Grand Canyon National Park
Fire Effects Monitoring Plan
April 1, 2000

Tonja Sojz — 4/1/00

Prepared by Fire Effects Specialist — **Date**

Kenneth Ulm — 4/3/00

Recommended by Prescribed Fire Manager — **Date**

L. Jerome Montague — 4/30/00

Approved by Chief, Natural Resources — **Date**

[signature] — 4/3/00

Approved by Chief, Fire and Aviation — **Date**

Table of Contents

Introduction

There are still questions about Grand Canyon's fire ecology, but the fire management program can manage ecosystems effectively by utilizing an adaptive management strategy as answers are provided through the Fire Effects Monitoring Program. Fire managers will continue to learn more about fire effects on vegetation and fuels with thorough monitoring efforts, prompting refined fire prescriptions and more effective future uses of prescribed fire. **The purpose of this plan is to guide fire monitoring activities at Grand Canyon National Park, ensuring information is collected consistently each year.**

The Fire Effects Monitoring Program focuses on four monitoring types at this time—South Rim Great Basin Conifer Woodland, South Rim Ponderosa Pine, North Rim Ponderosa Pine, and North Rim Ponderosa Pine with White Fir Encroachment. Many variables are measured in each ecosystem, but the focus is mainly on overstory trees, pole trees, and total fuel load. Additional monitoring types are under development for North Rim Meadows and North Rim Spruce-Fir. A forest and brush type may be established in Great Basin Conifer Woodlands for future fires of high intensity. Undeveloped monitoring types are not addressed in this plan.

The management of wildland fires depends on whether the fire is within prescription parameters as outlined in the Fire Management Plan. The fire will either be suppressed or managed as a Wildland Fire Use for Resource Benefits (WFURB) fire. Wildland Fire Use incidents are monitored and documented, but long-term fire effects are not studied under the program detailed in this document. This Fire Effects Monitoring Plan outlines efforts in monitoring all fires that occur at Grand Canyon National Park and in monitoring long-term vegetation and fuel load changes as a result of prescribed burning.

What is Monitoring?

It is important to understand what "monitoring" means, but many people interpret it differently. By definition, monitoring

- is a powerful tool that, if implemented early, can identify problems before they become crises:
- can be used to measure management success:
- is characterized, primarily, by objectives and being part of an adaptive management cycle:
- is not "research" (Elzinga et al. 1998).

"Surveillance" is the collective term used to describe measurements that document change over time, but are *not* used to make better resource management decisions. However, the actual monitoring techniques and analysis may be the same for both (Elzinga et al. 1998). The GRCA Fire Effects Monitoring Program employs all the

necessary techniques and analysis used in a comprehensive monitoring program, except that "management responses" have not been articulated. Therefore, by the above definition, the GRCA Fire Effects Monitoring Program is not part of an adaptive management cycle. The prescribed fire staff is actively working on changing this fact by sharing prescribed fire management information with resource management staff in order to collaborate in identifying trends, solutions, and management actions. This information sharing takes place through an annual two-day meeting and distribution of a comprehensive data analysis report. With continued collaborative efforts, GRCA may have a true adaptive management cycle in place for prescribed fire management. However, for the purpose of this report, "monitoring" will be used to describe the techniques outlined in the "1992 Western Region Fire Monitoring Handbook" (National Park Service 1992).

Monitoring is not research. Research is more rigorous in that control plots are in place to determine cause and effect of a certain treatment with statistical significance. Fire Effects Monitoring plots are not supplemented by control plots, therefore statistically significant inferences about cause and effect cannot be determined. Monitoring results can "raise a red flag" and a research study can be initiated to study the fire effects further.

Fire Effects Monitoring Goals

The primary aim of the Fire Effects Monitoring Program is to provide information to fire and resource managers, which allows them to affirm that prescribed fire objectives are being met or to identify and correct deficiencies. Fire Effects monitoring at Grand Canyon National Park is focused on pinyon-juniper woodlands and ponderosa pine associations at this time.

Table 1 lists the goals for the Grand Canyon Fire Monitoring Program in the first column. The remaining columns list key positions in the Grand Canyon Fire Monitoring Program and where their responsibilities lie. Some of these responsibilities are on going, while others need review only annually. This table helps eliminate confusion about where different positions fit into the big fire monitoring picture.

Table 1. Fire Effects Monitoring Program Goals and Responsibilities

Fire Monitoring Program Goals	Resource Manager	Rx Fire Manager	Rx Fire Specialist	Fire Effects Specialist	Lead Fire Monitor	Field Monitors	Regional Fire Ecologist
Collect data, enter data, manage data.					•	•	
Lead the Fire Effects Monitoring Crew in the field on a daily basis.					•		
Supervise the Fir e Effects Monitoring Program.		•		•			
Provide quality control guidelines for data collection and management.				•	•		•
Analyze data and provide written fire reports to verify objectives are met.				•	•	•	
Ensure personnel safety during field and office work.		•	•	•	•	•	
Document basic information for all prescribed fires and keep all monitoring information organized and properly backed-up		•	•	•	•	•	
Identify areas in which research should be initiated	•	•	•	•			•
Facilitate communication within the park, and between monitoring programs within the region, the NPS, and interagency	•	•	•	•			•

Grand Canyon National Park Forest and Woodland Vegetation

Due to extreme differences in climate, soils, and terrain, Grand Canyon National Park supports riparian habitats, hot desert scrub, pinyon-juniper, ponderosa pine, and high-elevation spruce-fir forests. Following, is a short summary of vegetation types where prescribed fire is used. For more information about Grand Canyon vegetation, see:

- Brown, D.E. (editor) 1982. Biotic communities of the American southwest-United States and Mexico. Desert Plants 4:(1-4).
- Hurst, M. 1977. An ecological description of forest communities on the North Rim of Grand Canyon National Park, Arizona. Grand Canyon, AZ: National Park Service, Grand Canyon National Park unpublished document, 46 pp.
- Mead, P. 1930. An ecological description of the Kaibab Plateau, Arizona. Master of Science dissertation, University of Chicago, 209 pp.
- Merkle, J. 1952. An analysis of a pinyon-juniper community at Grand Canyon, Arizona. Ecology 33:375-384.
- Merkle, J. 1954. An analysis of the spruce-fir community on the Kaibab Plateau, Arizona. Ecology 35:316-322.
- Merkle, J. 1962. Plant communities of Grand Canyon. Ecology 43:698-711.
- Phillips, A.M. III and B.G. Phillips. 1980. Vegetation and flora of Grand Canyon National Park, Arizona *In* Proceedings of the second conference on scientific research in the national parks. Vol 4, Resource analysis and mapping. San Francisco, CA. November 26-30, 1979. p 203-221.
- Phillips, B.G., KA.M. Phillips, III, and M.A.S. Bernzott. 1987. Annotated checklist of vascular plants of Grand Canyon National Park. Monograph Number 7, Grand Canyon Natural History Association, 79 pp.
- Rand, Patricia J. 1958. The plant communities of Grand Canyon National Park, Arizona. The Minnesota Academy of Science, Proceedings: Vols. XXV-XXVI p 88-90.
- Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11:230-275.
- Warren, P.L., K.L. Reichhardt, D.A. Mouat, B.T. Brown, and R.R. Johnson. 1982. Vegetation of Grand Canyon National Park. Technical Report No. 9., Cooperative Natural Park Resources Studies Unit, University of Arizona. 140 pp.
- Wolf, Joy J. and Joy N. Mast. 1998. Fire history of mixed-conifer forests on the North Rim, Grand Canyon National Park, Arizona. Physical Geography 19:1-14.

Spruce-fir forests dominate the North Rim ridgetops above 8700 feet. On north-facing slopes above 8200 feet, the forest is dominated by subalpine fir, white fir, Engelmann spruce, and aspen with Douglas fir and blue spruce at slightly lower elevations. Ponderosa pine occurs on drier, southwestern-facing sites along with Douglas fir and aspen. There are very few shrubs in this dense forest type, and herbaceous cover is sparse. There are plans to begin prescribed burning in limited areas of this forest on the northeastern park boundary in the Hayden and Vista IV units (Figure 1).

Mountain meadows are scattered throughout the forest in shallow valleys between north-south trending ridges. There is a rich diversity of grasses and forbs in these areas. It appears that soil moistures and cold temperatures inhibit seedling establishment in the

