



Fire Effects Monitoring for the Flagstaff Area National Monuments: Overview, Status, and Future Direction

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Summary

The intent of this report is to document the 2015 evaluation process for fire effects monitoring activities in the three Flagstaff Area National Monuments (Sunset Crater Volcano, Walnut Canyon, and Wupatki). The report contains overviews of the existing fire effects monitoring plots and data collection procedures, analyses of fire effects monitoring plot data collected between 1993 and 2009, and summaries of the decision process to determine the future direction of fire effects monitoring in each of the monuments. As a result of this evaluation process, 2 existing fire effects monitoring plots in Walnut Canyon National Monument, 16 existing fire effects monitoring plots in Wupatki National Monument, and 15 existing fire effects monitoring plots associated with Sunset Crater Volcano National Monument were discontinued and archived. In addition, a collaborative monitoring approach between the Grand Canyon National Park Fire Ecology Program and the Southern Colorado Plateau Inventory and Monitoring Network was adopted to manage 11 existing fire effects monitoring plots and 2 new collaborative plots in Walnut Canyon National Monument.

Introduction and Background

The three Flagstaff Area National Monuments (Sunset Crater Volcano, Walnut Canyon, and Wupatki) contain fire effects monitoring plots that were installed to evaluate both prescribed fires and wildfires in the 1990s and early 2000s. Responsibility for the management of these plots was transferred from the Saguaro National Park (SAGU) Fire Ecology Program to the Grand Canyon National Park (GRCA) Fire Ecology Program in 2014. As a part of the program transition, the plots were evaluated to assess their utility in providing “feedback that supports adaptive management and the assessment of treatment effectiveness” as directed by National Park Service (NPS) Reference Manual 18 (NPS 2014). Evaluation of the monitoring program is part of the adaptive management process and should include an assessment of data quality and the ability of the data to inform management questions of interest. Changes to the monitoring design should be made if management direction changes or if the monitoring is not sufficient to address management questions.

The fire effects monitoring program for the three Flagstaff Area National Monuments (FLAG) began in 1993 with the installation of monitoring plots in Walnut Canyon National Monument (WACA). WACA conducted two small (< 20 acre) prescribed fires in 1986 and 1987 (Appendix A) and proposed additional prescribed fires in the 1991 Fire Management Plan (NPS 1991). Fire effects monitoring plots were subsequently installed and burned in four prescribed fire units burned between 1995 and 1999 (Appendix A and Appendix B). Since 1999 WACA has had several lightning-ignited fires within its boundary that burned less than 5 acres (Appendix A) and has had no additional prescribed fires. One fuel treatment project was completed in 2010 around the Visitor Center and NPS operations area.

Fire effects monitoring plots were installed in both Wupatki National Monument (WUPA) and Sunset Crater Volcano National Monument (SUCR) in 2002. WUPA had a lightning-ignited wildfire followed by a human-ignited wildfire burn a combined 1,440 acres in 2002 (Appendix A), which prompted installation of the fire effects monitoring plots. Prior to 2002, WUPA had two lightning-ignited wildfires burn a total of 908 acres and since 2002 one lightning-ignited wildfire burned 1,414 acres within WUPA (Appendix A). No prescribed fires have been conducted in WUPA.

Sunset Crater Volcano National Monument (SUCR) collaborated with the Coconino National Forest to conduct a prescribed fire and associated fire effects monitoring in the Bonito Park area in 2002. The 2002 Bonito Park Prescribed Fire was outside the designated boundary of SUCR and no prescribed fires have occurred within the monument boundary. Four wildfires ranging in size from < 1 acre to 54 acres occurred within the SUCR boundary between 2002 and 2009 (Appendix A). In addition, one fuel treatment project occurred near the SUCR visitor center and associated facilities within the Coconino National Forest in 2012 (Appendix A).

Fire Effects Monitoring History and Data Analysis

Fire effects monitoring activities for FLAG were managed by the SAGU Fire Ecology Program from 1993 to 2014. Between 1993 and 2002, six monitoring types with a total of 44 plots were established across the three monuments following NPS Fire Monitoring Handbook (FMH; NPS 2003) protocols. Established plots were measured from one to six times between 1993 and 2009.

Walnut Canyon National Monument

Four monitoring types were established to assist managers of WACA with understanding fire effects to vegetation. The monitoring types were established in the late 1990s to assess the effects of four prescribed fires included in the WACA Fire Management Plan (NPS 1991) and were loosely based on existing monitoring types at Grand Canyon National Park.

Monitoring Types, Objectives, Data Collection, and Plot Visit Summary

The four monitoring types in WACA represent the two major vegetation types above the canyon rim. The ponderosa pine vegetation was initially segregated into three monitoring types for analysis based on burn season (NPS 2000; NPS 2001). However, this segregation has not corresponded with burn season over time, so the three ponderosa pine monitoring types have been combined into one monitoring type.

Pinyon-Juniper Monitoring Type

The pinyon-juniper (PIED) monitoring type is a high elevation woodland dominated primarily by pinyon pine (*Pinus edulis*) and juniper (*Juniperus* spp.) with ponderosa pine (*Pinus ponderosa*) occasionally present. The understory is sparse with pole and seedling trees of same species, shrubs such as rabbitbrush (*Chrysothamnus* spp.) and cliffrose (*Cowania mexicana*), and an herbaceous layer of mostly grass (blue grama, *Bouteloua gracilis*) with some legumes and buckwheat (*Eriogonum* spp.) present. The monitoring type was established to measure the effects of prescribed fire on vegetation and fuel loading. The management objectives for the monitoring type were to reduce fuel loading by 30-50% one year after fire, reduce pole-size tree density 10-30% two years after fire, and limit overstory tree mortality to 20% or less (Appendix C).

To assess the management objectives, 2 monitoring plots were placed within the defined burn units (Appendix B). Measurements of tree, shrub, herbaceous, and fuel variables were taken following standard FMH (NPS 2003) forest plot protocols as described in Appendix C. Both plots were installed in May 1997 prior to prescribed fire. Both plots were within the burn perimeter of the 1999 Meadow Prescribed Fire (Appendix A), but only one plot had post-fire measurements. Post-burn severity data were collected in the burned plot in May 1999 and full plot re-measurements were completed in the burned plot in August 1999 and August 2000 (Table 1). No plot re-measurement data were collected after 2000. The unburned plot may have been intentionally unburned to serve as a control, but no measurements were taken after the 1997 pre-fire measurement.

Table 1. Pinyon-juniper (*Pinus edulis*-*Juniperus* spp.; PIED) monitoring plots and measurement years. Monitoring status is the time of measurement in relation to fire activity: PRE – before fire, 01Post – immediately after the first fire, 01Year 1 – 1 year after the first fire, 01Year 2 – 2 years after the first fire, etc.” –“ indicates missed measurements.

		Monitoring Status and Measurement Year					
Fire	Plot ID	PRE	01Post	01Year 1	01Year 2	01Year 5	01Year 10
Meadow Rx	B:FPIED1D02:01	1997					
Meadow Rx	B:FPIED1D02:02	1997	1999	1999	2000	—	—

Ponderosa Pine Monitoring Type

The three ponderosa pine (PIPO) monitoring types represent high elevation forests dominated primarily by ponderosa pine (*Pinus ponderosa*) that were scheduled to be burned during different seasons. The physical

and biological descriptions of the three types were identical and they have now been combined into one monitoring type. The PIPO monitoring type has intermittent pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), and Gambel oak (*Quercus gambelli*) trees present. Common shrub species include cliffrose (*Cowania mexicana*), snakeweed (*Gutierrezia sarothrae*), and sage (*Artemisia* spp.) and blue grama (*Bouteloua gracilis*), mutton grass (*Poa fendleriana*), buckwheat (*Eriogonum* spp.), and a mix of legumes are generally present in the understory. The monitoring type was established to measure the effects of prescribed fire on vegetation and fuel loading. The management objectives for the monitoring type were to reduce fuel loading by at least 40% one year after fire, reduce pole-size tree density to less than 200 trees/acre, and limit large (>16" DBH) overstory ponderosa pine tree mortality to 10-20% (Appendix C).

To assess the management objectives, 11 monitoring plots were randomly placed within the defined burn units (Appendix B). Measurements of tree, shrub, herbaceous, and fuel variables were taken following standard FMH (NPS 2003) forest plot protocols as described in Appendix C. Nine plots were installed between 1993 and 1999 prior to prescribed fire in the Cabin, Rim, Meadow, and Pictograph burn units (Appendix A). Eight of the plots burned between 1995 and 1999, had immediate post-burn severity data collected, and had 2-4 full plot re-measurements in subsequent years. Some scheduled re-measurements for burned plots were not completed (Table 2). One plot was outside the perimeter of a prescribed fire and may have been treated as a control plot since it had 4 subsequent full plot re-measurements. Two plots were installed in 2000 outside of designated burn units and have not yet burned.

Table 2. Ponderosa pine (*Pinus ponderosa*; PIPO) monitoring plots and measurement years. Monitoring status is the time of measurement in relation to fire activity: PRE – before fire, 01Post – immediately after the first fire, 01Year 1 – 1 year after the first fire, 01Year 2 – 2 years after the first fire, etc." – indicates missed measurements.

Current Burn Unit	Fire	Plot ID	Monitoring Status and Measurement Year					
			PRE	01Post	01Year 1	01Year 2	01Year 5	01Year 10
Walnut North	Rim Rx	B:FPIPO1T09:01	1996	1996	1997	1998	2001	—
Walnut North	Rim Rx	B:FPIPO1T09:02	1996	1996	1997	1998	2001	—
Walnut North	Cabin Rx	B:FPIPO1G09:03	1993	1995	1996	1997	2000	—
Walnut North	Cabin Rx	B:FPIPO1G09:04	1993	1995	—	1997	2000	—
Walnut North	Meadow Rx	B:FPIPO1D09:05	1997	1999	1999	2000	—	—
Walnut South	Pictograph Rx	B:FPIPO1T09:06	1998	1999	2000	2001	2004	2009
Walnut South	Pictograph Rx	B:FPIPO1T09:07	1998	1999	2000	2001	2004	2009
Walnut South	Pictograph Rx	B:FPIPO1T09:08	1998	1999	2000	2001	2004	2009
Walnut South	Pictograph Rx	B:FPIPO1T09:09	1998	—	2000	2001	2004	2009
Walnut North		B:FPIPO1T09:10	2000					
Walnut North		B:FPIPO1T09:11	2000					

Data Analysis and Assessment of Objectives

The pinyon-juniper monitoring type has only two plots and only one of those plots burned. Therefore, no analysis of objectives could be performed. Pre-fire data from the two plots suggest that 19 plots would be needed to assess fuel loading to the 90% confidence level specified in Appendix C, 196 plots would be needed to assess pole-size tree density to the 90% confidence level, and 76 plots would be needed to assess overstory tree density to the 90% confidence level in the pinyon-juniper monitoring type.

The ponderosa pine monitoring type description sheet (Appendix C) sets monitoring objectives that include 90% confidence levels for fuel loading, pole-sized tree density, and large ponderosa pine tree density. In order to achieve these monitoring objectives, additional plots would need to be installed. Pre-fire data from the eleven existing plots suggest that 12 plots would be needed to assess fuel loading to the 90% confidence level, 15 plots would be needed to assess pole-size tree density to the 90% confidence level, and 35 plots would be needed to assess large ponderosa pine tree density to the 90% confidence level in the ponderosa pine monitoring type.

In addition to the pre-fire variability in fuel loading and tree density, variability in prescribed fire intensity and post-fire drought impacts affect the number of plots needed to adequately assess changes in the forests of WACA. Similar to many other areas in the Southwestern United States, WACA experienced extreme drought conditions from 2000 to 2002 following the prescribed fires of the late 1990s. High levels of mortality in conifer species, Gambel oak, and aspen occurred in WACA in the years following the drought and this mortality cannot be separated from changes in tree density due to prescribed fire. The analysis in the following section does not attempt to separate changes in fuel loading or tree density based on cause (prescribed fire or drought).

Ponderosa Pine Monitoring Type

The four prescribed fires that burned ponderosa pine monitoring plots between 1995 and 1999 burned with a range of fire effects. Burn severity measurements collected after the fires indicate that understory vegetation was sparse along most of the transect points prior to fire and transect points that had understory vegetation present were mostly unburned (Fig. 1). Fire effects to ground cover (litter, duff, and woody debris) were highly variable with an average of 24% of points per plot unburned and an average of 42% of points per plot moderately to heavily burned (Fig. 1). Fire effects to overstory trees were similarly mixed. Overstory tree char height (the highest point of char noted on individual tree boles) ranged from an average of 0 feet to an average of 10 feet in individual plots with an overall average of 4 feet across all plots. Overstory tree scorch height (the highest point of foliar death due to scorch) ranged from an average of 4 feet to an average of 22 feet in individual plots with an overall average of 15 feet across all plots. The percent of overstory tree canopy scorched by fire ranged from an average of 3% to an average of 66% in individual plots with an overall average of 37% across all plots.

The first management objective for prescribed fire in the ponderosa pine monitoring type was to reduce total fuel loading by at least 40% one year after fire. The average reduction in total fuel loading for the 8 plots that have burned to date was 43% with mean fuel loading reduced ($P = 0.02$) from an average of 18.4 tons/acre before fire to an average of 8.8 tons/acre one year after fire.

