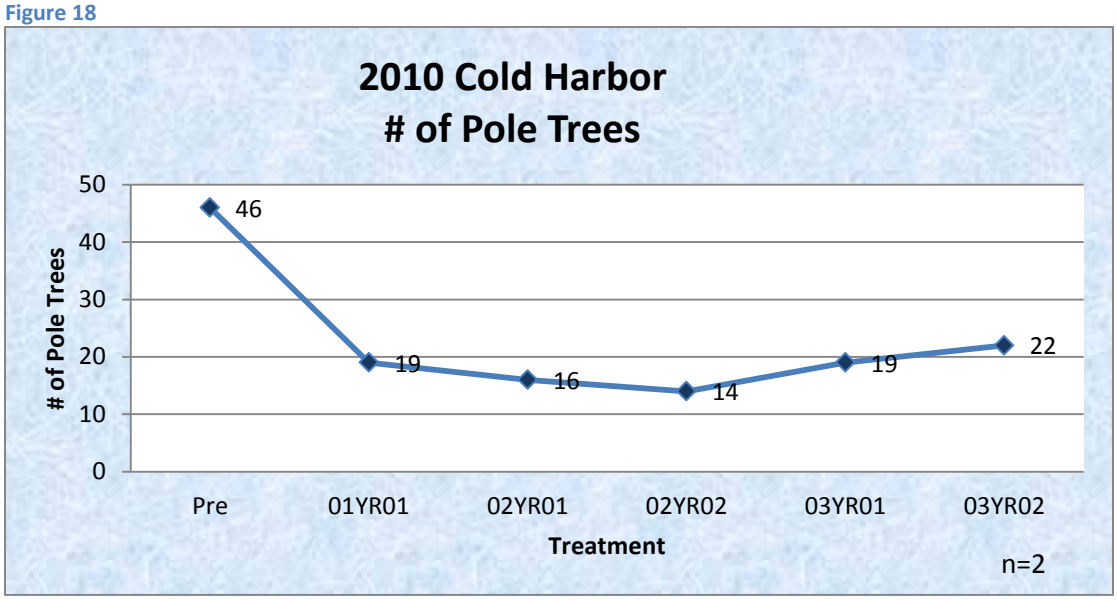
Relative percent cover by lifeform and nativity. No error bars used with two plots.

Figure 17



Number of pole trees in the Cold Harbor unit after three prescribed fires.

Figure 18



VIII. 2010 Results and Discussion – Cold Harbor

After the third burn, objectives are being met for the Cold Harbor unit. The objective to reduce shrub density cover was dropped last year due to the difficulty in accurately tallying *Ericaceous* species. There continues to be an increase in grasses and sedge species which is an excellent sign (Figure 17). This open pine habitat historically had a significant open grass understory. There have been very few non native species noted in the plot areas to date. The density of pole trees has been decreased by 50% (Figure 18) after three burns. A few seedling trees have now moved into the pole size class, however the level still remains below half of pre burn levels. Standard error was not calculated for results due to the unit only having two plots with the entire area only 20 acres in size. This unit is on schedule to be treated again in 2012.

t

Appomattox Courthouse (APCO)
2011 Fire Effects Monitoring Annual Report

I. Program Overview

2011 Summary

No prescribed burns or monitoring took place at Appomattox Courthouse this year, therefore additional data analysis was not completed. Prescribed burns are planned for 2012 include the Ferguson Field and additional grass units.

Future Plans

2010 data analysis indicate the achievement of all but one objective in the Ferguson Field. With the onset of smaller travel budgets and increasing workloads the monitoring interval will be modified to every three years. This will continue to provide the necessary data to evaluate whether management goals and objectives are being met and whether undesired effects are occurring. The Ferguson Field and N.C. woodlot unit will be monitored after it is burned. This may occur in spring 2013 at the discretion of park management.

II. Park Overview

APCO is located in Appomattox County, Virginia, and is comprised of 1,743 acres that contain a number of nationally significant cultural resources, the majority of which are historical in nature. Natural resources include woodlands, wetland systems, cultivated fields and grasslands, and various small creeks that, altogether, present a landscape relatively unchanged since 1865. The acreage of the park is comprised of: 45% agricultural fields (approximately 400 acres are leased), pastures, and lawns, 45% forests, 6% streams /wetlands, and 4% developed areas.

On April 9, 1865, after four years of Civil War, approximately 630,000 deaths and over 1 million casualties, General Robert E. Lee surrendered the Confederate Army of Northern Virginia to Lieutenant General Ulysses S. Grant, at the home of Wilmer and Virginia McLean in the rural town of Appomattox Court House, Virginia.

III. Ferguson Field

Most of the grassland areas in the park have been managed in one form or another for years. Currently, approximately 400 acres of grasslands are managed for cool-season grasses (primarily fescues) for hay production (~200 acres) and for pasture for cattle grazing (~ 200 acres) through the Historic Property Leasing Program. Fifty-four acres (Sweeney Prizery Field and Village Back Field) are managed as native, warm-season grasses for hay production through the same program. Forty-two acres (Ferguson Field and Upper Nash Field) are managed as a mature grassland community.

The Mid-South historically contained vast acreages of native grassland and savannas with scattered trees and shrub cover, which was maintained by fire. Through the years, these have been replaced with non-native grasses such as meadow fescue (*Schedonorus pratensis*). Agriculture, trees and suburban development have also replaced open fields with Native Warm Season Grasses (NWSGs). Native warm season grasses provide critical habitat for numerous songbirds and wildlife species. These native grasslands are the most endangered ecosystems in the Mid-South and as a result of their loss numerous wildlife and grassland bird species have experienced steep, long term declines.

The vegetation of the Ferguson Field is characterized by native perennial grasses include *Andropogon virginicus, Tridens flavus, Sorghastrum nutans, Panicum virgatum* and *Andropogon gerardii*. Non-native perennial grass is mostly meadow fescue (*Schedonorus pratensis*). Annual grasses include many *Panicum* species. Native forbs, shrubs and trees include *Solidago* species, *Erechites hieracifolia*, *Symphoricarpos orbiculatus*, *Rubus* species, *Juniperus virginiana*, and *Pinus virginiana*. Invasive, non-native vegetation includes *Rosa multiflora* and *Centaurea maculosa*.

Ferguson field was a pasture utilized for cattle grazing until 2001. The field was treated with a selective herbicide in 2002 to reduce non-native perennial grasses and replanted with a mixture of Native Warm Season Grasses (NWSGs) including *Sorghastrum nutans, Panicum virgatum* and *Andropogon gerardii*. The field was first burned in the spring of 2009. A few weeks following the initial prescribed fire, the Mid Atlantic Exotic Plant Management Team re-treated the newly re sprouting cool season meadow fescue (*Schedonorus pratensis*). This combination of burning and follow up spraying was notably successful at reducing the coverage of this non native grass.

Map of Ferguson Field grassland plots.

Figure 19

IV. Goals and Objective

Goals

The primary goal is to maintain the historic scene of April 9, 1865 that the park commemorates, while creating a diverse grassland habitat. This is being accomplished by mechanically removing the trees, herbicide treatment of exotic vegetation, bushogging, and through the use of prescribed fire.

Burn Objectives

- >90% consumption of fine fuels as measured immediately post burn.
- < 5% mineral soil exposure prior to green up as measured immediately post burn.

Monitoring Objectives

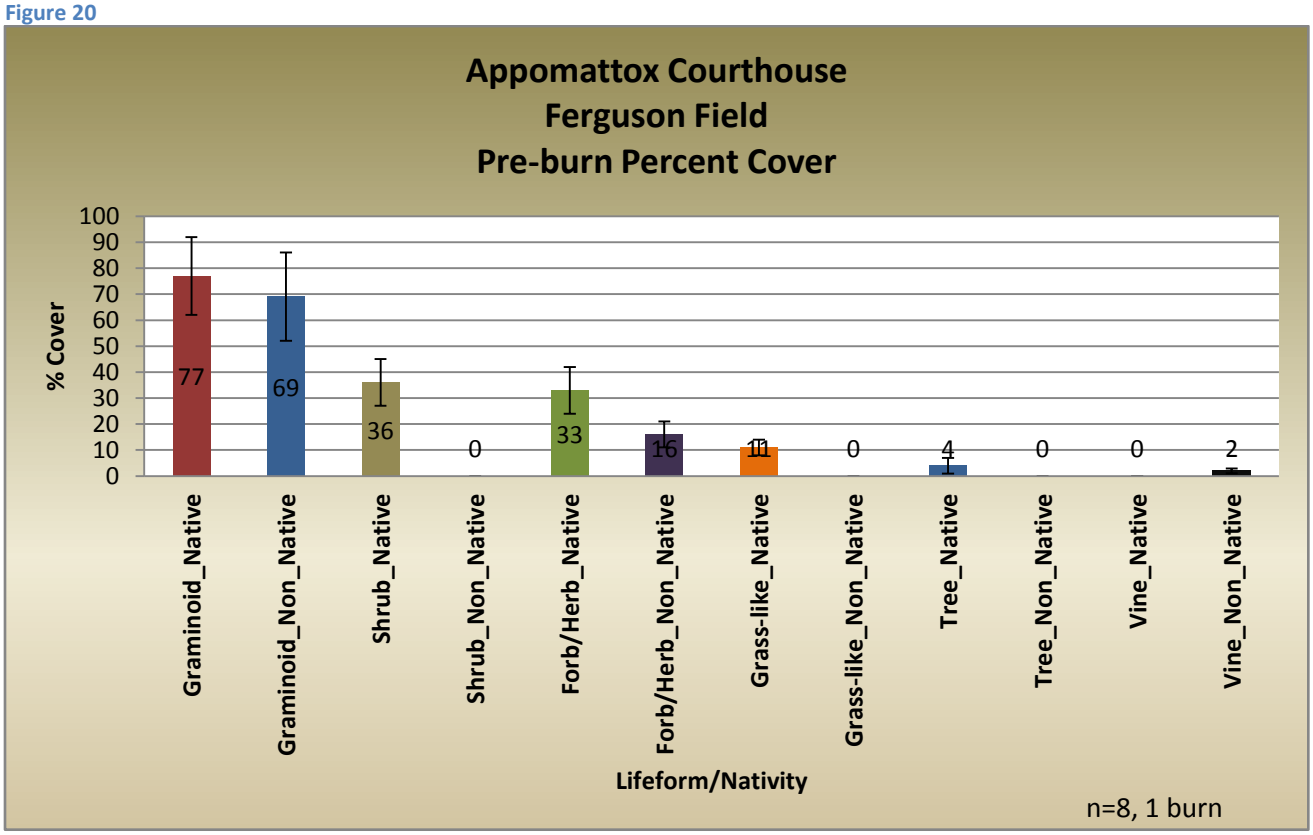
- Percent cover of woody species < 25% as measured after three treatments.
- Percent cover of non-natives grasses and forbs < 25% as measured after three treatments.
- Percent cover of native grasses and forbs >75% as measured after three treatments.

2010 data. Table of objectives for fields at APCO.

Ferguson Field Mixed Grassland	Maintain percent cover of woody species <25%	Woody species= 9 (±3)	**Yes**	2010
	Percent cover of non-natives grasses and forbs < 25%.	Non-native grass = 38 (±7) Non-native forbs = 10(±4)	**Yes**	2010
	Percent cover of native grasses and forbs >75%.	Native grasses = 83 (±7) Native forbs = 13 (±4)	**Yes**	2010

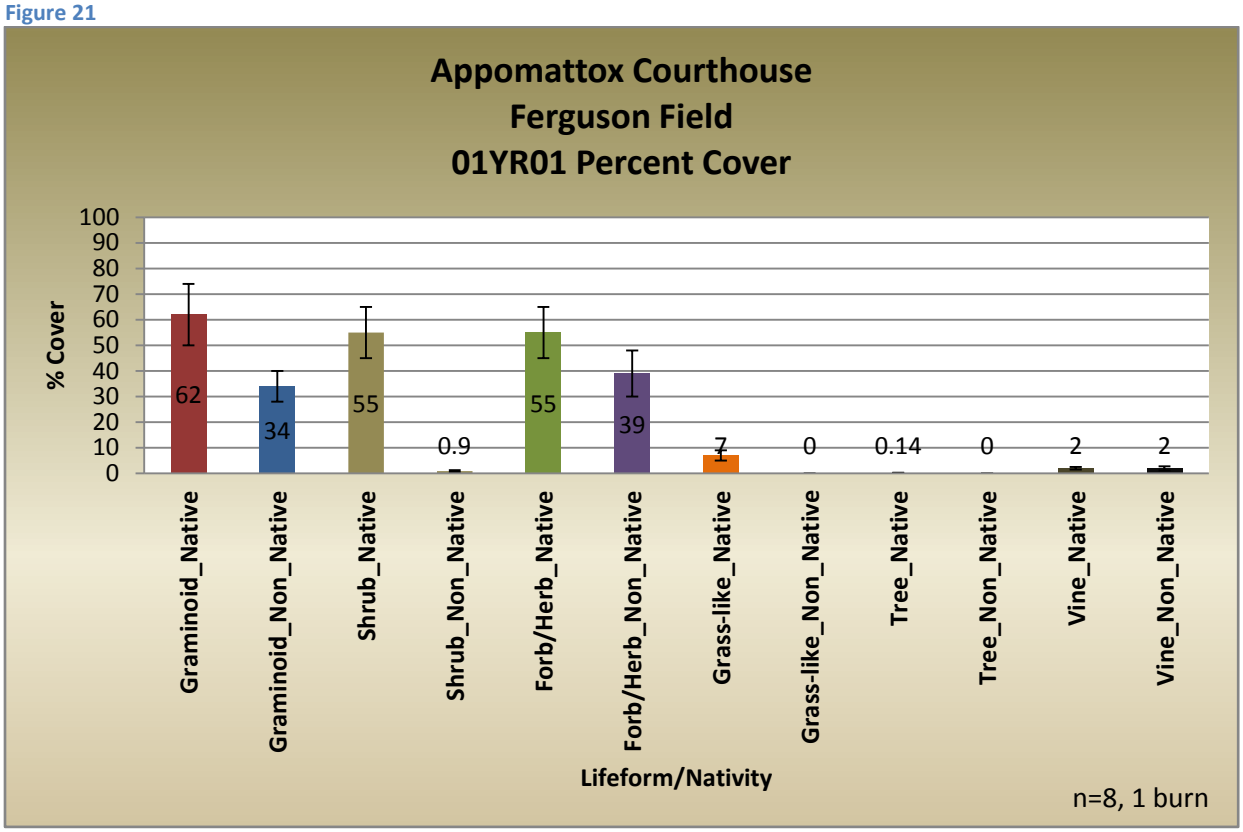
Percent cover by lifeform and nativity for Ferguson Field pre burn.

Figure 20



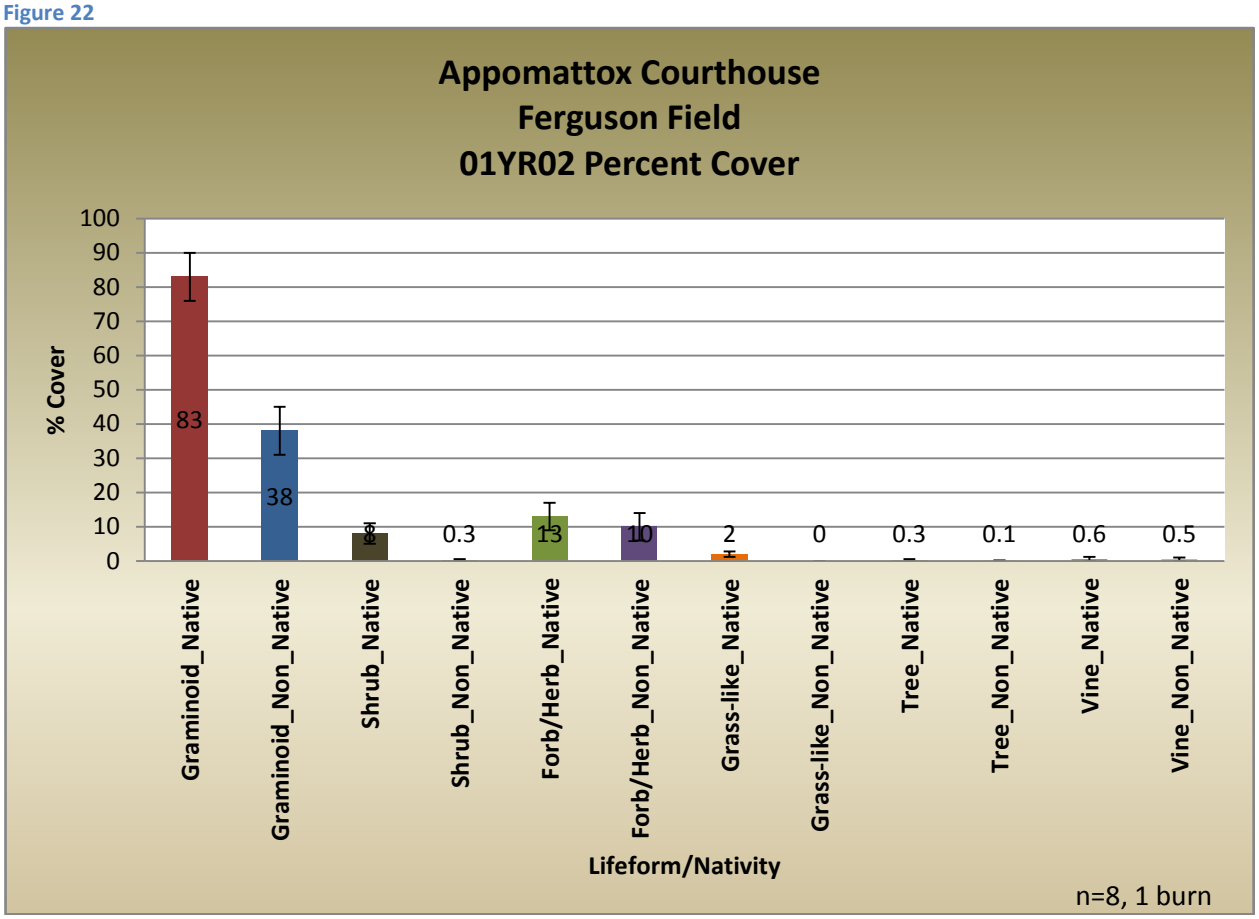
Percent cover by lifeform and nativity for Ferguson Field after one prescribed fire, year one.

Figure 21



Percent cover by lifeform and nativity for Ferguson Field after one prescribed fire, year two.

Figure 22



V. Results and Discussion – Ferguson Field

A combination of prescribed fire and herbicide treatment has been used throughout the field to meet management objectives. Native warm season grasses have continued to show an increase in the second year of monitoring after the initial prescribed fire. Percent cover of native grasses is 83% (±7) (Figure 22) in 2010 compared to 77 (±15) (Figure 20) in pre burn monitoring. More remarkably non native grasses have decreased from 69% (±17) (Figure 20) to 38% (±7) (Figure 22). In early 2010 the Mid Atlantic Exotic Plant Management Team (EPMT) treated large patches of fescue with the herbicide Glyphosate. While non native grass cover still exceeds the objective to maintain cover < 25%, significant progress has been made after one burn in meeting this objective. Furthermore, shrub levels have decreased from 36% (±9) (Figure 20) in pre burn monitoring to 8% (±3) (Figure 22). The Mid Atlantic EPMT also treated much of the field with Garlon 4 in early spring/summer 2010 to control the highly invasive non native herb spotted knapweed. The spotted knapweed rosettes accounted for 55% (±10) (Figure 21) cover after the initial burn treatment. After the herbicide treatment, percent cover had been reduced to 10% (±4) (Figure 22). The herbicide application also impacted native herb cover with a decrease from 55% (±10) (Figure 21) in 2009 to 13% (±4) (Figure 22) in 2010. Native herbaceous plant cover are expected to rebound in the next few years as the knapweed is kept in check through spot herbicide treatments. This multi -faceted approach of burning and herbicide application appears to be effective in restoring this native warm season grass fields after being managed as pasture lands for many years.