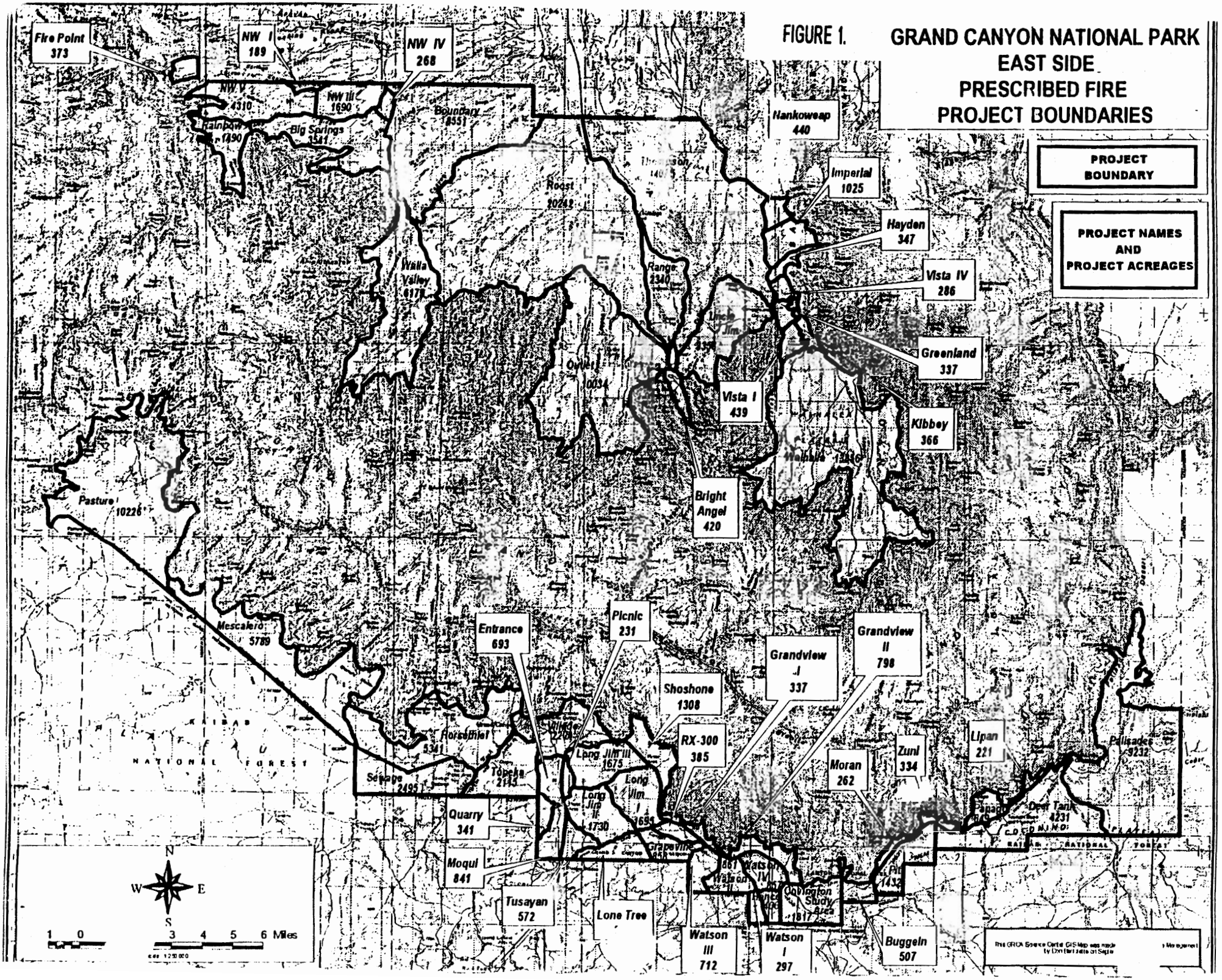


FIGURE 1. GRAND CANYON NATIONAL PARK EAST SIDE PRESCRIBED FIRE PROJECT BOUNDARIES
PROJECT BOUNDARY
PROJECT NAMES AND PROJECT ACREAGES
Fire Point 373
NW I 189
NW IV 268
NW V 4310
NW III 1690
Rainbow 1490
Big Springs 1541
Boundary 8551
Nankoweap 440
Imperial 1025
Roost 10242
Hayden 347
Vista IV 286
Wells Valley 6171
Range 1340
Greenland 337
Vista I 439
Kibbey 366
Bright Angel 420
Pasture 10226
Mescalero 5789
Entrance 693
Picnic 231
Grandview I 337
Grandview II 798
Shoshone 1308
RX-300 385
Zuni 334
Upan 221
Palisades 9232
Moran 262
Horsethief 5341
Long Jim III 1675
Long Jim I 1694
Long Jim II 1730
Topeka 2143
Sespe 2495
Quarry 341
Moqui 841
Tusayan 572
Lone Tree
Watson III 712
Watson I 297
Buggeln 507
Desert Tank 4231
Watson IV 1817
Watson II 1432
N
W
E
S
1 0 3 4 5 6 Miles

meadows, although edges are being invaded by conifers and aspen (Moore 1994). Fire may be used in and around meadows to prevent encroachment by tree species.

Ponderosa pine forests occur between 7000-8200 feet on both rims, mixing with pinyon-juniper at lower elevations, and with spruce-fir forests at higher elevations. At the higher elevations on the North Rim, what was once ponderosa pine-dominated forest is being severely encroached by white fir due to fire suppression activities over the last 100 years. Pure stands of ponderosa pine can be found on the most southern plateaus of the North Rim and in drainages on the South Rim. Ponderosa pine forests burned every 2-15 years before fire suppression activities (Duhnkrack 1982, Swetnam and Baisan 1996).

Pinyon-juniper woodlands occur below the ponderosa pine and extend into the canyon in many areas. Dominanted by *Pinus edulis* and *Juniperus osteosperma*, pinyon-juniper forests are limited on the North Rim to the southern tips of the plateaus that extend into the canyon, but are the most dominant cover type on the South Rim. A well-developed understory of shrubs and herbs is present. Pinyon-juniper forests surrounding the South Rim Village have been burned by hand ignition and "jack-potting" over the past 10 years to reduce the threat of wildfire. Jack-potting refers to a method by which fire crews walk through the forest and stack scattered fuels into piles for greater consumption when the piles are ignited. Numerous open areas exist in this forest type along the South Rim as a result of high-intensity, stand-replacement wildfires.

The area treated by prescribed fire exists, for the most part, on the rims of the Grand Canyon, in forested areas. Occasionally, a fire may creep down slope over the rim into scrub but does not usually burn below the Coconino layer. At this time, prescribed fire has not been used in grass-dominated ecosystems on the rims.

Monitoring Levels

There are four fire monitoring levels: (1) Reconnaissance, (2) Fire Conditions, (3) Immediate Post-fire Effects, and (4) Long-term Change. Tasks are cumulative—conditions monitored at higher levels include all tasks at lower levels. Every fire is monitored at levels 1 and 2 no matter if it contains long-term vegetation and fuel monitoring plots (FMH plots). For Levels 3 and 4, permanent monitoring plots are randomly distributed over a monitoring type that contains many prescribed burn units. Some burn units have more than five plots, while others have none. The plots are meant to monitor trends in vegetation at a landscape level, not to detect change in individual burn units. To monitor each burn unit at a statistically valid level with long-term vegetation monitoring plots is unrealistic because it would necessitate hundreds of plots.

On occasion, we may choose to forego full plot installation in a burn unit and opt to monitor only 1 or 2 variables, using the same protocols as for the full plot installation. For example, if fuel load reduction is of primary concern on a particular unit and no FMH plots exist on this unit, only Brown's transects may be installed and monitored to obtain accurate results for this variable. Some areas can be monitored long-term using photo points, instead of vegetation

or fuel measurements. Photographs can provide a useful qualitative record of change. Consultation between the Burn Boss, the Prescribed Fire Manager, and the Fire Effects Specialist will determine what levels of monitoring are needed for burn units.

Level 1 Monitoring: Reconnaissance

Level 1 monitoring is "reconnaissance" and utilized when a fire has little potential for growth and is located in an inaccessible area. Fire location, size, fuel type, activity, and potential for spread are recorded as well as resource concerns and smoke movement. Most Level 1 monitoring is done via helicopter at a frequency decided by the Burn Boss or Incident Commander (IC). *Level 1 monitoring alone is rarely utilized for monitoring prescribed fires* unless it is late in the burning season and the prescribed fire is relatively inactive but not declared "out". During late-season burns aerially ignited on the North Rim, monitors may only be able to collect Level 1 information via helicopter flights or photographs from the South Rim.

Level 2 Monitoring: Fire Conditions

Level 2 monitoring includes fire conditions *and* reconnaissance for all fires in the park. Monitors may have a few days to a few weeks to prepare for monitoring a prescribed fire. Preparation includes a variety of tasks and there are many forms for documenting prescribed fire information at Grand Canyon (Appendix A). If a fire is ignited by air on the North Rim late in the season, and no fire monitors are on-site, fire conditions will be documented by the Burn Boss and recorded on the form RX-6: Daily Prescribed Fire Monitoring Report. For a WFURB, the assigned fire monitor will document fire conditions as appropriate.

All prescribed fire monitoring information and a copy of the burn plan is kept in binders in the fire office. **All** prescribed fire monitoring documentation must be put in these files, whether originals or photocopies, including slides and photos from the fire. Operational information is kept in a separate file in the Prescribed Fire Manager's office. WFURB documentation goes to the IC or the files kept in Fire Dispatch.

Tasks Associated with Monitoring a Prescribed Fire

Days/Weeks before ignition:

1. Understand burn objectives
2. Get familiar with burn unit boundaries
3. Establish photo points for smoke/vegetation at Burn Boss' request
4. Make sure Monitoring Kit is ready (list of required items is in Appendix B of this document)
5. Sample fuels, monitor 10-hour sticks, and rain gauges at Burn Boss' request
6. Install pin flags for Fire Behavior Observation Circles (FBOCs)
7. Request spot weather forecasts for days preceding ignition at Burn Boss' request
8. Deploy Data-RAM 2000 at Burn Boss' request

Day of Ignition:

1. Attend briefing
2. Bring Monitoring Kit and helium tank to location for releasing pibal
3. Report pibal results to Burn Boss
4. Monitor fire throughout burning period with smoke, fire, and weather observations, and photos. Take notes to use in narrative report.
5. Monitor smoke throughout burning period and throughout evening at Burn Boss' request.
6. File all paperwork in 3-ring binder for that burn unit
7. File photo record sheets in binder for "photos to be matched with record sheets".

Day(s) after ignition:

1. Go to photo points to take smoke photos as soon as it's light enough for a good exposure
2. Monitor smoke as needed in sensitive areas at Burn Boss' request
3. Send film in for processing ASAP
4. Re-stock monitoring kit from cache
5. Identify needs for re-supply/ordering
6. Monitor Data-RAM 2000 at Burn Boss' request

Two weeks after burning of unit is completed:

1. File processed photos as they come back
2. Collect and summarize documentation from DataRAM 2000 using template for graphs
3. Give final monitoring report to Burn Boss and Prescribed Fire Manager
4. File final monitoring report in burn unit binder

Six-to-Ten weeks after burn is completed:

1. When appropriate, give written report on post-burn fire effects to Rx Fire Manager. This is necessary if FMH plots were burned in the unit or subunit.

Forms to Use when Monitoring a Prescribed Fire

RX-1: Weather observations

This form is mostly self-explanatory. The burn boss will dictate how often weather observations should be taken. Take observations from a variety of locations (valley bottoms, ridgetops, southwest slopes, etc). Report observations over the tactical channel so all firefighters are aware of changing weather conditions. Indicate when critical levels are reached (low fuel moistures, gusty winds, etc). Fill out the header completely. Read the burn plan to understand the prescription and inform Burn Boss if weather observations fall outside of prescription.

