



National Park Service Mississippi River Fire Management Zone/Barrens to Bayous Fire Monitoring Network Fire Ecology Annual Report Calendar Year 2017



On the Cover:

During a training event in August of 2017, NPS Fire Planners, Ecologists, and Fire Effects Monitors from the Northeast and Southeast Regions collect burn severity data from the Chimney Tops 2 wildfire. Pictured (from left) are: Allyson Arulanantham (Appalachian Zone), Missy Forder (SERO), Andy Ruth (NERO), Carol Fields (MS River Zone), Cynthia Worthington (MS River Zone), Rob Klein (App Zone), Bob Boensch (MS River Zone), and Matt Wood (App Zone).

Mississippi River Zone Fire Effects Monitoring Program Annual Report, 2017

Robert F. Boensch
Carol Anne Fields
Meghan Whitman
Cynthia Worthington

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Mississippi River Zone Fire Monitoring Program
(Barrens to Bayous Fire Monitoring Network)
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A. Summary

2017 was a year of prominent change in personnel and direction for the Mississippi River Zone fire ecology program. The fire effects crew continued with laudable momentum serving parks within the network by maintaining a comprehensive schedule for monitoring fire and vegetation plots. For the first year since 2014, the fire effects team has become fully staffed. The crew supported the Mississippi River Zone Fire Management in wildland and prescribed fire efforts and provided support to natural resource management staff for zone parks.

Sixty plots were monitored in 2017, including two newly installed forest plots at Cumberland Island National Seashore (Table 1). Invaluable assistance was provided by members of the Appalachian/Piedmont Fire Effects Monitoring Program, Wylie Paxton and Alyson Arulanantham as well as Southeast Coast I&M botanist, Sarah Corbett.

The crew collaborated with Natchez Trace Parkway's resource management staff on a funded PMIS project for the federally threatened Price's Potato Bean (*Apios priceana*), and has helped guide planning and implementation of the project. In September, the fire ecologist met with private preserve managers who maintain a robust local population of Price's Potato Bean, and obtained permission to collect over 1500 seeds for restoration. Additionally, a small population of plants on the Natchez Trace Parkway were monitored, mapped, and tagged.

In July, fire effects crews and ecologists from the eastern and southeastern monitoring networks rendezvoused at Great Smoky Mountains National Park for a fire ecology meeting. This was a great opportunity to collaborate with the various networks, discuss issues impacting NPS fire ecology, and work together in the field. The group received guidance from Missy Forder and Nate Benson on how to evolve NPS fire ecology programs to increase efficiency, become more adaptive with ecological monitoring, and best serve the parks within our respective networks. Many thanks to Rob Klein, Southern Appalachian/Piedmont fire ecologist for planning the event and sharing his knowledge on monitoring the effects of fire.

This year the program hired two career seasonal monitors. After the hiring freeze was lifted, Cynthia Worthington and Meghan Whitman were hired in April. In an attempt for year round coverage, Cynthia is planned to work during summer monitoring months and Meghan will provide program support during the winter prescribed fire season. Worthington previously worked as a fire effects monitor at a number of NPS units and Whitman served as the Lead Fire Effects Monitor at Wind Cave National Park. The career-seasonal employees were able to overlap for a month prior to Whitman's departure to spend the summer with the Wind Cave in South Dakota. Their seasons again overlapped in the fall when Meghan returned to the Natchez Trace Parkway prior to Worthington's furlough. The team also welcomed Bob Boensch as the new Mississippi River Zone Fire Ecologist in May 2017 (Table 2).

During the spring prescribed fire season, Lead Monitor Carol Fields served as FEMO for parks including; Shiloh National Battlefield (SHIL), Natchez Trace Parkway (NATR), Little River Canyon Preserve (LIRI), Stones River National Battlefield (STRI), Horseshoe Bend National Military Park (HOBE) and Big South Fork (BISO). Boensch and Whitman assisted in a fall prescribed burn treatment at SHIL. Whitman traveled to GRSM as an engine crewmember for burning in the Cades Cove Unit. The crew provided support for national wildfire and all-hazard incidents acting in the roles of Lead READ, REAF, ICT5(T) and FALB in California, Florida, Mississippi and Puerto Rico.



Figure 1. Dozerline repair in the Sierra NF



*Figure 2. CBI Monitoring on Chimney Tops 2 Fire.
Pictured: A Ruth, M. Woods (sorry), M. Forder,
B.Boensch, R. Klein*



Figure 3. Interagency Wildland Firefighter Crew assisting with Hurricane Maria recovery in Puerto Rico

Table 1. Fire Effects Plot Workload and Total Plots Installed

Park	Monitoring Type	Type Code	Plot Type	Pre-burn	Immed. Post	Annual	Annual Total	Total Plots
Cumberland Island National Seashore	Mixed Loblolly Pine Plantation	PLAN	Fuels Plot	0	0	4	4	4
	Longleaf Pine – Darlington Oak – Wiregrass Woodland	ARIS	FMH Forest Plot	2	0	0	2	6
Gulf Islands National Seashore	Sand Pine - Scrub Oak	PICL	FMH Forest Plot	0	0	0	0	12
	Longleaf - Slash Pine	PIPA	FMH Forest Plot	0	3	0	3	12
	Pitcher Plant Savannah	SAAL	FMH Forest Plot	0	0	0	0	1
	Fuels Monitoring	FUELS	Fuel Plot	0	1	0	1	4
Mammoth Cave National Park	Redcedar – Oak Glade	JUVI	FMH Forest Plot	0	0	0	0	7
	Indiangrass Grassland	SONU	FMH Grass Plot	0	0	0	0	8
	Big Bluestem Grassland	ANGE	FMH Grass Plot	0	0	0	0	5
	Oak-Hickory Woodland	OAHI	FMH Forest Plot	0	0	1	1	9
	Chestnut Oak Woodland	QUMO	FMH Forest Plot	0	0	0	0	3
	Fuels Monitoring	FUELS	Fuels Plot	0	0	0	0	4
	Old Field	OLFI	FMH Forest Plot	0	0	1	1	2
Little River National Preserve	Shortleaf Pine Forest	PIEC	FMH Forest plot	0	3	4	7	12
	Green Pitcher-plant Bog	SAOR	FMH Forest Plot	0	1	5	6	6
	Mary's Fire	QUMO	CBI	0	4	0	4	4
	Chestnut Oak Forest		FMH Forest Plot	0	1	2	3	7
Natchez Trace Parkway	Oak-Hickory Woodland	OAHI	FMH Forest Plot	0	0	3	3	6
	Post Oak Savanna	QUST	Mod. F. Plot ⁺	0	0	3	3	6
	Redcedar Encroached Prairie	JUVI	FMH Brush Plot	0	4	0	4	4
	Loblolly Pine Forest	PITA	FMH Forest Plot	0	0	2	2	14
	Redcedar Encroached Prairie	BLACK BELT	FMH Grass Plot	0	0	0	0	4
	Potato Bean Woodland	APR	Rare Plant	0	0	1	1	1
	Tennessee Barrens	TNBA	Mod. F. Plot ⁺	0	0	0	0	3
	Japanese Grass Invaded Streamside Forest	MIVI	FMH Grass Plot	0	0	0	0	10
Horseshoe Bend NMP	Mixed Montane Longleaf Forest	PIPA	FMH Forest Plot	0	0	0	0	5
Stones River National Battlefield	Little Bluestem Fields	SCSC	FMH Grass Plot	0	0	0	0	15
	Central Basin Barrens	ANTE	FMH Grass Plot	0	0	5	5	9
	Grassland Restoration Areas	ANVI	FMH Grass Plot	0	7	0	7	10
	Fuels Monitoring	FUELS	Fuels Plot	0	0	0	0	3
	Redcedar Woodland	JUVI	FMH Forest Plot	0	0	0	0	1
Russell Cave NM	Chestnut Oak Forest	QUMO	FMH Forest Plot	0	0	0	0	1
Vicksburg NMP	Exotics Monitoring	VICK	Photo Plot	0	0	0	0	6
Shiloh NMP	Oak-Hickory Woodland	OAHI	FMH Forest Plot	0	3	0	3	4

Total	2	27	31	60	207*
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Table 2. Fire Ecology Staffing 2017

Ecologist and Monitors	Starting Date	Ending Date	# of Pay Periods	READ Qualified (Yes or No)	Training and Development
Bob Boensch	05/08/17	12/31/17	26	No	NEPA/Section 106 Training, SE Fire Ecology Meeting, Fire Ecology Congress, All Hazards Resource Advisor (Intro, Intermediate) FFI Online Training, Oak Woodlands & Forests Fire Consortium Webinars, Southern Fire Exchange Webinars, ESRI online ArcGIS Pro training
Carol Fields	010/1/17	12/31/17	26	Yes	Fire Refresher, Lead READ fire assignment, LIRI RSS, NEPA/Section 106 Training, Advanced Plant ID, Fundamentals of Ecology, Bioblitz, Breeding Bird Surveys, SE Fire Ecology Meeting, Fire Ecology Congress, Audubon Christmas Bird Count
Meghan Whitman	04/09/17 10/01/17	04/28//17 10/01/17	2.5 5.5 (8 total)	No	Seasonal FX Position @ WICA, Fire Refresher
Cynthia Worthington	04/02/17	10/14/17	14	Yes	Fire Refresher, REAF assignment, Advanced Plant ID, SE Fire Ecology Meeting, NEPA/Section 106 Training



Figure 4. Unusual observation of an Old World Danaid Eggfly butterfly at Cumberland Island NS



Figure 5. Eastern-Eyed Click Beetle blending in on wildfire scarred log at Cumberland Island NS

2017 Management Objectives and Monitoring Results

Monitoring results are discussed separately for each zone park. Data entry is current to the end of calendar year 2017 and all analyses conducted this year have used the most recent data. Results are within 80% confidence intervals of the mean unless otherwise noted. Basic formulas for each analysis are displayed in the management objectives column. Significant changes in monitoring results are in **bold** font. Fuel reduction objectives/results are mean percent reduction from pre-burn to immediate post-burn. Stand density objectives/results are for five-year post-burn mean stand density. Results that went opposite of the intended objective (or significantly exceeded a limit) will be in Red font with a + or - symbol.