The second management objective for prescribed fire in the ponderosa pine monitoring type was to reduce pole-size (1-6" DBH) tree density to 200 trees/acre or less. However, no time frame was specified for this objective. Prior to fire, pole-size tree density averaged 259 trees/acre in the 8 plots that have burned to date. Two years after the prescribed fires, pole-size tree density was reduced ($P = 0.006$) to an average of 129 trees/acre. Five years after the prescribed fires, pole-size tree density was reduced ($P = 0.002$) to an average of 105 trees/acre (Fig. 2).

The third management objective for prescribed fire in the ponderosa pine monitoring type was to limit mortality of large (>16" DBH) ponderosa pine trees to 10-20%. However, no time frame was specified for

this objective. Large ponderosa pine tree density did not change from pre-fire values across the ponderosa pine monitoring type as a result of the prescribed fires during either the two-year or the five-year post-fire measurement ($P \geq 0.18$; Fig. 3).

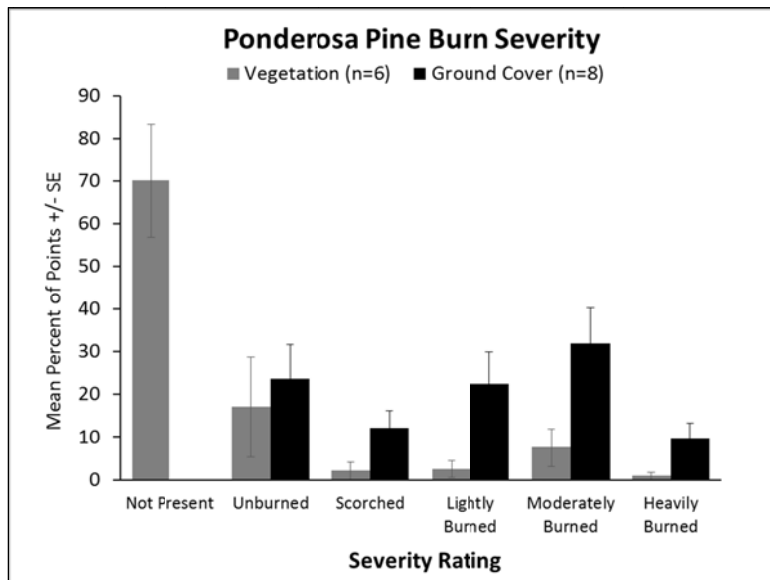


Figure 1. Mean ($\pm$ SE) percent of transect points in each burn severity rating class for vegetation (all above-ground plant parts) and ground cover (litter, duff, and woody debris) in the ponderosa pine monitoring type.

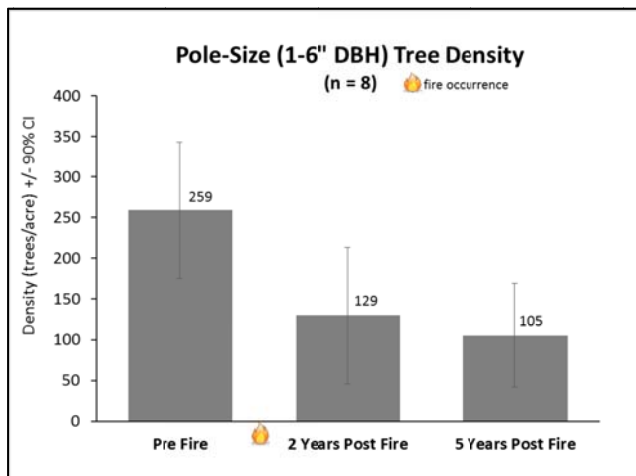


Figure 2. Mean ($\pm$ 90% CI) pole-size (1-6" DBH) tree density before and after fire in the ponderosa pine monitoring type.

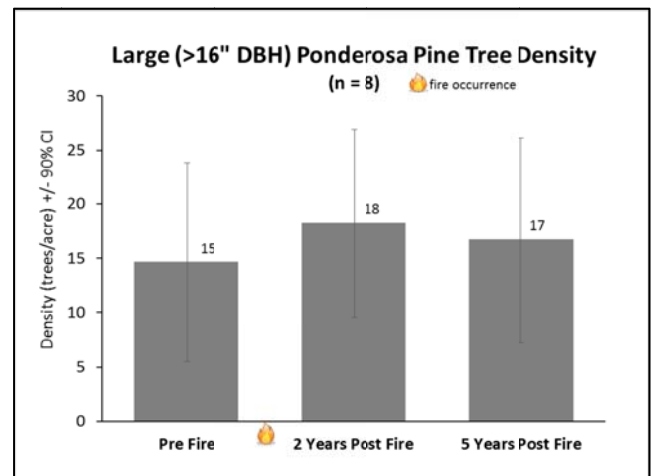


Figure 3. Mean ($\pm$ 90% CI) large (>16" DBH) ponderosa pine tree density before and after fire in the ponderosa pine monitoring type.

The FMH monitoring types are designed to evaluate the range of fire effects due to prescribed fire across the landscape and should generally not be used to assess the effects of individual prescribed fires due to low sample size and plot installation protocols that incorporate the larger monitoring type. However, this limitation of the FMH protocol can mask important results that may be of interest to park managers. In WACA, the 1999 Pictograph Prescribed Fire was notable for a high level of scorch to overstory trees (Short 2003; Pictograph Rx Fire Project folder on file with the FLAG Natural Resource Program) followed by extreme drought conditions that likely combined to reduce large tree density in this area. Four FMH plots

were monitored in the Pictograph Prescribed Fire. These four plots had an average scorch percent of 61%, an average scorch height of 21 feet, and an average char height of 9 feet. In addition, pole-size (1-6" DBH) tree density was reduced from an average of 231 trees/acre before the fire to an average of 41 trees/acre 10 years after the fire and large (>16" DBH) ponderosa pine tree density was reduced an average of 42% from an average of 11 trees/acre before the fire to an average of 8 trees/acre 10 years after the fire.

Wupatki National Monument

Two monitoring types were established to assist managers of WUPA with understanding fire effects to the Plains/Great Basin grasslands in the monument. Both monitoring types were established following the State and Antelope Wildfires of 2002 (Appendix A). Since the plots were established following wildfire, pre-fire data do not exist and control plots were installed for comparison to burned plots.

Monitoring Types, Objectives, Data Collection, and Plot Visit Summary

The two monitoring types in WUPA were established to monitor vegetation recovery following a wildfire but were never formally described using the standard FMH Monitoring Type Description Sheet (FMH-4; NPS 2003). Since the monitoring types were not formally described, the physical and biological criteria used to establish the plots and the full details of the data collection protocols are not completely known. In addition, no management or monitoring objectives were documented for the plots.

Measurements of species presence and cover in both monitoring types were taken along 30-meter transects following standard FMH (NPS 2003) line-intercept protocols for brush plot measurement. In addition, individual juniper trees were counted in a 30-meter long by 2-meter wide brush belt co-located with the line-intercept transects.

To assess vegetation change in response to the wildfires, 4 monitoring plots were located outside the Antelope Wildfire perimeter in the black grama (*Bouteloua eriopoda*; BOER) monitoring type, 5 monitoring plots were located outside the Antelope Wildfire perimeter in the galleta (*Hilaria jamesii*; HIJA) monitoring type, and 7 monitoring plots were located within the Antelope Wildfire perimeter in the galleta (*Hilaria jamesii*; HIJA) monitoring type (Table 3; Appendix B). The control plots (those outside the Antelope Wildfire perimeter) were measured in September 2002 and August 2003. The burned plots (those inside the Antelope Wildfire perimeter) were measured in August 2003. No plot data were collected after 2003.

Table 3. Black grama (*Bouteloua eriopoda*; BOER) and galleta (*Hilaria jamesii*; HIJA) dominated grassland monitoring plots and measurement years. Monitoring status is the time of measurement in relation to fire activity: PRE – before fire, 01Post – immediately after the first fire, 01Year 1 – 1 year after the first fire, etc." –" indicates missed measurements.

		Monitoring Status and Measurement Year					
Plot Type	Plot ID	PRE	01Post	01Year 1	01Year 2	01Year 5	01Year 10
Control - BOER	C:BBOER1T01:01	2002		2003	—	—	—
Control - BOER	C:BBOER1T01:02	2002		2003	—	—	—
Control - BOER	C:BBOER1T01:03	2002		2003	—	—	—
Control - BOER	C:BBOER1T01:04	2002		2003	—	—	—
Control - HIJA	C:BHIJA1T01:01	2002		2003	—	—	—
Control - HIJA	C:BHIJA1T01:02	2002		2003	—	—	—
Control - HIJA	C:BHIJA1T01:03	2002		2003	—	—	—

		Monitoring Status and Measurement Year					
Plot Type	Plot ID	PRE	01Post	01Year 1	01Year 2	01Year 5	01Year 10
Burned- HIJA	B:BHIJA1T01:04	—	—	2003	—	—	—
Burned- HIJA	B:BHIJA1T01:05	—	—	2003	—	—	—
Burned- HIJA	B:BHIJA1T01:06	—	—	2003	—	—	—
Burned- HIJA	B:BHIJA1T01:07	—	—	2003	—	—	—
Burned- HIJA	B:BHIJA1T01:08	—	—	2003	—	—	—
Burned- HIJA	B:BHIJA1T01:09	—	—	2003	—	—	—
Control - HIJA	C:BHIJA1T01:10	2002		2003	—	—	—
Control - HIJA	C:BHIJA1T01:11	2002		2003	—	—	—
Burned- HIJA	B:BHIJA1T01:12	—	—	2003	—	—	—

Data Analysis and Assessment of Objectives

No management or monitoring objectives were documented for the WUPA grassland plots. However, the mortality of juniper encroachment and the response of herbaceous cover and species richness to the wildfire are of interest to WUPA managers. Juniper encroachment into these grassland areas was patchy and initial data indicate that a minimum of 32 – 42 plots are needed in each monitoring type to assess juniper density to the 80% confidence level. In contrast, sufficient plot data were collected in both monitoring types to assess change in herbaceous cover and species richness. Initial data indicate that a minimum of 2 plots are needed in each monitoring type to assess herbaceous species cover to the 80% confidence level and a minimum of 3-5 plots are needed in each monitoring type to assess herbaceous species richness to the 80% confidence level.

The unburned control plots in the BOER and HIJA monitoring types documented a range of juniper encroachment with 44% (4 out of 9) of the plots documenting no juniper presence in the 30 meter by 2 meter brush belt, 33% (3 out of 9) of the plots documenting 1-2 living juniper individuals in the brush belt, and 22% (2 out of 9) of the plots documenting 3-5 living juniper individuals in the brush belt. No dead junipers were recorded in the unburned control plots. Most burned HIJA plots contained no juniper individuals (4 out of 7 plots; 57%). Plots that did contain juniper had between 75% (1 out of 7 plots) and 100% (2 out of 7 plots) mortality of juniper individuals one year after the fire.

The unburned control plots in the BOER and HIJA monitoring types had similar ($P \geq 0.38$) herbaceous cover and species richness in both 2002 and 2003. Burned HIJA plots had an average of 36% herbaceous cover in 2003, while unburned (BOER and HIJA combined) plot herbaceous cover was 11% higher ($P = 0.05$) with an average herbaceous cover of 47% in 2003 (Fig. 4). Species richness was similar ($P = 0.72$) in burned and unburned plots in 2003 and averaged 13-14 species per plot (Fig. 5).

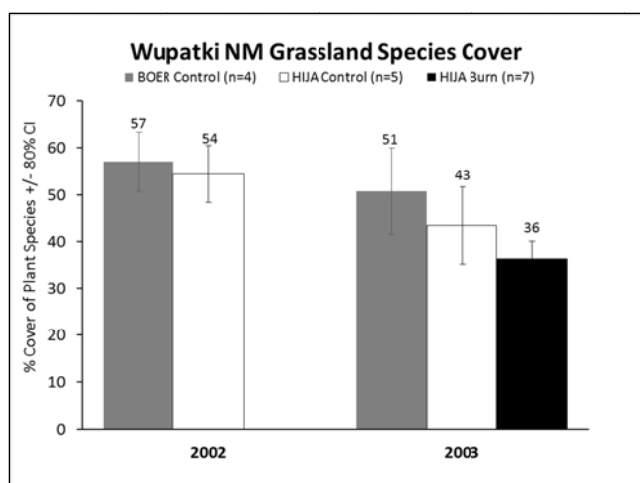


Figure 4. Mean ($\pm 80\%$ CI) herbaceous species cover in the WUPA grassland monitoring types.

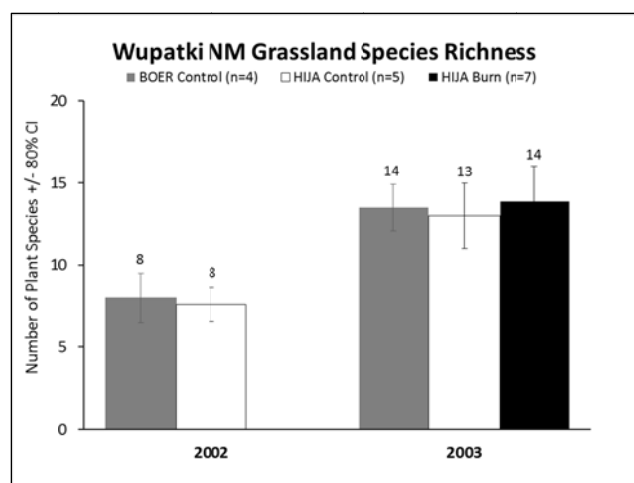


Figure 5. Mean ($\pm 80\%$ CI) herbaceous species richness in the WUPA grassland monitoring types.