RX-2: Pilot Balloon observations

At Grand Canyon National Park a pilot balloon (pibal) is released before every prescribed burn to indicate where the smoke will travel. Take the helium tank to the field with the monitoring kit. Pibal instructions and accessories are in the kit. Record pibal information on the form and relay information on wind direction to Burn Boss. If the pibal shears off, winds are strong, and if it rises straight up, winds are light. Estimate where smoke will go in relation to sensitive areas (highways, canyon, villages, and trails).

RX-3: Smoke observations

Smoke is one of the most critical factors in the decision to ignite a prescribed fire at Grand Canyon National Park. Before ignition, identify points where smoke observations can be taken. These points should be easy to locate again and should provide a view of the smoke column and nocturnal drainage areas. Also consider establishing photo points where there will not be smoke impacts, to document existing haze. Take observations and photographs at these points numerous times throughout the day. Try to choose only a few points and take repeated photos from the same locations, rather than lots of pictures at lots of different places. Strive for comparable photos. Also, choose photo points in areas where smoke may be a problem (highways, canyon, villages, and critical receptors identified in the burn plan) and monitor smoke in these areas. Consult with the Burn Boss and read the burn plan to understand smoke issues for each burn. Read the burn unit's smoke management plan if one was prepared.

In most cases, the Data-RAM 2000 machine will also be used to monitor smoke. Procedures for use of this machine are covered in Appendix B of this document. A dichot machine owned by ADEQ is set up at the Tusayan Airport and is maintained by the Fire Effects Staff. This machine may also need to sample more frequently during a prescribed fire. Consult with Burn Boss. Machine instructions are in Appendix B of this document.

RX-4: Fire Behavior observations

All monitors should receive instruction on how to measure flame length, flame zone depth, and rate of spread before taking these measurements on a fire. Record observations on the form. Try to take observations from a variety of locations to indicate fire behavior in different fuel types or on different slopes or aspects. Take photographs to match up with the observations, but don't just photograph the big flames—document the range of conditions. Read the burn plan so you understand the prescription and inform Burn Boss if fire is not in

prescription. Go back to a location where you did fire behavior observations and take another photo of the area when cool. If possible, take a photo a week later also. Comparable photos over time are good. Use rulers in close-up photographs of duff and litter consumption. Make maps of photo points that can be visited a few weeks or a year later and document azimuths.

RX-5: Photographic Record Sheet
Photos provide some of the best documentation. For every roll of film you shoot, you must fill out a photo record sheet. Use slide film. Make sure the databack feature is "on" when using the camera and try to record the "time" photo taken from the clock on the back of the camera. This helps when sorting photos later because you can match the times rather than the description alone. Write descriptions as best you can on the form (Fire Behavior in PIPO, Column from Helibase, Smoke in Tusayan) and write down the azimuth of the photo when appropriate (it may not always matter). If you find a good photo point over the course of the day, draw a map to locate that point, record the azimuth, and call it something like, "Shoshone Photo Point 1". Then record this for the description on the photo record sheet during the rest of monitoring. This is especially helpful for smoke monitoring. Back at the office, this sheet gets put in the binder "Photo Record Sheets to Match with Photos". When developed photos come back, you just need to go to one binder to figure out which roll it could be.

RX-6: Daily Prescribed Fire Monitoring Report
This form does not have to be completed in the field, but can be used for taking notes for the report to be typed at the office at the end of the day. There are sections to write narratives about weather, smoke observations, fuel consumption, effects on poles and overstory, and fire behavior. This form must be completed before leaving the office on the day of ignition. *Do not wait until the next day.* During multiple ignition days, events will run together and narratives will become less detailed. Attach the following items:

- A map with acreage of burned area for that day.
- All monitoring forms *except* photo record sheet
- A copy of the fire weather forecast request fax from Fire Dispatch.

Use the burn plan prescription or FMH-4 to fill in the "range of conditions" column for the prescription for the burn unit. Use the monitoring sheets to determine the range observed that day while monitoring. Explain any differences in the third column.

File the report in the binder for that burn project. Reports are filed in reverse chronological order and tabs are made to separate ignition dates. These reports may be compiled once the burn is completed, merging information from sampling machines and using photographs taken during the burn.

The Burn Boss will need to fill out this report if there are no on-site fire monitors for an ignition day. It is imperative that if FMH plots are burned, there is corresponding fire behavior documentation.

ICS Unit Log
Fill out a unit log for each monitoring team to document major events. This often helps to jog your memory at the end of the day when it's time to write the Daily Prescribed Fire Monitoring Report.

Spot Weather Forecast Request Form
This is a standard form provided by NOAA. Fill in the header before going to the field and give the information (a photocopy) to Fire Dispatch so you don't have to repeat all this information over the radio. Use a cell phone to relay this information to Fire Dispatch if possible. Start taking weather observations as early as possible, ½ hour apart, and get 3 observations before calling them in. Take them from different elevations if possible. Cloud types can be important to fire weather forecasters, so use a guide to identify cloud types and cloud cover. Fire Dispatch will call you back in the afternoon with the forecast. Be ready to write it down. Request a copy of the forecast when you get back to the office and include it with other monitoring forms. It is sometimes helpful to the forecaster if you take evening observations to use for the spot forecast the next day.

GRCA Personnel Cost Tracking Form
In order to provide a reliable estimate of the cost of burning a unit, we need to fill these out after each shift and turn them in to the Prescribed Fire Specialist when the burn is complete. Every person needs to be responsible for filling these out completely. If the ignition will take a few days, each person can fill out a separate sheet and keep track for the duration of the burn. These sheets must be given to the Prescribed Fire Specialist at the end of an incident.

FMH 2-A Forest Plot Burn Data Sheet
Use this form when monitoring a Fire Behavior Observation Circle (FBOC) on an FMH plot in a burn unit. If the unit is being burned with aerial ignition, you cannot monitor the plot, but need to do your best to estimate fire behavior conditions from similar areas around the fire perimeter using the RX-4. Before the plot is burned, set up the FBOCs using pink pin flags in a 10' circle around the beginning and end stakes of all Brown's transects. Make sure igniters do not "dump" extra fuel on the plots to make them burn. Observe fire behavior and fill out the form. Take photos. You will not be able to monitor all 8 FBOCs, but monitor as many as you can. Be prepared to ask the Ignition Specialist to hold while monitors are in the interior taking observations. Keep this information with the Daily Prescribed Fire Monitoring Report, and put a copy in the folder for that FMH plot. If an FMH plot was burned but no monitors were on-site, record the date of the burn in the FMH plot folder on the site visit page. Ensure the POST read is added to the plot board so the plot is visited later that year.

RX-7 Final Prescribed Fire Monitoring Report
This report summarizes all the daily reports into a final document and is only prepared at the Prescribed Fire Manager's request. Attach maps of burn progression and summarize observed weather, smoke, and fire behavior. Also, summarize any special concerns noted during the burn. Include digital images when possible to illustrate weather, smoke, and fire behavior. Ideally, this should be completed as soon as possible after the burn unit is

complete. It can be completed by the Prescribed Fire Manager, Prescribed Fire Specialist, Fire Effects Specialist, or Burn Boss.

Tasks Associated with Monitoring a WFURB Fire

During a WFURB fire, monitors will likely be assigned to work directly under the Incident Commander or in the Operations section. Information will be documented as dictated by those in charge, but many forms used for monitoring prescribed fires can also be used for monitoring WFURB fires as needed. All documentation should be given to either the IC or the Fire Dispatch office at the end of every operational period to eventually be filed with other incident documents. Level 1 and 2 documentation for WFURB fires will not be kept in the fire effects office.

Level 3 Monitoring: Immediate Post-fire Effects

Level 3 monitoring includes reconnaissance, fire conditions, and immediate post-fire effects. Level 3 monitoring does not occur for WFURB fires—only prescribed fires. Immediate post-fire effects monitoring includes all monitoring done within 5 years of a fire. This level is where the majority of fire monitoring takes place at Grand Canyon National Park through data collection on permanent plots. Plot visits are tracked on an Excel spreadsheet. The Master FMH Plot Monitoring Table is too large to include in this document as a hard copy and is available on disk as an Excel 97 document.

Monitoring Types

FMH-4 Monitoring Type Descriptions are located in Appendix C and specify monitoring objectives and desired future conditions. All data analysis for monitoring types and descriptions of the plot network are in the Annual Fire Monitoring Report compiled for March 1 each year.

Standard Methods

Detailed methods are in the 1992 Western Region Fire Monitoring Handbook (National Park Service 1992) which is currently under revision. For different monitoring types, information is gathered in with different parameters but using the same methods. For example, seedlings are counted in a 10 x 25 meter area in some monitoring types and a 5x10 meter area in others. Specifications are noted in the Monitoring Type Description Sheets (FMH-4s) located in Appendix C. On every plot, information is gathered for overstory (diameter and condition), pole trees (diameter, height and condition), seedlings (height), fuels (woody, litter, and duff amounts), herbaceous presence (frequency and height), shrubs (frequency and condition). Metric units are used in monitoring, except for the dead and down woody fuels transects which are in English units. Eight different photographs are taken of each plot. Information on plot location and all plot data are kept in 3-ring binders in the Fire Effects Office on South Rim.

No control plots exist in the plot network. Control plots will not be funded by FIREPRO unless extreme cases warrant their installation. If there is a park-specific concern and a justified need for control plots, Intermountain Region will consider funding them. If GRCA

fire and resource management staff decide to install control plots, a plan for keeping fire out of such plots will have to be determined.

Plot reads are tracked in an Excel 97 spreadsheet called "plot status.xls". A copy of this spreadsheet is on the Fire Effects Specialist's computer and on the fire effects crew computer. Eacn winter, the plot workload is projected for the next five years depending on changes to burn priorities. This must be done in consultation with the Prescribed Fire Manager. Priorities for new plot installations are made and documented. The plot visits needed for the following summer can then be put on the plot board in the fire effects office, and all the field copies for those plots can be prepared.

To ensure monitoring occurs to specified standards at Grand Canyon National Park, checklists were developed in 1999. These checklists aid crewmembers in plot establishment and installation, plot reading, and data management. Copies of all checklists are in Appendix D.