LITTLE RIVER CANYON NATIONAL PRESERVE (LIRI):

The MS River Zone fire ecology/fire effects team made four trips to Little River in 2017. In March, there was a prescribed burn, with monitoring trips in April, July, and August. In August, the crew conducted a study using the Composite Burn Index (CBI) assessment protocol within the boundaries of the Martha's Fire. This wildfire occurred in October 2016 at the height of an extreme drought. This area had not previously been prescribed burned and had a substantial buildup of litter and duff. Monitoring efforts included the following goals:

- 1) Create a burn severity map of the wildfire
- 2) Survey fire effects on vegetation structure and composition
- 3) Scout for invasive plant species stimulated by high-severity fires

The MS River Zone fire effects team worked with the Appalachian/Piedmont fire effects team to create a differenced-Normalized Burn Ratio (dNBR) map of burn severity for the Martha's Fire (Fig. 6). During the August 2017 trip, the fire effects monitoring crew conducted assessments and photo-monitoring plots which correspond to Martha's Fire CBI plot points. Figure 7 and 8 are photos of burn severity including fuel consumption, resprouts, and overstory mortality.

Remaining questions for the effects of the Martha's Fire include:

- 1) What differences in tree mortality can be attributed to the wildfire vs. the drought?
- 2) Can the severity of prescribed fire be elevated to achieve accelerated results for restoration objectives?

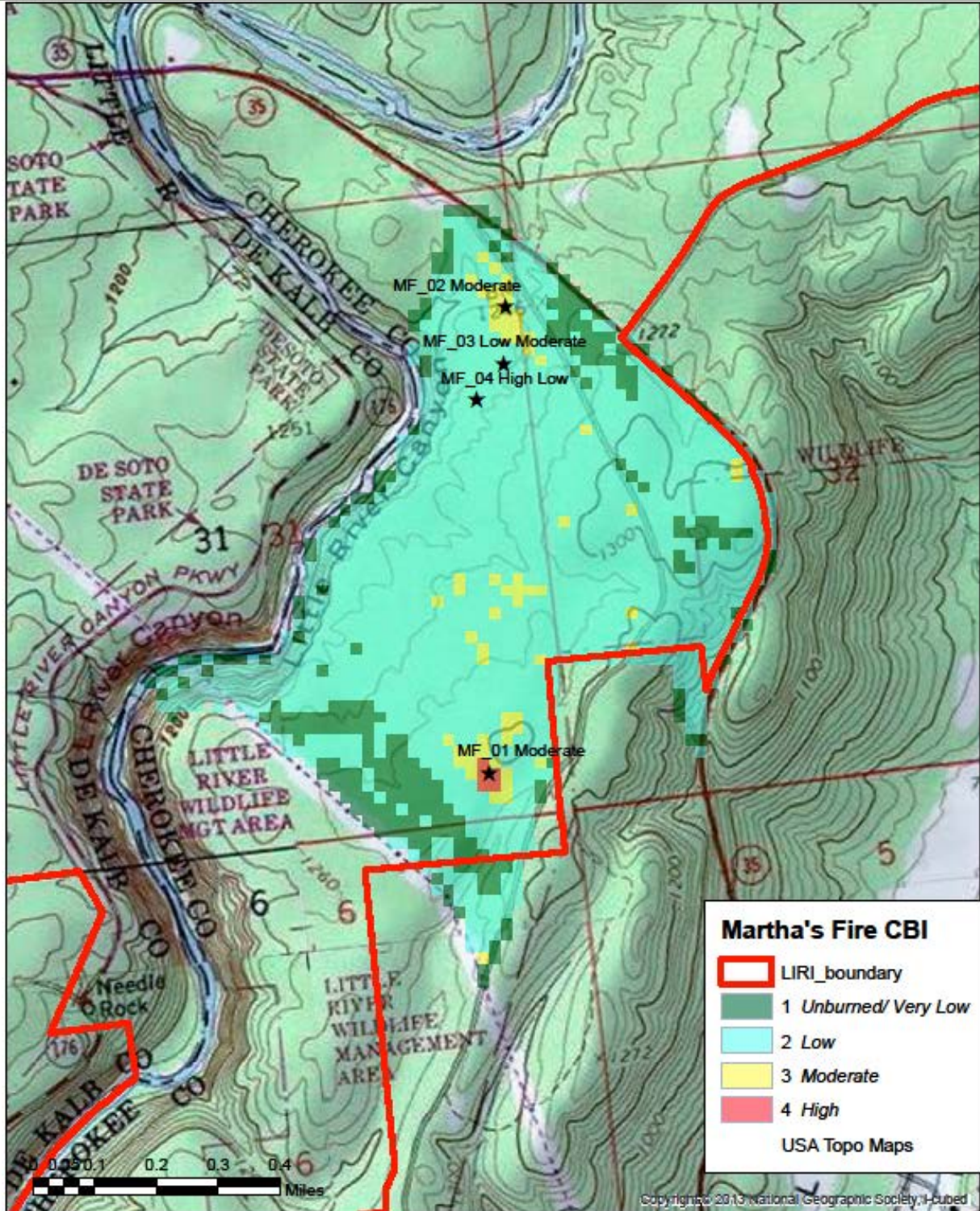


Figure 6. Martha's Fire CBI



Figure 7 and 8: MF_01 CBI plot photos of re-sprout response and substrate layer consumption post wildfire.

Additional information relating the findings of the Martha's Fire CBI assessment can be found in the Little River Canyon (LIRC) Martha's Fire Composite Burn Index (CBI) Monitoring Report 2017.

Monitoring Unit LIRI	Management Objective (Restoration)	Monitoring Results (80% confidence interval)	Objective Achieved?	Year Analysis Completed (Range of Data [Yrs] Included in Analysis)
Shortleaf Pine Forest (FPIEC1DG09)	25-80% reduction in pole-sized trees by 3 rd burn $\frac{\beta_{YR01} - 00Pre}{00Pre}$	Density reduction = 69.7% ($\pm 6.2\%$) after 3rd fire n=10, 5 burn units 78.5% ($\pm 5.3\%$) after 4 th fire n=6, 3 burn units 77% ($\pm 14\%$) after 5 th fire n=3, 2 burn units	YES	2018 (1999-2017)
	25-50% increase native grass and forb cover $\frac{\beta_{YR02} - 00Pre}{00Pre}$	Increase in native cover = 284% ($\pm 252\%$) after 1 st fire n=12, 6 burn units 233% ($\pm 104\%$) after 2 nd fire n=11, 5 burn units 440% ($\pm 257\%$) after 3rd fire n=9, 5 burn units 389% ($\pm 103\%$) after 4 th fire n=7, 4 burn units Total (Earliest-Latest) 239% ($\pm 89\%$) n=12	YES	2018 (1999-2017)
	20% reduction in total fuel loading by 3 rd burn $\frac{\beta_{Post} - before \beta}{before \beta}$	12.9% ($\pm 8.5\%$) after 1 st fire n=12, 6 burn units 31.8% ($\pm 7.8\%$) after 2 nd fire n=9, 5 burn units 26.6% ($\pm 12\%$) after 3rd burn n=10, 5 burn units 32.3% ($\pm 6.6\%$) after 4 th burn n=9, 4 burn units 64.5% ($\pm 8.6\%$) after 5th burn n=3, 2 burn units	YES	2018 (1999-2017)
	>25% reduction in litter fuel loading after each burn $\frac{\beta_{Post} - before \beta}{before \beta}$	Decrease of Litter = 51.3% ($\pm 5.8\%$) after 1 st fire n=12, 6 burn units 46.0% ($\pm 15.7\%$) after 2 nd fire n=9, 5 burn units 48.0% ($\pm 13.3\%$) after 3rd fire n=10, 6 burn units 41.2% ($\pm 12.6\%$) after 4 th fire n=9, 5 burn units 55.1% (N/A) after 5 th fire n=1, 1 burn unit	YES	2018 (1999-2017)

Green Pitcherplant Bog Forest (FSAOR1G10)	30-90% decrease in shrub cover by second year after 3rd burn <i><u>βYR02 – Earliest Read</u></i> <i>Earliest Read</i>	Decrease in cover = 24.3% ($\pm 9.4\%$) after 2nd fire <i>n</i> =6, 3 burn units 33% ($\pm 20\%$) after 3rd fire <i>n</i> =5, 2 burn units +4% ($\pm 16\%$) after 4th fire <i>n</i> =4, 3 burn units 12.7% ($\pm 13\%$) after 5th fire, <i>n</i> =3, 2 burn units +54.4% ($\pm 25.3\%$) after 6th fire, <i>n</i> =2, 1 burn unit +25% after 7th fire, <i>n</i> =2, 1 burn unit	Yes and No Plot average shrub cover has been reduced >30% by the second year after the 3rd burn, but the shrub cover rose above pre-burn levels one year after the 4th, 6th, and 7th burn	2018 (1999-2017)
	20% increase cover of green pitcherplant (<i>Sarracenia oreophila</i>) by second year after 3rd burn <i><u>βYR02 – Earliest Read</u></i> <i>Earliest Read</i>	Increase in Cover - 25% ($\pm 23\%$) after 2nd fire, <i>n</i> =5 66.2% ($\pm 7.5\%$) after 3rd fire, <i>n</i> =6 57% ($\pm 19.8\%$) after 4th fire, <i>n</i> =3 76% ($\pm 2.5\%$) after 5th fire, <i>n</i> =2	Yes/Uncertain ...	2018 (1999-2017)
	30-90% decrease in pole-sized trees by second year after 3rd burn <i><u>βYR02 – 00Pre</u></i> <i>00Pre</i>	Pole reduction = 25 % (± 23 %) after 2nd fire <i>n</i> = 5, 3 burn units 66.2 % (± 7.5 %) after 3rd fire <i>n</i>=6, 2 burn units 57% (± 19.8 %) after 4th fire <i>n</i> =3, 1 burn units 75.9% ($\pm 2.5\%$) after 5th fire, <i>n</i>=2 31% ($\pm 42.5\%$) after 6th fire, <i>n</i> =2 32% ($\pm 48\%$) after 7th fire, <i>n</i> =2	Yes and No All plots met the objective after the 3rd burn. Three plots met the objective after the 4th burn..	2018 (1999-2017)
Chestnut Oak Forest (FQUMO1G10)	20-60% reduction in pole-sized trees <i><u>βYR01 – 00Pre</u></i> <i>00Pre</i>	Density reduction = 56.3% ($\pm 10.3\%$) after 1st fire <i>n</i> =5, 3 burn units 56.2% ($\pm 15.9\%$) after 2nd fire <i>n</i> =3, burn units 77.2% ($\pm 11.9\%$) after 3rd fire <i>n</i>=3, burn units 88.9% ($\pm$ N/A) after 4th fire <i>n</i> =1 1 burn units	Yes	2018 (1999-2017)
	25-50% increase native grass and forb cover <i><u>βYR01 – 00Pre</u></i> <i>00Pre</i>	Increase in Cover = 141.5% ($\pm 146\%$) after 1st fire, <i>n</i> =3 32.5% (± 39.3) two years after 1st fire, <i>n</i> =6 151% ($\pm 139\%$) after 2nd fire, <i>n</i> =3 210.5% ($\pm 94\%$) after 3rd fire, <i>n</i>=3 80% ($\pm 18\%$) after 4th fire, <i>n</i> =2	Yes/Uncertain All plots must be burned and read to achieve minimum sample size.	2018 (1999-2017)