VI. NC Woodlot

Forested areas in the park include both natural and semi-natural stands of hardwoods and pine. The natural dominant forest type is oak-pine with oak species being dominant. Other tree species of lesser dominance include black walnut, shortleaf pine, Virginia pine, loblolly pine, sweetgum, black gum, black cherry, sycamore, tulip poplar, dogwood, redbud, sweet bay magnolia, red maple, hickory, and eastern redcedar. The understory is dominated by eastern redbud, sassafras, flowering dogwood, red maple, and black gum. Small stands of eastern redcedar also exist throughout much of the park. An abundance of mid-story and understory stems are present in most units. Most of the forest floor is densely shaded.

Map of forest plots at Appomattox Courthouse.
Figure 23

VII. Goals and Objective

Restore the cultural landscape associated with the Civil War Era 1865 that the park commemorates while restoring and promoting oak regeneration.

Burn Objectives

- Reduce >50% of the fine fuels over 75% of the unit as measured immediately post burn.
- Reduce pole sized trees by >30% as measured within one year post burn.
- Maintain >80% overstory oak trees as measured within one year post burn.

Monitoring Objectives

- >50% reduction in total fuel loading as measured after three treatments.
- >70% reduction in pole size tree density as measured after three treatments.
- >200 Oak seedlings per acre >60cm as measured after three treatments.
- >20% cover of native herbs as measured after three treatments.
- <20% cover of non-native species as measured after three treatments.

VIII. Discussion

Three pre burn forest monitoring plots were installed in 2010. The planned prescribed fire for 2011 was cancelled. A spring burn may occur in 2013 at the discretion of park management.

Shenandoah National Park
2011 Fire Effects Monitoring Annual Report

I. Program Overview

2011 Summary
With the help of the 2011 fire ecology summit, 8 forest plots were installed in the 1300 acre Wildcat / Riprap burn unit. This unit is targeted for prescribed fire in 2013. In the spring of 2011, the Jarman Gap unit was prepped and resources on site however it was not implemented due to unfavorable ventilation. This burn will be completed in spring of 2012.

Future Plans
The fire ecology program is trying to complete more projects at Shenandoah National Park. The first step in the process was collaborating with the Natural and Cultural Resources Division and completing a document prioritizing the use of prescribed fire by forest community type and Desired Future Conditions (DFC's). This document will serve as the foundation for the parks prescribed fire program. We currently have 20 forest plot installed in three monitoring types in three burn units. We are hopeful that 2 units will be completed in 2012 and the other in 2013.

II. Park Overview

Shenandoah National Park (SHEN) is located along the Blue Ridge Mountains in northwestern Virginia and lies closer to more people than does any other national park in the country (Connors 1988). There are 197,438 acres in the park, including 79,579 acres of designated wilderness. The park is divided into three management districts: north, central, and south. Elevations in the park range from 595 ft (181 m) at Front Royal to 4,049 ft (1,234 m) at the top of Hawksbill Summit. One particular aspect of the park is its 105 mile Skyline Drive, which runs the entire length of the park and was one of the first recreational highways of its types in the United States when it was opened to the public in 1934 (Connors 1988). The park also contains 101 miles of the Appalachian Trail, the nation's longest marked footpath (2,175 miles) and first national scenic trail, designated in 1968.

Approximately 93% of SHEN is dominated by second-growth forest, 2 percent is covered by wetland communities, and approximately 3 percent of the area is occupied by other vegetation communities such as barrens. Roughly 2 percent of the park is developed or disturbed by humans and includes drivable roads, parking lots, powerline right-of-ways, and building facilities (Young et al. 2009).

Vegetation of Shenandoah National Park
The composition of the second-growth forest at SHEN has been influenced by the topography, climate, geology, and natural disturbance regimes of the northern Blue Ridge Mountains, as well as by historic land use and other anthropogenic disturbances. Braun (1950) defines the Northern Blue Ridge as a forest section of the Oak-Chestnut Forest region. However, the loss of American chestnut (*Castanea dentata*) in the early 1900s changed the forest composition of the region. SHEN currently resembles the Oak-Hickory Forest region also described by Braun (1950) and 40% of the cover is comprised by oaks with hickories as secondary components. Due to a history of disturbance, SHEN represents one of the nation's most diverse botanical reserves, contains globally rare plant communities, and is an outstanding example of the Northern Blue Ridge Forest (National Park Service 1998). There are 1406 vascular plant species in Shenandoah National Park.

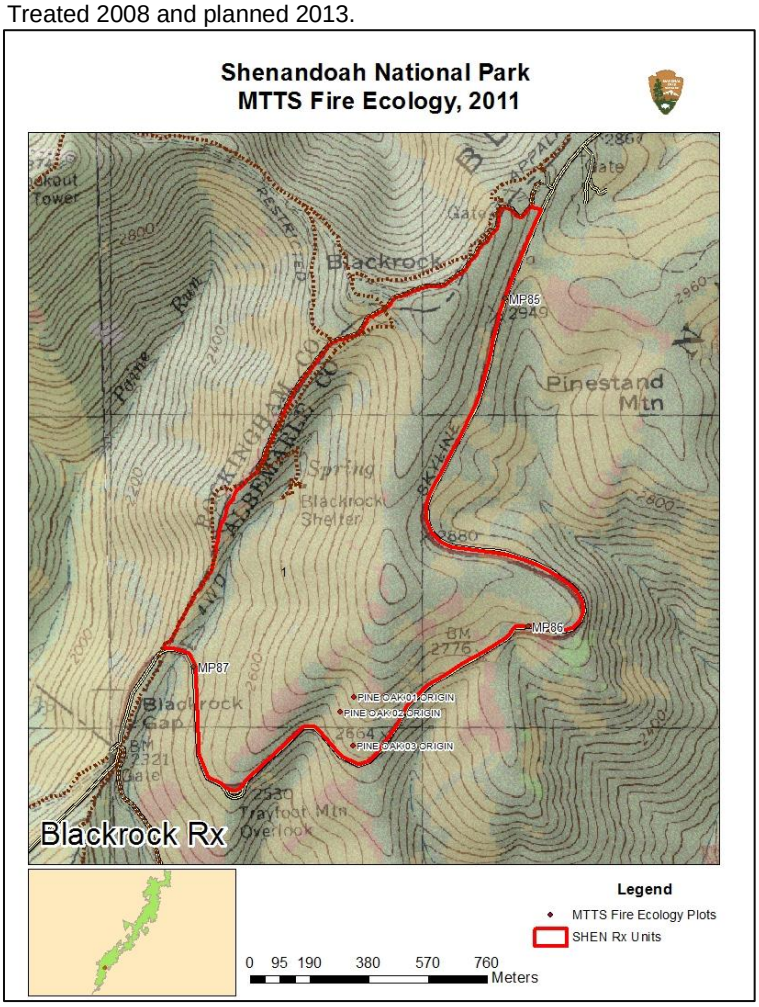
In 2009 the fire effects crew began establishing monitoring types in Shenandoah National Park in an effort to increase projects at the park. Three monitoring types have been established and include; Pine-Oak, Xeric Oak (Chestnut variant), and Mesic Oak. Two additional monitoring types are conceptualized and described to improve future prescribed fire management and monitoring activities including Xeric Oak (White Oak Variant) and Barrens Communities.

- **Pine Oak Monitoring Type**
  Central Appalachian Pine - Oak /Heath Woodland & Central Appalachian Xeric Chestnut Oak - Virginia Pine Woodland (Young et al. 2009)**.**
  In Shenandoah National Park, Pine-Oak stands typically occupy xeric, upper slopes and ridges on south to northwest aspects and at elevations ranging from 1550-3200 feet. Physiognomy of these stands ranges from closed forest (long-term fire exclusion) to open shrubland (coincident depredation by southern pine

beetle and stand-replacing wildfires). Though this community is widely distributed on the Blue Ridge and in the Park, it is most extensive on quartzite ridges in the south district and on the western slopes of the park. Contemporary Pine-Oak stands vary from closed forest to open woodland that are dominated by *Pinus rigida* or *Pinus pungens*, though most stands observed are dominated by *Pinus rigida*. *Quercus prinus* is consistently a co-dominant in these stands. Most frequent canopy associates include *Quercus coccinea, Quercus marilandica, Pinus virginiana*, and *Nyssa sylvatica*. Subcanopy tree strata are frequently dominated by numerous shade-tolerant species including *Nyssa sylvatica, Acer rubrum, and Sassafras albidum*. Typically, *Quercus ilicifolia* dominates a sporadic to very dense tall-shrub layer, while *Kalmia latifolia, Vaccinium pallidum, Vaccinium stamineum, Gaylussacia baccata*, *Lyonia ligustrina*, *Rhododendron periclymenoides*, and other ericads form a continuous low shrub stratum.
Due to extensive and multi-layered hardwood encroachment, most herb assemblages are very diffuse, while subshrub assemblages occasionally achieve conspicuous abundance. Greatest ground layer abundance is observed in areas characterized by shallow, rocky substrates and/or very open to sparse tree and shrub canopies, as well as along insolated corridors (i.e, trails, roads, gaslines, powerlines, etc.) that maintain favorable growing conditions in the face of extensive shade-displacement.

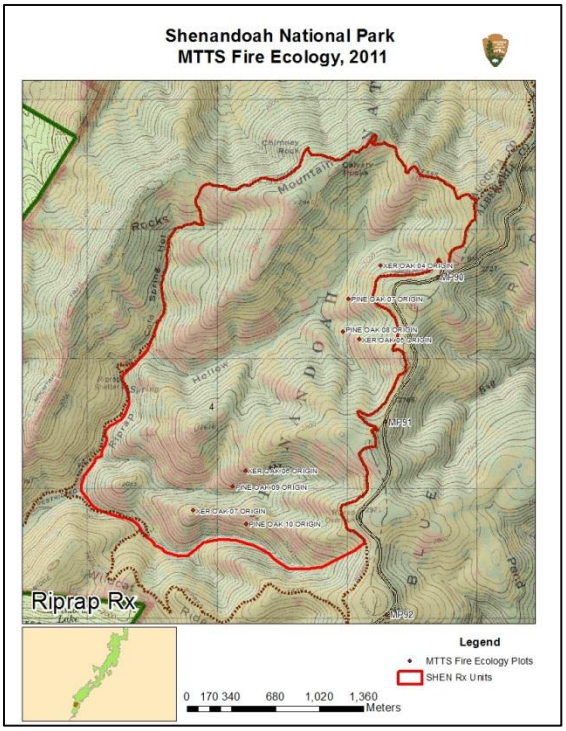
Discussing fire effects monitoring and prioritization at the 2011 Fire Ecology summit.

Blackrock prescribed fire unit. Pine-oak fire effects monitoring plots.
Treated 2008 and planned 2013.



Discussing Fire Effects at the Blackrock burn unit during the 2011 Fire Ecology summit.

Riprap / Wildcat prescribed fire unit. Pine oak and xeric oak forest plots.



- **Xeric Oak Monitoring Type: Chestnut Oak Variant**
  Central Appalachian Dry Chestnut Oak - Northern Red Oak / Heath Forest & Central Appalachian / Northern Piedmont Chestnut Oak Forest
  Xeric oak woodlands exhibit notable structural and compositional variety in the canopy, subcanopy, and herbaceous layers along a north-south gradient. MTTS Fire Ecology recognizes distinct xeric oak communities that are suitable prescribed fire target areas including the following put forth in "Vegetation of Shenandoah National Park in relation to environmental gradients" (Young et al. 2009): Central Appalachian/Northern Piedmont Chestnut Oak Forest, Central Appalachian Dry Chestnut Oak-Northern Red Oak/Heath Forest, Low-Elevation Mixed Oak/Heath Forest, Central Appalachian Acidic Oak-Hickory Forest. For the purposes of MTTS Fire Ecology, two xeric oak monitoring type descriptions are created to improve programmatic sampling design, statistical & analytical groupings, and the placement MTTS Fire Ecology plots within ecological variants that are recognizably distinct within the xeric oak complex.In Shenandoah National Park, Xeric Oak forests and woodlands occupy all geologic substrates, topographic positions and aspects, but is most associated with upper to midslope positions on south to west aspects. It occurs at elevations ranging from the lowest elevations in the park (800 feet) to 3000 feet (occasionally higher) on dry, infertile slopes and ridges, either straight or convex.
  Contemporary Xeric Oak forests and woodlands range from open to closed stands dominated by *Quercus prinus*. In certain stands, *Quercus alba*, *Quercus coccinea, Quercus rubra* and/or *Quercus velutina* achieve co-dominance. Overstory associates may include *Pinus pungens, Pinus rigida, Pinus virginiana, Carya glabra*, and *Fraxinus americana*. Midstory tree strata are frequently dominated by the following shade-tolerant species: *Nyssa sylvatica, Acer rubrum, and Sassafras albidum*. Typically, *Kalmia latifolia* dominates an abundant tall-shrub layer, while *Vaccinium pallidum, Vaccinium stamineum, Gaylussacia baccata*, *Lyonia ligustrina*, Rhododendron catawbiense, and *Rhododendron periclymenoides* form a continuous low shrub stratum.
  Ground layer herbaceous and subshrub cover is typically sparse, though rich assemblages are occasionally observed in areas characterized by rocky substrates and/or very open to sparse tree and shrub canopies, as well as along insolated corridors (i.e, trails, roads, gaslines, powerlines, etc.) that maintain favorable growing conditions in the face of extensive shade-displacement.

III. Goals and Objectives for pine oak and xeric oak monitoring types.

Goal

Reduce fuel loading by > 50% thereby decreasing the threat of a catastrophic wildfire.
Use low to moderate intensity prescribed fire to promote oak and pine recruitment through the reduction of duff depth and elimination of fire intolerant/shade-tolerant tree species.

Burn objectives

- Ensure the public experience no injuries.
- Ensure fire personnel receive no lost time injuries.
- Keep the fire within the defined boundaries of the unit.
- Reduce fuel loading by > 50% thereby decreasing the threat of a catastrophic wildfire.
- Keep ignition out of sensitive riparian areas.
- Use low to moderate intensity prescribed fire to promote oak and pine recruitment through the elimination of fire intolerant tree species.
- Accommodate trainees into the burn organization.
- Contribute to the preparedness of National Park Service and cooperating agency fire personnel.

Monitoring objectives

Pine Oak

1. Greater than 50% reduction in fuel loading.
2. >70% reduction of mesic pole size trees (2.5 - 15 cm dbh) (i.e. red maple, blackgum, sassafras and hickory.
3. 25 – 50% reduction in overstory tree density.
4. 200 tall (>60 cm in height) yellow pine seedlings (Pinus pungens, Pinus rigida, Pinus virginiana) per acre.
5. 40% cover of native herbs.
6. No net increase in invasive exotic species cover.
7.

Xeric Oak

1. Greater than 50% reduction in fuel loading.
2. >70% reduction of mesic pole size trees (2.5 - 15 cm dbh.
3. 15 – 30% reduction in overstory tree density.
4. 200 tall (>60 cm in height) Oak seedlings per acre.
5. 30% cover of native herbs.

No net increase in invasive exotic species cover.

IV. Discussion

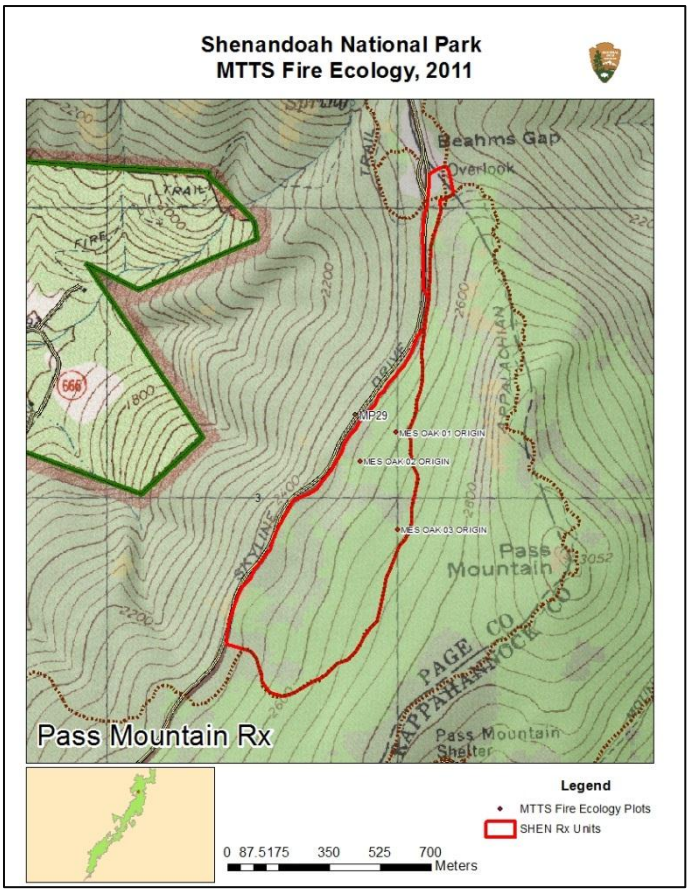
Only preburn data has been collected at the Jarman Gap and Wildcat / Riprap burn units. Jarman Gap is planned for the spring of 2012 and Wildcat /Riprap for spring of 2013. Post burn data has been collected at the Blackrock burn unit, but unfortunately preburn data was not. The Blackrock burn unit is planned to re-treated in the spring of 2013.

Desired conditions for vegetation monitoring types managed with prescribed fire at Shenandoah National Park.