Two practice plots were established on the Shoshone prescribed burn unit on the South Rim to be used annually as the first plot visit of the season. They are called SHOS 1 and SHOS 2. During the first week of work in summer, the crew can visit these two plots first and enter these data into the database for practice in Grand Canyon's methods.

Timing of Monitoring

Monitoring permanent plots generally proceeds from the warmest to coolest ecosystems in the park. Plot re-reads and installs begin in pinyon-juniper ecosystems on the South Rim and the ponderosa pine ecosystems on the South Rim. Next, plot re-reads and installations occur in North Rim ponderosa pine forests. The North Rim provides only a limited opportunity to adequately sample herbaceous plants, and by early September most are dead or dormant. The meadows on the North Rim (which may have plots installed in 2000) should be read in August. Ponderosa pine with white fir encroachment and mixed conifer should also be read before mid-September. In some years there will be an enormous plot load in a 2-month window during July and August. It may be necessary to split the Grand Canyon fire effects crew up into two teams, or to ask for assistance from other Grand Canyon fire employees or monitors from other parks.

Recording Data

There are numerous forms used for FMH plot monitoring. They are all available in their original formats in the 1992 Western Regional Fire Monitoring Handbook (National Park Service 1992). To lessen confusion and reduce recording errors, we have modified many of the data sheets to include methods specific to Grand Canyon and reminders for some methods. All of the modified sheets are available on the Fire Effects desktop computer and hard copies are stored in a folder labeled "Forms" in the Fire Effects office. Copies of these forms are at the end of this document in Appendix E.

Data Management and Quality Control

All data are entered into the fmh.exe program on the Fire Effects desktop computer when crew is on the South Rim. When working on the North Rim, data can be entered in fmh.exe

on any computer with the software installed, and appended to the desktop computer later. See the checklists in Appendix D for detailed information on data management.

The checklists are provided as a quality control guideline for data management. In addition to these checklists it is generally understood that all monitors are responsible for recording information accurately, entering information accurately, and avoiding plot trampling. Ultimately it is the responsibility of the Fire Effects Specialist to ensure the checks are taking place which ensure data quality. The Fire Effects Specialist is also responsible for monitoring design and interpretation, scheduling plot visits so data are collected at the right time of year, and ensuring crews are properly trained. The Fire Effects Specialist may delegate these responsibilities to the fire effects staff.

Equipment

For the Field

All common field equipment is located in the Fire Effects Office. Two gray and green bins hold most equipment, including the plot pack. One bin is for field equipment used on every plot, and the other is for "extra" equipment that is brought in the vehicle and left there in case equipment fails in the field. Checklists are provided to ensure both are packed with the proper equipment. Additional equipment is located in the Fire Effects storage locker upstairs of the Fire Cache on the South Rim. Camera equipment and film is in a file cabinet in the Fire Effects Office.

GPS

The Precision Lightweight GPS Receiver (PLGR) is kept in locked storage. The Fire Effects Specialist is the contact for use of the PLGR. It is not to be used by a non-government or volunteer employee under any circumstances and can never be left unattended or in an unlocked place. It also cannot be left unattended in a tent, a locked vehicle, or a locked hotel room. The PLGR is taken to all plot visits. To date, not all plots have had locations marked with the PLGR. In some cases, the PLGR has been used to mark the route into the plot. The PLGR can be downloaded to interface with ArcView.

Herbarium Supplies

Plant press materials, plant books, and the working herbarium are located in the Fire Effects Office at a desk dedicated to herbarium work. There are a variety of plant slides available and CD-ROM field identification guides are under development. Instruction for proper collection, pressing, and mounting of specimens is provided at the herbarium work desk, including "Preparing Herbarium Specimens of Vascular Plants" (Smith 1971) for comprehensive instructions. Efforts are made to deposit good-quality specimens in the park's Herbarium.

Data Analysis

Traditionally, data analysis is performed at the completion of each field season and reported in an annual report that must be given to a printer by mid-February for distribution March 1. Data analysis, for the most part, consists of graphs showing density over time with standard error bars. Tables show percent change for some variables. Most analyses are performed

with a combination of the FMH Software and Excel 97. The FMH-4s guide data analysis with a customized data analysis section. For information on the current results of the Fire Monitoring Program, see the most recent Annual Fire Monitoring Report.

If statistical testing for significance is necessary, we will determine if data are normally distributed. If so, we can use paired t-tests to detect change. Other tests may also be appropriate. We will consult a statistician at Northern Arizona University if necessary. If statistical testing is necessary we should obtain appropriate statistical software.

Results may be presented at conferences and other special meetings. Results that both support and contradict published fire literature will be of special interest.

Level 4 Monitoring: Long-term Change

Level 4 monitoring means continuing all Level 3 monitoring over an extended period and adding a statistically valid primary indicator of long-term change. This type of monitoring may alert fire managers to the potential misuse of fire in the ecosystem. As the Grand Canyon's plots continue to be monitored, analysis may suggest that some unpredicted change in the ecosystem is occurring. The fire effects staff will identify trends and make other resource managers aware of them. If necessary, control plots may be installed, or a research project may be established to investigate the trend further.

Special Resource Management Concerns

There are seven federally threatened or endangered wildlife species found in Grand Canyon National Park. An additional species, the peregrine falcon, has recently been delisted, but during a five-year monitoring period this species is generally accorded "threatened" status by the U.S. Fish and Wildlife Service. There are also 21 park species on the Arizona Game and Fish Commission's List of Threatened Native Wildlife in Arizona. The park also provides habitat for 12 species that were formerly considered Federal Candidate Category 2 species.

Only three of the federally listed species, the Mexican spotted owl, bald eagle, and peregrine falcon are likely to be affected by fire management activities. All planned burns will have compliance analysis conducted by the park Wildlife Biologist prior to ignition. When unplanned ignitions occur, the Wildlife Biologist or a designated representative is contacted through a process determined with Fire Dispatch to discuss management strategies.

There are over 116 alien plant species known to exist within the park (National Park Service 1997). The Fire Effects Monitoring crew will analyze the herbaceous transects each year and, at the least, provide an appendix in the Annual Prescribed Fire Summary detailing herbaceous species data. If an alien species population is found on a fire monitoring plot, the Revegetation Crew at the GRCA Science Center will be notified.

There are 63 vegetation associations described for Grand Canyon National Park (Warren et al. 1982). Over 1,400 species of vascular plants have been collected, a diversity which is attributed to the great variety of natural habitats within an 8,000 foot elevational change (Phillips et al. 1982). There is only one endangered plant in the park, the sentry milk-vetch (National Park Service 1997, page 2-26).

The sentry milk-vetch is known from two sites on the South Rim. One site of about 500 plants is protected by an enclosure, while the second site with two individuals is at a remote and seldom visited location. The species grows on limestone ledges between the canyon rim and the pinyon-juniper woodland. A second population on North Rim is considered to be an undescribed variety. Fire management activities are not likely to affect either varieties of this species. There are seven species of special concern, formerly known as Category 2 species. Fire management activities may affect the populations of three of these species: Grand Canyon rose, Grand Canyon catchfly, and Tusayan flame-flower. The other four species of special concern are found at sites below the canyon rims, outside of burn units, in woodland, desertscrub, and riparian environments. Fire management activities would not be likely to affect these populations.

A number of historic and archaeological sites exist within the Park. Prior to any planned ignitions, compliance from the park Archaeologist is necessary. These compliance procedures take place within the burn plan approval process.

Finally, there is growing concern about the reintroduction of fire to ponderosa pine forests that have had an artificial decrease in the natural fire return interval because of fire suppression. When fires are ignited in stands that have unnaturally high fuel load accumulations and uncommonly thick ladder fuels, there may be an increased potential for killing a large percentage of overstory trees. Caution must be used to prevent the unnecessary loss of overstory ponderosa pines during planned ignitions. Overstory mortality is monitored in appropriate monitoring types at Grand Canyon. The goal is to not to exceed an average mortality of 20% within 5 years post-fire for ponderosa pine larger than 16 inches diameter at breast height (dbh). An overstory tree, by definition in the Fire Monitoring Handbook (NATIONAL PARK SERVICE 1992), is any tree greater than 15 cm dbh (6" dbh).

Conclusion

Monitoring results are compiled after each field season and included in the Annual Prescribed Fire Report due annually on March 1. Results will also be presented at the annual Prescribed Fire and Resource Management meeting. Fire and resource managers will determine if the results of previous burns are acceptable, based on the goals stated in the FMH-4 Monitoring Type Description Sheets for each monitoring type. If monitoring results are not acceptable, or if resource needs change, changes to the burn program or burn objectives may be necessary. These changes might include some or all of the following: altering burning prescriptions or monitoring objectives; recognizing the need for a research project; or treating invasive species with alternate methods.

This monitoring plan will be reviewed annually by the fire and natural resource staffs and updated as necessary.

Literature Cited

Duhnkrack, J.A. 1982. Fire regime analysis of the ponderosa pine forest of the Grandview monocline on the South Rim of Grand Canyon National Park, Arizona. B.S. Thesis, Huxley College of Environmental Studies, Bellingham, Washington.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and monitoring plant populations, USDI, BLM, BLM/RS/ST-92/005_1730, 492 pgs.

Moore, M.M. 1994. Tree encroachment on the meadows of the North Rim of Grand Canyon National Park. Final Report, USDA NPS #CA 8000-8-0002. May 1994.

National Park Service. 1997. Grand Canyon National Park Resource Management Plan, Part One—Narrative. January 1997. 190 pp.

National Park Service, 1992. Western Region Fire Monitoring Handbook. 134 pp.

Smith, E.C. 1971. Preparing Herbarium Specimens of Vascular Plants. USDA Information Bulletin No. 358, 29 pp.

Swetnam, T.W., and C.H. Baisan. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. Pages 11-32 *In* C.D. Allen, editor. Proceedings of the Second La Mesa Fire Symposium, 29-30 March 1994, Los Alamos, New Mexico. USDA Forest Service General Technical Report INT-182.