Table 3. Little River Canyon National Preserve Fire Effects Monitoring Results

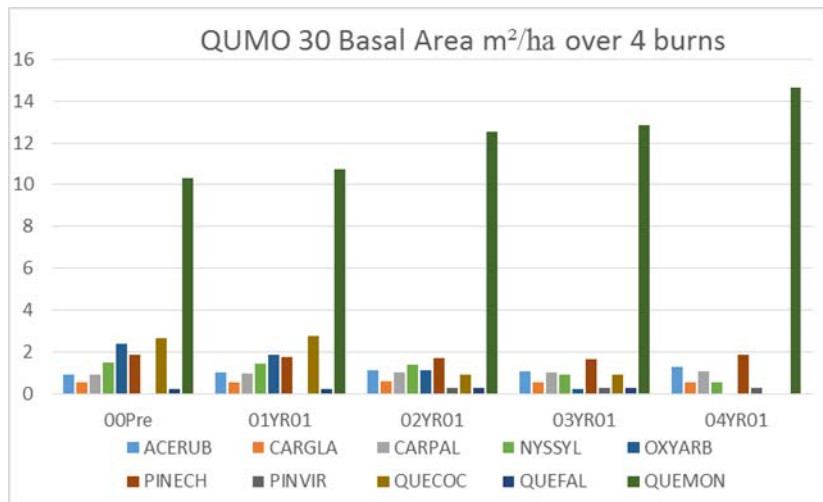


Figure 9. Overstory and Pole Tree Basal Area plot QUMO 30

Two QUMO plots in the 07/08 burn unit have complete overstory tree data one year post fire. QUMO 30 burned four times; 2002, 2007, 2009, and 2016. Figure 9 demonstrates that from pre-burn conditions compared to one year after the 4th burn both *Acer rubrum* (41.4%) and *Quercus montana* (42%) show significant increase. *A. rubrum* shows a slight decrease (6.4%) from 03YR01 read suggesting a 2 year fire return interval may reduce dominance of this species. *Pinus virginiana* moved in within a year after the second burn. The following species were mostly eliminated from the overstory and midstory after the fourth burn; *Cornus florida*, *Diospyrus virginiana*, *Oxydendrum arboreum*, *Quercus coccinea*, and *Quercus falcata*. The extreme drought of 2016 has a contributed effect on tree mortality.

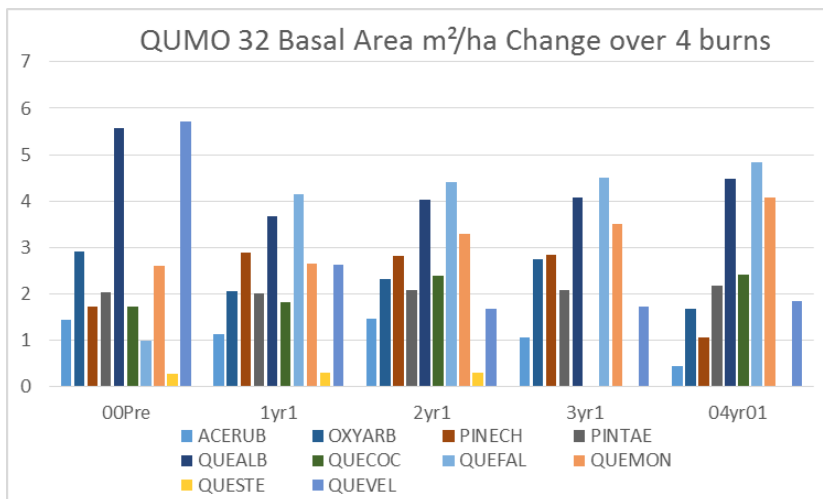


Figure 10. Overstory and Pole Tree Basal Area for plot QUMO 32

QUMO 32 burned four times; 2002, 2007, 2009, and 2016. Pre-burn to 04YR01 comparison shows a 70% decrease in *Acer rubrum*. Other decreases in overstory include *Cornus florida* 34%, *Diosporus virginiana* 100%, *Nyssa sylvatica* 100%, *Oxydendrum arboreum* 42%, *Pinus echinata* 38%, *Prunus serotina* 67%, *Quercus alba* 19%, *Quercus stellata* 100%, *Quercus velutina* 68%, and *Sassafras albidum* 30%. Species that benefited and either had no change or increased in basal area from four burns *Carya pallida* (no change), *Pinus taeda* 7%, *Quercus coccinea*, *Quercus falcata* 388%, and *Quercus montana* 58%.

FIRE EFFECTS BY MONITORING TYPE

Shortleaf Pine Forest (PIEC)

25-80% reduction of pole sized trees was achieved by the third burn with a reduction near 70%. Now that fire management units have been burned 3-5 times, this objective is in need of reexamination. This objective should be removed or changed to identify which species should be actively suppressed versus which species should be managed for. For example, *Pinus echinata* saplings should no longer be included within an overall pole reduction strategy nor should several oak species associated with this vegetation type.

The **25-50% increase in native grass and forb cover** remains a sound objective as there is great potential to increase forb cover. A future objective should identify a target range for percent cover as a restoration goal.

20% reduction in fuel loading after 3rd burn has been met by achieving a 26.6% reduction in fuel loading. Two plots still need a 3rd burn, however, the fuel load reductions are a temporary condition without regular fire.

>25% reduction of litter is an objective that can be observed immediately post burn by fire managers. There could be potential in increasing the reduction amount for this objective, as the Martha fire showed forest is resilient to higher fire severity, which may be necessary to restore the Shortleaf Pine forest.

Green Pitcher Plant Bog Forest (SAOR)

30-90% decrease in shrub cover by second year after 3rd burn was met at 33% with 5 out of

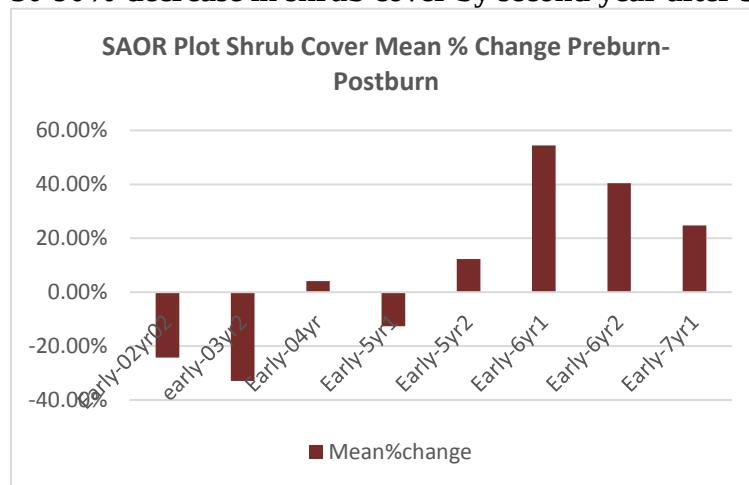


Figure 11

6 plots burned three times. It is possible for this mean percent to decrease below 30% with the addition of the remaining plot data. However, after the 3rd burn, the percent of shrub cover increases in all but one monitoring event. Comparing back to pre-burn levels, there was a 54% increase after the 6th burn and 25% increase after the 7th burn. The bogs are difficult to burn in conjunction with adjacent forests. When the adjacent forests burn under prescription conditions the bogs are typically too wet. When

the bogs dry out enough to burn, the adjacent forests are typically too dry to burn under ideal prescribed conditions. To address this, fire management has discussed burning them separately which increases costs for multiple operations. These bogs may benefit from TerraTorch ignitions during wet conditions, or as evidenced from the Martha fire, higher severity fires.

20% increase cover of green pitcherplant (*Sarracenia oreophila*) by second year after 3rd burn. The results of this monitoring objective fail to explain the actual fire effects on *Sarracenia oreophila*, since these plants have continued to decline in spite of burning.

SAOR 01 – 12.5% decrease by second year after 3rd burn. 25% increase compared to pre-burn levels remaining stable from second year after 4th burn through second year 6th burn. One year after 7th burn 50% increase compared to pre-burn cover.

SAOR 02 - No change throughout six burns and three plot reads

SAOR 03 – 100% increase two years after the 4th burn, but returning to pre-burn baseline two years after the 5th burn.

SAOR 04 - 50% increase second year after 1st burn, but returned to pre-burn levels three years after first burn.

SAOR 06 – 50% decrease second year after 1st burn, remaining throughout second burn, and returning to pre-burn level one year after 4th burn.

The percent mean increases are driven by 2 or 3 out of 5 plots(dependent on year). SOAR 05 does not have any occurrences of green pitcher plants and was not included in the analysis. Only the SAOR 01 plot maintained an increase in cover throughout the monitoring range 1999-2017.

30-90% decrease in pole-sized trees by second year after 3rd burn.

All plots met the objective after the 3rd burn. Three plots met the objective after the 4th burn. Two plots met the objective after the 5th burn. SAOR 01 met the objective of around 79% reduction post 6th and 7th burn. SAOR 02 had a +16% increase in poles post 6th and 7th burn.

Chestnut Oak Forest (QUMO)

20-60% reduction in pole-sized trees

This objective was met in the 1st and 2nd burn and was exceeded in the 3rd and 4th burns. This objective should be refined to reduce shade tolerant and mesic species while retaining desirable species.

25-50% increase native grass and forb cover

This objective was met, but has considerable variability between the plots. Seasonality and fire return intervals will be further investigated.