Monitoring Type[a]	Attribute	Indicator	Target Value {Citation}[b]
Pine-Oak CEGL00#-4996	Overstory Trees	Density: Basal Area of Trees (> 15 cm) m^2 per ha	11.25-15.5 m^2 per ha (all trees overstory and poles) {S BR FLN} Woodland 9-13.5 m^2 per ha (all trees overstory and poles) {SW VA FLN}
	Desirable Overstory Species (Yellow Pine / Oak)	Basal Area of Yellow Pine-Oak ($\geq$ 15 cm dbh) / Total Basal Area ($\geq$ 15 cm dbh) * 100	$\geq$ 80% {S BR FLN} > 50% Site Dependent {SW VA FLN}
	Pole-sized Trees	Density: Basal Area of Pole (15 cm $\geq$ Pole > 2.5 cm) m^2 per ha	11.25-15.5 m^2 per ha (all trees overstory and poles) {S BR FLN} Woodland 9-13.5 m^2 per ha (all trees overstory and poles) {SW VA FLN}
	Yellow Pine Seedlings	Percentage of Stems > 14 cm tall	> 50% site dependent {SW VA FLN} 11,000 stems per ha 5 year post burn per NPS FMH Plot {Jenkins et al. 2011}
	Oak Seedlings	Number of Stems per ha	> 400 stems per ha > 1 m tall {S BR FLN}
	Shrub Abundance	Percent Cover	< 30% {S BR FLN} < 10% per stand {Jenkins et al. 2011}
	Herb Abundance	Percent Cover	Woodland > 50% herbs{SW VA FLN}
Xeric Oak CEGL00#-6299, 8521, 8523, 8515 and 6057	Overstory Trees	Density: Basal Area of Trees (> 15 cm) m^2 per ha	13.5-20 m^2 per ha {S BR FLN} 13.5-18 m^2 per ha for Forest & 9-13.5 m^2 per ha for Woodland {SW VA FLN}
	Desirable Overstory Species	Basal Area of Yellow Pine-Oak ($\geq$ 15 cm dbh) / Total Basal Area ($\geq$ 15 cm dbh) * 100	$\geq$ 70% {S BR FLN}
	Pole-sized Trees	Density: Basal Area of Pole (15 cm $\geq$ Pole > 2.5 cm) m^2 per ha	< 2.25 m^2 per ha {S BR FLN}
	Seedlings	Density: number of stems per ha by species	$\geq$ 42 m per FMH seedling sample area. NPS FMH Plot {Steiner et al. 2008} 5, 58-120 and 120-240 stems per NPS FMH Plot {Brose et al. 2008} > 50% of stems that are oak > 14 cm tall {SW VA FLN}
	Shrub Abundance	Percent Cover	< 20 % {S BR FLN}
	Herb Abundance	Percent Cover	Forest > 25% > herbs and Woodland > 75% > herbs {SW VA FLN}

- **Mesic Oak Monitoring Type**
  Central Appalachian Montane Oak-Hickory Forest, Basic Type (Young et al. 2009); and, other types to follow.
  This monitoring type may be renamed Dry-Mesic Oak or lumped with other oak types in the future. In Shenandoah National Park, Mesic Oak stands occupy extensive mid- to high elevation areas (2000-3800 feet), on upper slopes and ridgetops of southeast to northwest aspects. Most frequently, this community occurs on sites underlain by metabasalt substrates (Catoctin Formation) on soils that are moderately to strongly acidic. Physiognomy ranges from closed forest (long-term fire exclusion) to open forest.
  Contemporary Mesic Oak stands are dominated by *Quercus rubra*. *Quercus alba, Fraxinus americana, Carya ovalis* are the most frequent canopy associates, though *Carya ovata, Carya*

cordiformis, and occasionally *Quercus velutina* are conspicuous components of the stratum. In areas characterized by advanced canopy closure, shade-tolerant tree species including *Acer rubrum, Betula lenta, Liriodendron tulipifera*, *Pinus strobus, Prunus serotina* and *Tilia Americana* are compositionally important in over-, mid-, and understory strata. Typically, mid- and understory strata are dominated by advancing mesophytic species including *Acer pensylvanicum*, *Acer rubrum*, *Fraxinus americana, Hamamelis virginiana, Lindera benzoin, and Ostrya virginiana.* In Mesic Oak stands, herbaceous cover is locally rich and continuous, though it is observably sparse in certain dry-mesic settings.
Pass mountain burn unit. Mesic oak plots.



V. Goals and objectives

Objectives are still being defined for the mesic oak monitoring type. This may be close enough to lump with the xeric oak monitoring types.

- **Xeric Oak Monitoring Type: White Oak Variant**

  Low-Elevation Mixed Oak / Heath Forest & Central Appalachian Acidic Oak - Hickory Forest (Young et al. 2009)

  In Shenandoah National Park, White Oak stands typically occupy low elevation (< 1600 feet), meta-sedimentary substrates on all aspects, though they are most associated with lower to midslope positions on south and west aspects. These stands commonly occur on streamside terraces along the west boundary of the Park and in close proximity to the Shenandoah Valley. Physiognomy of these stands ranges from closed forest (long-term fire exclusion) to very open matrix woodlands with associated barren complexes.

  Contemporary White Oak stands are characterized by closed to very open oak woodlands that are consistently co-dominated by *Quercus alba* and *Quercus prinus*. Most frequent canopy associates include *Carya glabra*, *Quercus coccinea*, *Quercus velutina*, *Pinus virginiana*, and *Pinus rigida*. *Quercus stellata* and *Quercus marilandica* notably increase in importance in open matrix woodland settings and/or in close proximity to barren complexes. Midstory tree strata are frequently dominated by advancing mesophytic species including *Acer rubrum*, *Amelanchier arborea, Carya*

glabra, Cercis canadensis, Fraxinus americana, Juniperus virginiana, Ostrya virginiana, and *Pinus strobus.* Sporadic mid- and low shrub layers are characteristically rich in ericaceous species including *Kalmia latifolia, Gaylussacia baccata, Vaccinium pallidum*, and *Vaccinium stamineum*. \
In these stands, subcanopy tree and shrub strata are significantly less developed than in the Chestnut Oak variant communities. As a result, herbaceous cover is comparatively rich and more continuously distributed throughout these woodlands. See Table 2 below for commonly encountered woody and herbaceous species in White Oak communities. Please note the list of species is neither complete nor restricted to white oak stands.
No plots have been established.

- **Proposed Barrens Monitoring Type**
  Central Appalachian Circumneutral Barren and analogs (Young et al. 2009 or ROMP)In Shenandoah National Park, Central Appalachian Circumneutral Barrens (Barrens) typically occupy low elevation exposures (< 1800 feet) on metabasalt substrates on southeast to southwest aspects, though they are most associated with lower to midslope positions on south and southwest aspects. Areas are characterized by moderately fractured, stepwise topography over the Catoctin Formation interspersed with soil beds that have been shown to be rich in calcium and magnesium (VA DCR 2007). Barrens commonly occur in complexes that are surrounded by xeric oak woodlands (Chestnut Oak & White Oak variants). Across barren complexes, physiognomy ranges from open woodlands with sparse, stunted canopies to prairie-like expanses of outcrops, ledges, as well as lichen- and moss-covered bedrock flats.
  Contemporary Barren Complexes are mixed-grass and forb dominated openings that exhibit mosaic spatial patterns with woodlands of predominantly *Quercus* species including *Quercus alba, Quercus coccinea, Quercus marilandica, Quercus prinus, Quercus stellata*, and *Quercus velutina*. *Quercus stellata* and *Quercus marilandica* notably increase in importance in open matrix woodland settings and/or in close proximity to barren complexes. Transition areas (edges) are frequently overgrown by overstory and midstory mixes of shade-tolerant trees including, but not limited to, *Carya glabra, Celtis occidentalis, Cercis canadensis, Fraxinus americanus, Juniperus virginiana*, and *Ostrya virginiana*. Discontinuous patches of *Rhus aromatica, Rosa carolina*, and *Symphoricarpos orbiculatus* dominate transition areas and, in some cases, open barren terraces. In open Barrens, typical herb assemblages are compositionally unique for the Park in that they support conspicuous swaths of C_4 grasses including *Bouteloua curtipendula, Schizachyrium scoparium, Sorghastrum nutans, Sporobolus clandestinus*, and *Sporobolus vaginiflorus*. *Danthonia spicata* and *Carex pensylvanica* are the dominant C_3 graminoids of open Barrens. Due to open growing conditions, herbaceous cover is comparatively rich and more continuously distributed throughout open barrens and matrix woodlands. Please note the list is typical of north district Central Appalachian Circumneutral Barrens, as originally described by VA DCR.
  No plots have been established.

- **Big Meadows Monitoring Type –** excerpted from a report by Wendy Cass, Botanist, Shenandoah National Park, 2/2/2011.

  Big Meadows is a 130 acre meadow dominated by grasses, sedges and short ericaceous shrubs (Figure1). Vegetation monitoring began in 1998 and is being used to describe the success of mowing and burning to maintain the Meadow as an open landscape.

  Vegetation monitoring takes place at 79 permanent 50 meter transects. Transect locations (Figure 2, Appendix A) and direction were randomly located using a stratified random design in 1998 / 1999 that was based on four meadow zones (east, central, north, and south) (Figure 2). However, the Meadow is currently managed in three zones (east, central, west) and sampling transects are currently sampled on a three year rotation that corresponds to the three management zones.

Since this monitoring program was established in 1998 it predates the fire ecology program. The fire effects crew and the SHEN botany crew work together to complete the monitoring each year.

Figure 1. Big Meadows, 2008.

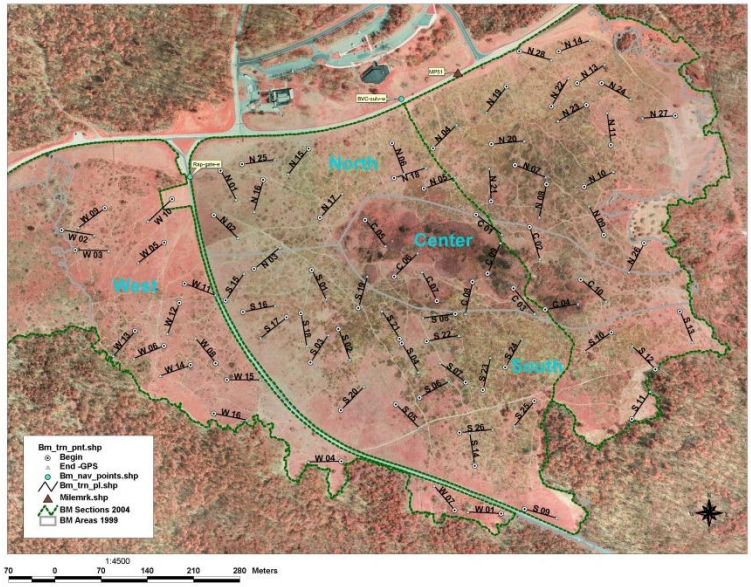


Figure 2. Image showing the location of the 79 Big Meadows sampling transects. Each transect measures 50 meters. The north, center, south, and west labels refer to the original zones used to stratify transects within the meadow. Current sampling and management actions use different zones (see Figure 4).

Assateague Island National Seashore (ASIS)
2011 Fire Effects Annual Report

Assateague Island is a 37-mile long barrier island located off the eastern coast of Maryland and Virginia. It is best known for its herds of feral horses, pristine beaches, and the Assateague Lighthouse. Assateague became a National Park in 1965 and together with the U.S. Fish & Wildlife Service Refuge and State Park, the land and water boundaries of Assateague Island total over 48,000 acres in Maryland and Virginia. Assateague Island National Seashore (ASIS) was established for the purpose of protecting Assateague Island in the states of Virginia and Maryland. Assateague is administered to provide recreational use and enjoyment consistent with the perpetuation and maintenance of the seashores natural environment.

Phragmites australis or common reed has been found in every U.S. state and is exponentially increasing in dominance in the coastal areas of the Eastern shore. Phragmites is a long-lived perennial that spreads rapidly by reproducing seeds and vegetatively by rhizome fragments. Rhizomes can grow several feet deep and stolons can grow horizontally 10 feet or more per year. The non-native invasive Phragmites reduces biological diversity in marshes by forming dense stands and crowding out native plants and wildlife that depend on these areas. Common reed is a serious threat to the rare and fragile habitat ASIS was established to protect.

In late Summer of 2008, 185 acres of Phragmites was aerially sprayed at Assateague Island National Seashore. In late winter of 2009, 200 acres were treated with prescribed fire to remove dead biomass and promote the re-establishment of native species. In 2010, an additional 260 acres were burned. The Northeast Region Fire Effects monitoring crew assisted the natural resource staff at Assateague Island National Seashore in monitoring the results of these spray and burn treatments with a newly designed monitoring scheme in 2010 and 2011. The monitoring design and results of this study were prepared by the parks ecologist Helen Violi.

ASSATEAGUE ISLAND NATIONAL SEASHORE

2011 Fire Effects Monitoring Summary

Assessing the efficacy of aerial herbicide spraying followed by burning in areas heavily infested with Phragmites australis

Prepared by: Helen Violi, Ecologist
2/1/2012

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Abstract
Aerial spraying and burning reduced the cover and density of non-native lineages of *Phragmites australis* on ASIS. Unfortunately, these treated areas are currently becoming re-infested at rates of between 19-24% per year. Restoration of several native plant taxa to treated areas occurred but have yet to approximate cover for untreated, "control" areas. Undesirable herbicide effects include invasion by other non-native plant species, an increase in the number and cover of undesirable "weedy" species and high woody plant mortality. Estimated infested acreage has dropped from over 500 to just ~200. However, the number of infestations detected has climbed from ~120 to over 1000. Many of these infestations have been detected in treated areas. Aggressive and rapid re-treatment of infestations in aerially sprayed areas is recommended and has a high probability of achieving control. Re-treatment can be performed using proven techniques that are unlikely to cause significant damage to the native plant community.

Project Overview
Non-native lineages of *Phragmites australis* (common reed or Phragmites) aggressively invade a wide range of plant communities throughout the United States, particularly along the Atlantic seaboard. On Assateague Island, the invasion of Phragmites has altered the structure and function of shrub and marsh ecosystems by reducing species diversity, nutrient cycles, and hydrological regimes. Phragmites also impacts recreational opportunities and overall visitor experience. Because it grows up to 6 m tall and forms dense monocultures, Phragmites blocks scenic vistas and renders areas unsuitable for many native birds and other wildlife species. This, in turn, has reduced opportunities for bird watching and viewing other wildlife. Phragmites also accumulates large amounts of above ground biomass, which increases the potential for wildfire. For large, monotypic stands of Phragmites on ASIS, aerially spraying herbicide (imazapyr) and burning were deemed necessary to significantly reduce the area infested with Phragmites and to promote the restoration of native vegetation.
A three year control effort (2008-2010) treated approximately 530 acres of Phragmites through aerial and ground-based application of herbicides. Over 188 and 260 acres were treated with imazapyr aerially in 2008 and 2009, respectively. Of these areas 197 acres were then burned in 2009 and another 326 acres 2010. Burns were conducted over 12 units (Fig. 1 and 2). Fire effects monitoring was conducted in 2010. The remaining acres were treated from the ground using several different techniques: cutting Phragmites and applying herbicide to stems, spraying herbicide using back-pack sprayers and from a skid sprayer mounted on a truck (Fig. 2).
Summary of GIS data

Analysis of spatial data indicates that aerially spraying and burning reduced the infested area by ~60%. One year post-treatment, significant reductions in remaining Phragmites infestations density (measured as percent cover) were also detected. However, two-years post-treatment, areas are becoming re-infested at rates between 19-24% per year. In these patches, cover doubled or tripled in most study plots between 2009 and 2010. This implies that treated stands will achieve their pre-treatment size and density several years after being aerially sprayed and burned,

Monitoring has also revealed that treated areas, perhaps in response to disturbance, are also becoming invaded by new populations of Phragmites. Overall remaining Phragmites populations (in treated and untreated areas) are mostly smaller, more numerous and more sparsely distributed across the landscape (Table 1).

In the summer of 2010, island-wide an aerial survey was conducted and ~1000 acres were ground-surveyed. Direct comparison of entire 2010 survey to the 2008 survey is difficult as ground-based survey methods may have differed. However, the 2008 aerial survey area can be compared to the same area surveyed in 2010 as survey methods were similar. Within this survey area, between 2008 and 2010 the number of infestations climbed from 119 to 379 but the estimated acreage dropped from 533 to 123. Three hundred and thirty four of these 2010 infestations occur in previously treated areas.

Analysis and Results for Fire Effects Monitoring Data

Plots were established in either burned, sprayed and burned or "control" areas post-treatment. Non-target effects associated with herbicide spraying and burning may have been severe per woody plant mortality data. Estimates of woody plant mortality are significantly higher in areas that have been aerially sprayed with herbicide and burned (ANOVA: $F_{2,35}$= 3.41, P< 0.0456). An estimated ~40% of mature woody plants are dead in both burned, and burned and sprayed areas, compared to ~17% in adjacent untreated areas (Fig. 3a). Mean dead woody plant cover is ~91% higher in these treated areas than in untreated areas (ANOVA: *NS*).

Analyses of plant species richness and for individual plant taxa were performed by dummy 83%coding treatments. Contrasts were between burned and unburned areas, or herbicide sprayed and unsprayed areas using a least squares regression. All areas sprayed with herbicide were also burned. All statistical analyses were performed in JMP. Statistical analyses were not performed on diversity indices (H') as the results of which are difficult to interpret.

Species richness is significantly higher in burned and sprayed areas; although, overall diversity is highest in control areas (Fig. 3; b, c and d). Cover by undesirable and non-native species is significantly higher in burned and sprayed areas (Fig. 3 e-h). Specifically, cover of non-native grasses, non-native forbs and sedges are all significantly higher in burned and sprayed areas. No significant differences in cover were detected for native forbs, shrubs, or rushes. Cover of non-native grasses, excluding Phragmites, was highest in burned and sprayed areas but did not differ from cover in control and burn only areas.

Plots were re-sampled in 2011 to document Phragmites rates of spread and cover change. In burned and sprayed areas, 90 percent of subplots were infested with Phragmites in both 2010 and 2011 (N = 100). Rate of spread increased in burned only and control areas in 2011 to 83% and 67% respectively (N = 120). This represents a 17% and 8% increase from 2010 estimates respectively. Change in Phragmites cover was over 259% in areas that were sprayed with herbicide and burned. Change in cover was much less in burned only areas and in control areas (Fig. 4). Burning alone did not appear to influence change in cover between 2010 and 2011 but did appear to be associated with high rates of spread. Areas that were sprayed with herbicide were associated with the greatest increase in Phragmites cover.

Management implications

Results from ASIS are similar to those found for other areas; typically, large well-established stands need to be treated every 3-5 years to maintain control. Aerial herbicide spraying and burning reduced the density and area of large, monotypic stands of Phragmites and increased cover by native plant species.

However, given current rates of Phragmites spread, further control efforts are urgently needed to prevent dense stands from becoming re-established in treated areas (Fig. 5). The presence of other non-native species in treated areas is cause for concern as several may have the potential to become invasive.

Burning was associated with significant mature woody plant mortality. Phragmites is well-adapted to fire whereas some native plants cannot tolerate burning in the coastal environment. All burn units are thought to have contained active infestations when burned. Future burning should only be attempted where complete control has been achieved. Aerially spraying and burning is more costly than ground-based treatments. Due to the additional expense, the negative non-target effects detected with fire effects monitoring, the high rates of re-infestation in treated areas and the high number of small infestations growing among native plants, the use of aerially spraying and burning has been suspended as a management strategy at ASIS.

Ground-based re-treatment of these areas by cutting and/or herbicide application should result in Phragmites control. If herbicide is applied using traditional ground-based methods (such as stem treatments, a wick applicator or backpack sprayer), damage to the native plant community can be minimized. Greater use of glyphosate in late summer/fall should also reduce damage to native plants as imazapyr is associated with greater damage to non-target plants.

Management Needs

The high number of infestations and high rates of spread for Phragmites in previously managed areas along ASIS is of concern to park resource managers. However, it is unclear as to whether these sites have always provided the conditions under which Phragmites has a competitive advantage and/or if aerially spraying and burning created more favorable conditions for Phragmites. These relatively large infestations were presumed to represent some of the oldest stands of Phragmites on ASIS. Monitoring has revealed that infestation spread is highly variable across ASIS. Resource management staff have proposed the construction of a simple GIS-based model to help determine what conditions are most important to predicting Phragmites occurrence and spread. Hopefully, following completion of the model, it will be possible to determine if the sites that have recently been aggressively managed provide superior conditions for Phragmites growth independently of spraying and burning. Routine monitoring of these areas remains a critical need.