Appendix A. Prescribed Fire Monitoring Forms

A-1: RX-1 Weather Observation Form

A-2: RX-2 Winds Aloft Computation Form

A-3: RX-3 Smoke Observation Form

A-4: RX-4 Fire Behavior Observation Form

A-5: RX-5 Fire Monitor Photographic Record Form

A-6: RX-6 Daily Prescribed Fire Monitoring Report

A-7: RX-7 Final Prescribed Fire Monitoring Report Outline

A-8: ICS Unit Log

A-9: Cost Tracking Form

A-10: Spot Weather Forecast Request Form

A-11: FMH 2-A

PERSONNEL COST TRACKING WORKSHEET

PROJECT NAME:_____ DATES:_____:_____, YR:_____ ACCOUNT #:_____ INTAGCY #_____

A-9

MOD/RESC NAME:		GS/WG+	REGULAR TIME			OVERTIME			HZD/ED/ND/HOL			
#	DATE	NAME/IDTFR	GRD	HRS	RATE	TOTL	HRS	RATE	TOTAL	HRS	RATE	TOTAL	TOTAL
	TOTALS >>>												GRAND TOTAL:

Notes:

PHASE IDENTIFICATION
1 = Planning
2 = Preparation
3 = Execution
4 = Evaluation

FORM RX I REVISED 3/94

WEATHER OBSERVATION FORM

RX-1

Grand Canyon National Park

Date: _____ Fire Name: _____ Monitor(s): _____ Page __ of ___

Fuel Model(s): _____

A-1

TIME	LOCATION	ELEV.	WIND SPEED	WIND DIR.	DB	WB	RH/DP	% CLOUD COVER TYPE	10 HR TLFM	1 HR TLFM	PIG	COMMENTS
PRESCRIPTION:												

GRCA.PF.04/99

WINDS ALOFT COMPUTATION FORM - 10 Gram Balloon (Pi-Ball)

RX-2

Grand Canyon National Park

Date: _____ Fire Name: _____ Monitor(s): _____ Page __ of ___

Location: _____ Elevation: _____ MSL* Surface Wind: _____

Temperature: _____ RH: _____ Weather: _____

A-2

A	B	C	D	E	F
TIME (Min.)	HEIGHT (Ft./AGL)**	CLINOMETER ANGLE (Deg.)	COMPASS AZIMUTH (Deg.)	WIND DIRECTION	COMMENTS
:30					
1:00	500'***				
1:30					
2:00	1000'				
2:30					
3:00	1500'				
3:30					
4:00	2000'				
4:30					
5:00	2500'				
5:30					
6:00	3000'				
6:30					
7:00	3500'				
7:30					
8:00	4000'				

* MSL - Mean Sea Level
** AGL - Above Ground Level
*** - Pi-Ball rises 500' per minute

SMOKE OBSERVATION FORM

RX-3

Grand Canyon National Park

Date: _____ Fire Name: _____ Monitor(s): _____ Page __ of ___

A-3

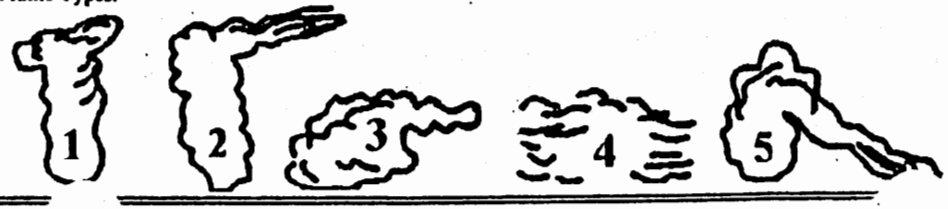
TIME	LOCATION	PLUME HEIGHT AGL*	PLUME DIR.	PLUME TYPE 1-5 (below)	% CLOUD COVER	OBSERVATIONS**

*AGL - Above Ground Level

** Include the following in Observations:

~Highway vis. ~Impacts to Sensitive Areas
~Fireline vis. ~Complaints
~Mixing height ~Color & Contrast
~Inversion height ~Forward & back scatter

Plume Types:



GRC

FIRE BEHAVIOR OBSERVATIONS FORM

RX-4

Grand Canyon National Park

Date: _____ Fire Name: _____ Monitor(s): _____ Page __ of ___

A-4

TIME	LOCATION	ELEV.	SPREAD DIR.*	ROS*	FL*	FZD*	FUEL MODEL	% SHADING*	% SLOPE	COMMENTS*		
PRESCRIPTION:												

*Spread Direction: B (backing), H (heading), or F (Flanking)
*Rate of Spread (ROS): in/sec or ft/min
*Flame Length (FL): nearest inch (0-23"); 0.5 foot (2-4'); 1.0 foot (4-15'); 5.0 feet (>15')
*Flame Zone Depth (FZD): nearest inch (0-23"); 0.5 foot (2-4'): 1.0 foot (>4')

*% Shading: combination of canopy & cloud cover
*Comments include: ~unusual fire behavior
~photo reference #
~FBOCS information

GRCA.PF 04/99

FIRE MONITOR PHOTOGRAPHIC RECORD FORM

Grand Canyon National Park

Date: _____ Fire Name: _____ Monitor(s)/Photographer(s): _____ Page __ of __

Camera Type: _____ Film: SLIDE or PRINT (circle one) ASA: _____

PHOTO #	TIME	AZIMUTH	DESCRIPTION/LOCATION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24*			

*Don't take slides past #24 -- they will not get processed!

~Make maps of photo points if necessary

RX-6 Daily Prescribed Fire Report

Fire Name:
Fire Number:
Date:
Lead Monitor:
Monitors:

Acres burned today:

Observation Location(s)
Aerial:
Ground:

Fuel Model/Vegetation Type:

Narrative of fire activity (flame lengths, rates of spread, unusual behavior):

Narrative of smoke dispersal (movement of column, size, color, special concerns):

Narrative of weather observations and comparisons to prescription:

Fuel consumption and comparisons to desired fire effects:

Other special concerns or significant events:

Attach map of burn unit with acreage burned today, and all weather and fire behavior observation forms.

Prepared by: Date:

RX-7 Final Prescribed Fire Monitoring Report Outline

Fire Name:
Fire Number:
Date:
Lead Monitor:
Monitors:

Size of Unit:
Number of Operational Periods:

Observation Location(s)
Aerial:
Ground:

Fuel Model/Vegetation Type:

Narrative of fire activity (flame lengths, rates of spread, unusual behavior):

Narrative of smoke dispersal (movement of column, size, color, special concerns):

Narrative of weather observations and comparisons to prescription:

Fuel consumption and comparisons to desired fire effects:

Other special concerns or significant events:

- **Attach map of burn unit with acreage burned.**
- **Summarize all weather and fire behavior observation forms in a spreadsheet with a column of burn prescription for comparison, and attach.**

Prepared by: Date:

UNIT LOG	1. INCIDENT NAME	2. DATE PREPARED	3. TIME PREPARED

4. UNIT NAME/DESIGNATORS.	5. UNIT LEADER (NAME AND POSITION)	6. OPERATIONAL PERIOD

PERSONNEL ROSTER ASSIGNED

NAME	ICS POSITION	HOME BASE

8. **ACTIVITY LOG** (CONTINUE ON REVERSE)

TIME	MAJOR EVENTS

TIME	MAJOR EVENTS

A-8-2

9. PREPARED BY (NAME AND POSITION)

WS FORM D-1
(12-86)
Pres. By WSOM D-41

FIRE WEATHER SPECIAL FORECAST REQUEST

(See reverse for instructions)

U. S. DEPARTMENT OF COMMERCE
NOAA
NATIONAL WEATHER SERVICE

I - REQUESTING AGENCY WILL FURNISH:

1. NAME OF FIRE OR OTHER PROJECT	2. CONTROL AGENCY	3. REQUEST MADE	
		TIME†	DATE

4. LOCATION *(By 1/4 Sec - Sec - Twp - Range)*	5. DRAINAGE NAME	6. EXPOSURE *(NE, E, SE, etc.)*

7. SIZE OF PROJECT *(Acres)**	8. ELEVATION*		9. FUEL TYPE	10. PROJECT ON:
	TOP	BOTTOM		☐ GROUND ☐ CROWNING

11. WEATHER CONDITIONS AT PROJECT OR FROM NEARBY STATIONS *(See example on reverse)*

PLACE	ELE-VATION	OB TIME†	WIND DIR. - VEL.		TEMP.		2ft.s. Blank)		REMARKS *(Indicate rain, thunderstorms, etc. Also wind condition and 10ths of cloud cover.)*
			20 FT.	EYE LEVEL	DRY	WET	RH	DP	

12. SEND FORECAST TO:	PLACE	VIA	ATTN: *(Name, if applicable)*

II- FIRE WEATHER FORECASTER WILL FURNISH:

13. FORECAST AND OUTLOOK:
(Specify Wind - 20 foot or Eye Level)

TIME † AND DATE: _____

NAME OF FIRE WEATHER FORECASTER	FIRE WEATHER OFFICE

III - REQUESTING AGENCY WILL COMPLETE UPON RECEIPT OF FORECAST

IV - FORECAST RECEIVED:	TIME †	DATE	NAME

Explanation of Symbols

† Use 24-hour clock to indicate time. Example: 10:15 p.m. = 2215; 10:15 a.m. = 1015
* For concentrations (as groups of lightning fires) specify "Concentration"; then give number of fires and size of largest. If concentrations are in more than one drainage, request special forecast for each drainage.
‡ No entry necessary. To be computed by the Fire Weather Forecaster.