Sunset Crater Volcano National Monument

Two monitoring types were established to assist managers of SUCR and the Coconino National Forest with understanding fire effects to vegetation. Both monitoring types were exclusively located in the Bonito Park Prescribed Fire Unit (Appendix A), and all plots were located on the Coconino National Forest. The Interagency Agreement between FLAG and the Coconino National Forest (Appendix D) describes the goals of the Bonito Park Prescribed Fire and the commitment of FLAG to provide fire effects monitoring support for the prescribed fire. In addition to the NPS fire effects monitoring, a pre- and post-fire vegetation and soil study was conducted by researchers from Northern Arizona University (Sisk and Loeser 2004).

Monitoring Types, Objectives, Data Collection, and Plot Visit Summary

The two monitoring types in the Bonito Park Prescribed Fire Unit were described and established in 2002. The monitoring types have very similar physical and biological characteristics with the exception of the differences in pre-fire conifer tree encroachment (Appendix C).

Montane Meadow Monitoring Type

The montane meadow monitoring type is a high elevation grassland dominated primarily by blue grama (*Bouteloua gracilis*) with a variety of other native grasses, forbs, and occasional shrubs present. The monitoring type was established to measure the effects of a low intensity fire applied via hand ignition in the fall on herbaceous cover and encroaching conifer density. The management objectives for the fire were to eliminate conifer encroachment and improve habitat for pronghorn and other species that require open meadows by increasing the production of grasses and forbs.

To assess the management objectives, 10 monitoring plots were systematically placed along two transects forming an "X" across the meadow (Appendix B) with one transect running at 160° for 950 meters and the other running at 320° for 1600 meters. Five plot origins were spaced evenly along each transect to represent the range of environmental conditions (elevation, moisture, etc) present in the prescribed fire unit and 30-meter long transects were established in random directions from the plot origin stakes. Measurements of species presence and cover were taken following standard FMH (NPS 2003) line-intercept protocols for grassland plot measurement (Appendix C).

The 10 plots were measured prior to the prescribed fire in July and August of 2002 and post-burn severity data were collected shortly after the prescribed fire in November 2002. Full plot re-measurements were completed approximately 1 year after the fire in August 2003 (Table 4). No plot re-measurement data were collected after 2003.

Table 4. Blue grama (*Bouteloua gracilis*; BOGR) dominated montane meadow monitoring plots and measurement years. Monitoring status is the time of measurement in relation to fire activity: PRE – before fire, 01Post – immediately after the first fire, 01Year 1 – 1 year after the first fire, etc.” –“ indicates missed measurements.

Fire Area	Plot ID	Monitoring Status and Measurement Year					
		PRE	01Post	01Year 1	01Year 2	01Year 5	01Year 10
Bonito Park Rx	B:GBOGR1T02:01	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:02	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:03	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:04	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:05	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:06	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:07	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:08	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:09	2002	2002	2003	—	—	—
Bonito Park Rx	B:GBOGR1T02:10	2002	2002	2003	—	—	—

Conifer Encroachment Monitoring Type

The conifer encroachment monitoring type is a high elevation grassland dominated primarily by blue grama that has been encroached by ponderosa pine (*Pinus ponderosa*). The monitoring type was established to measure the effects of a low intensity fire applied via hand ignition in the fall on encroaching conifer density. The management objectives for the fire were to reduce conifer encroachment by 20 - 40%.

To assess the management objectives, 5 monitoring plots were randomly located in the conifer encroachment belt along the western and northwestern edge of the meadow (Appendix B). Measurements of species presence and cover were taken along 30-meter transects following standard FMH (NPS 2003) line-intercept protocols for brush plot measurement. In addition, conifer density was recorded within a 50-meter long by 10-meter wide brush belt co-located with the line-intercept transect (Appendix C).

The 5 plots were measured prior to the prescribed fire in July and August of 2002 and post-burn severity and tree density data were collected shortly after the prescribed fire in November 2002. Full plot re-measurements were completed approximately 1 year after the fire in August 2003 (Table 5). No plot re-measurement data were collected after 2003.

Table 5. Ponderosa pine (*Pinus ponderosa*; PIPO) conifer encroachment monitoring plots and measurement years. Monitoring status is the time of measurement in relation to fire activity: PRE – before fire, 01Post – immediately after the first fire, 01Year 1 – 1 year after the first fire, etc.” –“ indicates missed measurements.

Fire	Plot ID	Monitoring Status and Measurement Year					
		PRE	01Post	01Year 1	01Year 2	01Year 5	01Year 10
Bonito Park Rx	B:BPIPO1T02:01	2002	2002	2003	—	—	—
Bonito Park Rx	B:BPIPO1T02:02	2002	2002	2003	—	—	—
Bonito Park Rx	B:BPIPO1T02:03	2002	2002	2003	—	—	—
Bonito Park Rx	B:BPIPO1T02:04	2002	2002	2003	—	—	—
Bonito Park Rx	B:BPIPO1T02:05	2002	2002	2003	—	—	—

Data Analysis and Assessment of Objectives

Sufficient plot data were collected in both Bonito Park monitoring types to assess change in the variables of interest. For the montane meadow monitoring type, pre-fire data indicate that a minimum of 3 plots are needed to assess herbaceous species cover and richness to the 80% confidence level specified in Appendix C. For the conifer encroachment monitoring type, pre-fire data indicate that a minimum of 4 plots are needed to assess conifer density to the 80% confidence level specified in Appendix C.

Montane Meadow Monitoring Type

The Bonito Park Prescribed Fire of 2002 did little to change herbaceous species cover or richness in the montane meadow monitoring type. Herbaceous species cover averaged 77% prior to the fire and 84% one year after the fire (Fig. 6), but this change was not statistically significant ($P = 0.40$). Similarly, change in species richness was not significant ($P = 0.49$) with an average of 15 species per plot before the fire and 16 species per plot one year after the fire (Fig. 7). The results for herbaceous species cover and richness are similar to those of Sisk and Loeser (2004) for these variables. Burn severity measurements collected after the fire indicate that most of the transect points were either unburned or very lightly burned (Fig. 8). A management objective of eliminating conifer encroachment was also given for this monitoring type. However, there were no conifers noted in any of the 10 plots either before or after fire.

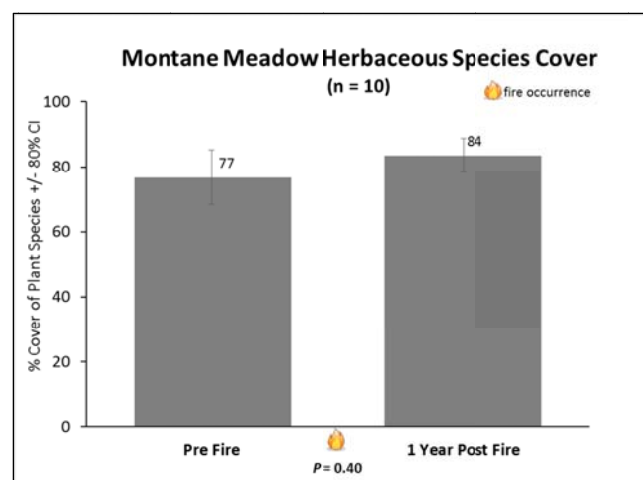


Figure 6. Mean ($\pm 80\%$ CI) herbaceous species cover before and after fire in the montane meadow monitoring type.

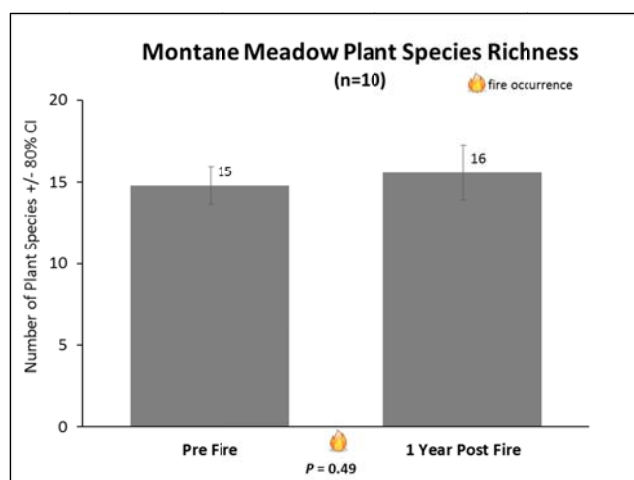


Figure 7. Mean ($\pm 80\%$ CI) herbaceous species richness before and after fire in the montane meadow monitoring type.

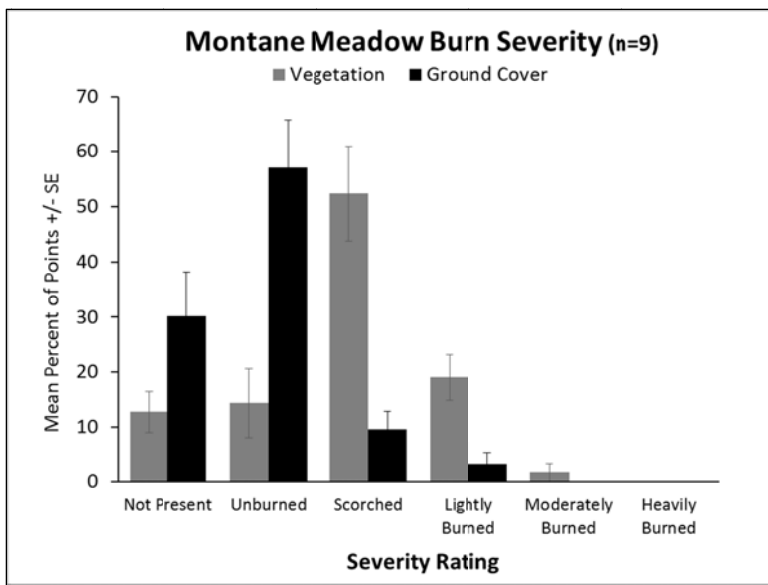


Figure 8. Mean ($\pm$ SE) percent of transect points in each burn severity rating class for vegetation (all above-ground plant parts) and ground cover (litter, duff, and woody debris) in the montane meadow monitoring type.

Conifer Encroachment Monitoring Type

The Bonito Park Prescribed Fire of 2002 did little to change conifer density in the conifer encroachment monitoring type. Conifer density averaged 209 trees/acre prior to the fire and 196 trees/acre one year after the fire (Fig. 9), but this change was not statistically significant ($P = 0.31$). Burn severity measurements collected after the fire indicate that most of the transect points were either unburned or very lightly burned (Fig. 10). As a result, a follow-up thinning treatment was conducted in the western meadow area in 2003 to manually remove the encroaching conifers.

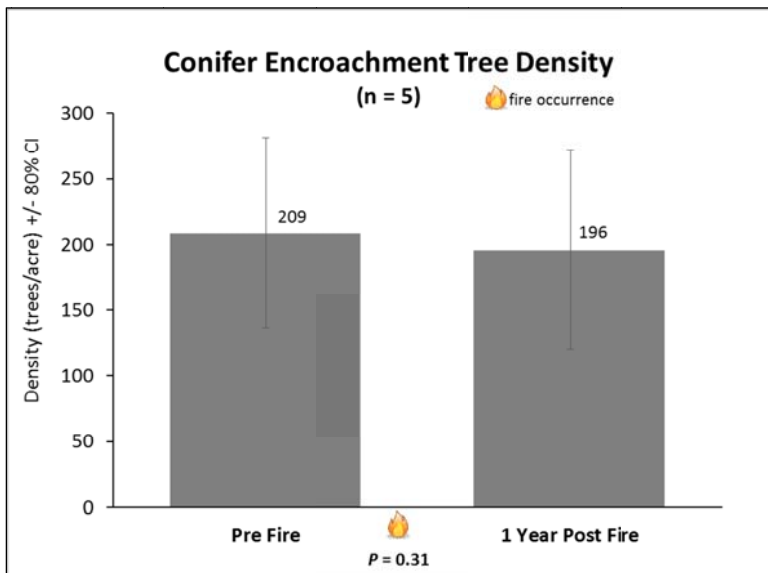


Figure 9. Mean ($\pm$ 80% CI) conifer tree density before and after fire in the conifer encroachment monitoring type.

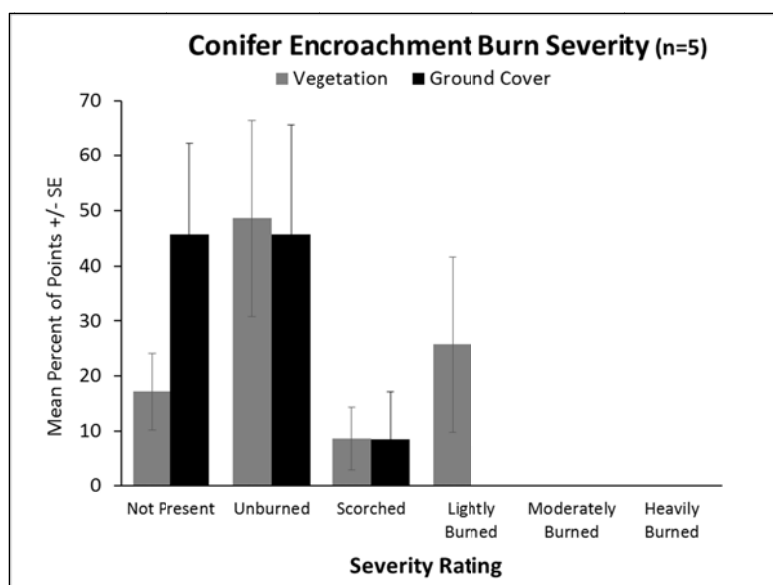


Figure 10. Mean ($\pm$ SE) percent of transect points in each burn severity rating class for vegetation (all above-ground plant parts) and ground cover (litter, duff, and woody debris) in the conifer encroachment monitoring type.