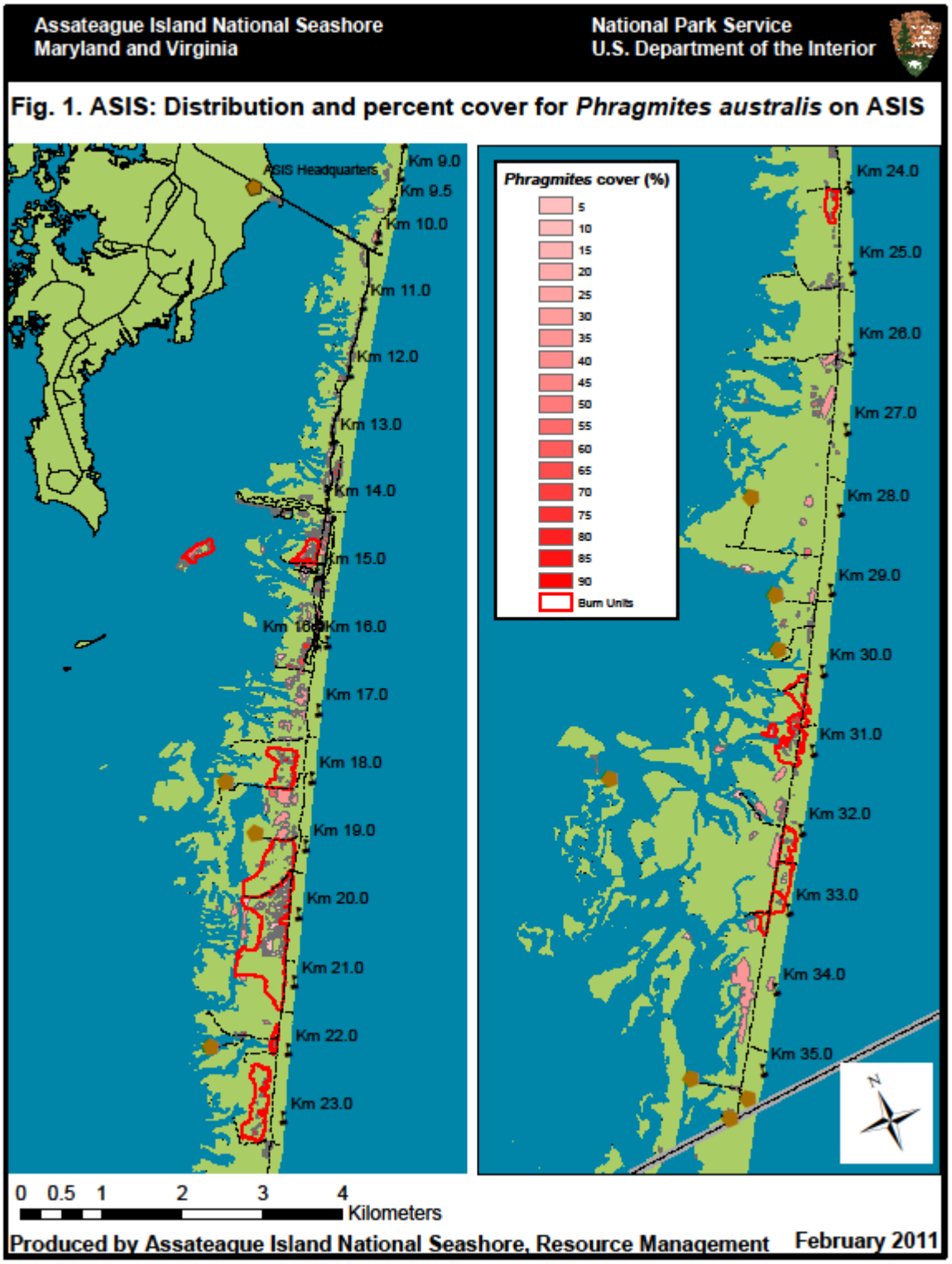

Fig. 1. ASIS: Distribution and percent cover for *Phragmites australis* on ASIS

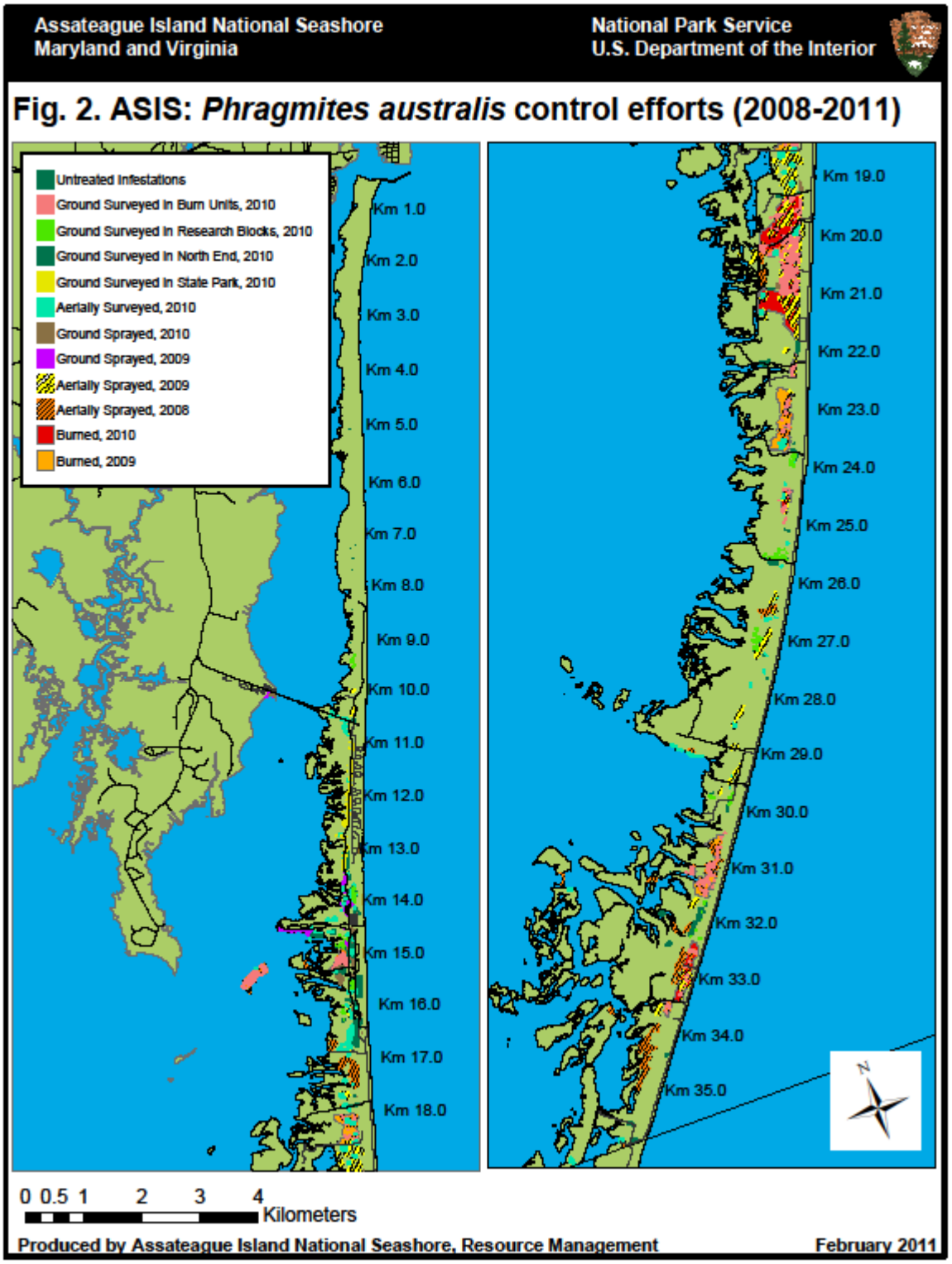

Fig. 2. ASIS: *Phragmites australis* control efforts (2008-2011)

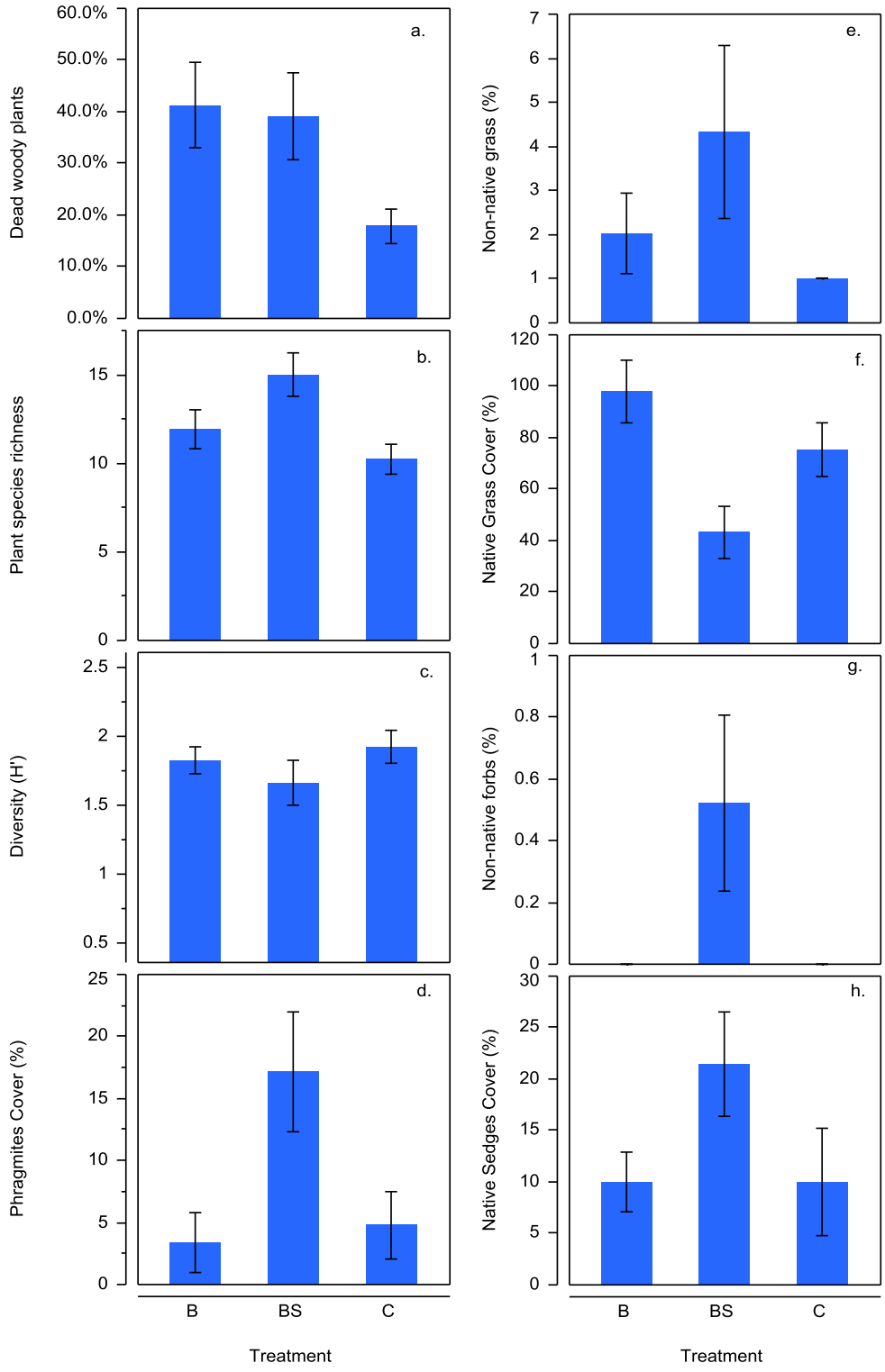

Fig. 3. Study areas include burned (B), burned and herbicide sprayed (BS) and controls (C). Woody plant mortality (ANOVA: $F_{2,35}$= 3.41, P< 0.0456).;b. Plant species richness (Burn = *NS*; Spray, *t ratio*= 2.44, P< 0.020).;c. Diversity (no statistical analyses performed on indices) ;d. Phragmites cover (Burn = *NS*; Spray, *t ratio* = 2.71, P< 0.011).;e. Non-native grass species excluding Phragmites (Burn = *NS*; Spray = *NS*).;f.

Native grass cover (Burn = *NS*; Spray, *t ratio* = 2.54, P< 0.016).;g. Non-native forbs (Burn = *NS*; Spray, *t ratio* = 2.34, P< 0.026) and h. Native sedges (Burn = *NS*; Spray, *t ratio* = 2.08, P< 0.045). Each error bar is constructed using 1 standard error from the mean. N = 35 for all tests.

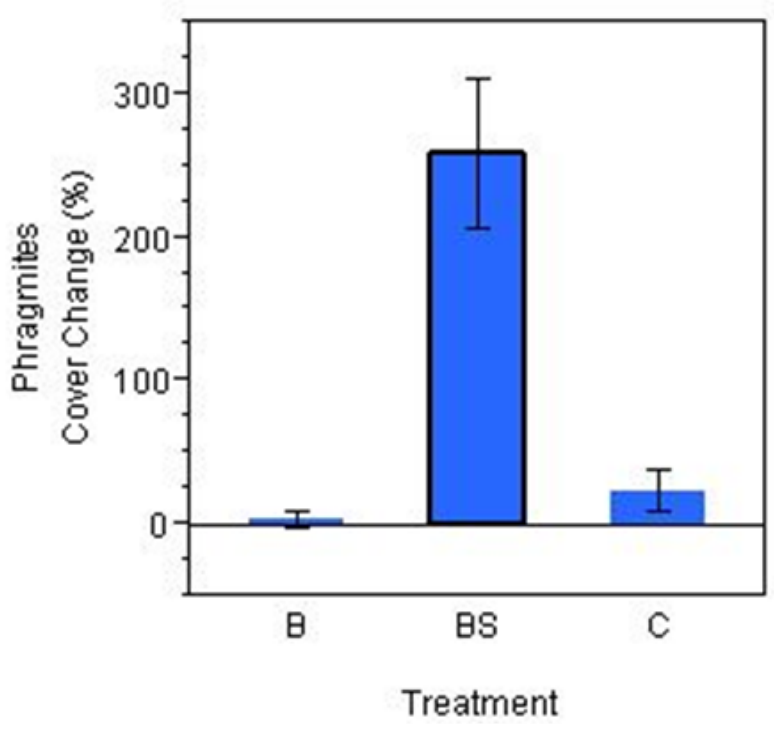

Figure 4. Percent change in Phragmites cover between 1 m^2 subplots in different study areas monitored in September 2010 and again in September 2011. Study areas include burned (B), burned and herbicide sprayed (BS) and controls (C). Areas treated with herbicide were clearly associated with the greatest increase in Phragmites cover whereas burning was not associated with high growth rates independently of herbicide (Contrasts: Burning [1-0]= *NS*; Spray [1-0], *t ratio* = 6.30, P< 0.0001). Twenty subplots were excluded in burned and sprayed areas of burn unit 2. This was necessary as these plots were almost completely infested with Phragmites and were re-treated. N = 120 for B and C and N = 100 for BS. Each error bar is constructed using 1 standard error from the mean.

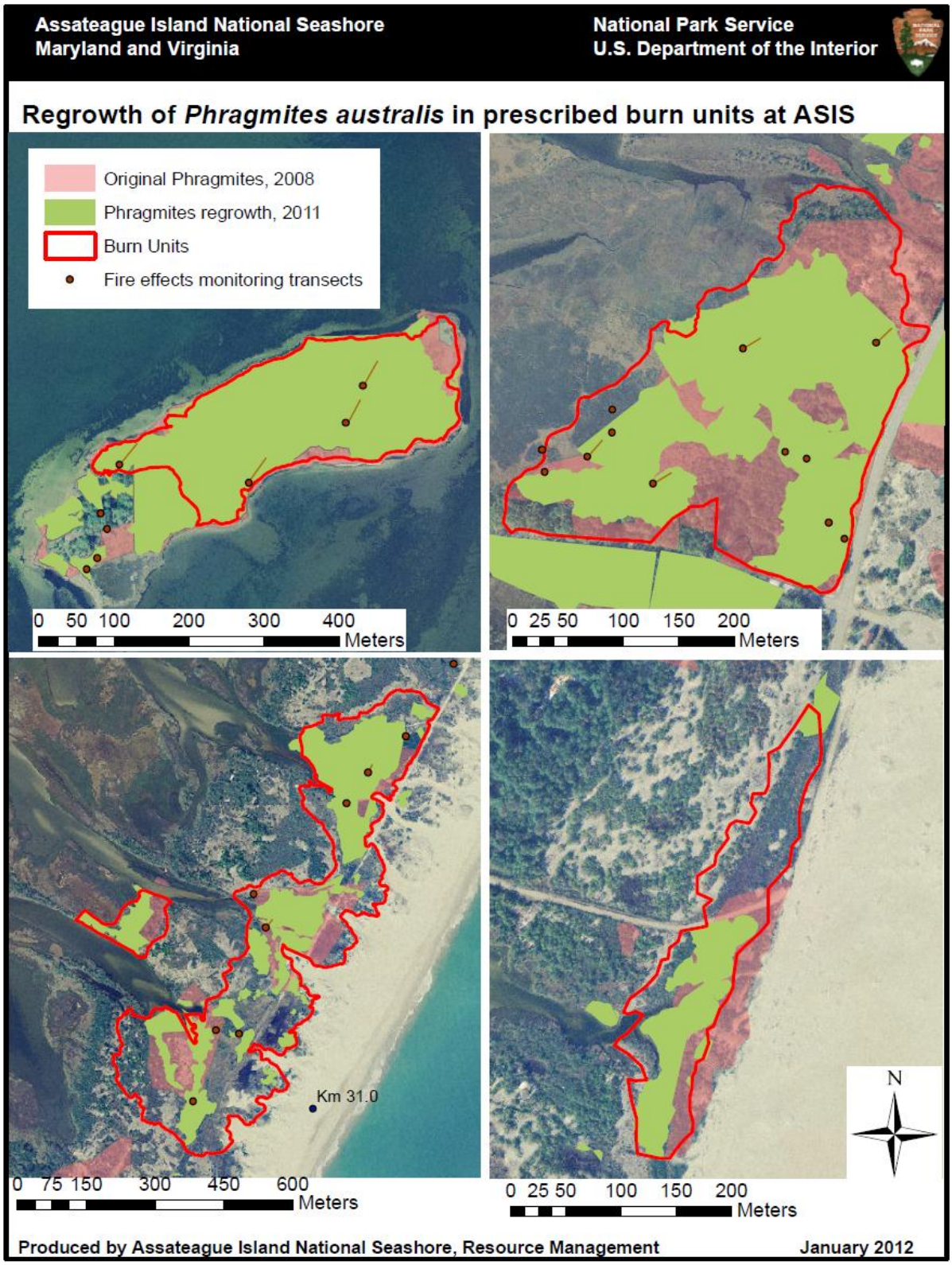

Figure 5. Regrowth of Phragmites in several prescribed burn units on ASIS.

Table 1. A comparison of *Phragmites australis* infestations observed in 2008 and 2010.