Figures 12 and 13. Fire effects in QUMO plot 32

HORSESHOE BEND NATIONAL MILITARY PARK (HOBE)

Monitoring Unit HOBE	Management Objective (Restoration)	Monitoring Results (80% confidence interval)	Objective Achieved?	Year Analysis Completed (Range of Data [Yrs] Included in Analysis)
Mixed Montane Longleaf Pine Forest (FPIPA1D07)	Decrease density of all pole trees by 20-90% as measured 1 year post burn <u>$\beta_{YR01} - 00Pre$</u> <u>$00Pre$</u>	Density reduction = 32.3% ($\pm 8.4\%$) after 1 st burn, n=5 66.2% ($\pm 5.7\%$) after 2nd burn, n=5 61.5% ($\pm N/A$) after 3 rd burn, n=1	YES	2018 (2004-2017)
	Decrease duff and litter loading by 40-90% as measured immediately post burn <u>$\beta_{Post} - before \beta$</u> <u>$before \beta$</u>	Decrease in Duff = 2.3% ($\pm 12\%$) after 1 st fire, n=5 +53.2% ($\pm 6.8\%$) after 2nd fire, n=5 +26.5% ($\pm 17.5\%$) after 3rd fire, n=4 Decrease in Litter = 38.5 ($\pm 14.5\%$) after 1 st burn, n=5 55.2% ($\pm 10\%$) after 2nd burn, n=4 26.8% ($\pm 10.3\%$) after 3 rd burn, n=4	Duff – NO Litter - YES and NO	2018 (2004-2017)
	Limit mortality of overstory longleaf pine (<i>Pinus palustris</i>) trees to less than 10% as measured 2 years post burn <u>$\beta_{YR02} - 00Pre$</u> <u>$00Pre$</u>	Change in Density = 3.85% ($\pm 8.7\%$) after 1 st burn, n=5 1.9% ($\pm 9\%$) after 2nd burn, n=5	YES	2018 (2004-2017)
	Cause no net gain in percent cover of exotic plants as measured one year and five years post burn <u>$\beta_{YR01} - 00Pre$</u> <u>$00Pre$</u>	Increase in cover = 0.0 % ($\pm N/A$ %) after 1 st fire (n=5, 4 burn units) 0.0 % ($\pm N/A$ %) after 2 nd fire (n=5, 4 burn units)	Yes No new occurrences of exotic plants have been detected in plots.	2018 (2004-2017)

Table 4. Horseshoe Bend National Military Park Fire Effects Monitoring Results

HOBE – PIPA

After the second burn, results show increased reduction of mesophytic species. Monitoring at HOBE did not detect natural regeneration of longleaf pine. Seedlings have germinated along fire breaks where litter and duff have been removed to contain prescribed fires. The main constraints for longleaf regen is high levels of duff and litter, since the seed needs mineral soil to germinate. A dense canopy of overstory and midstory trees outcompete the shade intolerant longleaf seedlings and other diverse herbaceous plants. Mesophytic vegetation provides a twofold problem of increasing levels of litter and duff as well as limiting sunlight into the understory.

A pronounced trend in PIPA 1 and 2 is the increase of the herbaceous cover with a decrease of four dominant, mesophytic overstory species in response to fire management.

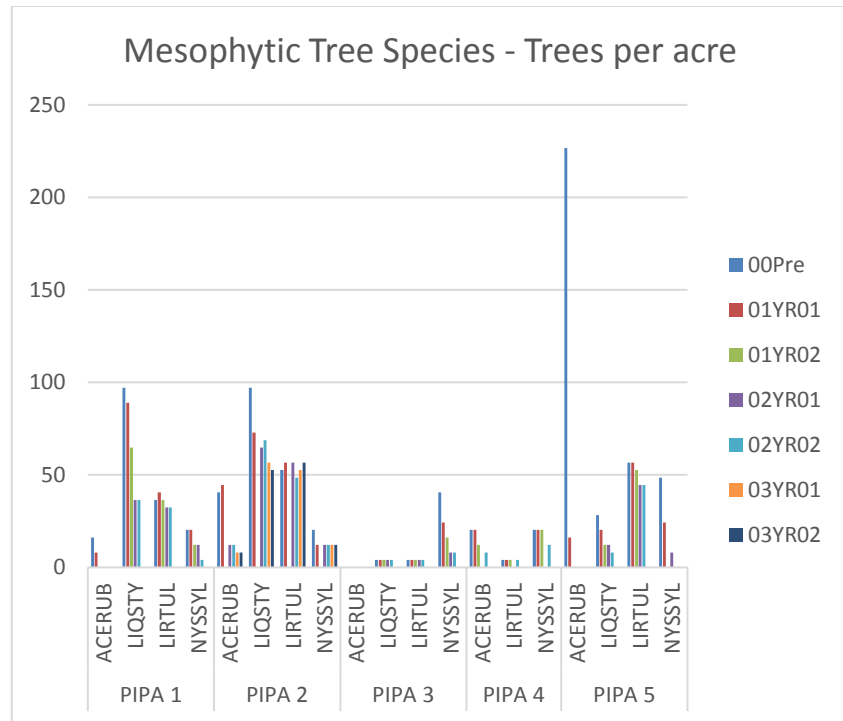


Figure 14: Horseshoe Bend Dominant Mesophytic Overstory Trees

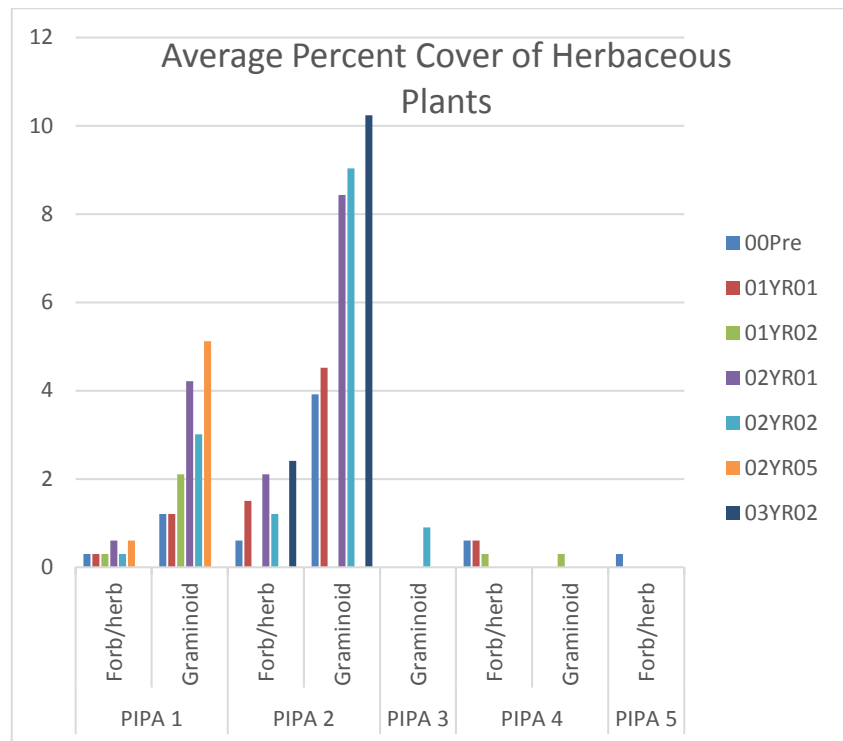


Figure 15: Horseshoe Bend Herbaceous Plant Cover

Mixed Montane Longleaf Pine Forest (FIPA1D07)

Decrease density of all pole trees by 20-90% as measured 1 year post burn. This objective was achieved in all post burn reads. This objective may need to be reexamined and modified to exclude *Pinus palustris* and other desirable oak species. It should target shade tolerant and mesic species.

Decrease duff and litter loading by 40-90% as measured immediately post burn

The objective for duff was mostly not met in these plots. While there was a reduction of 2% after the 1st burn there was an increase of 53% after the 2nd and 25% after the 3rd burn. This may not mean that duff reduction does not occur. During a June 2017 visit, the fire ecologist estimated that duff was reduced by half from the 2016 prescribed fires in the southern portion of the park by inspecting multiple locations on either side of the fire line. There were no longleaf pines or plots in this burn unit. Duff reduction is critical to establish naturally regenerated longleaf pine. One factor for the continual addition of duff may result from the dominance of mesic tree species that comprise the overstory and midstory. The hardwood litter generated and accumulated is notably more than what was historically found in these forests. These plots are located within stands of mature longleaf pine. It is possible that the combination of hardwood and pine litter contribute to conditions that maximize duff accumulation. This phenomena will be further investigated. In contrast, the litter reduction objectives were met for all three burns.

Limit mortality of overstory longleaf pine (*Pinus palustris*) trees to less than 10% as measured 2 years post burn

This objective was met with 2-4% increases in density after the 1st and 2nd burns. This objective will be critical during the restoration phase of fire management. The future of longleaf pine at HOBE will depend on retention and regeneration of these decadent, mature trees.

Cause no net gain in percent cover of exotic plants as measured one year and five years post burn.

Objective met. Only one occurrence of *Lonicera japonica* was observed which disappeared after a second burn and hasn't reappeared. If invasive species monitoring is deemed important, they should be surveyed over a much greater area than five 1000 square meter plots. This objective may need to be reexamined because it infers that prescribed fire may be a cause for increasing the percent cover for invasive plant species. This may be true in some regards, but fire alone is not the only factor in the spread of invasive/exotic plants.