WS FORM D-1 SUPERSEDES PREVIOUS EDITIONS

Forest Plot Burn Data Sheet

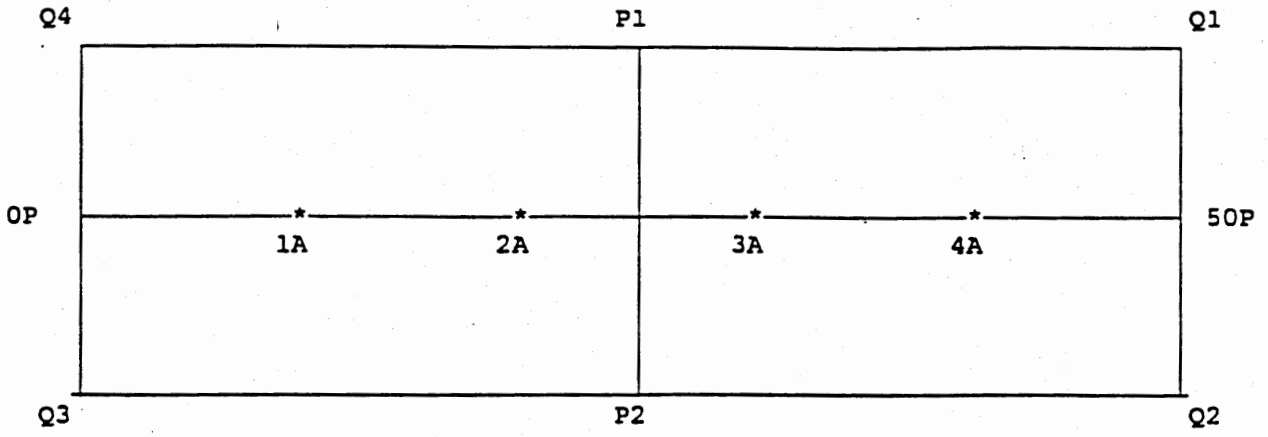
Plot ID _____ Date ___/___/___

Burn Unit _____ Recorder _____

Time Plot Ignited _____ at _____ Time Plot Out _____

0P-50P _____° 1A-1B _____° 2A-2B _____° 3A-3B _____° 4A-4B _____°

Draw location of "B" FBOCs and flaming fronts on map below:



*Indicate Slope_____

FBOC	Dist.	Lapse Time	ROS	Type of Fire	Flame Length	Flame Zone Depth	Photo	Comments
1A	5'	1:00	4.5 c/h	B	1-1.5'	18"	#12	too hot, had to leave

FMH-2F

Appendix B. Fire Monitoring Kit

B-1: Fire Monitoring Kit Checklist

B-2: Pibal Directions

B-3: Data RAM 2000 Cheat Sheet

B-4: Using the Tusayan Dichot Sampler

B-5: Smoke Monitoring—Guidelines from the Air Quality Specialist

Monitoring Pack Contents

Check Contents: Date top column and initial				
Camera				
5 rolls film				
Belt Weather Kit				
Electronic Wind Gauge (Turbometer)				
Skywatch Wind Gauge				
10-hour scale				
Extra set of 10-hour sticks in plastic				
Monitoring Forms in accordion file				
Pens/Pencils/Markers				
Monocular				
Compass				
Clinometer				
Calculator				
Piball directions				
Helium tank gauge and wrench				
Pilot balloons				
Park map				
Burn unit map, laminated				
Fireline Handbook				
Fire in the NPS brochures				
AA batteries, case				
AAA batteries, case				
Sticky notes				
4 various types of rulers for mapping				
360-degree protractor, clear				
USGS Timesaver				
Stopwatch				
Nomograms, laminated				
Fire Behavior Field Reference Guide				

English Area Grid				
Anderson's Fuel Models Guide				
Topo Aid for Lat/Long				
UTM Grid				
Smoke Monitoring Directions				
Large Notepad				

Instructions for Filling a Pi-Ball

READ ALL INSTRUCTIONS BEFORE BEGINNING

BEFORE YOU LEAVE

- Take a full helium tank from the Fire Effects office (under drafting table)
- Take a regulator, wrench, and balloons from Monitoring Kit (extra in cache)
- When transporting helium, make sure tank is secure—use truck with a bracket

WHEN YOU GET TO THE RX SITE

- Take current weather and fill out header on RX-2 form
- Put regulator on tank, tighten with wrench
- Open valve—should NOT hear hissing
- Put a balloon over the nozzle and fill just until you think it's going to break
- Tie off the balloon and go to an area to release it—somewhere open where balloon won't get hung up
- Get a compass, clinometer, stopwatch, RX-2 Winds Aloft form, and assistance (2-3 folks is best)
- Release balloon and measure Azimuth (D) and Clinometer Angle (C) every 30 seconds. Try not to take your eye off the pi-ball or you may lose it
- Record info until you can't see pi-ball any longer
- Fill out Wind Direction (E)
- Under Comments (F), note if balloon stayed low or rose straight up (where do you think smoke will go?)

*****Balloon rises 500' per minute*****

PLEASE RETURN ALL MATERIALS TO WHERE THEY WERE FOUND

DATA RAM CHEAT SHEET

- Before heading out, consider calling the National Bureau of Standards for the correct time (303.499.7111) and use this to check the clock on the DR. Re-set if necessary.

- Connect computer and data ram with grey cable
- DR must be on and running before booting computer (only applies to *some* computers)
- Turn computer on – or...
- If computer is not charged, exit run, turn DR off, and plug into DR's extension cord – turn DR and computer on
- On computer, run "MIE", "DR-COM"
- Check ID # on bottom of DR, and select correct ID #
- On DR, go to "main menu"
- "next screen" (main menu 2)
- "dump data"
- "dump all data"
- Wait to see data finish scrolling by
- On computer, select "file", "save text"
- Name file – use location initials and date (ex: pr091598.csv)
- Check to be sure file was saved
- Exit program and shut down computer
- On DR, "exit" and "exit" to reach "main menu"
- Check the clock against the "standard time" and fix if necessary
- "zero", wait, then "exit"
- "purge", wait, then "exit"
- "parameters"
- "clear data" – need to hit it 2x
- "average: 10 sec"
- "log data: on"
- "every 15 min" (00:15:00)
- "exit"
- "next screen"
- "autozero on", "every 3 hours"
- "alarm: off"
- "exit", "exit"
- "run (zeroed)"
- screen will say "run data", and will show some data if you wait a minute

- Back at the office, back up the data ASAP by moving the file to the designated Zip disk for that geographic location.

USING THE DICHOT AIR SAMPLER

Written by Tonja Opperman

September 5, 1997

Introduction

This unit is designed to measure particulate matter (PM10 and PM2.5) during a 24-hour sampling period which can be specified by the user. The unit can also be set to sample on the EPA's schedule which is once every sixth day. The unit has been calibrated for Tusayan and will be recalibrated by ADEQ every six months.

The dicot air sampler is located at the Grand Canyon Airport in Tusayan near a windsock on the west side of the runway near the north end. Access to the sampler is through a security gate which can only be entered by those who have completed an airport safety course or who have a security escort from the airport office. The sampling machine itself is not locked. The unit can be easily moved anywhere within the local area by disconnecting the hoses between the two instruments and picking up the palettes.

The unit must be plugged into an outlet. Inside the tan box, the two silver toggle switches need to be up/on and the wheel clock (large silver dial) time must be set in the proper quadrant. The wheel clock is divided into 6 areas, each corresponding to one 24-hour period. A small silver tab on the wheel clock marks the time the unit will turn on to begin a sample, while the small black tab turns off the unit. The wheel clock can be set to take a sample up to five days in advance by counting the days backwards from the start tab to the quadrant corresponding to the current day. For example, if today is Wednesday and you want the sample to take place on Saturday, Saturday corresponds to the day between the on/off tabs. Counting clockwise around the wheel clock, the quadrants correspond to Friday, Thursday, and Wednesday. The quadrant identified as Wednesday needs to be showing the current time with the red pointer. If the wheel clock needs to be turned, it only turns clockwise, and the red pointer does not move.

Make sure the two black hoses connecting the tripod with the tan box are in place. If the clear jar on the tripod unit fills with water (this is normal), empty and replace it. The unit is now ready for use.

Tools Needed

1. Empty cases for dirty filters
2. New filters
3. Run sheets (Sample Data Card)
4. Monitoring Schedule if using EPA schedule, or dates and times for manual schedule
5. Silicone grease for o-rings
6. Allen wrench (7/64)
7. Stubby phillips screwdriver
8. Pipe cleaners

TO TAKE OUT A DIRTY FILTER:

1. Turn machine on by flicking out the silver trip switch by the silver clock and let machine warm up for 2 minutes.

2. Before touching any dials, read the Rotameters—total and fine. They can range in values greater than and less than the Set Points. Set Points remain fixed for six months until the machine is re-calibrated.

3. Shut machine off and read the black dial (elapsed time meter reading) stop time.

4. Compute total time by subtracting, look at your watch for real time, and read the silver clock for wheel clock timer.

5. Fill out comments with hours filter was run if more or less than 24; specify if reading was a "regular" reading on the EPA schedule, or if it was a "manual" reading.

6. Take out dirty filters and put in correct clear containers, put these in a white cardboard envelope, and put this envelope and the run sheet in a large manila envelope to be mailed to ADEQ.

INSTALLING A CLEAN FILTER:

1. After taking out dirty filters, clean filters can be put in immediately. Write the RUN date on the filter (not the date you put the filter in the machine) and record I.D. numbers on run sheet. It is very important to keep track of these numbers. The yellow filter corresponds with the yellow mesh covering on the instrument, and the white filter with the white covering. Always put filters with shallow sides down.

2. Once new filters are installed, machine must be set up for a fresh run. Turn machine on using the manual switch near the silver wheel clock and let it warm up for 2

minutes. While it is warming up, fill in the header on the run sheet: Location, Run Date, Operator, Filter numbers, Start times for rotameters.

3. Turn the dials above and below the Rotameters (yellow columns) until the black balls are centered at the Set Points which are pointed out on each column with an arrow. These Set Points remain the same until the machine is recalibrated (every six months).

4. When the Set Points have been set, make sure the clock is showing the correct time and set to the correct quadrant.

5. Turn off the machine and record the Elapsed Time Meter Reading Start Time from the black dial.

6. Leave machine to take sample and come back to change filter within 5 days of sample date so a fresh filter is in place on every 6th day.

Cleaning the Air Sampler

About every two months, the tripod unit needs to be cleaned with a damp rag. Do not use abrasive cleaners, but only water with some mild detergent on a clean rag or paper towel. Look inside the tubes to see if there is any noticeable build-up. If so, the unit needs to be unscrewed and cleaned. Lightly lubricate the four o-rings with silicone gel before replacing them. Screw the unit back together.

Problems or Questions

Contact Tonja Opperman at Grand Canyon Prescribed Fire (638-7921) for general information and materials. Technical questions can be answered by Ralph Lucero or Bill Gantala at ADEQ (1-800-234-5677). Questions concerning laboratory work with the filters should be forwarded to Clay Juniel (1-800-234-5677) at ADEQ.