	2008			2010*		
	Number of Infestations	Acres	Average % Phragmites Cover	Number of Infestations	Acres	Average % Phragmites Cover
Forest	6	9.99	56.67	14	1.17	55.00
Marsh	13	17.27	70.00	75	12.53	47.36
Marsh/Forest	3	2.96	70.00	0	0.00	0.00
Shrub	85	328.35	54.47	258	55.35	46.34
Shrub/Forest	7	33.62	47.14	149	41.15	53.24
Shrub/Marsh	4	125.40	42.50	465	93.16	42.21
Shrub/Marsh/Forest	1	16.09	70.00	53	8.30	24.17
Total	119	533.68	55.97	1014	211.66	36.95

*Note: Survey area in 2010 included Assateague State Park.

APPENDIX A

Prioritizing forest communities and areas for the use of prescribed fire at Shenandoah National Park

Final Report Submitted to the National Park Service – November 2011

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Appendix 1. Contact information and affiliation for the participants involved in prioritizing and determining prescribed fire management at Shenandoah National Park. 29

Appendix 2. Calculations to match Steiner et al. (2008), Brose et al. (2008), and Jenkins et al. (2011) proffered guidelines for assessing success of oak and pine regeneration with Fire Monitoring Handbook (FMH) seedling protocols for fire ecology utilized by Mountains To The Sea National Parks in Virginia (MTTS). 30

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Introduction

National Park Service (NPS) units are mandated to ensure that wildland fire is fully integrated into land management planning. Director's Order #18: Wildland Fire Management (DO-18) (USDI National Park Service 2008) outlines National Park Service fire management policies, which are expanded upon in Reference Manual-18: Wildland Fire Management (RM-18) (National Park Service 2008). Both of these documents state that the National Park Service will manage wildland fire to protect the public, communities and infrastructure, conserve natural and cultural resources and maintain and restore natural ecosystems and processes. The objective of this project is to assist park managers in prioritizing the use of prescribed fire at Shenandoah National Park in order to foster and maintain fire dependent ecosystems. This project directly supports three of the mission goals of the National Park Service including 1) restoring and maintaining fire adapted ecosystems 2) science based management 3) integrating wildland fire with other NPS programs. The park's Resource Management Plan (RMP) states that management ignited prescribed fires are essential to the restoration of ecological integrity of Shenandoah National Park. Furthermore, priorities for prescribed fire planning must be well integrated with ecological understanding and monitoring efforts.

Throughout several one day workshops in late 2010 and 2011, biologists, ecologists, data managers and fire planners met to identify fire adapted vegetation communities and develop a simple spatial model. Moreover, it was determined during these meetings that park mangers wished to define target desired future conditions for each of the identified fire adapted vegetation communities. Broad target conditions were defined through literature review, consultation with Fire Learning Networks and academic researchers. In the future it is expected that additional selection criteria will be added to the model which will lead to project re-prioritization.

Shenandoah National Park (SHEN) is located along the Blue Ridge Mountains in northwestern Virginia and lies closer to more people than does any other national park in the country (Connors 1988). There are 197,438 acres in the park, including 79,579 acres of designated wilderness. The park is divided into three management districts: north, central, and south. Elevations in the park range from 595 ft (181 m) at Front Royal to 4,049 ft (1,234 m) at the top of Hawksbill Summit. One particular aspect of the park is its 105 mile Skyline Drive, which runs the entire length of the park and was one of the first recreational highways of its types in the United States when it was opened to the public in 1934 (Connors 1988). The park also contains 101 miles of the Appalachian Trail, the nation's longest marked footpath (2,175 miles) and first national scenic trail, designated in 1968.

Approximately 93% of SHEN is dominated by second-growth forest, 2 percent is covered by wetland communities, and approximately 3 percent of the area is occupied by other vegetation communities such as barrens. Roughly 2 percent of the park is developed or disturbed by humans and includes drivable roads, parking lots, powerline right-of-ways, and building facilities (Young et al. 2009).

Vegetation of Shenandoah National Park

The composition of the second-growth forest at SHEN has been influenced by the topography, climate, geology, and natural disturbance regimes of the northern Blue Ridge Mountains, as well as by historic land use and other anthropogenic disturbances. Braun (1950) defines the Northern Blue Ridge as a forest section of the Oak-Chestnut Forest region. However, the loss of American chestnut (*Castanea dentata*) in the early 1900s changed the forest composition of the region. SHEN currently resembles the

Oak-Hickory Forest region also described by Braun (1950) and 40% of the cover is comprised by oaks with hickories as secondary components. Due to a history of disturbance, SHEN represents one of the nation's most diverse botanical reserves, contains globally rare plant communities, and is an outstanding example of the Northern Blue Ridge Forest (National Park Service 1998). There are 1406 vascular plant species in Shenandoah National Park.

Young et al. (2009) built upon the earlier work of Berg and Moore (1941), Braun (1950), and Teetor (1988) in classifying the vegetation associations (VA) of SHEN in relation to physical processes (e.g., climate), landforms (e.g., geology and topography), and disturbance regimes (e.g., fire and prior land use history). Using the United States National Vegetation Classification System approach, Young et al. (2009) completed a mapping and distributional study of the plant communities of SHEN. Their research identified 35 vegetation associations, including 24 forest and woodland communities, one shrubland community, five wetland/seep communities, and five barren communities. These vegetation communities ranged from low- (<457 m [1,500 ft]), to mid- (458–913 m [1,500–3,000 ft]), to high- (>914 m [3,000 ft]) elevation sites and are found on acidic and basic soil types (Young et al. 2009). Two of the communities identified by this effort, the High-Elevation Greenstone Outcrop Barren and the Northern Blue Ridge Mafic Fen, are endemic to SHEN (Young et al. 2009).

Fire History and Fire Tolerant Vegetation Associations at Shenandoah National Park

Prior to 1750, fires intentionally set by American Indians were used to achieve a variety of results, including clearing land for agriculture, assisting in the management of favored vegetation, clearing routes of travel, herding game, and even waging war on neighboring tribes (Lambert 1989; Abrams 1992; Brose et al. 2001). From 1750–1930, increased European settlement augmented the frequency and intensity of disturbances in and around the park maintaining and, perhaps, expanding the oak-hickory and pine component in the forests (Brose et al. 2001). These fires probably varied in intensity and exerted a considerable influence upon vegetative composition. One effect may have been creating a forested landscape in which oak and hickory and, in some areas, pine were a dominant component of forests (Abrams 2005). In particular, the thick bark of oak, their ability to re-sprout from root stock after surface fires, the rapid germination of acorns on fire prepped forest floor, and the removal of competing species are all ways in which fire promotes the spread and persistence of oak (Abrams 1992). Zobel (1969) found fire scarring almost ubiquitous in stands of table mountain pine that he studied throughout the Appalachians, including the Blue Ridge. Fire contributes to maintenance of pines by removing the leaf litter layer, opening the canopy, releasing seed, and killing competing vegetation (Zobel 1969; Williams 1991). Since 1930, however, effective and active fire suppression effort in the United States has probably limited the regeneration of oak and pine forests at SHEN as well as central and southern Appalachia (NPS 2005). Researchers have found on xeric sites oak and pine were unsuccessful at regenerating in a disturbance regime lacking an adequate component (Brose et al. 2010)

There are four xeric-oak vegetation monitoring types at SHEN and pine forests at SHEN are represented by the central Appalachian pine – oak /heath woodland association (CEGL00#-4996). (Table 1; Mazzeo 1966; Young et al. 2009). These pines are all associated with dry, sterile soil and open areas (Mazzeo 1966). As in other parts of the Appalachians, the pine communities at SHEN are associated with westerly aspects on the upper slopes, shallow soils, xeric, and infertile habitats. In addition, pine communities occur on sites that are rapidly drained, acidic, and nutrient poor and may be maintained through periodic fire. The native southern pine beetle (SPB) also contributes a cyclic disturbance in the

Appalachians. The long term coexistence suggests that both fire and the insect have interacted to perpetuate yellow pine forests through mortality and regeneration (Jenkins et al., 2011). Jenkins et al., (2011) suggests that the SPB may have acted as a silvacultural shelterwood harvest in the maintenance of these systems. Frequent low surface fires coupled with an open structure from pine beetle mortality may have created the conditions necessary for pine regeneration (Jenkins et al., 2011; Brose et al., 2006).

Historical records indicate that the Blue Ridge province was the most fire prone area in the central Appalachian Mountains of Virginia and West Virginia from natural ignitions. (Lafon et al. 2007). Fire potentially could be used to restore and maintain an oak and pine component in the park's forests through the use of prescribed fire and allowing natural ignitions to burn. In particular, the vegetation associations of central Appalachian / northern piedmont chestnut oak (*Quercus prinus*) forest (CEGL00#-6299), low elevation mixed oak / heath forest (CEGL00#- 8521), central Appalachian dry chestnut oak – northern red oak (*Quercus rubra*) / heath forest (CEGL00#-8523), central Appalachian acidic oak-hickory forest (CEGL00#-8515), and central Appalachian dry-mesic chestnut oak-northern red oak forest (CEGL00#-6057) may benefit from the use of fire to promote regeneration. Without some fire or management for oak regeneration disturbance management, oaks may decline in SHEN to below pre-European settlement distributions (Brose et al. 2001). CEGL stands for Community Element Global and is most correctly referred to as the United States national vegetation global element code. Community type associations represent stands of vegetation of relatively homogeneous composition that share a set of characteristic species and recur on the landscape under similar environmental conditions. Association is the lowest and most detailed level of the United States National Vegetation Classification system (USNVC). A total of 40 vegetation community type associations have been described and 35 communities have been mapped at Shenandoah National Park (five communities were smaller than the minimum mapping unit).

At SHEN, the greatest chance for the use of fire to successfully regenerate oak will occur on xeric sites due to limitations from competing species and more sunlight reaching the forest floor. However, deer herbivory and nonnative species invasion are issues of concern on sites that have been treated by prescribed burning (T. Schuler, United States Forest Service, pers. comm., 2003). If prescribed fire is used in oak forests (or if natural fires are permitted to burn in this forest type) an overstory tree mortality rate of 15 percent (for low-fire intensity) to 67 percent (for high-fire intensity) can be expected (Regelbrugge and Smith 1994). In addition, data collected after the SHEN Complex Fire of 2000 reveals that low intensity fires killed the above ground portions of most saplings and shrubs, but eventually stimulated understory growth. Blackberry (*Rubus* spp.), mountain laurel (*Kalmia latifolia*), sassafras (*Sassafras albidum*), and black birch (*Betula lenta*) were the most common seedlings found post-fire. Northern red oak and black locust (*Robinia pseudoacacia*) saplings also increased post-fire (Cass 2002).

Methods

In a first step to prioritizing the use of prescribed fire to manage vegetation communities at SHEN, the vegetation associations that are tolerant of fire and require fire for regeneration and perpetuation were determined (Table 1). To that end, an initial meeting was held at the United States Geological Survey (USGS) Science Center in Leetown, West Virginia in May 2010 with several one-day follow up meetings held at SHEN in October 2010, January 2011, and March 2011. Over the course of these meetings, we focused on the goals and desired outcomes of the project and the project evolved from one focusing on general vegetation management at SHEN to one focusing on prioritizing the use of fire as a vegetation management tool. A variety of ecologists, botanists, and natural resource managers participated, to some degree, in one or more of these meetings. Participants represented state, federal, and non-profit organizations (Appendix 1).

After discussion and input at these meetings, we constructed a simple spatial model to assist in fire management prioritization of vegetation at SHEN. Inputs to the model included a map of vegetation associations (Young et al. 2009), maps of fire history boundaries and locations (D. Hurlbert, NPS-SHEN), and a map of search and rescue compartments for the park defined along ridgetops, streams, and trails (D. Hurlbert, NPS-SHEN). Additional data layers included maps of the park boundary, a map of fire suppression areas (M. Forder, NPS-SHEN), maps of cultural and historic districts (D. Hurlbert and A. Williams, NPS-SHEN) and maps of rare species locations (W. Cass and A. Williams, NPS-SHEN). Vegetation associations were recoded into five classes of fire tolerance based on consultations with botanists (G. Fleming, Virginia Natural Heritage, and W. Cass, NPS-SHEN) and a fire ecologist (M. Forder, NPS-SHEN) such that the most fire tolerant community (Central Appalachian Pine - Oak / Heath Woodland, CEGL#00-4996 was assigned a value of 1 and the least fire tolerant communities (e.g. Central Appalachian Acidic Seepage Swamp, CEGL00#-7853) were assigned a value of 5 (Table 1).

Vegetation association maps are represented as a raster Geographic Information Systems (GIS) layer with a resolution (cell size) of 17 by 17 meters (0.029 hectares, 0.07 acres). This raster representation formed the framework for the rest of the analysis (Figure 1).
Fire history maps were represented as polygons of historic fires boundaries (1925-2009) coded with year burned. Additional records of historic fires were available that were represented as point locations with attributes of years burned and fire control acres. We created polygons around the fire centroids equivalent in area to the recorded acreage burned. We converted all fire history polygons to a raster representation and combined them such that we could calculate the following information for every 17x17 meter pixel (ground area) in the park: (1) the most recent year burned (Figure 2); (2) the number of times burned (or whether the area has never burned) since fire records were kept (1925); (3) the average return interval in years between fires.

Table 1. Vegetation association and fire tolerance codes for communities at Shenandoah National Park. Only communities coded very tolerant (1) through somewhat tolerant of fire (3) are included in the table.

Monitoring Type	CEGL[a]	Fire Tolerance	Vegetation Association Name	USNVC Name[b]	Information from Vegetation Map Report[c]
Pine-Oak	4996	1	Central Appalachian Pine - Oak / Heath Woodland	*Pinus (pungens, ridiga) - Quercus prinus / (Quercus ilicifolia) / Gaylussacia baccata* Woodland	Shenandoah National Park stands are usually located on xeric upper slopes and crests, with south to northwest aspects. Elevational range in the park is about 470 to 970 m (1550-3180 feet). Physiognomy of existing stands varies from open shrubland nearly lacking an overstory (because of mortality from pine beetles) to nearly closed forest in fire-suppressed situations. *Pinus rigida* (pitch pine) appears to be the dominant pine in the majority of park stands, with fewer stands dominated by *Pinus pungens* (Table Mountain pine) or codominated by the two species. On marginal, fire-suppressed sites, this community may be difficult to distinguish from more xeric variants of CEGL006299. In most cases, it can be distinguished by its more open, woodland physiognomy, the prominence of *Pinus* (pine) spp., and its very dense, multi-tiered shrub layer dominated by *Quercus ilicifolia* (bear oak) and/or ericads.
Pine-Oak	8540	3	Central Appalachian Xeric Chestnut Oak - Virginia Pine Woodland [cliff community]	*Pinus virginiana - Quercus prinus - (Pinus pungens) / Schizachyrium scoparium - Dichanthelium depauperatum* Woodland	This association is known from scattered outcrops of all the major geologic classes of the park. Sites are steep, solar-exposed, mid- and upper-slope outcrops with veneers and pockets of shallow, low-fertility soils. Vegetation type is a mixed woodland with more or less equal dominance by oaks and pines. Stands are typically stunted, with trees less than 10 m tall and often somewhat gnarled. This community is most similar to variants of CEGL004996 that occur on xeric outcrops. These variants typically contain mixtures of *Quercus prinus* (chestnut oak), *Pinus pungens* (Table Mountain pine), and *Pinus rigida* (pitch pine), with ericaceous shrubs and *Quercus ilicifolia* (bear oak) occupying crevices and shallow soil mats.
Xeric-Oak	6299	2	Central Appalachian / Northern Piedmont Chestnut Oak Forest	*Quercus prinus - (Quercus coccinea, Quercus rubra) / Kalmia latifolia / Vaccinium pallidum* Forest	In Shenandoah National Park, this community is generally associated with dry, infertile slopes from the lowest elevations commonly up to about 915 m (3000 feet). Stands have overstories that vary from very open to closed. Overstory trees are often somewhat stunted and gnarled. *Quercus prinus* (chestnut oak) is generally the sole canopy dominant, often in nearly pure stands. Less frequent mixed stands may be codominated by *Quercus coccinea* (scarlet oak), *Quercus velutina* (black oak), and/or *Quercus rubra* (northern red oak). The ericaceous species *Kalmia latifolia* (mountain laurel), *Gaylussacia baccata* (black huckleberry), and *Vaccinium pallidum* (Blue Ridge blueberry) heavily dominate the shrub layer in variable combinations, usually covering 25-75% (occasionally nearly 100%) of a given area. As site moisture and/or soil fertility increase, this type can intergrade with CEGL008523, which generally has *Quercus rubra* (northern red oak) as a codominant, a greater number of tree and shrub associates, a more patchy ericad component, and significantly higher herb richness. A few stands at higher elevations are also transitional to CEGL006299. At the xeric end of the site gradient, it may intergrade with CEGL004996.

Table 1 (continued). Vegetation association and fire tolerance codes for communities at Shenandoah National Park. Only communities coded very tolerant (1) through somewhat tolerant of fire (3) are included in the table.

Monitoring Type	CEGL[a]	Fire Tolerance	Vegetation Association Name	USNVC Name[b]	Information from Vegetation Map Report[c]
Xeric-Oak	8521	2	Low-Elevation Mixed Oak / Heath Forest	*Quercus alba - Quercus (coccinea, velutina, prinus) / Gaylussacia baccata* Forest	All park sites are gentle (0- to 10-degree) lower slopes and flats at very low elevations (<567 m).The vegetation is a closed to very open oak forest with mixed and variable canopy dominance by *Quercus alba* (white oak), *Quercus coccinea* (scarlet oak), and *Quercus prinus* (chestnut oak). Various *Pinus* (pine) spp., including *Pinus virginiana* (Virginia pine), *Pinus echinata* (shortleaf pine), *Pinus strobus* (eastern white pine), and *Pinus rigida* (pitch pine), are frequent overstory associates, particularly following fire or logging disturbances.
Xeric-Oak	8523	2	Central Appalachian Dry Chestnut Oak - Northern Red Oak / Heath Forest	*Quercus prinus - Quercus rubra / Vaccinium pallidum - (Rhododendron periclymenoides)* Forest	It ranges from 260 to 1060 m (850-3480 feet) elevation. This association tends to occur on moderately steep to gentle, usually straight or convex upper slopes with infertile soils and warm aspects. It occupies the middle portion of the environmental gradient between the shallow, very infertile soils occupied by Central CEGL006299 and the more fertile soils occupied by several oak-hickory forests. It can be distinguished from CEGL006299 by its higher overall species richness, a more diverse herb flora, greater importance of *Quercus rubra* (northern red oak) in the overstory, and lower importance of *Kalmia latifolia* (mountain laurel) in the shrub layer. Compared to CEGL008516 and CEGL008514, it has lower overall species richness, a less diverse and dense herb flora, a more abundant ericaceous shrub component, and an overstory that lacks a dominant hickory component.
Xeric-Oak	8515	2	Central Appalachian Acidic Oak - Hickory Forest	*Quercus alba - Quercus prinus - Carya glabra / Cornus florida / Vaccinium pallidum / Carex pensylvanica* Forest	This association is apparently restricted in the park to very low elevations up to 485 m (1600 feet). This vegetation probably occupies less fertile sites on the same shaly soils that support CEGL008516 at higher elevations. Distinguished from other oak-hickory forests in the park by its occurrence on metasedimentary substrates at very low elevations, by the strong dominance of *Quercus alba* (white oak), and by the presence of low-elevation xerophytes such as *Pinus virginiana* (Virginia pine), *Quercus stellata* (post oak), and *Quercus marilandica* (blackjack oak).
Mesic Oak	3683	3	Central Appalachian Basic Woodland	*Fraxinus americana - Carya glabra / Muhlenbergia sobolifera - Helianthus divaricatus - Solidago ulmifolia* Woodland	In Shenandoah National Park, this community type occurs on steep, southeast- to southwest-facing, very rocky slopes often forming a woodland matrix around large cliffs and outcrops. Elevation ranges in the park from 425 to 790 m (1400-2600 feet). Documented sites were generally assessed as xeric. This association is a woodland dominated by *Fraxinus americana* (white ash) and *Carya glabra* (pignut hickory), occurring in dry, rocky, fertile soils. Vegetation consists of open to very open woodlands with stunted canopies of 6- to 15-m tall trees.