Fire Effects Monitoring Plot Status and Future Direction

A meeting to discuss the current status and future direction of fire effects monitoring in the three Flagstaff Area National Monuments was held on March 4, 2015. Meeting participants included staff from the Flagstaff Area National Monuments, Grand Canyon National Park Branch of Fire and Aviation, and the Southern Colorado Plateau Inventory and Monitoring Network (SCPN) (Table 6). The meeting included discussion on the history of fire effects monitoring in each of the monuments, the status and future plans of vegetation monitoring by the SCPN in each of the monuments, the goals of the fire management program and scheduled fire management activities in each of the monuments, and the future needs for fire effects monitoring in each of the monuments. The meeting discussion points and decisions on future fire effects monitoring needs are summarized for each monument in the following sections.

Table 6. Participants in the March 4, 2015 fire effects monitoring meeting for the three Flagstaff Area National Monuments (FLAG). GRCA = Grand Canyon National Park Branch of Fire and Aviation and SCPN = Southern Colorado Plateau Inventory and Monitoring Network.

Participant	Title	Association
Li Brannfors	Lead Fire Effects Monitor	GRCA
Windy Bunn	Fire Ecologist	GRCA
Kayci Cook	Superintendent	FLAG
Jim DeCoster	Plant Ecologist	SCPN
Lisa Leap	Chief of Resources	FLAG
Dan Pearson	South District Fire Management Officer	GRCA
Megan Swan	Botanist	SCPN
Mark Szydlo	Biologist	FLAG
Paul Whitefield	Natural Resource Specialist	FLAG

Walnut Canyon National Monument

The two existing fire effects monitoring types in WACA contain plots that have burned in prescribed fire in the past. The pinyon-juniper monitoring type contains only two monitoring plots, which are not sufficient to assess the previous management objectives for this monitoring type. The pinyon-juniper vegetation type is narrowly distributed within WACA, the natural fire regime in pinyon-juniper at WACA is not well understood, and the current FLAG Fire Management Plan (FMP; NPS 2009) intentionally states there are no current objectives for managing with prescribed fire or allowing wildfires to burn for resource objectives in the pinyon-juniper vegetation type. Pinyon-juniper patches may be burned intermittently when they are located within a larger prescribed fire unit targeting ponderosa pine. For the above-mentioned reasons, the meeting participants decided to archive the existing pinyon-juniper fire effects monitoring plots. The original plot folders and electronic data were transferred to the FLAG Museum and Archive Collections at the Museum of Northern Arizona in March 2015. It is unknown whether the plots are still marked with rebar stakes and tags. A copy of the FFI database containing the plot data, including plot coordinates, is archived on the NPS Integrated Resource Management Applications (IRMA) portal (NPS 2011; Reference Code: 2222935).

The ponderosa pine monitoring type contains 11 fire effects monitoring plots and 8 of those plots burned in prescribed fires in the mid-to-late 1990s. The most recent prescribed fire in WACA occurred in 1999; however, the current FLAG FMP (NPS 2009) includes a renewed effort to manage the ponderosa pine forests with prescribed fire over the next 5 – 10 years. In addition, the SCPN added WACA ponderosa pine

monitoring to its integrated upland vital signs monitoring (DeCoster et al. 2012) in 2014 and adapted 10 of the existing fire effects monitoring plots to meet its long-term monitoring objectives (Appendix B). Since management goals for the ponderosa pine forest include understanding both fire effects and long-term trends, the meeting participants decided that a collaborative monitoring approach between the GRCA Fire Ecology Program and the SCPN that incorporates the existing fire effects monitoring plots should be established. The original FMH plot folders and electronic data will be retained by the GRCA Fire Ecology Program and future plot measurements and data management will be coordinated between the GRCA Fire Ecology Program and the SCPN. A copy of the FFI database containing the existing plot data is available on the NPS IRMA portal (NPS 2011; Reference Code: 2194013).

Wupatki National Monument

The existing fire effects monitoring plots in WUPA are located within or near the Antelope Wildfire perimeter and were only monitored during the year of the fire and the year after the fire. Neither long-term plans nor management objectives were established for either of the monitoring types and the established plots were not installed to represent the monitoring types across their extents within the monument. In 2007, the SCPN began long-term integrated upland monitoring in the Limy Upland and Sandstone Upland ecological sites in WUPA and has since installed 60 vegetation and soil plots in the monument (DeCoster and Swan 2013). The upland ecological sites overlap in extent with the existing fire effects black grama and galleta monitoring types and provide additional data on these monitoring types outside of the direct vicinity of the Antelope Wildfire. Given the recent efforts by the SCPN to fully characterize and monitor the upland vegetation in WUPA and the limited extent of the fire effects monitoring plots, the meeting participants decided to archive the existing black grama and galleta fire effects monitoring plots. The original plot folders and electronic data were transferred to the FLAG Museum Collection and Archives at the Museum of Northern Arizona in March 2015. It is unknown whether the plots are still marked with rebar stakes and tags. A copy of the FFI database containing the plot data, including plot coordinates, is archived on the NPS IRMA portal (NPS 2011; Reference Code: 2222001).

There are no current plans to initiate prescribed fire or allow wildfires to burn for resource management objectives within WUPA. Since wildland fire is not anticipated to be used as a management tool in WUPA in the near term, the meeting participants decided that no new fire effects monitoring plots are currently needed in the monument. However, the Coconino National Forest recently implemented a multiple objective wildfire strategy on all lands to the south of WUPA. FLAG will consider including both prescribed fire and multiple objective wildfire management strategies in future fire management planning. Opportunities may arise in the future to use the existing SCPN monitoring plots to understand the effects of wildfire to the monument's vegetation.

Sunset Crater Volcano National Monument

The existing fire effects monitoring plots in SUCR are located on Coconino National Forest land that is not anticipated to be transferred to the park. Therefore, the meeting participants decided to archive the existing montane meadow and conifer encroachment fire effects monitoring plots and transfer the data to the Coconino National Forest. The original plot folders and electronic data were transferred to the Flagstaff Ranger District Fire Management Specialist in April 2015. It is unknown whether the plots are still marked with rebar stakes and tags. A copy of the FFI database containing the plot data, including plot coordinates, is archived on the NPS IRMA portal (NPS 2011; Reference Code: 2221713).

The current FLAG FMP (NPS 2009) does not include prescribed fire or allow wildfires for resource management objectives within SUCR. After the FLAG FMP was finalized, the Coconino National Forest implemented a multiple objective wildfire strategy on all lands adjacent to SUCR. FLAG will consider including this fire management strategy in future fire management planning. Since wildland fire is not anticipated to be used as a near-term management tool in SUCR, the meeting participants decided that no

new fire effects monitoring plots are currently needed in the monument. The SCPN has conducted a limited amount of rare plant community monitoring in the monument but does not anticipate continuing that monitoring effort. SUCR is not included in the SCPN long-term integrated upland vital signs monitoring.

Next Steps

The responsibility for providing information to the FLAG on long-term vegetation trends and fire effects to vegetation will be shared between the SCPN and the GRCA Fire Ecology Program. SCPN will monitor two ecological sites in WUPA and one ecological site in WACA on a panel schedule consistent with its long-term integrated upland monitoring protocols (DeCoster et al. 2012). The GRCA Fire Ecology Program will measure fuel and other fire-related variables in the ponderosa pine forests in WACA when those forests are scheduled to burn and on a fixed schedule after burning. If some of the SCPN monitoring plots in WUPA burn, FLAG resource management staff should work with the GRCA Fire Ecology Program to determine whether post-fire monitoring of the plots (outside of the SCPN schedule) would provide useful feedback to the monument managers.

A fire effects monitoring plan should be developed for WACA. The 11 existing FMH plots in the ponderosa pine monitoring type are not sufficient to assess the previous management objectives to the 90% confidence level that was outlined in the 1999 monitoring type description sheet (Appendix C). However, since 1999, management objectives have changed and monitoring objectives should be re-evaluated to reflect this change. In addition, 2 new plots have been installed by the SCPN and 1 existing plot was determined by the SCPN to be inconsistent with the monitoring type description (Appendix B). In order to ensure that continued fire effects monitoring efforts are addressing management needs, the following items should be addressed in the new fire effects monitoring plan.

- New management objectives for ponderosa pine forests are outlined in Sections 4.5.8 and 4.5.9 and Appendix K-6 of the 2009 Flagstaff Area Monuments Fire Management Plan (NPS 2009). These objectives should be used as a guide to revise the existing management and monitoring objectives for the ponderosa pine monitoring type in the Monitoring Type Description Sheet.
- New minimum plot calculations should be completed based on the revised objectives to determine whether the existing plots provide a sufficient sample to evaluate the management objectives.
- Data collection and management protocols and responsibilities should be determined in collaboration with the SCPN and documented to ensure continued data quality and integrity.

Literature Cited

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- Short, K.C. 2003. Complexity and variation in the effects of low-severity fires on forest biota. Dissertation. University of Montana, Missoula, Montana.
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Appendix A: Fire History Maps

Walnut Canyon National Monument Recent Fire Activity

Wupatki National Monument Recent Fire Activity

SUCR (Sunset Crater Volcano National Monument) Fire History



Walnut Canyon National Monument Recent Fire Activity

★ Visitor Center

Transportation

- NPS Admin Request Road
- Paved Road
- Secondary Hwy
- Trail
- Unpaved Road

Lightning Ignited Fires

- Oak Fire (2006, 3 acres)
- Falcon Fire (2009, <1 acre)

Prescribed Fires

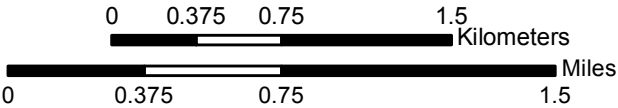
- Walnut Fire #1 (1986, 6 acres)
- Walnut Fire #2 (1987, 19 acres)
- Cabin Fire (1995, 74 acres)
- Rim Fire (1996, 72 acres)
- Meadow Fire (1999, 44 acres)
- Pictograph Fire (1999, 152 acres)

WACA Boundary

WACA Private Inholding

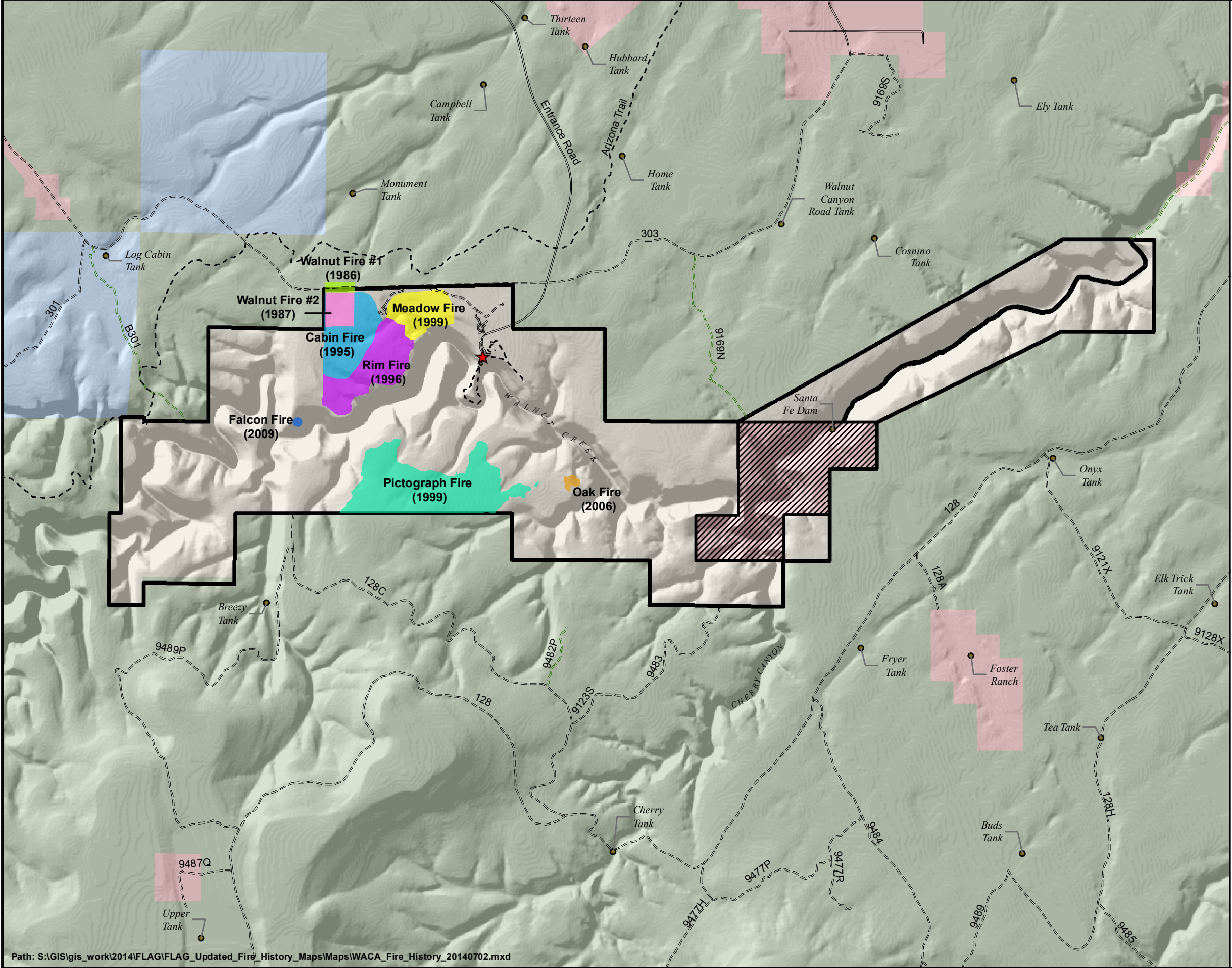
- Forest Service
- National Park Service
- Private
- State Trust