B-5

Smoke Monitoring

Background

Smoke from any type of fire in Grand Canyon National Park and the surrounding forests has a real potential to degrade visibility in the Park. Effective fire management can reduce this impact substantially, both in terms of the amount of smoke produced, and the length of time it is present.

Visibility is our ability to see through the air. Many separate factors are involved in good visibility, including the ability to see great distances, see color and texture, and to see contrast (clouds against the sky, shadows, and the like). Visibility impacts, as opposed to health and odor impacts, are the result of light interacting with the particles of smoke in the air. There are two interactions: absorption and scattering. Soot is the main culprit for absorption. Light hitting soot particles is simply absorbed. It is no longer present to carry information from a scenic vista to our eyes. Absorption darkens the scene.

Scattering is more complicated. Light travelling from a distant vista travels in a straight line to our eyes. Particles along the light path can scatter, or reflect, some of this light in a new direction. This reduces the amount of light from the vista that reaches our eyes. At the same time, particles can scatter light that is *not* from the vista toward our eyes, as if it was from the vista. Most of this light comes from the sun or sky, and looks white. Thus, we can envision particles reducing the light we want, and increasing the light we don't want. Our eyes perceive this confusion of light as haze.

Basics

So, what are we looking for in smoke monitoring? Probably one of the most important aspects is to be aware of is how the vista looks *without* smoke. Then, you can gage the impacts cause by the smoke. Remember that regional visibility at Grand Canyon varies through the year, regardless of local fire activity. Summer is the haziest, with spring following close behind. Winter is the clearest, and fall is usually good, too. Air behind cold fronts is usually cleaner, strong southerly or southwesterly winds generally bring in dirtier air. Of course, there are exceptions, so keep a critical eye on visibility.

Keeping the same observation points is critical to evaluating how the smoke impacts change. Beforehand, try to pick out vantage points on both sides of the projected plume so that you can record changes through the day (see the discussion of forward and back scattering below), and over the course of a fire. Chasing the plume around can give good information about the heaviest impacts, but the "evolution" of impacts over the life of a fire is very important.

A brief note about weather can help explain your observations, too. Strong winds and precipitation can clear out smoke quickly, helping to explain why impacts on different days or from different fires vary.

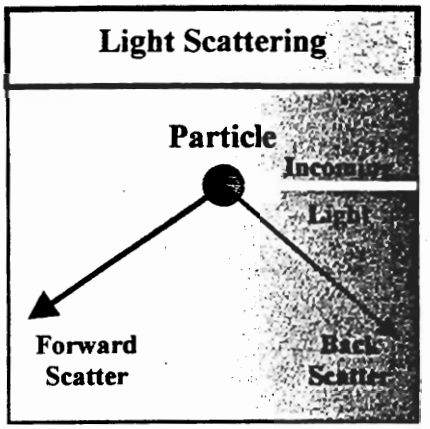
Things to observe include white haze in the Canyon. Do even nearby features dim a little? How far away can color be seen? Very distant landmarks (Mt. Trumbull, the San Francisco Peaks, and Navajo Mountain) can be a clue about how clear the air is. But beware! Such long sight paths mean you may be looking through haze that is not in the Park, but rather, a dust storm on the Painted Desert, smoke in a distant forest, or the like. So, take your long-range visibility observations with a grain of salt.

Try to include information in your summary that supports your observations. Just saying "little impact" is not as valuable as "little impact, forward scattering does not hide Coronado Butte."

Looking at visibility in a direction opposite the smoke can help define what regional conditions are (how much haze is present upwind of the fire). This can be tricky if you are observing features inside the Canyon, since nighttime smoke drainage can disperse, creating a general haze below the rim regardless of wind directions above the rim. Comparisons with other days and other fires may be valuable, especially if those comparisons are tied to an observation that others can relate to, or help you to keep track of improvement or deterioration.

Forward and Back Scattering

Early and late in the day, two special types of scattering become more and more important. Most of light that is scattered by particles in the air does not change its direction dramatically. It is very unusual for light to reverse its direction when it is scattered, more common for it to be scattered perpendicular to its original direction, and most common for it to change directions just a bit. We say that most light is scattered forward (see the following diagram).



When you look toward the sun, a white haze can appear very thick because of forward scattering. But if you turn 180 degrees and look away from the brilliant forward scattering, the same haze looks dark due to "back scattering." The higher the sun is in the sky, the less likely you are to encounter forward and back scattering (unless you're at Phantom looking at the Sun above the South Rim). When skies are overcast, the haze often appears uniform. Neither forward nor back scattering are operating since the clouds scatter the light and it is coming from all directions. Therefore, recording cloud cover is important. If the overcast is patchy, pay attention to whether or not the spot you're looking at is in sun or shade, too.

You can use forward scattering to your advantage when looking for haze structure, like inversion tops, plumes, etc. Since the haze is so bright, you may even be able to see "currents" or flow within the haze. It may also be easier to watch the top of the haze or smoke rise as ground temperature increases.

Photography

The same criteria you use to look at smoke and haze should be used in photographing it. Think of your photos as a time-lapse movie documenting smoke behavior. At the same time, they can also document the severity of impacts at sensitive receptors. Various studies have found that film does a very good job of duplicating what the human eye experiences.

Bottom Line

Visibility is the most threatened air resource in Grand Canyon National Park. If all else fails, thorough smoke monitoring can help us improve our ability to reduce smoke impacts. And when we do burn with little impact, good records document our achievement. Be objective. Various instruments around the Park are also monitoring visibility, but they are not as portable as you are. Roving eyes and objective reports can place the "$\mu g/m^3$" and the "b_{ext}" readings the instruments collect into a context that relates to the visibility resource we are here to protect.

Carl Bowman, January 2000

Appendix C. FMH-4 Monitoring Type Descriptions

C-1: PIED—South Rim Great Basin Conifer Woodland

C-4: PIPO—South Rim Ponderosa Pine

C-8: PIPN—North Rim Ponderosa Pine

C-12: PIAB—North Rim Ponderosa Pine with White Fir Encroachment

C-16: Data Analysis Checklist

FMH-4 MONITORING TYPE DESCRIPTION SHEET
Grand Canyon National Park

Monitoring Type Code: FPIED1D02

Monitoring Type Name: Great Basin Conifer Woodland

Prepared by: Duhnkrack, Schroeder, Kuenzi, Kaplan in 1991 and 1993

Updated by: Tonja Opperman and Ken Kerr

Date: December 18, 1999

PHYSICAL DESCRIPTION
Located at 6400 to 7000 feet elevation on the South Rim with 0-20% slope, all aspects. Soils are shallow and loamy with gravelly consistency derived from Kaibab limestone. Bare, rocky areas are common.

BIOLOGICAL DESCRIPTION
Ninety percent of overstory stems are pinyon pine and/or Utah juniper with ponderosa pine as an occasional overstory tree; absolute canopy cover is 20-60%. The understory is sparse with pole trees of same species as overstory except for an occasional Gambel oak. Shrubs include mormon tea, banana yucca, snakeweed, serviceberry, cliffrose, apache plume, and rabbitbrush. Herbaceous plants include bluegrass, paintbrush, blue grama, locoweed, lupine, and squirreltail. Combined cover for brush and herbs is <50%.

REJECTION CRITERIA
Large rock outcroppings or barren areas >20% of the plot; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones; areas burned within the past 10 years; areas with more than 3 overstory ponderosa pine trees or >10% ponderosa pine cover; areas with >75% cover of either pinyon pine or Utah juniper.

DESIRED FUTURE CONDITION
This monitoring type is mainly located around the South Rim Village area and is being treated to reduce hazardous fuel conditions that could present an urban interface problem. One goal for this monitoring type is to maintain the fuel load at a level that does not exceed 20 tons/acre. A second goal is to limit the overstory tree mortality to 20%, but at this time there has not been a comprehensive literature search to determine what a realistic overstory density goal should be. A study in northern Arizona suggests an average of 360 trees/ha (145 trees/acre) (Klopatek 1986) on 3 plots. This monitoring type is

not burned with a true underburn in many instances, but is instead pile burned due to concerns around developed areas.

BURN PRESCRIPTION

Units will be burned during the monsoon season or from September until May or until green-up using head, flanking, and backing fires as needed to meet burn objectives.

Fire Prescription Elements	
RH = 20-50%	Live Fuel Moisture = 60-120%
Dry Bulb = 50-90 F	Average Flame Length = 1-6 feet
Average Mid-flame Winds=0-7mph G15mph	Average Rate of Spread = 1-28 chs/hour
10-hour TLFM = 6-12%	1000-hour TLFM = 9-20%

MONITORING VARIABLES IN ORDER OF IMPORTANCE

1. Fuel Loading

PRESCRIBED FIRE PROJECT OBJECTIVES—First Entry Burn

1. Reduce total average fuel load (including all woody material, litter, and duff) so as not to exceed 20 tons/acre (49 tons/ha). *Preburn fuel loads range from 6 to 26 tons per acre (15-64 tons/ha) on 5 plots.*
2. Limit overstory mortality of all species to an average of 20% within 5 years post-burn.

FIRE MONITORING OBJECTIVES

1. Install enough plots to sample total fuel load with 80% confidence that totals are within 20% of the true population mean.
2. Install enough plots to sample overstory tree density with 80% confidence that values are within 20% of the true population mean.

DATA ANALYSIS

See FMH-4 Data Analysis Checklist

Literature Cited

Klopatek, J.M. 1986. Nutrient patterns and succession in pinyon-juniper ecosystems of northern Arizona. In: Proceedings—pinyon-juniper conference. USDA Forest Service GTR-INT-215 pp 391-396.