Table 1 (continued). Vegetation association and fire tolerance codes for communities at Shenandoah National Park. Only communities coded very tolerant (1) through somewhat tolerant of fire (3) are included in the table.

Monitoring Type	CEGL[a]	Fire Tolerance	Vegetation Association Name	USNVC Name[b]	Information from Vegetation Map Report[c]
Mesic Oak	6057	3	Central Appalachian Dry-Mesic Chestnut Oak - Northern Red Oak Forest	*Quercus prinus - Quercus rubra / Hamamelis virginiana* Forest	In Shenandoah National Park, this mixed oak forest community occurs from the lower elevations to at least 1000 m (3300 feet). Shenandoah National Park stands are somewhat variable in composition. However, *Quercus prinus* (chestnut oak) and *Quercus rubra* (northern red oak) are consistently present and codominant in the overstory, although each may dominate small areas within stands. Only rarely does an individual ericaceous species cover more than 10% in a plot. sample. It can be distinguished from CEGL006299 and CEGL008523 by its more mesic habitats, more diverse woody composition, lower density/cover of ericaceous species, and much greater diversity of low-cover herbaceous species
Mesic Oak	8516	3	Central Appalachian Montane Oak - Hickory Forest (Acidic Type)	*Quercus prinus - Quercus rubra - Carya ovalis / Solidago (ulmifolia, arguta) - Galium latifolium* Forest	This forest community is restricted to the upper flanks and crests of ridges in the south district.Classification Comments: This association is similar to CEGL008514, which occurs at somewhat lower elevations CEGL008515 which occurs at much lower elevations in the park. This association has an open, mixed canopy dominated by several oaks and hickories. Trees tend to be slightly stunted (often <20 m tall) on the drier and more exposed sites. *Quercus prinus* (chestnut oak) and *Carya ovalis* (red hickory) are the most abundant canopy species, but *Quercus rubra* (northern red oak) is a constant, sometimes codominant associate.
Mesic Oak	8514	3	Central Appalachian Basic Oak - Hickory Forest (Submontane / Foothills Type)	*Quercus rubra - Quercus prinus - Carya ovalis / (Cercis canadensis) / Solidago caesia* Forest	Shenandoah National Park stands of this association occur on lower- to middle-elevation slopes from 365 to 850 m (1200-2800 feet) elevation. This association is a true oak-hickory forest with mixed canopy dominance by several *Quercus* (oak) spp. and *Carya* (hickory) spp. *Carya ovalis* (red hickory), *Quercus rubra* (northern red oak), and *Quercus prinus* (chestnut oak) are consistent codominants.
Mesic Oak	8506	3	Northern Red Oak Forest (Pennsylvania Sedge - Wavy Hairgrass Type)	*Quercus rubra - Quercus alba / Ilex montana / Dennstaedtia punctilobula - Carex pensylvanica - Deschampsia flexuosa* Forest	In Shenandoah National Park, this type is limited to gentle, mostly convex slopes and crests on the highest metabasalt and granitic ridges. All but one stand occur above 915 m (3000 feet) elevation. It forms an extensive, almost continuous patch from the vicinity of Big Meadows north to the vicinity of The Pinnacle and Marys Rock. Smaller, outlying patches occur on Hightop, Stony Mountain, The Sag, Mount Marshall, Hogback and other high-elevation ridges.

[a] CEGL stands for Community Element Global and is most correctly referred to as the United States national vegetation global element code.

[b] USNVC stands for United States National Vegetation Classification System.

[c] Young, J., G. P. Fleming, W. B. Cass, and C. Lea. 2009. Vegetation of Shenandoah National Park in relation to environmental gradients, version 2.0. Technical Report NPS/NER/NRTR-2009/142. National Park Service, Philadelphia, Pennsylvania.

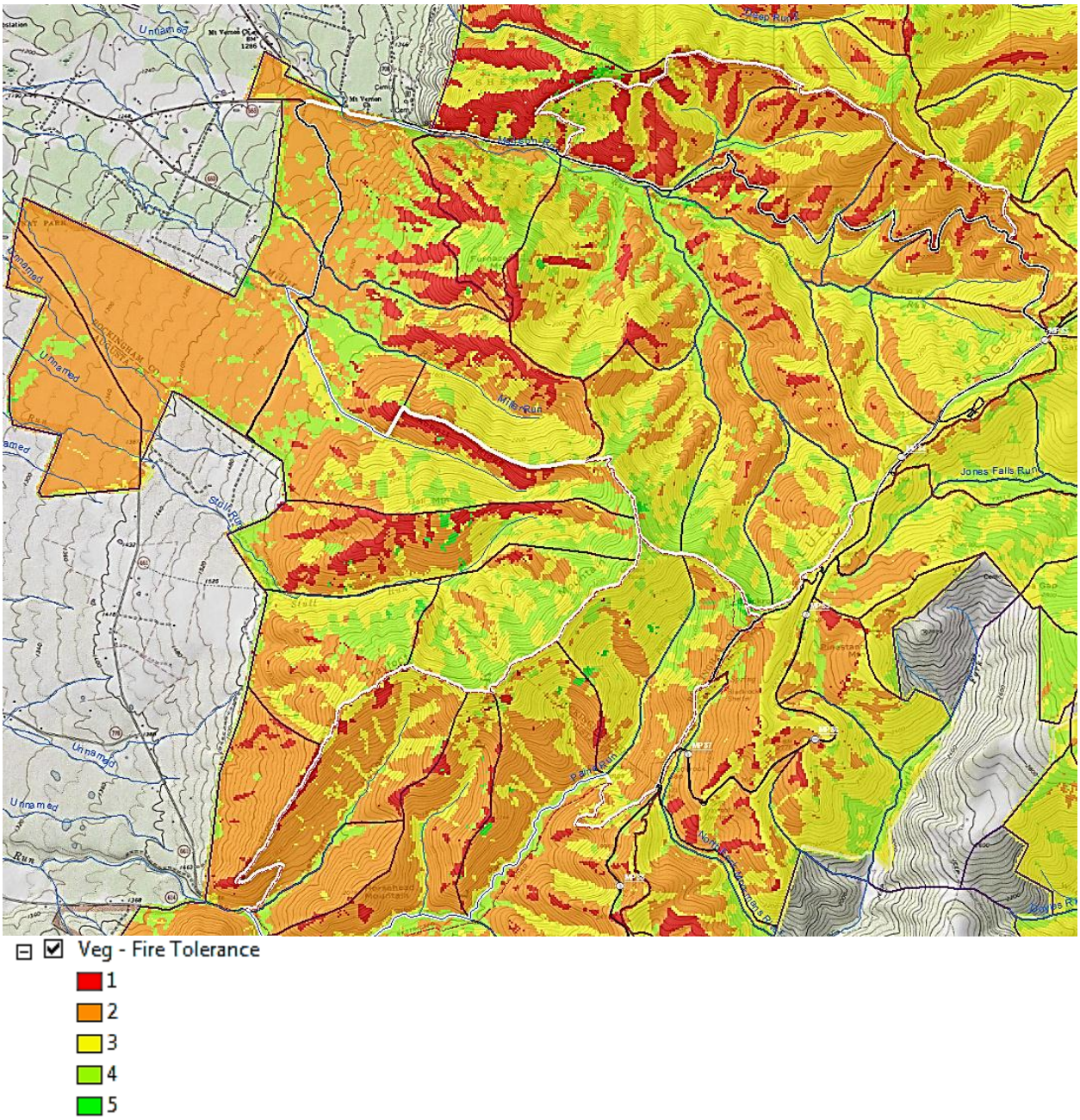
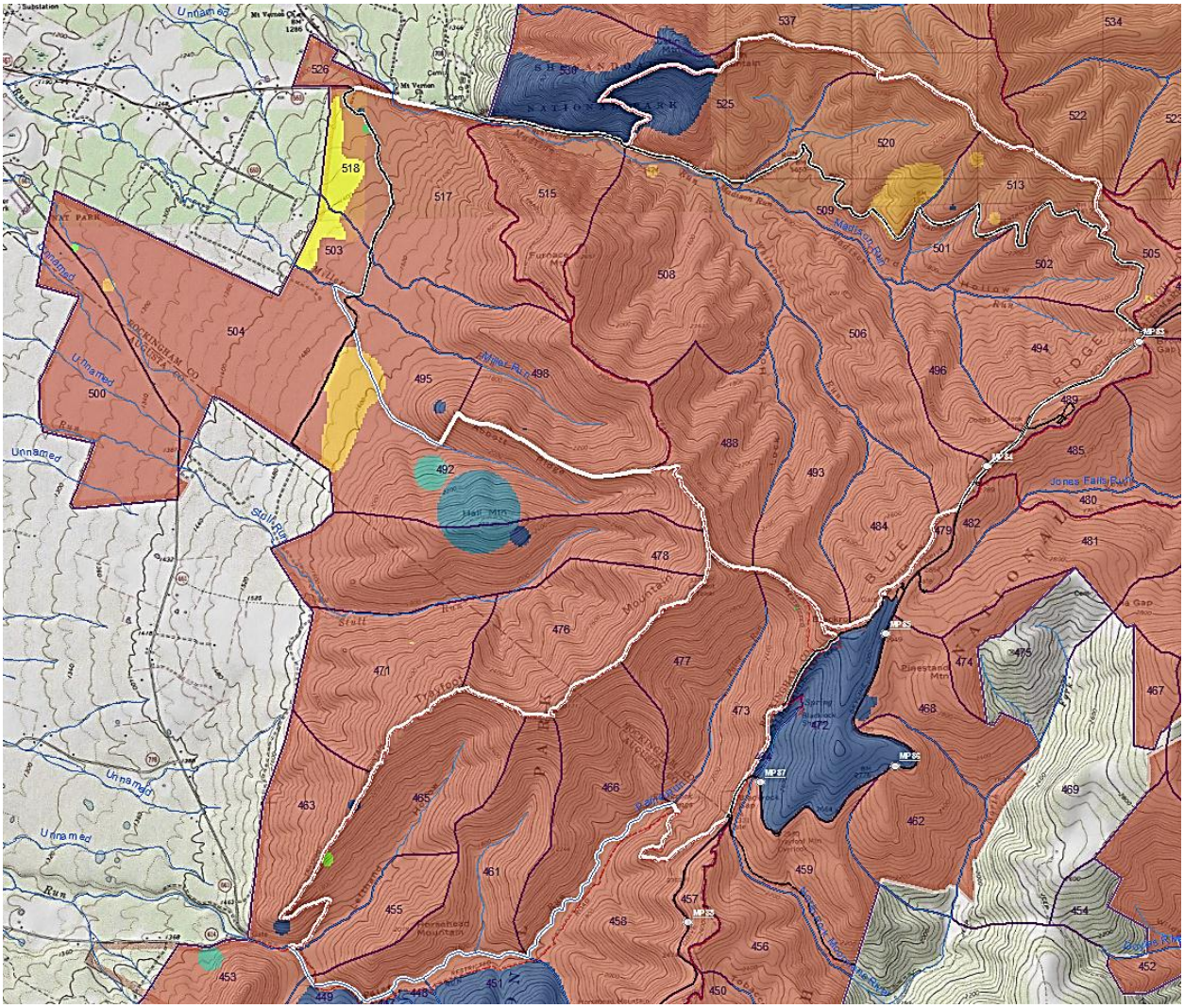


Figure 1. Fire tolerance code map based on vegetation community showing the Blackrock and Trayfoot areas of SEHN. Also shown are lines depicting search and rescue compartments (purple), fire planning units (white), roads (black), and trails along ridgelines (red dashed). The highest fire tolerances have the lowest numbers and are depicted by red and orange on the map. The lower fire tolerances are shaded in green.



Years since burned

Value

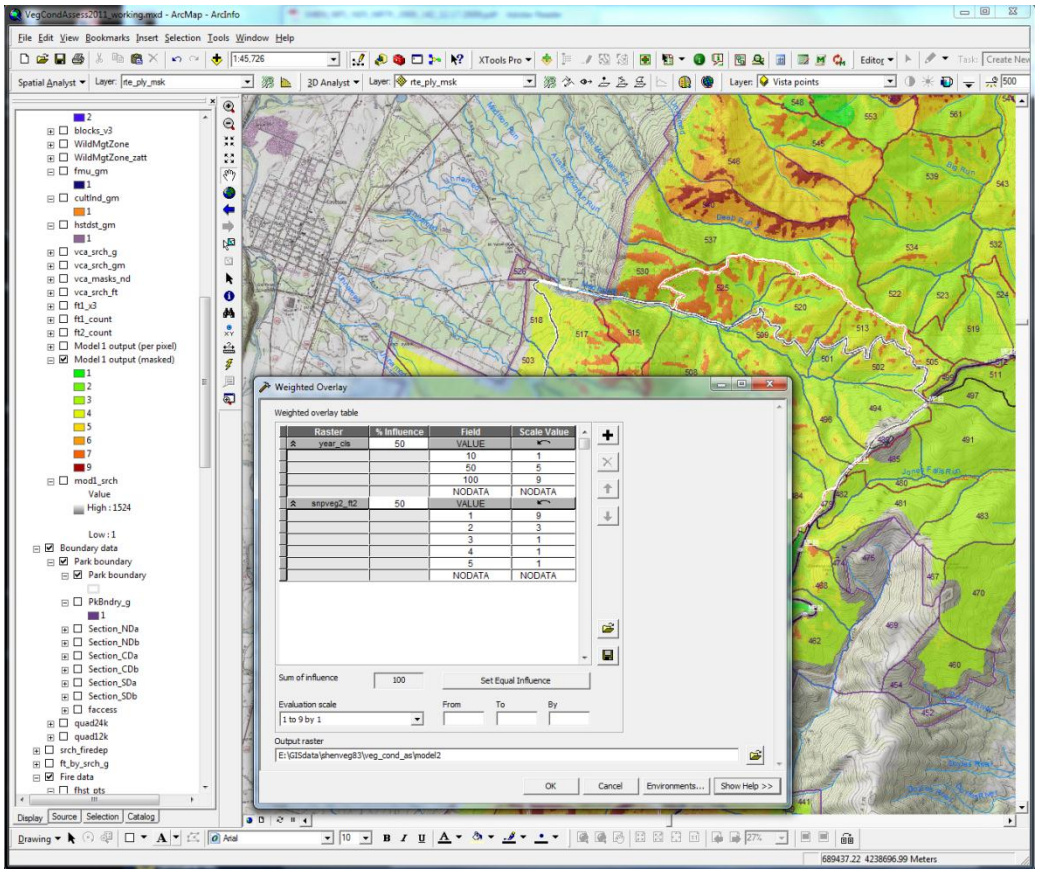
High : 87

Low : 3

Figure 2. Years since last burned raster map generated from fire history polygons showing the Blackrock and Trayfoot mountain areas of SHEN . Note the circular areas that were derived as circular buffer polygons from fire history points. Also shown are lines depicting search and rescue compartments (purple), fire planning units (white), roads (black), and trails along ridgelines (red dashed).

We used a GIS weighted overlay method in ArcGIS to rank and combine layers into a prioritization model. The weighted overlay method assigns a relative importance to each value on input layers (e.g. ranked from 1-9), and then combines layers together using a common measurement scale. Weights can be given to different layers to change their relative importance for the final prioritization. We used two equally weighted inputs in this draft modeling effort, vegetation fire tolerance and years since last burned. We first recoded the years since last burned into three classes (< 5 years, 5-15 years, > 15 years), and gave each class a relative ranking for prioritization (1, 9, and 5, respectively). We reasoned that areas burned less than 5 years ago were already within their desired fire return interval and would not need immediate attention while areas that burned between 5 and 15 years ago were the highest priority since they would need to be re-burned soon to maintain their desired fire return interval. Areas that burned longer than 15 years ago were given higher priority than areas recently burned, but lower priority than areas burned from 5-15 years ago. We rationalized with time, money and staff constraints we could only undertake a few projects each year. This system would allow us to focus on priority areas and apply fire with enough frequency to achieve desired results. We assigned relative rankings for vegetation fire tolerance, prioritizing those vegetation communities that were most fire tolerant (fire tolerances 1,2,3,4,5 were ranked 9,3,1,1,1 respectively). The weighted overlay methods combines the ranked input layers (Figure 3) and results in an output layer where each pixel is assigned a ranking from 1-9 that is a combination of the input rankings. This is the same method used by Hiers et al. (2003) for prioritizing prescribed burning areas, but their model had 11 input criteria derived from group meetings with managers and biologists. Areas assigned a “9” on the output map are highest priority for fire management on both vegetation fire tolerance criteria and years since last burned criteria.

Figure 3. Weighted overlay Geographic Information System method as implemented for draft fire management prioritization model results. Note resulting map depicting ranked (1-9) model prioritization outputs and areas excluded (masked) from the final result.



Results and Discussion

The main products of this process were a series of maps that depict the weighted overlay output at the pixel level, and summarized the outputs by fire planning "compartments" represented by search and rescue polygons previously defined for the park (Figures 4a-f). We used search and rescue polygons (Search Grid) as fire planning compartments because (1) they are defined along ridgetops, streams, roads, and trails which are natural firefighting boundaries, (2) the search and rescue units are of a reasonable size (average 316 acres) for planning burn units, (3) the units are inclusive of the entire park, and (4) park GIS staff had already expended considerable effort in their definition. There were 627 search and rescue compartments defined for the park. We summarized and mapped the acreage in the two highest priority model output classes by search and rescue grid (class 9 and class 7, there was no class 8 on the output maps) (Figures 4a-f).

We created GIS "masks" or exclusion areas by creating raster layers from polygon maps of fire exclusion (FMU) zones, historic districts, cultural zones, and by creating 20-meter buffer polygons around rare species point and polygon layers. For this initial project, rare species were placed into these exclusion zones. However, several rare plant species may benefit from forest openings created by prescribed fire (e.g., Phlox buckleyi, Solidago simplex) and may be included for fire management prioritization in the future. Raster pixels that fell within these exclusion zones were set to zero value and were not included in acreage summaries or on maps depicting burn priorities. The fire planning compartments that received the highest rankings for burn priority are located in the southern portion of the park (Figures 4e-f). These planning compartments contain pine and oak vegetation associations on xeric sites and are primarily located on south-western aspects.