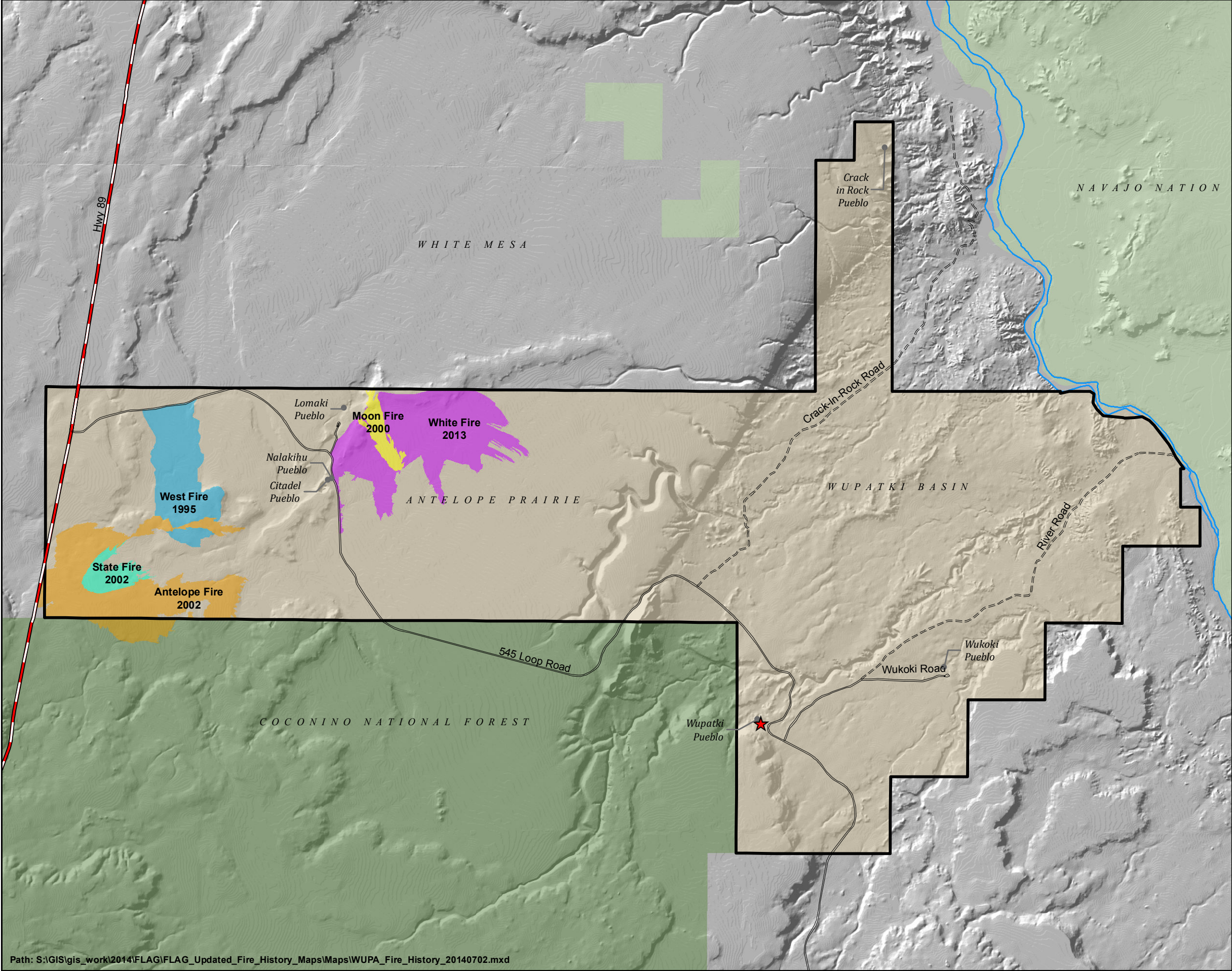
N



Produced by the Flagstaff Area National Monuments

Date: 7/10/2014





Wupatki National Monument Recent Fire Activity

★ Visitor Center

Transportation

- Paved Road
- == Secondary Hwy
- == Unpaved Road

□ WUPA Boundary

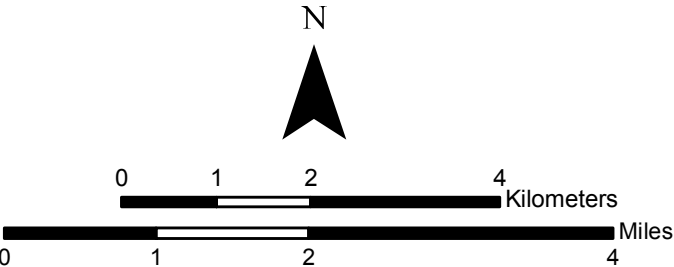
Fire History

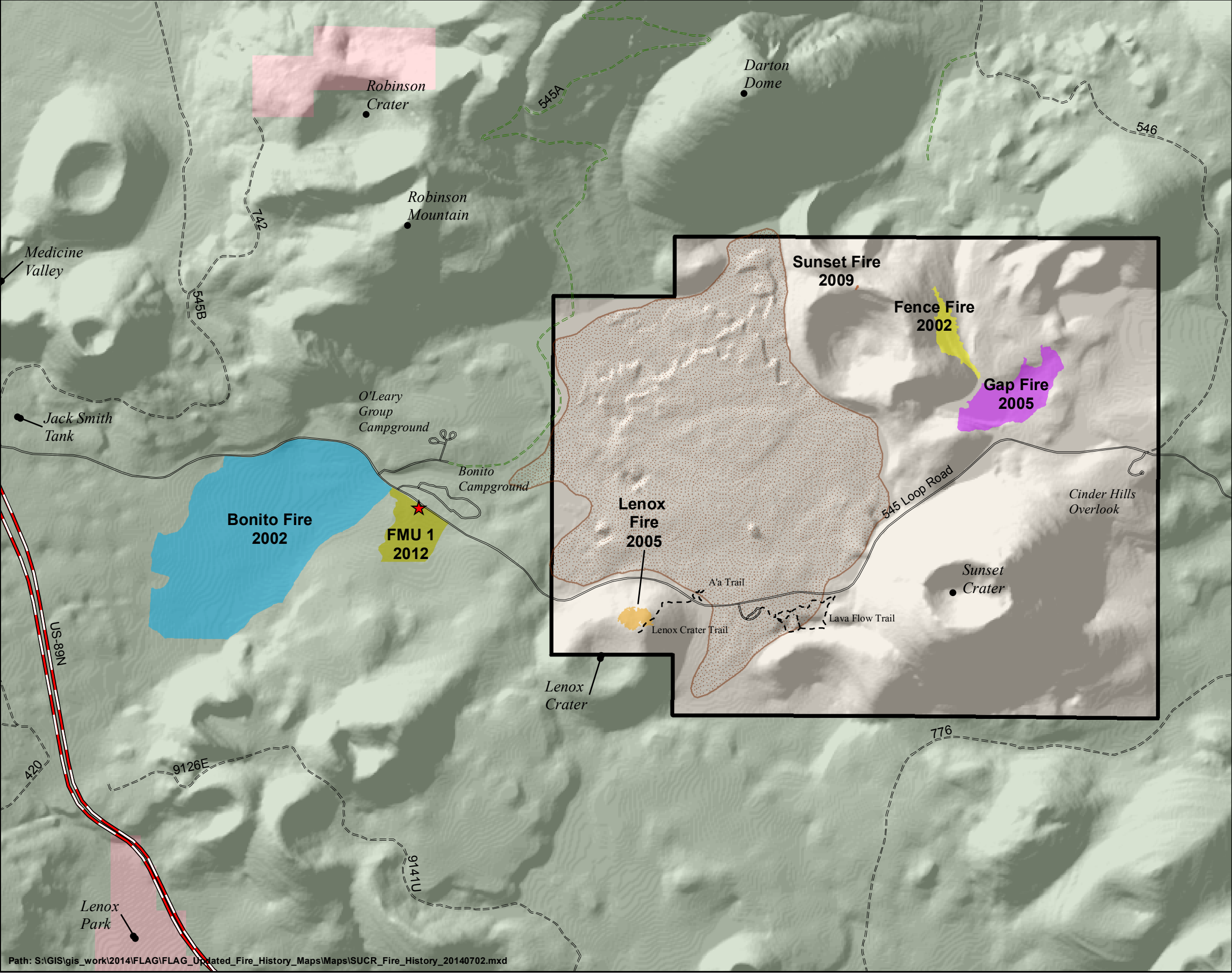
- West Fire (1995, 765 acres)
- Moon Fire (2000, 143 acres)
- Antelope Fire (2002, 1278 acres)*
- State Fire (2002, 168 acres)
- White Fire (2013, 1414 acres)

— Little Colorado River

- Forest Service
- Navajo Nation Reservation
- National Park Service

*Human caused - cigarette tossed from a passing car.
All other fires ignited by lightning.





Path: S:\GIS\gis_work\2014\FLAG\FLAG_Updated_Fire_History_Maps\Maps\SUCR_Fire_History_20140702.mxd

SUCR Fire History

★ Visitor Center

Transportation

- NPS Admin Request Road
- Paved Road
- == Secondary Hwy
- - - Trail
- == Unpaved Road

■ Bonito Lava Flow

□ SUCR Boundary

Lightning Ignited Fires

- Fence Fire (2002, 14 acres)
- Gap Fire (2005, 54 acres)
- Lenox Fire (2005, 6 acres)
- Sunset Fire (2009, <1 acre)

Prescribed Fires

- Bonito Fire (2002, 316 acres)

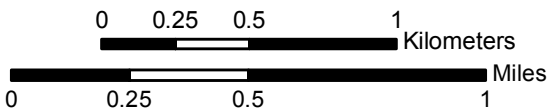
Fuels Treatment

- FMU 1 (2012, 34 acres)

Land Ownership

- Forest Service
- National Park Service
- Private

N



Produced by the Flagstaff Area National Monuments

Date: 7/21/2014

Appendix B: Fire Effects Monitoring Plot Maps

Walnut Canyon NM Fire Effects Monitoring Plots

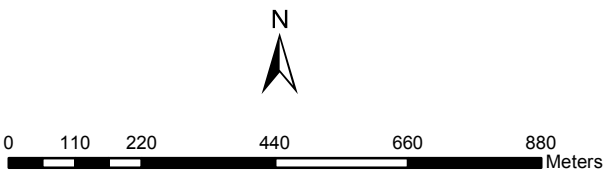
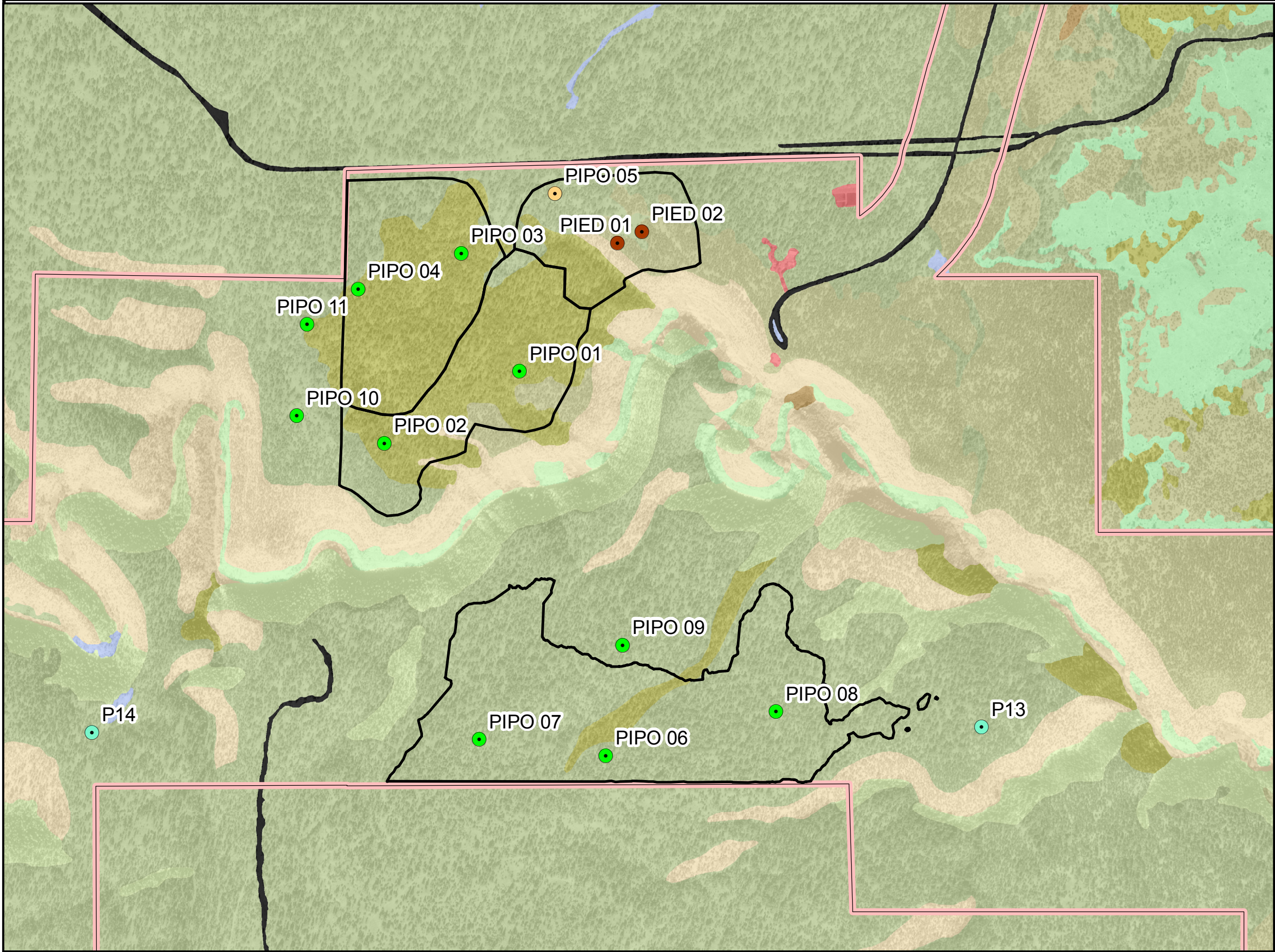
Wupatki NM Fire Effects Monitoring Plots