Monitoring Unit GUIS	Management Objective (Restoration)	Monitoring Results (80% confidence interval)	Objective Achieved?	Year Analysis Completed (Range of Data [Yrs] Included in Analysis)
Sand Pine – Scrub Oak (FPICL1D0)	20-40% litter and duff reduction immediate post-burn $\frac{\beta_{Post} - \text{before } \beta}{\text{before } \beta}$	Decrease in Litter = 42% (± 17.9) after 1 st burn n=8 +20.9% (± 89%) after 2 nd burn n=6 8.7% (± N/A) after 3 rd burn n=1 Decrease in Duff = 14.9% (± 24%) after 1 st burn n=8 1.2% (± 52.6%) after 2 nd burn n=6 54.5% (± N/A) after 3 rd burn n=1	Partially Yes High variability	2018 (2000-2017)
	40-60% reduction of pole-sized trees by 2 nd year after 3 rd burn $\frac{\beta_{YR02} - 00Pre}{00Pre}$	Reduction = 9.8% (± 4%) after 1 st burn, n=10 35.2% (± 18%) after 2nd burn n=6 57.5% (± N/A) after 3 rd burn, n=1	Insufficient data. But trend is positive.	2018 (2000-2017)
	20-40% increase in herbaceous cover by 2 nd year after 3 rd burn $\frac{\beta_{YR02} - 00Pre}{00Pre}$	Increase in cover = 124.3% (± 56%) after 1 st burn, n=11 130.5% (± 70%) after 2nd burn, n=6 37.5% (N/A) after 3 rd burn, n=1	Insufficient data. But trend suggests the objective is being accomplished.	2018 (2000-2017)
Longleaf – Slash Pine Savanna (FPIPA1D07)	50-90% hardwood pole reduction by one Year after the 3 rd burn. $\frac{\beta_{YR01} - 00Pre}{00Pre}$	Reduction = 47.2% (± 7%) after 1 st burn, n=6 72.8% (± 12.2) after 2nd burn, n=7 33.2% (± 22.5%) after 3 rd burn, n=4 87.4% (± 6%) after 4 th burn, n=3	Insufficient data. But trend is positive.	2018 (2000-2017)
	20-40% litter and duff reduction immediate post- burn $\frac{\beta_{Post} - \text{before } \beta}{\text{before } \beta}$	Decrease in Litter = 62% (± 5.3%) after 1 st burn n=8 43.2% (± 35%) after 2nd burn n=10 43% (± 26%) after 3 rd burn n=8 +36% Increase (± 75%) after 4th burn n=3 Decrease in Duff = 14% (± 14%) after 1 st burn n=8 40% (± 12%) after 2 nd burn n=10 41% (± 12%) after 3rd burn n=8 51% (± 5%) after 4 th burn n=3	Partially Yes High variability	2018 (2000-2017)

	20-40% increase of herbaceous cover by 2 nd year after 3 rd burn. $\frac{\beta YR02 - 00Pre}{00Pre}$	Increase in cover = 36.6 % (± 28.8 %) after 1 st fire, n=7, 3 burn units 149 % (± 71 %) after 2 nd fire, n=6, 3 burn units 29 % (± 38.4 %) after 3 rd fire, n=4 139% (± 44 %) after 4th fire, n=3	Yes, but... Several more plots need to be burned and read to be conclusive.	2018 (2000-2017)
	Limit mortality of longleaf and slash pine to 20% $\frac{\beta YR02 - 00Pre}{00Pre}$	Density Reduction = 13.2 % (± 11.7%) after 1 st fire, n=11, 4 burn units 22.2 % (± 11.5 %) after 2nd fire n=10, 4 burn units 23 % (± 9.8 %) after 3rd fire n=6, 3 burn units 16.9 % (± 6.1 %) after 4 th fire, n=3	Yes and No Objective met for 1 st and 4 th burn. Objective exceeded for 2 nd and 3 rd burn.	2018 (2000-2017)
Pitcherplant Savannah (FSAAL1G010) Wet Pine Savanna/Mesic Flatwoods Fuels (added to increase sample size of fuels analysis)	Decrease duff loading by 0-20 % immediate post burn Decrease litter loading by 20-40% immediate post-burn $\frac{\beta Post - before \beta}{before \beta}$	Decrease in Duff = 16.7% (16.7%) after 1 st fire, n=4 8% (1.3%) after 2 nd fire, n=2 47.5% (N/A) after 3 rd fire, n=1 54.3% (N/A) after 4 th fire, n=1 Decrease in Litter = 62.6% (4.5%) after 1 st fire, n=4 65% (8.6%) after 2 nd fire, n=2 66% (N/A) after 3 rd fire, n=1 73% (N/A) after 4 th fire, n=1	Yes	2018 (2001-2017)
	Limit mortality of overstory pine trees to less than 20% measured 2 years post burn $\frac{\beta YR02 - 00Pre}{00Pre}$	Overstory Mortality = 4.5% after 1 st burn 25% after 2 nd burn 82% after 3rd burn 03YR02 – 00Pre / Pre calculated at 82% mortality to overstory pines. Requires further investigation to confirm. May be influenced by hurricane damage and long term stress induced from hurricane event.	Yes for 1st fire No – beyond 2nd fire	2018 (2001-2017)
	Reduce pole tree density by 40-90% $\frac{\beta YR02 - 00Pre}{00Pre}$	Decrease in density = 0 % after 1 st burn 17% after 2 nd burn 50% after 3 rd burn – 1 year post 100 % after 3 rd burn – 2 years post	YES, but... All poles were <i>Pinus palustris</i>	2018 (2001-2017)
	Reduce shrub density by 40-90% $\frac{\beta YR02 - 00Pre}{00Pre}$	Shrub Reduction = -10% after 1 st burn +51.5% after 2nd burn -4.6% after 3 rd burn	No Data based on 1 plot.	2018 (2001-2017)
	Cause no net decrease in cover of yellow trumpets (<i>Sarracenia alata</i>) $\frac{\beta YR02 - 00Pre}{00Pre}$	Increase in cover = 100 % (± N/A %) after 1 st fire n=1, 1 burn units)	Yes/Uncertain* Only one plot is installed in this monitoring type	2018 (2001-2014)

	00Pre	100 % (± N/A %) after 2nd fire n=1, 1 burn units) 200 % (± N/A %) after 3rd fire n=1, 1 burn units)		
	Increase herbaceous component of the understory by 20-40% measured 2 years after the 3rd burn $\frac{\beta YR02 - 00Pre}{00Pre}$	Increase in cover = -27.7 % (± N/A %) after 2nd fire n=1, 1 burn units) 21.5 % (± N/A %) after 3rd fire n=1, 1 burn units)	Yes/Uncertain* Only one plot is installed in this monitoring type	2018 (2001-2014)

Table 5. Gulf Islands National Seashore Fire Effects Monitoring Results

GULF ISLANDS NATIONAL SEASHORE (GUIS)

Sand Pine – Scrub Oak (FPICL1D07)

20-40% litter and duff reduction immediate post-burn

This objective had highly variable results with some data collected for five years after the 2nd burn. All comparisons were made using post burn reads compared to the previous two year post burn reads as this was the most consistently collected data. Six of the eight plots had a reduction of total fuels for both the one year and two year after fire reads. The trend began to rise for total fuels in all plots from 2 year reads to 3 year after burn reads. Litter measurements were particularly variable showing a mean decrease of 42% after the 1st fire and a mean increase of +20% after the 2nd fire. Duff was more moderate showing a 14% decrease the first year and 1% the second. The third burn only had one plot and measured a 55% reduction. This objective will be reconsidered in the future.

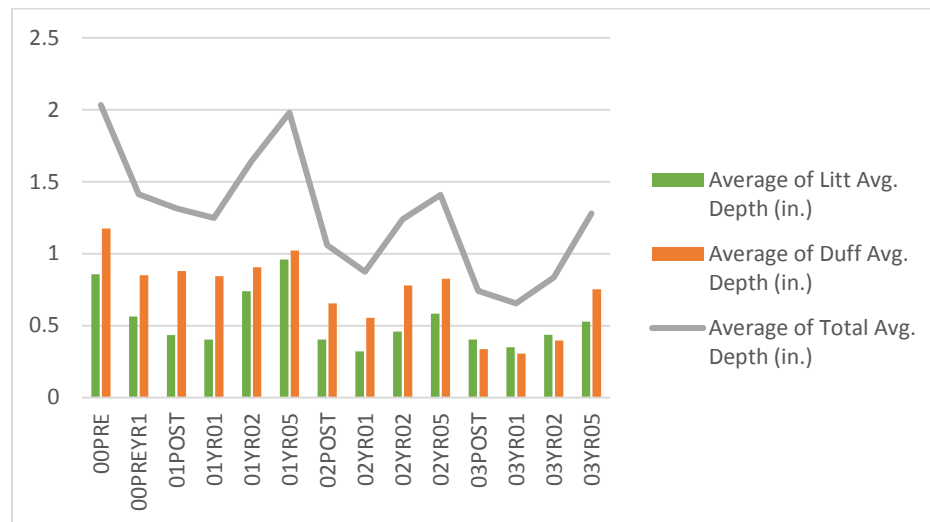


Figure 16. Litter and Duff Consumption for Sand Pine – Scrub Oak

40-60% reduction of pole-sized trees by 2nd year after 3rd burn

Only one plot has been measured 2 years after a 3rd burn, but the trend suggests the objective was accomplished. There appears to be a lag for pole reduction in these plots with a reduction of 10% after the first fire, 35% after the second fire, and 58% measured in the single plot after the third fire.

20-40% increase in herbaceous cover by 2nd year after 3rd burn

The herbaceous cover responds rapidly in this monitoring type showing a 124% increase after the first fire and 130% after the second. Only one plot was measured after three burns and it shows a 38% increase. Numerous factors could be involved for this reduced percent increase. This is an interesting and important objective that remains inconclusive, but offers a positive trend.

Longleaf – Slash Pine Savanna (FIPA1D07)

50-90% hardwood pole reduction by one Year after the 3rd burn.

Data is currently inconclusive for this objective, but the overall trend is very positive for this monitoring type. The objective was met after the 1st, 2nd, and 4th burns. It was not met after the 3rd burn which was due to no change in two plots (PIPA 11, 12). Plots PIPA 01 and 10 experienced reductions of 83% and 50% respectively. This is a well-crafted and specific objective and may be utilized in other monitoring types as well.

20-40% litter and duff reduction immediate post-burn

In most cases this objective was achieved. PIPA 06 was the outlier which skewed the mean percent change after the fourth burn. It is notable that PIPA 06 saw an increase in litter from preburn to after the third burn as well, but didn't affect the mean as strongly.

The duff only fell short of the objective after the 1st burn where the biggest contributor was PIPA 05 experiencing an increase of 49% in the duff layer.

20-40% increase of herbaceous cover by 2nd year after 3rd burn.

The plots that were monitored for this objective have met it. More plots need to be burned and monitored to achieve a minimum sample size.