Prioritization of the use of prescribed fire to manage vegetation at SHEN is only a first step. In particular, park managers want to understand if prescribed fire is producing the desired result (e.g., maintenance and expansion of appropriate vegetation associations). Desired future conditions (DFC's) have been established for several SHEN vegetation monitoring types that would be managed with prescribed fire. (Table 2). These desired conditions include indicators and target values for different size classes within a forest stand (Table 2). Objectives of repeated prescribed fire application in Central Appalachian oak forests include increasing the rate of oak regeneration where it is insufficient and maintaining oak regeneration where it is adequate. The primary goal is to restore and maintain fully stocked oak stands capable of long-term self-perpetuation.

Two research endeavors (Steiner et al. 2008; Brose et al. 2008) proffered guidelines for assessing success of oak regeneration (Appendix 2). We converted their plot methodologies (and numbers) to establish guidelines that match Fire Monitoring Handbook (FMH) seedling protocols for fire ecology used by Mountains-to-the-Sea (MTTS) National Parks in Virginia (Appendix 2). These guidelines for assessing success of oak regeneration at SHEN were summarized along with general guidelines for assessing general fire-adapted pine regeneration in Table 3. These numbers are meant to help gauge project success related to desired regeneration conditions for oak and pine established by SHEN (Table 3). Oak and pine Research Foresters were also consulted including Dr. Tom Schuler from the Northern Research station and Dr. Tom Waldrop from the Southern Research station to draft these target conditions. Target values drafted by two Fire Learning Networks were also included in Table 2. The U.S. Fire Learning Network (USFLN) is a cooperative project of The Nature Conservancy, agencies of the Department of the Interior and the USDA Forest Service, the network was created in 2002. The USFLN is

part of the larger joint program, Fire, Landscapes and People: A Conservation Partnership, which includes education and training components, the network operates at both national and local levels to overcome barriers to reducing hazardous fuels build-up and restoring fire-dependent ecosystems. The Southwest Virginia Fire Learning Network (SWFLN) encompasses over a half million acres in the western most portion of the state. The priority target areas for the group are fire dependent dry oak forests and woodlands, pine oak heath woodlands, northern red oak forests and early successional patch communities. As part of this effort, fire ecologists, botanists and land managers have begun describing the desired structure and composition of the forest based upon the best available research of pre settlement fire regimes of the central Appalachian. Similarly, The Southern Blue Ridge Fire Learning Network (SBRFLN) project area covers 2.7 million acres of land managed by partners in Georgia, North Carolina, South Carolina and Tennessee. The partnership has identified shortleaf pine-oak-heath, dry mesic oak-hickory and high-elevation red oak forests as target communities for restoring fire regimes. Local managers have also begun describing desired future conditions for these target communities. Shenandoah National Park is not a formalized member of either FLN, but does actively participate in meetings. Desired conditions included in this document represent the most current available information on similar ecological communities even though the areas are geographically distinct.

As funds become available, prescribed fire plans will be prepared for the high ranking compartments and pre- and post-monitoring of vegetation will be conducted to determine how the vegetation responds to prescribed fire treatments.

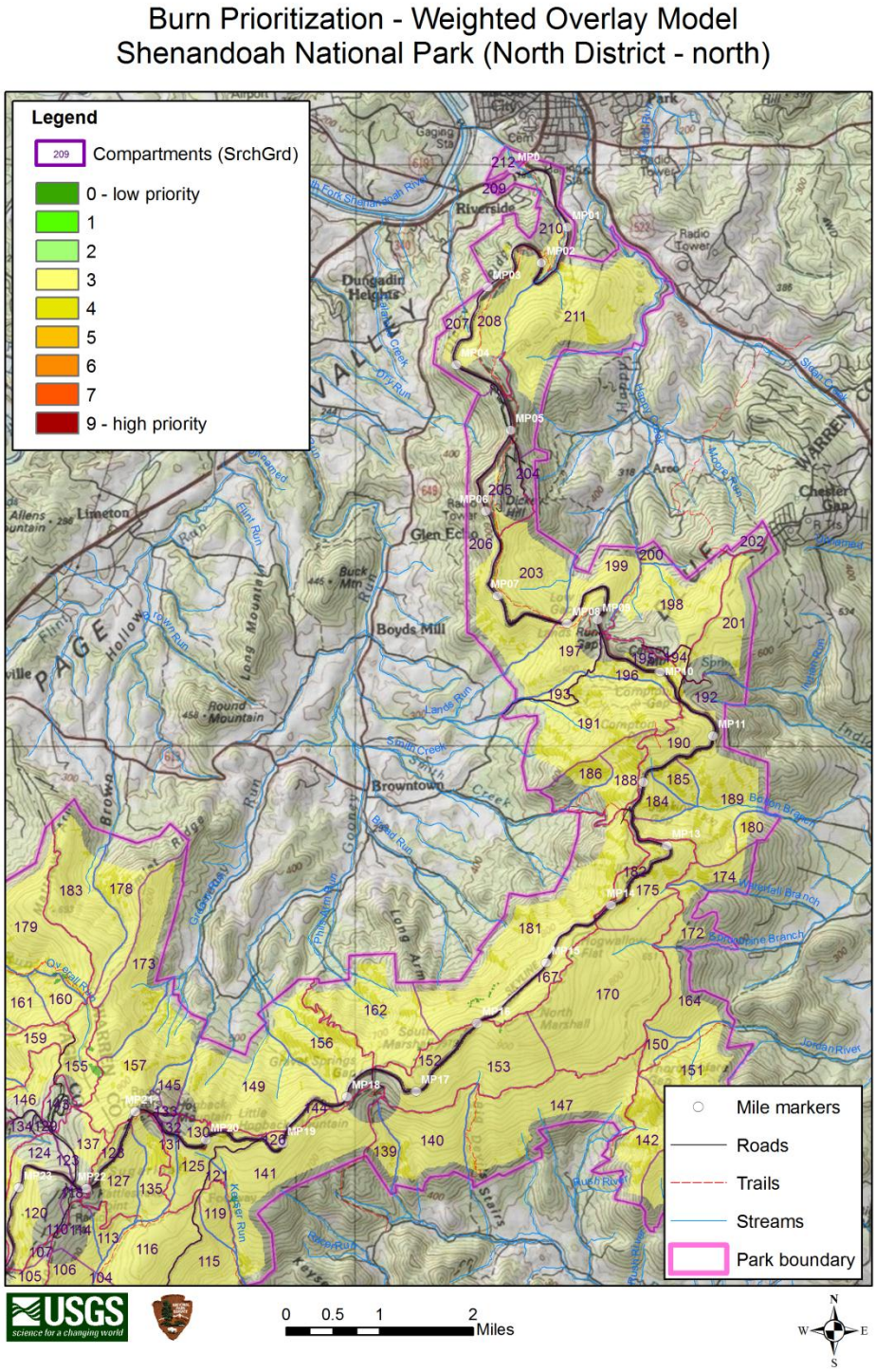


Figure 4a. Burn priority determined using a weighted overlay model for 637 fire management compartments at Shenandoah National Park. The six burn priority maps represent north and south portions of the North, Central, and South Districts.

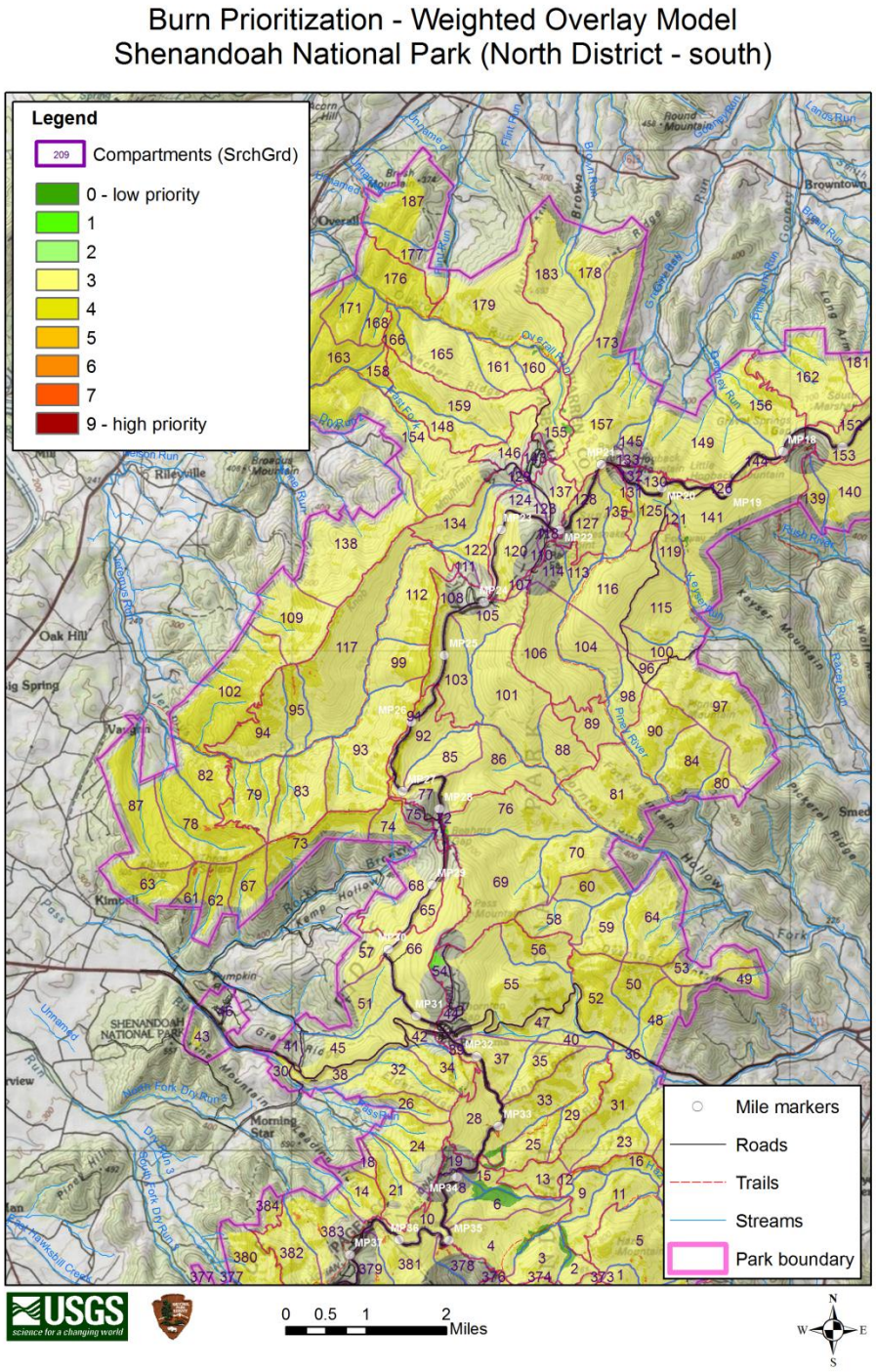


Figure 4b. Burn priority determined using a weighted overlay model for 637 fire management compartments at Shenandoah National Park. The six burn priority maps represent north and south portions of the North, Central, and South Districts.

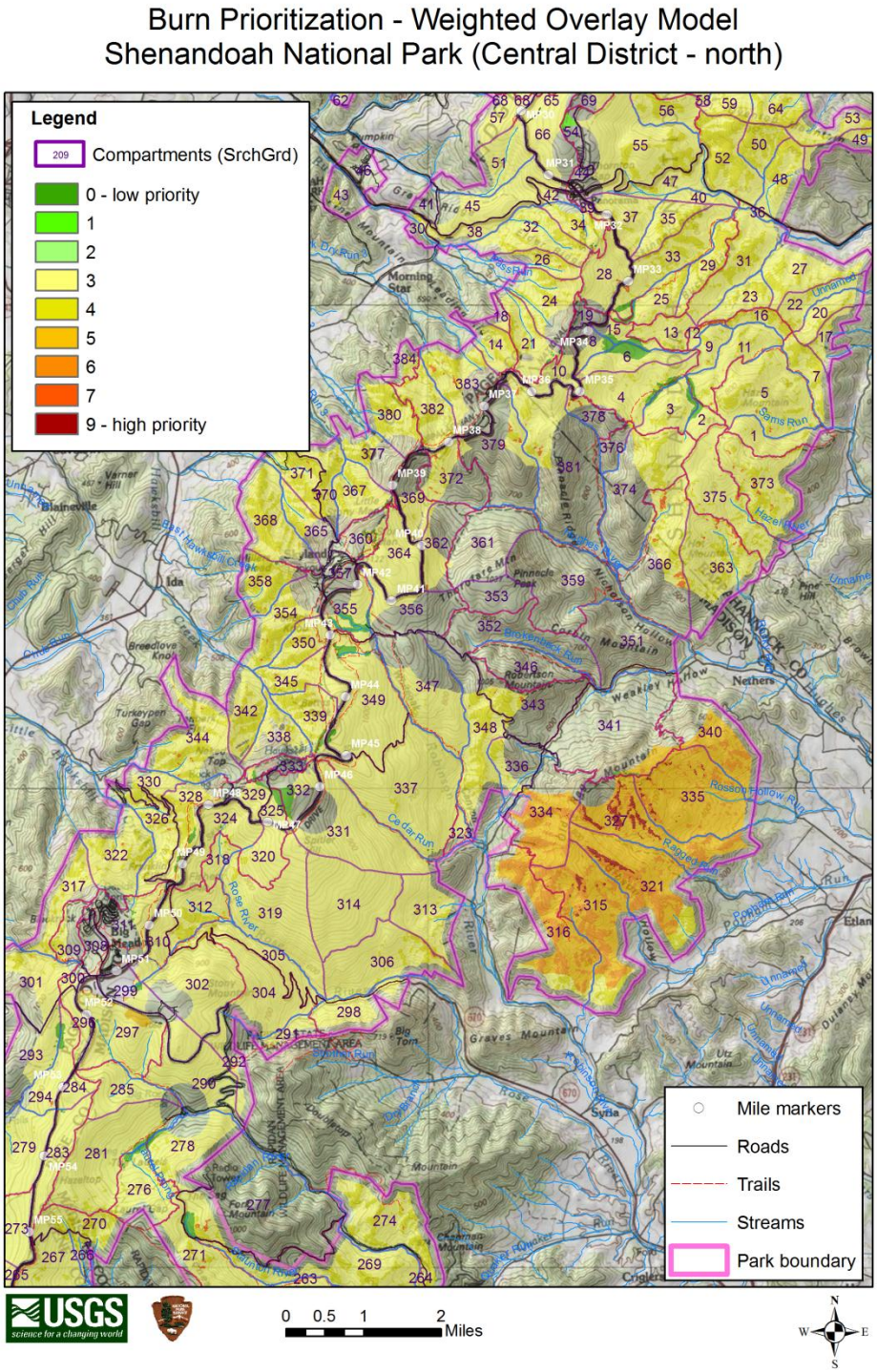


Figure 4c. Burn priority determined using a weighted overlay model for 637 fire management compartments at Shenandoah National Park. The six burn priority maps represent north and south portions of the North, Central, and South Districts.

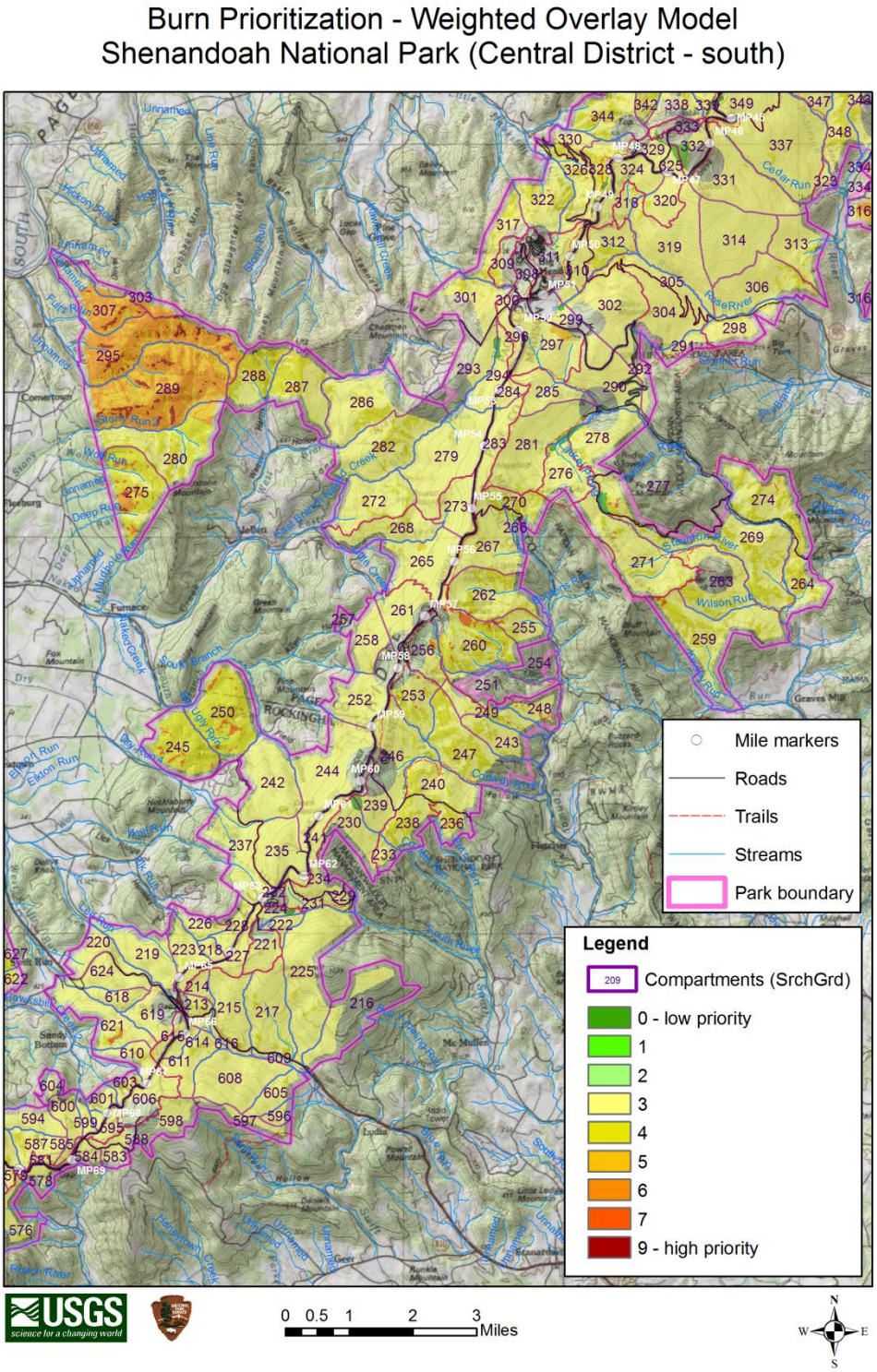


Figure 4d. Burn priority determined using a weighted overlay model for 637 fire management compartments at Shenandoah National Park. The six burn priority maps represent north and south portions of the North, Central, and South Districts.