Sunset Crater Volcano NM Fire Effects Monitoring Plots



Walnut Canyon NM Fire Effects Monitoring Plots

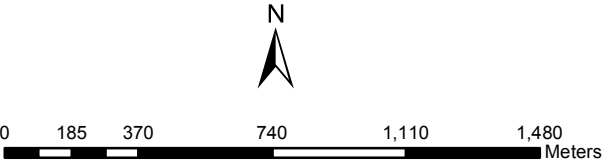
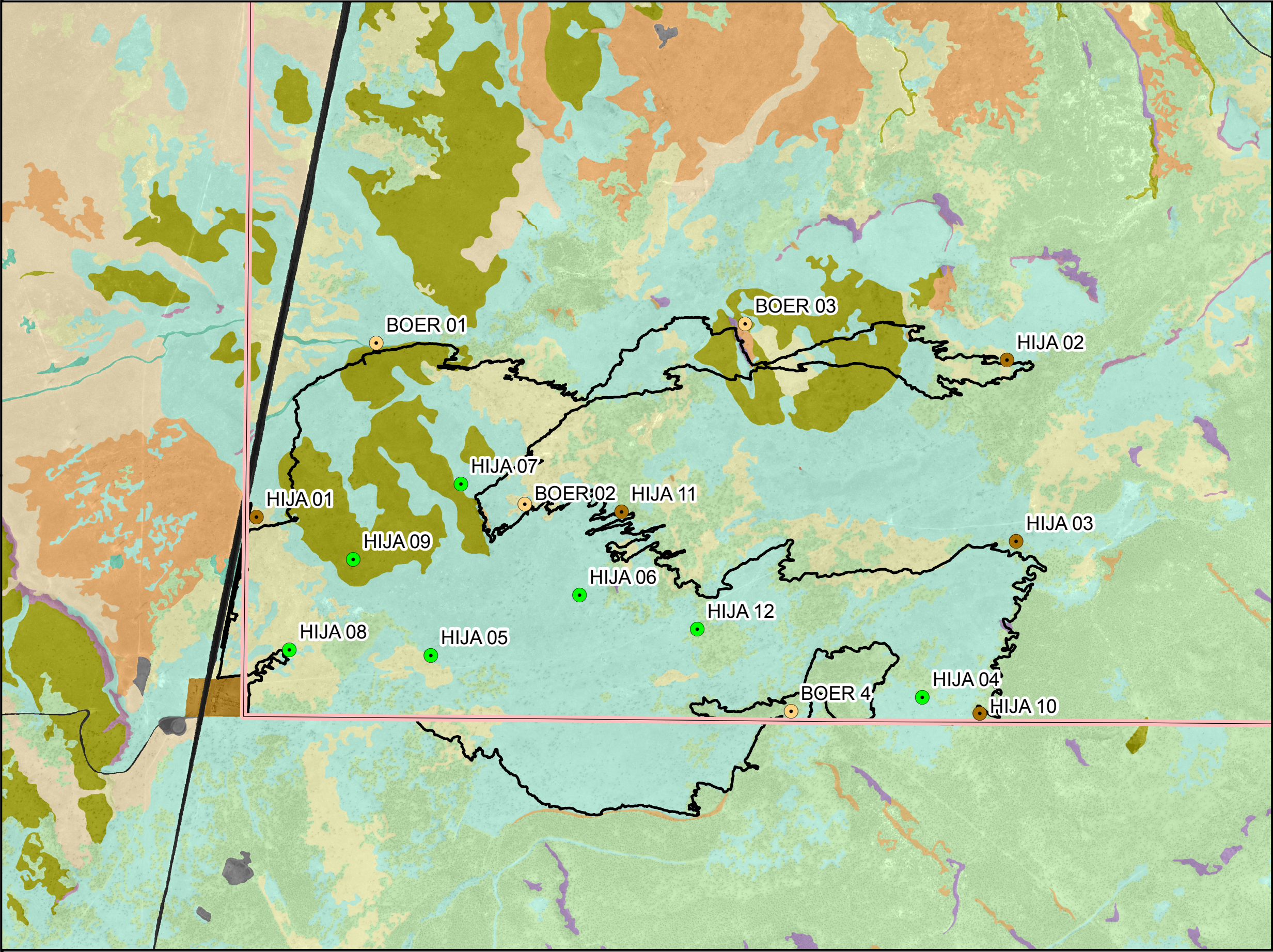
- Plot Type**
- Collaborative FMH / I&M Ponderosa Pine (PIPO) - existing
 - Collaborative FMH / I&M Ponderosa Pine (PIPO) - new
 - FMH Ponderosa Pine (PIPO)
 - FMH Pinyon-Juniper (PIED)
- Vegetation / Land Cover**
- Blue Grama - Mt. Muhly Grassland
 - Canyon Floor & Limestone Rim
 - Douglas-fir / Gambel Oak Forest
 - Facilities & Residential Land
 - Pinyon Pine - Utah Juniper Woodland
 - Ponderosa Pine - Pinyon Pine - Juniper Woodland
 - Ponderosa Pine Woodland Complex
 - Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
 - Snakeweed / Modified Grassland
 - Sparsely Vegetated
 - Transportation Routes & Utilities





Wupatki NM Fire Effects Monitoring Plots

- Plot Type**
- FMH Galleta (HIJA) - Burned
 - FMH Galleta (HIJA) - Control
 - FMH Black Grama (BOER) - Control
- Monument Boundary**
- Antelope Fire - 2002**
- Vegetation / Land Cover**
- Apache Plume Cinder Shrubland
 - Basalt Outcrop Shrubland
 - Black Grama Mixed Shrubland
 - Black Grama Grassland
 - Cinder Barren
 - Commercial Development
 - Fourwing Saltbush Drainageways
 - Galleta Grassland
 - Needle-and-Thread Grassland
 - Oneseed Juniper Woodland
 - Rabbitbrush Shrubland
 - Sand Bluestem Grassland
 - Snakeweed / Galleta Grassland
 - Mines, Quarries and Gravel Pits
 - Transportation and Utilities





Sunset Crater Volcano NM Fire Effects Monitoring Plots

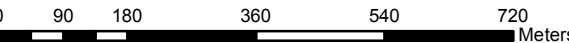
Plot Type

- FMH Montane Meadow (BOGR)
- FMH Conifer Encroachment (PIPO)

- Monument Boundary
- Bonito Park Rx - 2002

Vegetation / Land Cover

- Apache Plume / Cinder Sparse Vegetation
- Sparse Vegetation
- Facilities
- Lava Beds
- Montane Grassland
- Pinyon Pine - Utah Juniper Woodland
- Ponderosa Pine Woodland
- Rock Outcrop and Scree Shrubland
- Sand Bluestem Herbaceous Vegetation
- Strip Mines, Quarries, and Gravel Pits
- Transportation, Communications, and Utilities



Produced by GRCA Fire Ecology
August 2015

Appendix C: Monitoring Type Descriptions (FMH-4s)

Walnut Canyon National Monument (WACA)

Pinyon-Juniper (FPIED1D02)

Ponderosa Pine (FPIPO1D09, FPIPO1G09, and FPIPO1T09)

Sunset Crater Volcano National Monument (SUCR)

Montane Meadow (GBOGR1T02)

Conifer Encroachment (BPIPO1T02)

FMH-4 MONITORING TYPE DESCRIPTION SHEET

Monitoring Type Code: FPIED1D02

Date Described: 07/24/1999

Monitoring Type Name: Pinyon-Juniper

Preparer(s): K. Schon

Desired Conditions: A comprehensive literature search needs to be done for this type. Objectives were based on reducing fuel loads to decrease the chance for catastrophic wildland fire.

Burn Prescription (including other treatments): Not developed

Management Objective(s):

1. Reduce hazardous fuel loading by 30-50% one year post burn.
2. Reduce pole tree density 10-30% two years post burn.
3. Limit overstory tree mortality to less than 20% two years post burn and beyond.

Monitoring Objective(s):

1. Measure average total fuel load to be 90% confident that our sample mean is within 25% of the population mean.
2. Measure average pole tree density to be 90% confident that our sample mean is within 25% of the population mean.
3. Measure overstory tree mortality to be 90% confident that our sample mean is within 20% of the population mean.

Objective Variable(s): Total fuel load; pole tree density; overstory tree mortality

Physical Description: Located at 6,400 - 7,000 feet elevation with 0 - 20% slope, all aspects. Soils are shallow with gravelly consistency derived from Kaibab limestone. Bare rocky areas are common.

Biological Description: 90% of overstory stems are pinyon pine (*Pinus edulis*) and /or juniper (*Juniperus* spp.) with ponderosa pine (*Pinus ponderosa*) mixed in. Absolute canopy coverage is 20 - 60%. The understory is sparse with pole and seedling trees of same species. Common shrubs include rabbitbrush (*Chrysothamnus* spp.) and cliffrose (*Cowania mexicana*). The herbaceous layer is mostly grass (blue grama, *Bouteloua gracilis*) with mixed in legumes and buckwheat (*Eriogonum* spp.).

Rejection Criteria: Large rock outcrops >25% of plot; riparian areas where species composition and structure change; <20 meters from road or another FMH plot.

Notes:

FMH-4

PLOT PROTOCOLS (FPIED1D02)

(Opt) = Optional

GENERAL PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Preburn	Control Treatment Plots (Opt)		N	Herb Height (Opt)	Y
	Herbaceous Density (Opt)		N	Abbreviated Tags (Opt)	Y
	OP/Origin Buried (Opt)		N	Herb. Fuel Load (Opt)	N
	Voucher Specimens (Opt)	Y		Brush Fuel Load (Opt)	N
	Count Dead Branches of Living Plants as Dead (Opt)				N
Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): 10 m					
Length/Width Sample Area for Shrubs: 50 × 5 m Stakes Installed: All					
Herbaceous Frame Dimensions: n/a					
Herbaceous Data Collected at: Q4-Q1 and Q3-Q2					
Burn	Duff Moisture (Opt)		N	Flame Depth (Opt)	Y
Postburn	100 Pt. Burn Severity (Opt)		N	Herb. Fuel Load (Opt)	N
	Herbaceous/Shrub Data (Opt): FMH – ~~15/16/17/18~~ Do not collect				
FOREST PLOT PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Overstory (>15 cm)	Live Tree Damage (Opt)	Y		Live Crown Position (Opt)	Y
	Dead Tree Damage (Opt)		N	Dead Crown Position (Opt)	N
	Record DBH Year-1 (Opt)	Y			
Length/Width of Sample Area: 50 × 20 m		Quarters Sampled: Q1 ▪ Q2 ▪ Q3 ▪ Q4			
Pole-size (≥2.5 ≤15)	Height (Opt)	Y		Poles Tagged (Opt)	N
	Record DBH Year-1 (Opt)	Y		Dead Pole Height (Opt)	Y
	Length/Width of Sample Area: 25 × 20 m		Quarters Sampled: Q1 ▪ Q2		
Seedling (<2.5 cm)	Height (Opt)	Y		Seedlings Mapped (Opt)	N
	Dead Seedlings (Opt)	Y		Dead Seedling Height (Opt)	Y
	Length/Width of Sample Area: 10 × 10 m		Quarters Sampled: Q1		
Fuel Load	Sampling Plane Lengths (ft): <u>6</u> 1 hr ▪ <u>6</u> 10 hr ▪ <u>12</u> 100 hr ▪ <u>50</u> 1,000 hr-s ▪ <u>50</u> 1,000 hr-r				
Herbaceous	Cover Data Collected at: Do not collect				
Postburn	Char Height (Opt)		N	Poles in Assessment (Opt)	N
	Collect Severity Along: Fuel Transects				

FMH-4 MONITORING TYPE DESCRIPTION SHEET**Monitoring Type Code:** FPIPO1D09, FPIPO1G09, and FPIPO1T09**Date Described:** 07/22/1999**Monitoring Type Name:** Ponderosa Pine**Preparer(s):** K. Schon

Desired Conditions: A literature search has been initiated by GRCA fire effects and SAGU fire effects to determine the DFC of the PIPO type Northern AZ. Preliminary research suggests that there were anywhere from 19-25 overstory trees per acre during pre-settlement and PIPO comprised over 90% of the basal area, with the remainder occupied by pinyon, juniper, and Gambel oak (Covington and Moore 1994, Covington et al. 1998). Usually crown cover was less than 25% with trees clumped in groups of 2-44 individuals (Woolsey 1911, White 1985). All size classes were typically represented, but it was not a continuous pattern - trees were arranged in distinct size groups due to a number of decades between regeneration events (White 1985). Frequent openings occurred, dominated by grasses and other herbaceous plants. Total fuel loads were typically 2-8 tons/acre with averages estimated from 0.2-9.3 tons/acre (Covington and Moore 1992, Covington and Moore 1994, Harrington and Sackett 1992).