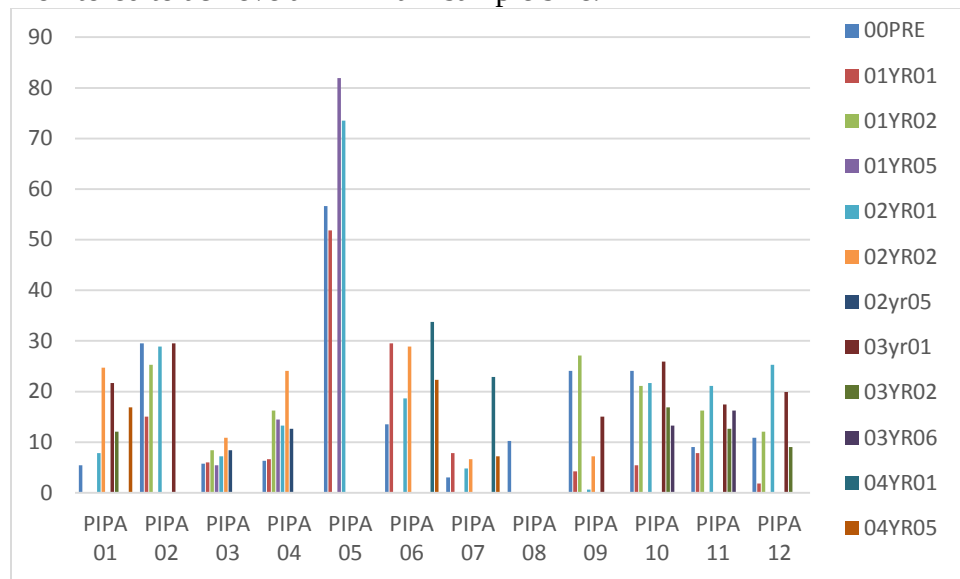


Figure 17.

Limit mortality of longleaf and slash pine to 20%

This objective should be more specific. Data analysis conducted on overstory trees > 15 cm.. Results will differ if seedlings are accounted for. Objectives were met for 1st and 4th burns and were not met for 2nd and 3rd burns. It may prove to be a good future objective to maintain the species in the overstory. Multiple other factors can be attributed to higher mortality after the 2nd and 3rd burns. For example, after the 1st burn total fuel loading returned near or above preburn

levels. Also, the area is affected by periodic hurricanes which cause direct mortality, stress trees to succumb to low-moderate fire effects that would otherwise be tolerated, and also accounting for insect and disease damage. This could be within tolerable limits if considered a result of first entry fires and may well be the cost for a fire hardened forest. Continued reductions of these overstory species may only be of concern if the trend continues with the 4th and 5th burns, but is unlikely with a frequent fire regime.

Pitcherplant Savannah (FSAAL1G010) Wet Pine Savanna/Mesic Flatwoods

Decrease duff loading by 0-20 % immediate post burn

Objective was not met for the 1st and 2nd burn. This may be attributed to fire personnel using caution for first entry burns and is typically a prudent approach. Wet Pine savanna habitats in good condition usually do not have much duff if any and now that this plant community has been reintroduced with fire higher severity prescribed fires can be utilized with less caution.

The objective was successfully attained on the 3rd and 4th burns.

Decrease litter loading by 20-40% immediate post-burn

Litter reduction objectives have been successfully met for each prescribed burn.

Limit mortality of overstory pine trees to less than 20% measured 2 years post burn

Overstory Mortality =

-4.5% after 1st burn

-25% after 2nd burn

-82% after 3rd burn

03YR02 – 00Pre / Pre calculated an 82% change to overstory pines. Requires further investigation to confirm. May be influenced by hurricane damage, salt water intrusion, and/or long term stress induced from hurricane event.

Reduce pole tree density by 40-90%

The only poles measured in this plot are *Pinus palustris*. There is no reason to reduce this species. If other species were present as poles within this plot, this might be a good objective to suppress every other species except Longleaf Pine. Zero percent were reduced with the first burn, 17% with the 2nd, 50% were reduced one year after the third, and 100% were reduced by the second year of the 3rd burn.

Three big factors for mortality of Longleaf Pine poles are lack of sunlight, fuel loading, and poor timing of fire. When they bolt from the grass stage, they are at their most vulnerable. They require full sun and an open habitat to strengthen as they rapidly grow. Another factor is too long of a period without fire during the bolting stage. If fuels are allowed to accumulate beyond 2 growing seasons, it creates fire intensities beyond their ability to survive. Additionally, if they are “candling” when the terminal bud is exposed beyond the needles, fire can kill them. This period is typically only around two weeks in the Spring.

Reduce shrub density by 40-90%

This objective was not met. It will be necessary to reconsider to fire return interval here. To achieve this objective would take a minimum of a two year fire return interval for the next three prescribed fires. Additionally, chemical and/or chemical treatment may be necessary to restore

this site. Shrub reduction was achieved after the 1st burn by 10% and 3rd burn by 4.6%. After the 2nd burn shrub density increased by over 50%.

Cause no net decrease in cover of yellow trumpets (*Sarracenia alata*)

Pitcher plants are resilient and often remain dormant or in a grass like appearance for many years when they are overgrown by midstory shrubs and/or a dense overstory. They responded favorably to every fire by increasing 100% over the 1st and 2nd burns, and 200% after the 3rd burn.

Increase herbaceous component of the understory by 20-40% measured 2 years after the 3rd burn

Although herbaceous plants declined by 27% after the 2nd burn, this objective was met by the 3rd burn with a 21.5% increase in the understory

A more ambitious goal of increasing the understory by 200% compared to pre-burn conditions

Monitoring Unit NATR	Management Objective (Restoration)	Monitoring Results (80% confidence interval)	Objective Achieved?	Year Analysis Completed (Range of Data [Yrs] Included in Analysis)
Mixed Loblolly Pine Forest (FPITA1D09)	Reduce total fuel load by 20-40% immediately post-burn $\frac{\beta_{Post} - \text{before } \beta}{\text{before } \beta}$	Total fuel reduction = 38.7% (± 4.3 %) after 1st fire n=13, 7 burn units 9.3 % (± 12 %) after 2 nd fire n=13, 7 burn units 12.6 % (± 15 %) after 3 rd fire n=9, 4 burn units 9 % (± 17.3 %) after 4th fire n=6, 3 burn units	YES Objective met after the first burn and not met after subsequent burns. Need to reconsider objectives for this monitoring type.	2018 (2001-2017)
	Reduce conifer poles (2.5-15.0 cm dbh) > 25% one year after 3 rd fire $\frac{\beta_{YR01} - 00Pre}{00Pre}$	Density reduction = 55 % (± 31 %) after 3rd fire n=6, 4 burn units 48.3 % (± 20.3 %) after 4 th fire n=6, 4 burn units	YES	2018 (2001-2017)
	Cause no net gain in percent cover of exotic plants after 5 burns $\frac{\beta_{YR01} - \text{earliest read}}{\text{earliest veg. read}}$	Change in percent cover = +122.5% (± 6.2%) after 1st burn, n=9 -32.7% (± 1.2) after 2 nd burn, n=4 -71.4% (± 1%) after 3rd burn, n=5 -94% (N/A) after 4 th burn, n=1	Insufficient data Plots have not burned 5 times, but trend is positive.	2018 (2001-2017)
Black Belt Prairie (BJUV1D06)	25-50% reduction of redcedar (<i>Juniperus virginiana</i>) density after 5 years of burning $\frac{07YR01 - 00Pre}{00Pre}$	Reduction = 94.6% after 8 fires, n=4, 1 burn unit	YES	2018 (1998-2017)
Midsouth Savanna (FQUST1D09)	Increase cover of native herbaceous plants by >200% after three burns $\frac{\beta_{YR01} - 00Pre}{00Pre}$	Increase in herb cover = 15.4% (± 31 %) after 3 rd fire, n=2, 1 burn units 168.7% (± 77%) after 4th fire, n=3, 1 burn units	NO Not all plots have burned three times	2018 (2011-2017)
	Reduce mean density of pole-sized trees by >50% after 3 burns $\frac{\beta_{YR01} - Pre00}{Pre00}$	Density reduction = 30% (± 7.8 %) after 3 rd fire, n=3, 1 burn unit 36% (± 6.7 %) after 4 th fire n=3, 1 burn unit	NO Not all plots have burned three times	2018 (2011-2017)
	Reduce over-story of Eastern Red Cedar (<i>Juniperus virginiana</i>) by > 50% after 3 burns	Density increase = + 8.2% (± 0.8%) after 3rd burn, n=3 + 13.6% (± 3.2%) after 4th burn	NO Not all plots have burned three times	2018 (2011-2017)

Oak-Hickory Woodland (FOAHI1D09)	Reduce litter and duff load by 30-40% after 3 burns $\frac{\beta Post - 00Pre}{00Pre}$	Litter reduction = 50% ($\pm 19\%$) after 1 st fire, n=5, 3 burn units 60.7% ($\pm 11\%$) after 2nd fire, n=5, 3 burn units 58.5% ($\pm 17\%$) after 3rd fire, n=4, 3 burn units 15% (N/A) after 4 th fire, n=1. 1 burn unit Duff reduction = +7% ($\pm 51\%$) after 1 st fire, n=5, 3 burn units 7% (± 40) after 2 nd fire, n=5, 3 burn units 35% ($\pm 18\%$) after 3rd fire, n=4, 3 burn units +1% (N/A) after 4 th fire, n=1, 1 burn unit	YES	2018 (2006-2017)
	Reduce mean density of pole-sized trees by 20-30% after 3 burns $\frac{Post\ 3rd\ Burn - Earliest\ Read}{Earliest\ Read^*}$ 3 units burned three times, 1 unit burned four times	Pole tree reduction = 20.5% ($\pm 5\%$) after 3rd fire, n=4	YES	2018 (2006-2017)
Japanese Grass Invaded Streamside Forest (FMIVID09)	Decrease percent cover of Japanese grass (<i>Microstegium vimineum</i>) by 50% one year post treatment $\frac{\beta YR02 - Pre00}{Pre00}$	**Microstegium was misidentified in the pre reads, significantly** Value of this plot type will be reexamined.	Uncertain	2018 (1999-2017)

Table 6. Natchez Trace Parkway Fire Effects Monitoring Results

Natchez Trace

Mixed Loblolly Pine Forest (FPITA1D09)

Reduce total fuel load by 20-40% immediately post-burn

This objective was met after the first burn (39%), but not after subsequent burns (second 9.3%, third 12.6%, and fourth 17.3%).

Reduce conifer poles (2.5-15.0 cm dbh) > 25% one year after 3rd fire

Density objectives have been met for reducing conifer poles by 55% after third burn and by 48% after fourth burn.