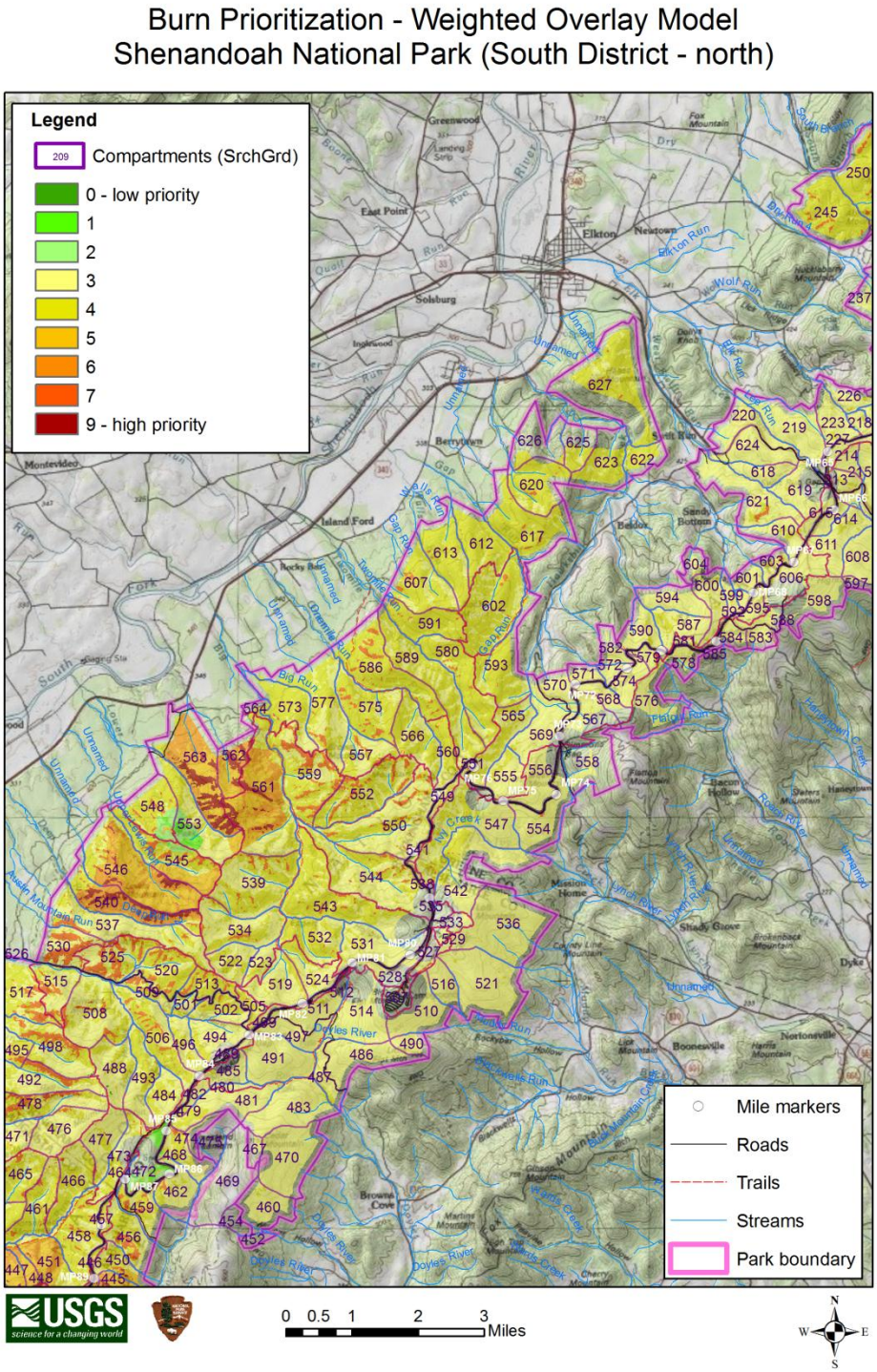


Figure 4e. Burn priority determined using a weighted overlay model for 637 fire management compartments at Shenandoah National Park. The six burn priority maps represent north and south portions of the North, Central, and South Districts.

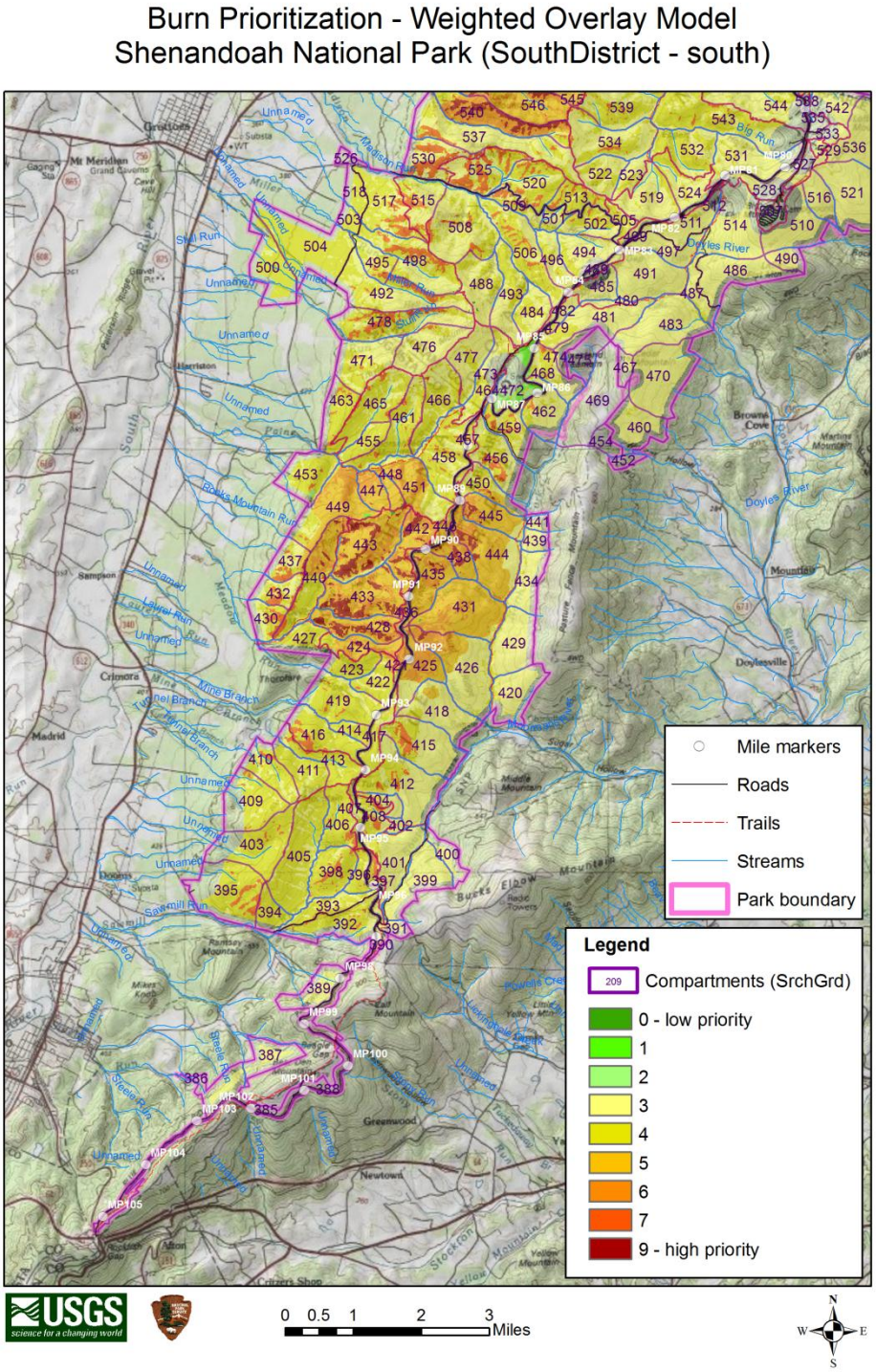


Figure 4f. Burn priority determined using a weighted overlay model for 637 fire management compartments at Shenandoah National Park. The six burn priority maps represent north and south portions of the North, Central, and South Districts.

Table 2. Desired conditions for vegetation monitoring types managed with prescribed fire at Shenandoah National Park.

Monitoring Type[a]	Attribute	Indicator	Target Value {Citation}[b]
Pine-Oak CEGL00#-4996	Overstory Trees	Density: Basal Area of Trees (> 15 cm) m^2 per ha	11.25-15.5 m^2 per ha (all trees overstory and poles) {S BR FLN} Woodland 9-13.5 m^2 per ha (all trees overstory and poles) {SW VA FLN}
	Desirable Overstory Species (Yellow Pine / Oak)	Basal Area of Yellow Pine-Oak ($\geq$ 15 cm dbh) / Total Basal Area ($\geq$ 15 cm dbh) * 100	$\geq$ 80% {S BR FLN} > 50% Site Dependent {SW VA FLN}
	Pole-sized Trees	Density: Basal Area of Pole (15 cm $\geq$ Pole > 2.5 cm) m^2 per ha	11.25-15.5 m^2 per ha (all trees overstory and poles) {S BR FLN} Woodland 9-13.5 m^2 per ha (all trees overstory and poles) {SW VA FLN}
	Yellow Pine Seedlings	Percentage of Stems > 14 cm tall	> 50% site dependent {SW VA FLN} 11,000 stems per ha 5 year post burn per NPS FMH Plot {Jenkins et al. 2011}
	Oak Seedlings	Number of Stems per ha	> 400 stems per ha > 1 m tall {S BR FLN}
	Shrub Abundance	Percent Cover	< 30% {S BR FLN} < 10% per stand {Jenkins et al. 2011}
	Herb Abundance	Percent Cover	Woodland > 50% herbs{SW VA FLN}
Xeric Oak	Overstory Trees	ensity: Basal Area of Trees (> 15 cm) m^2 per ha	13.5-20 m^2 per ha {S BR FLN} ^{2} per ha for Forest & 9-13.5 m^2 per ha for Woodland {SW VA FLN}
	sirable Overstory Species	Basal Area of Yellow Pine-Oak ($\geq$ 15 cm dbh) / Total Basal Area ($\geq$ 15 cm dbh) * 100	$\geq$ 70% {S BR FLN}
	Pole-sized Trees	Basal Area of Pole (15 cm $\geq$ Pole > 2.5 cm) m^2 per ha	< 2.25 m^2 per ha {S BR FLN}
	Seedlings	Density: number of stems per ha by species	12 m per FMH seedling sample area. NPS FMH Plot {Steiner et al. 2008} 5, 58-120 and 120-240 stems per NPS FMH Plot {Brose et al. 2008} > 50% of stems that are oak > 14 cm tall {SW VA FLN}
	Shrub Abundance	Percent Cover	< 20 % {S BR FLN}
6299, 8521, 8523, 8515 and 6057	Herb Abundance	Percent Cover	Forest > 25% > herbs and Woodland > 75% > herbs {SW VA FLN}

Table 2 (continued). Desired conditions for vegetation monitoring types managed with prescribed fire at Shenandoah National Park.

Monitoring Type[a]	Attribute	Indicator	Target Value {Citation}[b]
k CEGL00#-8516 and 8514	Overstory Trees	ensity: Basal Area of Trees (> 15 cm) m^2 per ha	$\geq$22.5 m^2 per ha {SW VA FLN}
	Pole-sized Trees	Basal Area of Poles (15 cm $\geq$ Pole > 2.5 cm) m^2 per ha	Forest > 25% > Forbs {SW VA FLN}

ınds for Community Element Global and is most correctly referred to as the United States national vegetation global element code.

refers to Southern Blue Ridge Fire Learning Network working group. Buchanan, Beth et al. Regional Fire Ecologist, USFS. April 2009.

N refers to the Southwest Virginia Fire Learning Network working group. Lindblom, Sam et al. Fire Manager, VA TNC. February 2010.

refers to the National Park Service Fire Monitoring Handbook.

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ɔttschalk, S. B. Horsley, P. D. Knopp, J. N. Kochendoerfer, B. J. McGuinness, G. W. Miller, T. E. Ristau, S. H. Stoleson, and S. L. Stout. 2008. Prescribing regeneration treatments for mixed oak forests in lantic region. General Technical Report NRS-33. U.S.D.A., Forest Service, Northern Research Station.

Table 3. Guidelines for assessing success of oak and fire-adapted pine regeneration at Shenandoah National Park.

Guideline Sources[a]	Dominant Vegetation Type	Requirements Necessary to Achieve a Fully Stocked Oak or Pine Stand
Steiner et al. 2008	Oak	Total Oak Height ≥ 11 feet per 0.001 acre plot
MTTS Fire Ecology	Oak	Total Seedling Height ≥ 138 feet per 0.0125 acre plot
Brose et al. 2008	Oak	Oaks > 3 feet tall: ≥ 1 stem per 0.0026 acre plot
		Oaks 0.5-3 feet tall: 12-25 stems per 0.0026 acre plot
		Oaks < 0.5 feet tall: 25-50 stems per 0.0026 acre plot
MTTS Fire Ecology	Oak	Oaks > 3 feet tall: ≥ 5 seedling stems per 0.0125 acre plot
		Oaks 0.5-3 feet tall: 58-120 seedling stems per 0.0125 acre plot
		Oaks < 0.5 feet tall: 120-240 seedling stems per 0.0125 acre plot
Tom Waldrop	Pine	Post-burn duff depth < 3 cm
Jenkins et al. 2011	Pine	Overstory density reduced by 40% , understory density reduced by 80%
		Post-fire shrub cover < 10%
		Post-burn duff depth < 4 cm
		10,118 stems per ha of pine seedlings 5-year post burn,
		Reduction in total fuels by 60%
MTTS Fire Ecology	Pine	Overstory density reduced by 40% , understory density reduced by 80%
		Post-fire shrub cover < 10%
		Post-burn duff depth < 4 cm ≥ 51 stems of pine seedlings per 0.0125 acre plot 5-year post burn, or 10,118 stems per ha of pine seedlings 5 years post-burn

[a] Steiner, K. C., J. C. Finley, P. J. Gould, S. Fei, and M. McDill. 2008. Oak regeneration guidelines for the central Appalachians. Northern Journal of Applied Forestry 25: 5-16.

MTTS Fire Ecology refers to the Fire Monitoring Handbook seedling protocols for fire ecology utilized by Mountains To The Sea National Parks in Virginia.

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Although detailed fire plans will be prepared for each prescribed burn, current scientific literature emphasizes the following general considerations that should be applied when using prescribed fire treatments to achieve the maintenance and expansion of appropriate vegetation associations at SHEN:

1. Pines and upland oaks are well suited to periodic surface fires (Brose et al. 2010). Pre-burn/treatment monitoring should occur (Brose et al. 2008).
2. Vegetation monitoring should occur not more than 5 years post-burn.
3. Fires have historically occurred in xeric pine oak stands approximately every 5-7 years. (Aldrich et al. 2010; Lafon et al. 2005).
4. Prescribed fire should be low moderate -intensity every 3-7 years. (Per. Com. Waldrop 2011; Jenkins et al 2011).
5. Prescribed fires with medium to low intensity and medium-high flame lengths of 6-8 feet will result in successful yellow pine regeneration and be safer to accomplish (Waldrop pers. Comm. 2011; Waldrop et al. 2006; Jenkins et al. 2011; Aldrich et al., 2010).
6. Pines and upland oaks are well suited to periodic surface fires (Brose et al. 2010).
7. If only one burn, it should be high intensity (Brose 2010; Jenkins et al. 2011).
8. Fires have historically occurred in the spring when trees were dormant. (Hoss et al., 2008; Aldrich et al., 2010).
9. Fires should occur in late winter/spring (Brose et al. 1999; Brose 2010).

Prescribed fire accompanied by mechanical thinning:

1. Research of burn effects on oak regeneration has accompanied pre-burn silvicultural treatments. Apply canopy removal, permit 3 years for oak root to respond to opening and then apply burn (Wendel and Smith 1986; Brose et al. 1999).
2. Oak regeneration has historically been achieved “naturally” in the Appalachians through a combination of two processes: canopy disturbance and periodic fire (Abrams 1992; Brose et al. 2008).

This project has shown that Shenandoah forests dominated by xeric oak and pine associations are a high priority, and an appropriate choice for using fire as a regeneration tool. Two other vegetation associations including Central Appalachian Basic Oak - Hickory Forest (CEGL00#-8514), and the Central Appalachian Montane Oak - Hickory Forest (Acidic Type) (CEGL00#-8516) may also yield sites on which burning is an appropriate tool to encourage forest regeneration. In the future, collaborative efforts to describe and delineate the ecology and spatial extent of other floristically significant communities throughout the park may prompt re-prioritization. Specifically, prescribed fire management of fire adapted / tolerant rare plant communities, and xeric oak matrix woodlands and their associated open barren communities may be coupled to restore and maintain these communities. This spatial model and subsequent desired condition table is not intended to be static, but to serve as a tool for fire managers to evaluate regularly and select burn units annually, as well as to help determine project effectiveness. As monitoring information is obtained and analyzed, target desired future conditions will be re-evaluated and refined.

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Appendix 2. Calculations to match Steiner et al. (2008), Brose et al. (2008), and Jenkins et al. (2011) proffered guidelines for assessing success of oak and pine regeneration with Fire Monitoring Handbook (FMH) seedling protocols for fire ecology utilized by Mountains To The Sea National Parks in Virginia (MTTS).

1. Steiner et al. (2008) utilized 1/1000 acre circular plots and suggested that 11 feet of oak/plot resulted in fully stocked stands.

   Where:
   - 1/1000 acre experimental plot = 0.001 acre
   - FMH seedling sampling area of 50 m^2 = 0.0125 acre
   - 11 feet of experimental oak regeneration
   - *X* = number of oak feet needed on Fire Monitoring Handbook (FMH) seedling sample

   Therefore:
   X = 0.0125/0.001 * 11
   X = 137.5 feet of oak regeneration needed on FMH seedling sample

2. Brose et al. (2008) utilized 1/385 acre circular plots to evaluate successful oak regeneration requirements in the following three size classes: Competitive (> 3 feet tall), Established (0.5-3 feet), and New (< 0.5 feet). Their findings indicated that 1, 12-25, and 25-50 stems/plot of competitive, established, and new oaks were required, respectively.

   Where:
   - 1/385 acre experimental plot = 0.0026 acre
   - FMH seedling sampling area of 50 m^2 = 0.0125 acre
   - 1, 12-25, and 25-50 stems of competitive, established, and new oaks, respectively
   - *X* = number of oak stems/class needed on FMH seedling sample

   Therefore:
   For Competitive Oak Class
   X = 0.0125/0.0026 * 1
   X = 4.8 oak stems/competitve needed on FMH seedling sample
   For Established Oak Class
   X = 0.0125/0.0026 * 12 or 25 (to apply range)
   X = 57.7-120.2 oak stems/established needed for FMH seedling sample
   For New Oak Class
   X = 0.0125/0.0026 * 25 or 50 (to apply range)
   X = 120.2-240.4 oak stems/new needed for FMH seedling sample
3. Jenkins et al. (2008) utilized 1 acre plots and suggested that $\geq$ 10,000 stems per hectare of pine seedlings 5-year post burn resulted in fully stocked pine stands. According to their research,

there are also requirements for fuel reduction, duff layer depth, and vegetation density and cover at the forest stand level to accompany stems per plot guidelines.

Where:

- 1 hectare experimental plot = 2.471 acre
- 10,000 stems per hectare = 4,047 stems per acre
- FMH seedling sampling area of 50 m^2 = 0.0125 acre
- *X* = number of pine seedlings 5-year post burn needed on Fire Monitoring Handbook (FMH) seedling sample

Therefore:

X = 0.0125/1 * 4,047

X = 50.6 number of pine seedlings 5-year post burn needed FMH seedling sample

Appendix 3. Central Appalachian fire-related literature bibliography.

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