Burn Prescription (including other treatments): Not developed**Management Objective(s):**

1. Reduce total fuel loading by at least 40% one year post burn
2. Reduce pole sized tree density to 0-200 trees/acre (more research needs to be done on this objective to determine if this is a viable number).
3. Limit mortality of *Pinus ponderosa* with a DBH greater than 16 inches to 10-20%.

Monitoring Objective(s):

1. Measure the average total fuel load in the ponderosa pine forest with a sufficient sample size to be 90% confident that the sample mean will be within 25% of the population mean.
2. Measure the average pole tree density in the ponderosa pine forest with a sufficient sample size to be 90% confident that the sample mean will be within 25% of the population mean.
3. Measure overstory tree mortality of trees with a DBH greater than 16 inches to be 90% confident that the sample mean will be within 20% of the population mean.

Objective Variable(s): Total fuel load; pole tree density; overstory mortality

Physical Description: Located at 6,000-7,500 feet elevation on level to rolling terrain, including all aspects. Soils are moderately shallow derived from Kaibab limestone parent material.

Biological Description: Dominant tree species is ponderosa pine (*Pinus ponderosa*). Pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), and Gambel oak (*Quercus gambelli*) may be present. Common shrubs are cliffrose (*Cowania mexicana*), snakeweed (*Gutierrezia sarothrae*), and sage (*Artemisia* spp.). Common herbaceous species are blue grama (*Bouteloua gracilis*), mutton grass (*Poa fendleriana*), buckwheat (*Eriogonum* spp.), and a mix of legumes.

Rejection Criteria: Large rock outcrops >25% of the plot, riparian areas where the vegetation changes composition and structure, <20 meters from a road or another FMH plot, areas <5 meters from an archeological site.

Notes (2- 6 added by P. Grissom in 2013 and W. Bunn in 2015):

- 1) In 1998 transect 0 (from 50P to 0P) was added to the FPIPO1T09 type for herbaceous vegetation. This is important to note as it may cause some analysis problems with previous plot measurements of this type that only have transect 1 and 2 data (Rim burn plots).

- 2) The ponderosa pine monitoring type was originally segregated into 3 monitoring types based on projected time of year for burning. However, this segregation has not corresponded with burn season over time, so the monitoring types have been combined. Original plot assignments are as follows: FPIPO1D09 – PIPO 5; FPIPOG09 – PIPO 3 and 4; FPIPOT09 – PIPO 1, 2, 6, 7, 8, 9, 10, and 11.
- 3) Shrub belt width was periodically changed on some plots, and belt width was not noted on several data sheets. Confidence in data is low as the FFI database contains the most reasonable guess for sampled area when it was not noted.
- 4) Herbaceous species show high variability in which species are present and how much canopy they have produced based on seasonal timing of sampling. Sampling season is fairly inconsistent throughout the dataset and will likely affect any analysis.
- 5) Seedling density sample area was periodically changed on some plots, and sample area was not noted on several data sheets. Confidence in data is low as the FFI database contains the most reasonable guess for sampled area when it was not noted.
- 6) The following plot protocols summary represents the most common sampling scenario employed. Individual plots and measurements may differ from these protocols as noted above.

References:

Covington, W.W. and M.M. Moore. 1992. Postsettlement changes in natural fire regimes: Implications for restoration of old-growth ponderosa pine forests. In Old-Growth forests in the Southwest and Rocky Mountain regions: proceedings of a workshop, p. 81-99. USDA For. Serv. Gen. Tech. Rep. RM-213.201p.

Covington, W.W., M.M. Moore, P.Z. Fulé, H.B. Smith. 1998. Grand Canyon forest ecosystem restoration report on pre-treatment measurements of experimental blocks. Northern Arizona University unpublished manuscript.

Covington, W.W. and M.M. Moore. 1994. Southwestern ponderosa pine forest structure: changes since Euro-American settlement. *Journal of Forestry* 92:39-47.

Harrington M.G. and S.S. Sackett. 1992. Past and present fire influences on southwestern ponderosa pine old growth. In Old-growth forests in the Southwest and Rocky Mountain regions: proceedings of a workshop, p.81-99. USDA For. Serv. Gen. Tech. Rep. RM-213.201p.

White, A.S. 1985. Presettlement regeneration patterns in a southwestern ponderosa pine stand. *Ecology* 66:589-94.

Woolsey, T.S. Jr. 1911. Western yellow pine in Arizona and New Mexico. USDA For. Serv. Bull. 101.64 pp.

FMH-4 PLOT PROTOCOLS (FPIPO1D09, FPIPO1G09, and FPIPO1T09)

(Opt) = Optional

GENERAL PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Preburn	Control Treatment Plots (Opt)		N	Herb Height (Opt)	Y
	Herbaceous Density (Opt)		N	Abbreviated Tags (Opt)	Y
	OP/Origin Buried (Opt)		N	Herb. Fuel Load (Opt)	N
	Voucher Specimens (Opt)	Y		Brush Fuel Load (Opt)	N
	Count Dead Branches of Living Plants as Dead (Opt)				N
Burn	Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): 10 m				
	Length/Width Sample Area for Shrubs: 50 × 5 m		Stakes Installed: All		
	Herbaceous Frame Dimensions: n/a				
	Herbaceous Data Collected at: Q4-Q1 and Q3-Q2 and 0P-50P (selected plots)				
Postburn	Duff Moisture (Opt)		N	Flame Depth (Opt)	Y
	100 Pt. Burn Severity (Opt)		N	Herb. Fuel Load (Opt)	N
Herbaceous/Shrub Data (Opt): FMH – ~~15/16/17/18~~ Do not collect					
FOREST PLOT PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Overstory (>15 cm)	Live Tree Damage (Opt)	Y		Live Crown Position (Opt)	Y
	Dead Tree Damage (Opt)		N	Dead Crown Position (Opt)	Y
	Record DBH Year-1 (Opt)	Y			
Pole-size (≥2.5 ≤15)	Length/Width of Sample Area: 50 × 20 m		Quarters Sampled: Q1 ▪ Q2 ▪ Q3 ▪ Q4		
	Height (Opt)	Y		Poles Tagged (Opt)	varies
	Record DBH Year-1 (Opt)	Y		Dead Pole Height (Opt)	Y
Seedling (<2.5 cm)	Length/Width of Sample Area: 25 × 10 m		Quarters Sampled: Q1		
	Height (Opt)	Y		Seedlings Mapped (Opt)	N
	Dead Seedlings (Opt)	Y		Dead Seedling Height (Opt)	Y
Fuel Load	Length/Width of Sample Area: 25 × 10 m		Quarters Sampled: Q1		
	Sampling Plane Lengths (ft): <u>6</u> 1 hr ▪ <u>6</u> 10 hr ▪ <u>12</u> 100 hr ▪ <u>50</u> 1,000 hr-s ▪ <u>50</u> 1,000 hr-r				
Herbaceous	Cover Data Collected at: Do not collect				
Postburn	Char Height (Opt)		N	Poles in Assessment (Opt)	N
	Collect Severity Along: Fuel Transects				

FMH-4

MONITORING TYPE DESCRIPTION SHEET

Monitoring Type Code: GBOGR1T02

Date Described: 07/30/2002

Monitoring Type Name: Montane Meadow

Preparer(s): K. Schon and J. Leckie with additions from the Bonito Park Restoration proposal and pre-burn monitoring trip report

Desired Conditions: Maintain Bonito Park as a grassland area suitable for wildlife, such as antelope and grassland birds.

Burn Prescription (including other treatments): Low intensity broadcast burn applied via hand ignition in the fall.

Management Objective(s):

1. Eliminate conifer encroachment.
2. Improve habitat for pronghorn and other species that require open meadows by increasing the production of grasses and forbs.

Monitoring Objective(s):

1. Measure herbaceous cover to be 80% certain of detecting a 20% change in cover.
2. Measure conifer density to be 80% certain of detecting a 30% change in density.

Objective Variable(s): Tree density, herbaceous cover and height, species diversity.

Physical Description: This monitoring type only includes areas within Bonito Park. Bonito Park is a 400 acre high elevation (7,000 feet) park (or prairie) located between the San Francisco Peaks and Sunset Crater Volcano National Monument. The area is dominated by montane meadow soils with lava rock. All slopes and aspects are included.

Biological Description: Bonito Park is a high elevation grassland dominated primarily by blue grama (*Bouteloua gracilis*) with a variety of other native grasses, forbs, and occasional shrubs present.

Rejection Criteria: Areas within 5 meters of identified archeological sites; areas within 50 meters of roads, parking lots, burn unit boundaries, human-created trails, easements, or other recent and continuous source of disturbance; large rock outcroppings >25% of the plot; coniferous tree cover >10% of the plot.

Notes:

- 1) Plots were systematically placed along two transects and were not randomly located. The two transects formed an "X" across the meadow with one transect running at 160° for 950 meters and the other running at 320° for 1600 meters. Five plot origins were spaced evenly along each transect to represent the range of environmental conditions (elevation, moisture, etc) present in the prescribed fire unit.
- 2) 30-meter long transects were established in random directions from the plot origin stakes. Standard FMH line-intercept protocols for grassland plots were followed for herbaceous measurements.
- 3) A 10-meter wide observation belt (centered on the transect) was established to account for additional species present but not recorded on the transect.

FMH-4 PLOT PROTOCOLS (GBOGR1T02) (Opt) = Optional

GENERAL PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Preburn	Control Treatment Plots (Opt)		N	Herb Height (Opt)	Y
	Herbaceous Density (Opt)		N	Abbreviated Tags (Opt)	
	OP/Origin Buried (Opt)		N	Herb. Fuel Load (Opt)	N
	Voucher Specimens (Opt)			Brush Fuel Load (Opt)	N
	Count Dead Branches of Living Plants as Dead (Opt)				N
	Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): 10 m				
	Length/Width Sample Area for Shrubs: n/a		Stakes Installed: All		
	Herbaceous Frame Dimensions: n/a				
Herbaceous Data Collected at: 0P-30P					
Burn	Duff Moisture (Opt)		N	Flame Depth (Opt)	N
Postburn	100 Pt. Burn Severity (Opt)		N	Herb. Fuel Load (Opt)	N
	Herbaceous/Shrub Data (Opt): FMH – ~~15/16/17/18~~ Do not collect				
FOREST PLOT PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Overstory (>15 cm)	Live Tree Damage (Opt)			Live Crown Position (Opt)	
	Dead Tree Damage (Opt)			Dead Crown Position (Opt)	
	Record DBH Year-1 (Opt)				
Pole-size (≥2.5 ≤15)	Length/Width of Sample Area:			Quarters Sampled:	
	Height (Opt)			Poles Tagged (Opt)	
	Record DBH Year-1 (Opt)			Dead Pole Height (Opt)	
Seedling (<2.5 cm)	Length/Width of Sample Area:			Quarters Sampled:	
	Height (Opt)			Seedlings Mapped (Opt)	
	Dead Seedlings (Opt)			Dead Seedling Height (Opt)	
Fuel Load	Length/Width of Sample Area:			Quarters Sampled:	
	Sampling Plane Lengths (ft): <u> </u> 1 hr ▪ <u> </u> 10 hr ▪ <u> </u> 100 hr ▪ <u> </u> 1,000 hr-s ▪ <u> </u> 1,000 hr-r				
Herbaceous	Cover Data Collected at: Do not collect				
Postburn	Char Height (Opt)			Poles in Assessment (Opt)	
	Collect Severity Along: Herbaceous Transect				

FMH-4 MONITORING TYPE DESCRIPTION SHEET

Monitoring Type Code: BPIPO1T02

Date Described: 07/31/2002

Monitoring Type Name: Conifer Encroachment

Preparer(s): K. Schon with additions from the Bonito Park Restoration proposal and pre-burn monitoring trip report

Desired Conditions: Maintain Bonito Park as a grassland area suitable for wildlife, such as antelope and grassland birds.

Burn Prescription (including other treatments): Low intensity broadcast burn applied via hand ignition in the fall.

Management Objective(s):

1. Reduce encroaching conifers by 20-40%.

Monitoring Objective(s):

1. Measure tree density to be 80% certain that the sample mean is within 25% of the true population mean.

Objective Variable(s): Tree density

Physical Description: This monitoring type only includes areas within Bonito Park. Bonito Park is a 400 acre high elevation (7,000 feet) park (or prairie) located between the San Francisco Peaks and Sunset Crater Volcano National Monument. The area is dominated by montane meadow soils with lava rock. All slopes and aspects are included.

Biological Description: This monitoring type includes the areas of the Bonito Park montane meadow that are encroached by ponderosa pine (*Pinus ponderosa*). The montane meadow is dominated by blue grama (*Bouteloua gracilis*).

Rejection Criteria: Areas within 5 meters of identified archeological sites; areas within 20 meters of roads, parking lots, burn unit boundaries, human-created trails, easements, or other recent and continuous source of disturbance; large rock outcroppings >25% of the plot; overstory tree cover >10% of the plot; density of open-growth ponderosa pine pole and seedling trees <20% of the plot; ponderosa pine tree density <80% of total tree density.

Notes:

- 1) Plots origins were randomly located in the encroachment belt along the western and northwestern edge of the meadow.
- 2) 50-meter long transects were established in random directions from the plot origin stakes.
- 4) Standard FMH line-intercept protocols for brush plots (30 meter transect) were followed for herbaceous measurements. A 10-meter wide observation belt (centered on the transect) was established to account for additional species present but not recorded on the transect.
- 3) Conifer encroachment was counted in a 50-meter long by 10-meter wide (measured on the left side of the transect when viewed from 0P to 50P) belt.