Cause no net gain in percent cover of exotic plants after 5 burns

The main exotic plants in these plots are *Ligustrum sinense*, *Lonicera japonica*, and *Microstegium vimineum*. After the first burn these exotics increased by 123%; however, the general trend has been a reduction in exotics after each subsequent fire. Percent cover has reduced by 33% after the second burn, 71% after the third burn, and 94% after the fourth burn. Two plots that had an absence of fire for five and ten years show the exotics increasing in cover by around 200% while another plot absent of fire for five years did not have a significant increase.

Black Belt Prairie (BJUVI1D06)**25-50% reduction of Eastern red cedar (*Juniperus virginiana*) density after 5 years of burning**

Red cedar was reduced by 94.6% after eight burns. While exceeding the upper end of this objective, this is still a very good result for the Black Belt Prairie site at Chickasaw Village. Mechanical thinning has been ongoing to facilitate the reduction of this invasive yet native species. Red cedar has dominated much of the remaining prairie habitat to the exclusion of nearly all other vegetation and will quickly return to this site with an absence of fire. Nearly all remaining Black Belt prairie sites in Mississippi not undergoing frequent mowing or prescribed fire are dominated with Eastern red cedar.

Midsouth Savanna (FQUST1D09)**Increase cover of native herbaceous plants by >200% after three burns**

Not all plots have burned three times. Three plots that have burned four times and show a 169% increase in native plant cover. While short of the objective, the trend is positive and may be achieved with additional fire.

Reduce mean density of pole-sized trees by >50% after 3 burns

Three plots have a 30% reduction of pole sized trees after three burns and a 36% reduction after four burns. Additional burning and other restoration treatments may help achieve this objective.

Reduce over-story of Eastern Red Cedar (*Juniperus virginiana*) by > 50% after 3 burns

This objective has not been met with plots having an increase in density of 8.2% after the third burn and 13.6% after the fourth. As these Eastern Red Cedar trees become more mature, they also become less susceptible to fire by dominating other vegetation and restructuring the surface fuels to become less flammable. Fire alone will not achieve this objective and additional restoration treatments will be necessary.

Oak-Hickory Woodland (FOAHI1D09)**Reduce litter and duff load by 30-40% after 3 burns**

Litter reduction objective was achieved after the third burn with a reduction of 58.5%

Duff reduction objective was also achieved by reducing 35% of duff after the third burn

Reduce mean density of pole-sized trees by 20-30% after 3 burns

Pole tree reduction of 20.5% was achieved after the third burn.

CUMBERLAND ISLAND NATIONAL SEASHORE (CUIS)

Monitoring Unit CUIS	Management Objective (Restoration)	Monitoring Results (XX% confidence interval)	Objective Achieved?	Year Analysis Completed (Range of Data [Yrs] Included in Analysis)
Dry Longleaf Pine – Oak Woodland (FARIS09)	Decrease duff and litter loading by 40-90% as measured immediately post burn $\frac{\beta_{Post} - \text{before } \beta}{\text{before } \beta}$ $\frac{\beta_{YR01} - \text{Pre00}}{\text{Pre00}}$	Decrease in Duff = Post fire = +30.3% ($\pm 23\%$) n=4 1 Year after fire = 9% ($\pm 26\%$) n=4 Decrease in Litter = Post fire = 32% ($\pm 6.2\%$) n=4 1 Year after fire = 17% ($\pm 15\%$) n=4	No	2018 (1999-2017)

Table 7. Cumberland Island National Seashore Fire Effects Monitoring Results

Dry Longleaf Pine – Oak Woodland (FARIS09)

Decrease duff and litter loading by 40-90% as measured immediately post burn

Cumberland Island had only one prescribed fire conducted with fire effects monitoring plots read pre and post burn. The objective of decreasing duff and litter by 40-90% as measured post burn may be ambitiously high for this monitoring type. The live oak trees within these units reduce fire behavior and create conditions for lower intensity fires. Data collected shows a 30% increase in duff immediately post burn, but one year after the burn there was a 9% decrease. This is likely due to charred litter appearing like duff, then weathering down over time to present an overall decrease a year later. This may indicate duff measurements are better monitored 1 year after fire. Litter objectives were nearly met at a reduction of 32% immediately post burn. One year later there was a 21% increase in litter.

First entry burns should typically be applied under conditions that favor lower severity fires; therefore, this could be considered a successful burn.

Other Parks within the Mississippi River Fire Management Zone Fire Effects Monitoring Network

Analysis was not conducted on several parks for this annual report. The parks listed below have been treated with prescribed fire, are planning for prescribed fire, or are interested in supporting fire management.

ABLI Abraham Lincoln Birthplace National Historic Site

BISO Big South Fork National Recreation Area

CARI Cane River Creole National Historical Park

FODO Fort Donelson National Military Park

JELA Jean Lafitte National Historic Park and Preserve

MACA Mammoth Cave National Park

SHIL Shiloh National Military Park

STRI Stones River National Military Park

VICK Vicksburg National Military Park

B. Program Information

Please complete the tables below which contain additional information that we feel is valuable to compile on an annual basis to help assess the fire ecology program workload.

Planning - 2017

Park	Does Park have written DFCs? (yes or no)	Date Park-level Monitoring Plan completed (or revised)	Number of Project- or Community-level Monitoring Plans	BAER Plan Assists
Abraham Lincoln Birthplace NHP	No	N/A	0	0
Chickamauga and Chattanooga NMP	No	N/A	0	0
Cumberland Island National Seashore	No*	2014 (Draft)	0 (2) †	0
Fort Donelson National Battlefield	No*	N/A	0	0
Gulf Islands National Seashore	No*	2010 (Draft)	0 (3)	0
Horseshoe Bend National Military Park	No	N/A	0 (1)	0
Jean Lafitte NHP and Preserve	No	N/A	1	0
Little River Canyon National Preserve	No	N/A	0 (3)	0
Mammoth Cave National Park	No	2013 (Draft)	0 (6)	0
Natchez Trace Parkway	No	2007	0 (6)	0
Russell Cave National Monument	No	N/A	0 (1)	0
Shiloh National Military Park	No*	N/A	0 (1)	0
Stones River National Battlefield	No*	N/A	0 (3)	0
Vicksburg National Military Park	No*	N/A	0	0

Table 8. Zone Park Planning

*Does not have written DFCs that have measurable objectives for park vegetation, but does have general desired landscape goals.

†Number in brackets represents number of Monitoring Type Descriptions (FMH 4).

Monitoring--2017

Park	% 2017 Data Entered	% 2017 Data Quality Checked	# Prescribed Fires Monitored*	# Non-fire Fuels Treatments Monitored*	# Wildfires Monitored *	# BAER/BAR Treatments Monitored*
Cumberland Island National Seashore	100%	100%	1	0	0	0
Gulf Islands National Seashore	100%	100%	2	0	0	0
Horseshoe Bend National Military Park	100%	100%	0	0	0	0
Little River Canyon National Preserve	100%	95%	5	0	1	1
Natchez Trace Parkway	100%	95%	6	1	0	0
Mammoth Cave National Park	100%	100%	1	0	0	0
Shiloh National Military Park	100%	100%	2	0	0	0
Stones River National Battlefield	100%	100%	3	0	0	0
Vicksburg National Military Park	100%	100%	0	0	0	0

Table 9. * Number of treatment units with treatment effects monitoring conducted. Include pre-burn and post-burn monitoring but not burn-day monitoring.

Communicating Results – 2017

Park	# of Project Monitoring Reports completed	# of Annual meeting(s) with Park staff	# of Formal presentations of results	Do you use Minitab?†
Cumberland Island Nat. Seashore	0	1	0	Yes
Gulf Islands National Seashore	0	1	0	Yes
Horseshoe Bend NMP Park	0	1	0	Yes
Jean Lafitte NHP and Preserve	0	1	0	No
Little River Canyon National Pres.	0	1	0	Yes
Mammoth Cave National Park	0	1	0	Yes
Natchez Trace Parkway	0	1	0	Yes
Russell Cave National Monument	0	0	0	No
Shiloh National Military Park	0	1	0	Yes
Stones River National Battlefield	0	1	0	Yes
Vicksburg National Military Park	0	1	0	No

Table 10. † A SER enterprise license is used by the Mississippi River Zone Fire Ecologist, Minitab Release 18.*

Research – 2017

Park	Are research needs identified in FMP or Monitoring Plan? (yes or no)	# of Proposals Submitted in 2017	# of Research Projects Supported in 2017*	Additional Comments
Cumberland Island National Seashore	Yes	0	0	
Gulf Islands National Seashore	Yes	0	0	
Horseshoe Bend National Military Park	No	0	0	
Jean Lafitte NHP and Preserve	Yes	0	0	Pre-burn floatant marsh monitoring has been established by Southern Illinois University ~2008
Little River Canyon National Preserve	No	0	0	
Mammoth Cave National Park	Yes	0	1	Ongoing research concerning fire and Indiana bat habitat/LIDAR vegetation mapping by the University of Kentucky
Natchez Trace Parkway	Yes	0	2	Blackbelt Prairie Restoration, Apios priceana reintroduction
Shiloh National Military Park	No	0	0	
Stones River National Battlefield	No	0	0	
Vicksburg National Military Park	No	0	0	

Table 2. *Number of funded research projects, new or ongoing, supported by the fire ecology program including logistical info or support, staffing, etc.