FMH-4

PLOT PROTOCOLS (BPIPO1T02)

(Opt) = Optional

GENERAL PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Preburn	Control Treatment Plots (Opt)		N	Herb Height (Opt)	Y
	Herbaceous Density (Opt)		N	Abbreviated Tags (Opt)	
	OP/Origin Buried (Opt)		N	Herb. Fuel Load (Opt)	N
	Voucher Specimens (Opt)			Brush Fuel Load (Opt)	N
	Count Dead Branches of Living Plants as Dead (Opt)				N
Burn	Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): 10 m				
	Length/Width Sample Area for Shrubs: n/a		Stakes Installed: All		
	Herbaceous Frame Dimensions: n/a				
	Herbaceous Data Collected at: 0P-30P				
	Duff Moisture (Opt)		N	Flame Depth (Opt)	N
Postburn	100 Pt. Burn Severity (Opt)		N	Herb. Fuel Load (Opt)	N
	Herbaceous/Shrub Data (Opt): FMH – ~~15/16/17/18~~ Do not collect				
FOREST PLOT PROTOCOLS		YES (Y)	NO (N)	YES (Y)	NO (N)
Overstory (>15 cm)	Live Tree Damage (Opt)			Live Crown Position (Opt)	
	Dead Tree Damage (Opt)			Dead Crown Position (Opt)	
	Record DBH Year-1 (Opt)				
Pole-size (≥2.5 ≤15)	Length/Width of Sample Area:			Quarters Sampled:	
	Height (Opt)			Poles Tagged (Opt)	
	Record DBH Year-1 (Opt)			Dead Pole Height (Opt)	
Seedling (<2.5 cm)	Length/Width of Sample Area: 50 × 10 m belt			Quarters Sampled:	
	Height (Opt)			Seedlings Mapped (Opt)	
	Dead Seedlings (Opt)			Dead Seedling Height (Opt)	
Fuel Load	Length/Width of Sample Area: 50 × 10 m belt			Quarters Sampled:	
	Sampling Plane Lengths (ft): <u> </u> 1 hr ▪ <u> </u> 10 hr ▪ <u> </u> 100 hr ▪ <u> </u> 1,000 hr-s ▪ <u> </u> 1,000 hr-r				
Herbaceous	Cover Data Collected at: Do not collect				
Postburn	Char Height (Opt)			Poles in Assessment (Opt)	
	Collect Severity Along: Herbaceous Transect				

Appendix D: Interagency Agreement between Flagstaff Area National Monuments and the Coconino National Forest for the 2002 Bonito Park Prescribed Fire

Page 1 of 2

1. Fiscal Year 2002	2. IA # IA 747002010	3. Other agency # 02IA11030402-630	4. Type ☒ Original ☐ Modification	5. Modification #
6. This Agreement is entered into by the National Park Service: Park/Office: Flagstaff Area National Monuments Location: 6400 N. Highway 89, Flagstaff AZ 86004			7. Amount of this transaction	\$9,000.00
			8. Previous amount, if applicable	n/a
			9. Total amount	\$9,000.00
[X] To have work performed for the NPS by the agency named in Item 11. [] To perform work for the agency named in Item 11.			10. Under the authority of: ☒ Economy Act, 31 USC 1535 ☐ (Cite authority)	
11. Name of Agency: USDA Forest Service Coconino National Forest Location: 2323 E Greenlaw Lane Flagstaff AZ 86004			12. Economy Act determination attached? ☐ Yes ☐ N/A	
			13. BPC approval: ☐ Yes ☐ Not Required	

14. Statement of Work:

(See attached)

15.	REQUESTING (PAYING) AGENCY National Park Service	SERVICING (BILLING) AGENCY USDA Forest Service
16. Agency Location Code	16a. 14-10-0099	16b. 12-40-1100
17. Fund account symbol/appropriation	17a.	17b. 12X1106
18. Period of fund availability	18a. Fiscal Year 2002	18b. Fiscal Year 2002
19. Account/cost structure	19a. 7460 -H12	19b.
20. Procurement Contract	20a.	20b. n/a
21. Name of agency contact	21a. Paul Whitefield	21b. Alvin Brown
22. Contact's telephone number	22a. (928) 526-1157 ext 235	22b. (928) 527-5493

23. Billing method: On-Line Payment and Collection (OPAC)

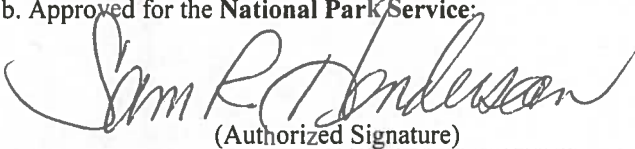
24. Billing frequency: ☐ Annually ☐ Quarterly ☐ Monthly ☒ Other (*Identify*) Payment in full upon receipt of invoice via OPAC.

25. Send OPAC supporting documentation to: (Name and address, including zip code):

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE - INTERMOUNTAIN REGION
INTERAGENCY / INTRA-AGENCY AGREEMENT

Agreement No.
Page 2 of 2

Execution of this Agreement constitutes an obligation against the requesting (paying) agency, and authority for the performing (billing) agency to proceed with the work and services to be performed. Nothing contained herein shall be construed as binding the paying agency to expend in any one fiscal year any sum in excess of appropriations made by Congress for the purposes of this Agreement for that fiscal year. This IA may be modified at any time during the agreement period by written agreement between the parties and may be terminated by either party after giving 60 days written notice.

26a. Approved for the National Park Service :		27a. Approved for the USDA Forest Service	
 (Authorized Signature)		 (Authorized Signature)	
Typed name: Robin Stoddard		Typed name: Elizabeth Blake	
Title: Contracting Officer Flagstaff Area National Monuments	Date: 7-22-02	Title: Agreements Officer Coconino National Forest	Date: 8/29/02
26b. Approved for the National Park Service :		27b. Approved for the USDA Forest Service	
 (Authorized Signature)		 (Authorized Signature)	
Typed name: Sam Henderson		Typed name: Jim Golden	
Title: Superintendent, Flagstaff Area National Monuments	Date: 7-22-02	Title: Forest Supervisor Coconino National Forest	Date: 8/29/02

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE - INTERMOUNTAIN REGION
INTERAGENCY / INTRA-AGENCY AGREEMENT

The following information should be used to complete the corresponding blocks on the face of this form:

1. Enter the current four-digit fiscal year.
2. Enter the NPS document number. (The standard 15-digit NPS Procurement Instrument Identification Number [PIIN] number is required for all agreement documents in accordance with NPS-20, Appendix A. PIIN is assigned by the Contracting Officer.)
3. Enter the other agency's document number.
4. Check appropriate box.
5. Enter the sequential modification number (e.g. 0001), if applicable.
6. Enter the NPS park or office name; City and State; and indicate whether NPS is the Servicing or Requesting Agency by checking the appropriate box.
7. Enter the amount of this transaction including all direct and indirect costs required to provide the service.
8. If this is a modification, enter the previous aggregate amount.
9. Enter sum of Blocks 7 and 8.
10. If under the Economy Act, check box. Cite other authority if not Economy Act.
11. Enter the name and location of the other agency.
12. Pursuant to FAR 17.503, an Economy Act determination is required by the Requesting Agency and approved by Requesting Agency's Contracting Officer. The determination shall state that the supply or service being provided by the other agency cannot be obtained as economically or conveniently by contracting directly with a private source and is in the best interest of the Government. Check "Yes" and attach the Determination unless NPS is not the Requesting Agency or the IA is under an authority other than the Economy Act.
13. Approval by the NPS Bureau Procurement Chief (BPC) is required for actions when NPS is the Requesting Agency and the aggregate funds are expected to be \$250,000 or above. Check either "Yes" or "Not Required".
14. Describe the work to be performed, including deliverables, project duration, and any other item not covered on this form.
15. Insert the appropriate agency names and/or acronyms in Requesting Agency and Servicing Agency blocks.
16. Enter the 8-digit Agency Location Code (ALC) for both agencies. The NPS ALC is 14-10-0099. Obtain other agency's ALC from that agency's Finance Office.
17. Enter the Treasury fund account symbol for the funds, which will be used to pay for and/or reimburse the work for each agency. (PWRO budget may need to assist in providing this for PWR parks)
18. Enter the period of fund availability of the designated funds. (NOTE: The period of availability of funds transferred pursuant to an Economy Act agreement may not exceed the period of availability of the source appropriation.)
19. Enter the account number for each agency that will be used to pay for and/or reimburse the work.
20. Enter the appropriate contract number, if applicable.
21. Enter the name of a contact person for each agency.
22. Enter the telephone number of the contact person.
23. Identifies billing method as OPAC. No entry required.
24. Check appropriate box or identify other.
25. Enter name and address of person who should receive supporting documentation for each bill.
(NOTE: If the Requesting Agency is other than NPS, that agency should complete this block.)
26. To be signed by the authorized official(s) for the National Park Service. Enter typed name, title, and date of each signature for the respective approving official. If NPS funds are being obligated, an authorized official must be a NPS Contracting Officer.
27. To be signed by the authorized official(s) for the other agency. Enter typed name, title, and date of each signature for the respective approving official.

SUBMITTAL

For Interagency Agreements authorized under the Economy Act, submit this form to the appropriate acquisition office where the IA number will be assigned, the Economy Act Determination and Findings Approval will be made, and the BPC approval will be satisfied. The program office should provide the Determinations and Findings Requirement to assist with the Economy Act Determination and Findings Approval.

This form may be used to supplement the other agency's document when that agency is the Requesting (Paying) Agency.

After signature by both parties, a fully executed copy with original signatures shall be returned to the acquisition office for record purposes.

STATEMENT OF WORK

BACKGROUND AND OBJECTIVES:

Bonito Park, a montane meadow of approximately 400 acres surrounded by ponderosa pine forest, is located within the Coconino National Forest adjacent to NPS visitor facilities for Sunset Crater Volcano National Monument. The park is also located adjacent to the Bonito Campground, which is operated by a concessionaire on behalf of the USDA Forest Service. The vegetation of Bonito Park was historically disturbed by dry-land farming activity, but native grasses, wildflowers, forbs, and shrubs have recovered over much of the area since farming ceased. In addition, young ponderosa pine seedlings and saplings are encroaching well into the western and southern margins of the meadow, and may eventually shade out the herbaceous understory if left unmanaged. There is considerable scientific evidence that prior to Euro-American settlement, the tree spacing and structure of ponderosa pine forest within the Coconino National Forest and Flagstaff area were more open, and that the forest structure was largely influenced by a natural wildfire regime of frequent low intensity fires.

The USDA Forest Service, Coconino National Forest, and the National Park Service, Flagstaff Area National Monuments have a mutual interest in using management-ignited fire to restore and maintain the montane meadow vegetation in Bonito Park. The park lies to the West-Southwest of the Sunset Crater Volcano National Monument visitor center and the Bonito Campground. Maintaining an open meadow within this area minimizes the threat of catastrophic wildfire to these facilities. A management-ignited fire would have other benefits, including: (1) maintaining natural scenery from along the Sunset Crater Volcano National Monument access road and the Bonito Campground; (2) restoring native grass and forb vegetation within the meadow; and, (3) maintaining habitat for pronghorn and other grassland adapted species. This Interagency Agreement is established for the Flagstaff Area National Monuments and the Coconino National Forest to share funding, staff, equipment, and other resources necessary to plan and implement the Bonito Park Management-ignited Fire.

STATEMENT OF WORK:

A. *The USDA Forest Service agrees to:*

1. Complete the work tasks specified in the Appendix 1: Scope of Work (attached).

B. *The National Park Service agrees to:*

1. Reimburse the USDA Forest Service up to \$9,000 for completion of tasks described in Appendix 1: Scope of Work (attached).

**U.S. Department of Interior - National Park Service - Flagstaff Area National Monuments
Interagency Agreement #**

2. Designate the Natural Resource Specialist, Flagstaff Area National Monuments, to serve as the NPS Contracting Officer's Technical Representative to provide interagency coordination and logistic support as needed to complete the work tasks.
3. Install vegetation plots to monitor fire effects.

C. *Both Agencies Agree to:*

1. Share staff, equipment, maps, file information, and other resources as needed to plan a management-ignited fire in the Bonito Park area of the Coconino National Forest, including:
 - Completing surveys of cultural resources, sensitive species, etc.
 - Completing NHPS sect. 106 compliance review.
 - Consulting with culturally-affiliated Native American tribes.
 - Completing NEPA compliance review and documentation.
2. Share staff, equipment, and other resources as needed to implement a management-ignited fire in the Bonito Park area of the Coconino National Forest, including:
 - Improve a fire line around the burn area perimeter.
 - Mechanically thin ponderosa pine seedlings and saplings within the burn area.
 - Monitor ground-disturbance and exclude fire from certain areas within the burn area in order to prevent or mitigate impacts to cultural resources.

**APPENDIX 1:
SCOPE OF WORK**

Task Number 1 - The USDA Forest Service will complete compliance documentation from a cultural resource survey of the Bonito Park area of the Coconino National Forest (approximately 400 acres), and participate and provide input to the NEPA ID Team.

Task Number 2 - The USDA Forest Service will complete the NEPA Analysis, including compliance review, maintaining the project record, and finalizing the appropriate decision documents.

Task Number 3 - The USDA Forest Service will provide supporting workforce for burn prep and operations, including line preparation, ignition personnel, holding forces, and cultural resource monitoring.