C. Fire ecologist accomplishments and areas of focus

Category	Percent Time	Accomplishments and/or areas of activities
<i>Planning</i>	<i>20%</i>	• Reviewed and contributed to FODO FMP. Participated in review for BISO, MACA, and HOBE FMP. • Composed and revised section 7 consultation letter for HOBE burn plan. • FMP, EA, EIS, CE, section 7 consultation, monitoring plan, burn plan development & review, etc. • Reviewed SHIL, BISO, burn plans. • Fire Effects program planning. MS River Zone planning (senior staff discussions), • Generate and maps and GIS compilation • Developed new photo monitoring protocol
<i>NPS Meetings/ task groups</i>	<i>10%</i>	• <i>Participated in Leadership Committee at NATR</i> • <i>Internal scoping for ASIS FMP and FMP EA</i>
<i>Interagency work</i>	<i>5%</i>	• <i>Participated in Southern Pine Beetle SPB planning with USFS</i> • <i>Collaborated with North Mississippi Land Trust to collect Apios priceana seed from private lands</i>
<i>Wildfire Assignments</i>	<i>0%</i>	<i>None to date</i>
<i>Prescribed fire projects</i>	<i><5%</i>	<i>FIRB and FFT2 on two prescribed fires</i>
<i>Non-fire fuels projects</i>	<i>10</i>	• <i>Assisted with the planning and execution of managing a large volunteer group at VICK for creating new firelines and removing woody vegetation within viewsheds.</i> • <i>Assisted in Juniperus virginiana removal within Blackbelt Prairie restoration areas.</i>
<i>Research</i>	<i><5%</i>	• <i>Led collection efforts to gather Apios priceana tissue for genetic study.</i> • <i>Reviewed and shared ecological literature.</i> • <i>Correspondence with Universities</i>
<i>Data collection</i>	<i>3%</i>	<i>Assisted with collection of FMH data. Installed FMH plots. Field work at NATR, CUIS, STRI, Coonewah Preserve</i>
<i>Data entry</i>	<i><2</i>	<i>Monitors completed data entry, corrected data within FFI</i>
<i>Data analysis</i>	<i>10%</i>	• <i>Performed statistical tests and analysis of fire effects data for Zone Parks.</i> • <i>Summarized and shared fire effects data with Zone Parks when requested.</i> • <i>Work completed for 2017 Annual Report.</i>
<i>Supervision/Admin</i>	<i>10%</i>	• <i>Supervised lead monitor and 2 FTSF Fire Effects Monitors, completed performance evaluations, IDP's</i> • <i>Travel authorization/vouchers and time paperwork</i> • <i>Research and seek guidance on various scenarios</i>

Training	10%	• Attended Association for Fire Ecology (AFE) Conference • Section 106 and NEPA Training • Civil Treatment for Leaders • FFI Workshop online and in person • All Hazards Resource Advisor - Introduction and Intermediate • Firefighter refresher • Active Shooter Training • CPR/First Aid • Supervisory and required NPS training. • PT
Travel out-of-park for plot or project work	10%	Site visits with Zone Parks, monitoring, meetings, and project implementation. Supported FEMA team in Puerto Rico for Hurricane Maria recovery
Miscellaneous	<5%	Communication; E-mails, phone calls, informal planning discussions. Meetings with Park staff, outreach with partners

D. Fire effects crew accomplishments and areas of focus

This section deals with roles and functions of the fire effects crew. Identify accomplishments and/or focus areas along with a rough estimate of the amount of time spent in these areas (see table format and example below).

Fire Effects Crew 2017 Accomplishments/Focus Areas

Category	Percent Time	Notes
FMH plots	20%	Monitored 60 standard FMH Plots
WUI plots	0%	No scheduled WUI plots for 2017
CBI plots	5%	Post burn monitoring on wildfire
Other plot work	5%	Rare Plant Monitoring, NATR Breeding Bird Surveys
Wildfire assignments	5%	Served in variety of roles including: FFT2, FFT1(T), FEMO, READ/REAF • NATR wildfire incidents • Wildfire assignments in California and Mississippi.
Prescribed fire projects	15%	Served in variety of roles including: FFT2, ATVO, FFT1, FEMO, Holding at NATR, LIRI, HOBE, BISO, SHIL and STRI Consultation for Rx burns
Non-fire fuels projects	2%	NATR Blackbelt Restoration, exotic, and hazard fuels removal projects Assisted with WUI vegetation clearing/saw work
Travel out-of-park for plot or project work	20%	Installed FMH plots at CUIS FMH monitoring at STRI, SHIL, MACA, GUIIS, LIRI, Tishomingo State Park
Data entry	15%	Copied, scanned, entered and checked FMH and other fire effects data
Data analysis	1%	Fuels Analysis
Supervision/Admin	10%	Payroll, travel authorization/voucher, hiring etc.
Training	5%	Firefighter Refresher, Advanced Plant ID, NEPA/Section 106 Training, SE Fire Ecology Meeting, Fire Ecology Congress
Miscellaneous	5%	Collected, identified, and preserved plant specimens for long-term data collection consistency and reference NATR Recycling Committee Herpetile and Bat Monitoring NATR Bioblitz: Guided multiple walks for the public about birds and native flora. Staffed resource management booth. Organized and lead local Audubon Christmas Bird Count.

E. 2018 Direction

2017 experienced three new employees to the Fire Effects Monitoring team for a total team of four staff members. The Fire Program has also faced reductions to the overall fuels budget where the Fire Effects team derives their program budget. National and regional guidance has recognized that our programs are unable to maintain the previous model of dividing our time, energy, and resources equally throughout the zone parks. Previous monitoring schedules have proven to be unsustainable under near term budget allocations; however, it is possible to continue addressing the needs for ecological monitoring of fire effects by using the following strategies:

- Focusing on a few parks each year rather than spreading resources throughout the zone. The focus may change from one year to the next, but over time should be equitable. The fire ecology program is undergoing a review to address how to best serve the needs of the zone parks, more fully incorporate adaptive management, and more closely fitting the programs' goals to its means.
- Reexamine and modify burn objectives to specifically address the most important and relevant questions about the resource. Many objectives are anachronistic and reflect uncertainty to the effects of fire prior to first entry treatments. In many cases, current science demonstrates that fire is essential for maintaining ecological processes, building resilience to disturbance, and preserving biodiversity. A re-examination of the burn objectives shall formulate new objectives that focus on positive indicators for the specific monitoring type, burn unit, and ecosystem.
- Continue full engagement in prescribed fire operations and general support to fire management and other federal emergency response missions.
- Differentiate restoration regime objectives for the short and long term.
- Describe maintenance phase conditions and objectives for monitoring types and burn units within the zone parks.
- Coordinate additional treatments to compliment fire management – Even optimally applied fire management is often not be enough to restore and maintain NPS lands in a manner that fulfills our obligation to “conserve wild life unimpaired”.
- Continue to cultivate proactive and willing partners for continuing fire management within the respective parks.
- Utilize, develop, and apply a wider array of statistical methods and techniques to determine the best approach to shape data collection for site specific objective. Explore methods outside from the Fire Monitoring Handbook (FMH) protocol. Continue learning and utilizing R Programming for additional capacity for data analysis. Conduct more comprehensive data analysis.
- Prioritize and continue replicating data collection methods from long term monitoring plots. Augment these methods with complementary approaches.
- Remain open and explore the utility of new technology such as Terrestrial Lidar, Photogrammetry, unmanned aerial vehicles (UAV's), infrared imagery, and spherical photography. We are currently trialing pre and post burn photo-monitoring using 360° spherical pictures.
- Use monitoring expertise to experiment with complimentary treatments such as herbicides, mechanical, TerraTorch, seeding of herbaceous species to increase fine fuels, enhancing positive indicator species, exotic and invasive species management in sensitive sites, and other opportunistic projects.

Do to the similarity in programs between the Appalachian/Piedmont Fire Effects Monitoring Program (A/P) and the Mississippi River Zone Fire Effects Monitoring Program, we are incorporating lessons learned and methods developed by the A/P program to increase our own efficiency and effectiveness. Examples include using varied plot types to include modified FIREMON Species Composition, Fuels Transect, CBI, and Photo Point protocols. Using a variety of complementary methods and tools has demonstrated to provide a productive approach.

Many of the parks within the Mississippi River Zone are historically “high fire return interval” ecosystems. After prolonged periods without fire, these systems often change dramatically into new plant assemblages that no longer tolerate fire management in the same way it once had. The resilience of these long unburned ecosystems to fire management has become degraded from the subsequent dominance of fire-intolerant woody vegetation. In some cases, we have been using historic “maintenance” fire regimes to do the work of restoration. Many of our fire managed parks require a “restoration” phase fire regime, which typically may need either a shorter fire return interval or a complementary mechanical or chemical treatment. For example, if a site historically burned at a 5-8 year return interval and is long unburned, using a 2-3 year return interval may hasten the restoration process and more quickly return the site to a maintenance phase of 5-8 year fire return interval so long as a carefully designed firing operation is anticipated and executed. There is risk for long term negative consequences from using high intensity fire early into a restoration phase, indicating the prerequisite balance between fire severity and frequency. A fire return interval that is too far apart will either merely “reset the clock” to conditions similar to the previous burn or slowly degrade the shade tolerant, fire intolerant ecosystem undergoing prescribed fire without the benefit of restoring the fire adapted or fire dependent elements of the ecosystem.

Many fire management units within zone parks may perpetually generate shade tolerant and mesic species if canopy openness is not monitored and considered for new objectives. Many managers may become concerned with opening up forest canopies because it necessitates mortality to some number of overstory trees. Higher severity fires may be appropriate in some cases to diminish dominant, shade tolerant, and mesic species. This will also reduce the seed sources and potentially lessen the need for more active management later.

Fire management is often not enough for many of these fire dependent ecosystems and requires other techniques such as mechanical or chemical treatments. To receive the greatest restoration benefit from fire management, Parks may need to coordinate additional management activities that complement the potential effects of fire on the landscape. Fire management staff necessarily must focus on the areas where fire can do the most good. A goal outlined in the National Cohesive Wildland Fire Management Strategy states to “Actively manage the land to make it more resilient to disturbance, in accordance with Management Objectives.” This is central to our strategies.

Objectives will be reexamined and refined in order to provide better focus for allocating staff time. Some future prescribed fire objectives may include:

- Duff reduction goals that relate to current and future number of executed burns
- Target shade tolerant and/or mesophytic negative indicator species for reduction at site specific burn units and monitoring types.
- Give focus on herbaceous understory response and utilize site level positive indicator species to gauge fire effects. For example, increase bluestem (*Schizocharium sp.*) to >5%

- Explore canopy closure/openness measurement protocols to develop and track restoration objectives. These may be particularly useful for restoring upland/dry oak species and many of the southern pine species.

Scientific consensus recognizes that fire is a critical ecological process throughout the world and especially in the southeast United States. Altered fire regimes have threatened native plant and animal assemblages resulting in loss of resilience and biodiversity. It is our goal to address the issues of resilience and biodiversity through fire effects monitoring rather than confirm what is already obvious to fire management practitioners.

F. Overall Data Entry Status and FFI suggestions

Program Data

- Our data is contained primarily in FFI and is estimated to be >90%
- We will begin collecting some data in FY 18 that will be a broad census of geo-referenced data, for example, a population census of *Apios priceana*, and *Pinus palustris*.

Many thanks to all the folks who support fire management and the conservation of life's diversity found within our National Parks.

The End.