Plot Protocols for PIED

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width	2 x 50 meters		Stakes Installed: All		
	Number of Belts recorded	2				
	Herbaceous Data and Brush Data Collected at: Q4-Q1 and Q3-Q2					
Burn and Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt		√	Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory Note: DRC on JUOS trees with multiple stems >2/tree.	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	25 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt		√
Fuel Load	Sampling Plane Length	100 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

FMH-4 MONITORING TYPE DESCRIPTION SHEET
Grand Canyon National Park

Monitoring Type Code: FPIPO1D09

Monitoring Type Name: South Rim Ponderosa Pine

Prepared by: Tonja Opperman and Ken Kerr

Date: December 18, 1999

PHYSICAL DESCRIPTION

Located at 6000 to 7500 feet elevation on the South Rim on level to rolling terrain, including all aspects. Soils are moderately shallow with a silty loam texture. All are derived from Kaibab limestone parent material. Occasional barren rock outcrops.

BIOLOGICAL DESCRIPTION

Total overstory[1] stems are 50-100% Pinus ponderosa. Pinus edulis, Juniperus osteosperma, and Quercus gambelli may be present. Absolute canopy cover is 20-60%. The understory is a mix of the same overstory species. Common shrubs include Artemisia tridentata, Gutierrezia sarothrae, and Cowania mexicana. Common herbaceous plants include Bouteloua gracilis, Poa fendlariana, and Lupinus spp.

REJECTION CRITERIA

Large rock outcroppings or areas >20% of the plot with <10% ground cover; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas burned within past 10 years; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones. Areas with greatest amount of basal area contained in a species other than ponderosa pine.

DESIRED FUTURE CONDITION

At this time a literature search has been initiated to determine the desired future condition of ponderosa forests at Grand Canyon National Park, but it is not complete. Preliminary research suggests that there were anywhere from 19-25 overstory trees per acre (47-62 trees/ha) during pre-settlement and ponderosa pine comprised over 90% of the basal area, with the remainder occupied by pinyon, juniper, and Gambel oak (Covington 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

[1] Overstory trees are defined in the Fire Monitoring program as trees with a diameter at breast height of 15 cm (6 in) or greater. This definition does not take individual tree dominance or crown position into account.

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 to 8 tons/acre (5-20 tons/ha) with averages estimated from 0.2 to 9.3 tons/acre (0.5-23 tons/ha) (Covington 1992, Covington 1994, Harrington and Sackett 1992). A postburn increase in fuel loads is acceptable after the initial prescribed fire treatments.

BURN PRESCRIPTION
Units will be burned during the growing, transition, and dormant seasons with head, flanking, and backing fires as needed to meet burn objectives. Units may be burned at six-year intervals for up to three consecutive treatments or until a Desired Future Condition is met. Prescription element ranges and treatment objectives developed using past experience, BEHAVE program, and FOFEM program.

Fire Prescription Elements	
RH = 10-80%	Live Fuel Moisture = n/a
Dry Bulb = 40-80 F	Average Flame Length = 1-10 feet
Average Mid-flame Winds=0-15mph G30mph	Average Rate of Spread = 1-40 chs/hour
10-hour TLFM = 3-15%	1000-hour TLFM = 9-25%

MONITORING VARIABLES IN ORDER OF IMPORTANCE
1. Overstory density
2. Fuel Load
3. Pole density

PRESCRIBED FIRE PROJECT OBJECTIVES—First Entry Burn
Immediately Post-Burn:
1. Reduce total fuel load by at least 30% on average, as measured over the landscape immediately post-burn (fuel reduction efforts will continue until the Desired Future Condition of 0.2-9.3 tons/acre is achieved).
2. Limit crown scorch to 30% on *Pinus ponderosa* with dbh greater than or equal to 16" (40 cm).

Two Years Post-Burn:
1. Reduce *Pinus ponderosa* poles with dbh of 1-6 inches (2.5-15 cm) to average 0-200 trees/acre (0-494 trees/ha). *This is a conservative target and more research is needed to define a better pole density target; there are currently 0-730 poles/ac (0-1800 poles/ha) of* Pinus ponderosa *in this size class.*

Five Years Post-Burn
1. Achieve and maintain a five-year post-burn density of 19-25 trees/acre of *Pinus ponderosa* in the 16"+ size class.

PRESCRIBED FIRE PROJECT OBJECTIVES—Second Entry Burn
Objectives will be written for this section, once results from first entry burn are known.

PRESCRIBED FIRE PROJECT OBJECTIVES—Third Entry Burn
Objectives will be written for this section, once results from first and second entry burns are known.

FIRE MONITORING OBJECTIVES
1. Install enough plots to be 80% confident that overstory ponderosa pine density figures are within 20% of the true population mean.
2. Install enough plots to be 80% confident that total fuel load estimates are within 20% of the true population mean.
3. With less than 30 plots, estimate pole densities with the most confidence possible. At this time over 70 plots are needed to monitor poles due to a high variation in the preburn pole densities.

DATA ANALYSIS
See FMH-4 Data Analysis Checklist

Literature Cited

Covington, W.W. and M.M. Moore. 1992. Postsettlement changes in natural fire regimes: implications for restoration of old-growth ponderosa pine forest. *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. and M.M. Moore. 1994. Southwestern ponderosa pine forest structure. J. For. 39-47.

Covington, W.W., M.M. Moore, P.Z. Fule, H.B. Smith. 1998. Grand Canyon Forest Ecosystem Restoration Report on Pre-treatment measurements of experimental blocks. Northern Arizona University unpublished manuscript.

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. 64pp.

Plot Protocols for PIPO

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width	2 x 50 meters		Stakes Installed: All		
	Number of Belts recorded	2				
	Herbaceous Data and Brush Data Collected at: Q4-Q1 and Q3-Q2					
Burn and Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt		√	Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
Note: DRC for multiple-stemmed JUOS >2 stems/tree.	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	25 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt		√
Fuel Load	Sampling Plane Length	100 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

FMH-4 MONITORING TYPE DESCRIPTION SHEET
Grand Canyon National Park

Monitoring Type Code: FPIPN1D09

Monitoring Type Name: North Rim Ponderosa Pine

Prepared by: Tonja Opperman and Ken Kerr

Date: December 18, 1999

PHYSICAL DESCRIPTION

Located at 6,900 to 8,900 feet elevation on the North Rim with slopes from 0% to 60%, including all aspects and depending on elevation. Soils are moderately shallow on ridgetops with silty loams occurring in drainage bottoms. All soils are derived from Kaibab limestone parent material.

BIOLOGICAL DESCRIPTION

Total canopy cover is at least 25%. *Pinus ponderosa* dominates the overstory[2], comprising at least 80% of overstory species. Other possible overstory species include occasional *Abies concolor*, *Populus tremuloides*, *Pseudotsuga menziesii*, and *Picea engelmanni*. The understory is composed of mostly (75% or more) *Pinus ponderosa* poles. Common brush species are *Robinia neomexicana*, *Berberis repens, Rosa fendleri*, and *Ceanothus fendleri*. Common herbaceous plants include *Achillia lanulosa, Carex* spp., *Poa fendleriana, Sitanion hystrix,* and *Viguiera multiflora.*

REJECTION CRITERIA

Large rock outcroppings or barren areas >20% of the plot; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones; areas burned in the last 10 years; areas with >20% overstory cover of trees other than ponderosa pine; areas with pole densities including >25% species other than ponderosa pine, and areas with >50% canopy cover of Robinia neomexicana.

DESIRED FUTURE CONDITION

At this time a literature search has been initiated to determine the desired future condition of North Rim *Pinus ponderosa* at Grand Canyon National Park, but it is not complete. These forests were likely open stands with relatively few, large overstory trees, dominated by an herbaceous understory. Research suggests in one study that there were 56 *Pinus ponderosa* trees per acre (138 trees/ha) in North Rim *Pinus ponderosa* stands (Covington 1992), and in another study that

[2] Overstory trees are defined in the Fire Monitoring program as trees with a diameter at breast height of 15 cm (6 in) or greater. This definition does not take individual tree dominance or crown position into account.

there were 40-55 trees/acre (99-136 trees/ha) on the Kaibab Plateau during presettlement times. Pole-sized trees less than six inches in diameter (15 cm) were estimated to be in groups of 200-400 but no density figures are given (Rasmussen 1941). The fire frequency on the North Rim is estimated at 2 to 15 years for these elevations (Wolf and Mast 1998) but this study did not incorporate forests on the very southernmost parts of the plateaus. It is likely that the forests on the edges of the North Rim plateaus were less dense due to drier conditions and more frequent lightning-caused fires. Fuel loads ranged from 0.2 to 9.3 tons/acre (0.5-23 tons/ha) (Covington 1992). An increase in postburn fuel loads is acceptable after the initial prescribed fire treatments.

BURN PRESCRIPTION

Units will be burned during the growing, dormant, and transition seasons from summer (June) to fall (November). In drier years the time period may move into April and/or December. The following values present a range of conditions that may be used to accomplish objectives. Optimal values and relationships exist between these ranges that relate to on-the-ground fire effects achieved as well as resistance to control. Prescription element ranges and objectives were developed using past experience, BEHAVE program, and FOFEM program.

Fire Prescription Elements	
RH = 10-80%	Live Fuel Moisture = n/a
Dry Bulb = 40-80 F	Average Flame Length = 1-10 feet
Average Mid-flame Winds=0-15mph G30mph	Average Rate of Spread = 1-40 chs/hour
10-hour TLFM = 3-15%	1000-hour TLFM = 9-25%

MONITORING VARIABLES IN ORDER OF IMPORTANCE

1. Overstory density
2. Fuel Load
3. Pole density

PRESCRIBED FIRE PROJECT OBJECTIVES—First Entry Burn

Immediately Post-Burn:

1. Reduce total fuel load by at least 30% on average, as measured over the landscape immediately post-burn (fuel reduction efforts will continue until the Desired Future Condition of 0.2-9.3 tons/acre is achieved).
2. Limit crown scorch to 30% on *Pinus ponderosa* with dbh greater than or equal to 16" (40 cm).

Two Years Post-Burn:

1. Reduce Pinus ponderosa poles with dbh of 1-6 inches (2.5-15 cm) to average 0-200 trees/acre (0-494 trees/ha). *This is a conservative target and more research is needed to define a better pole density target; Preburn pole*

densities range from 0-500 Pinus ponderosa *trees/acre (1235 trees/ha) and average of 51 trees/acre (126 trees/ha) in this monitoring type on 6 plots.*

Five Years Post-Burn

1. Achieve and maintain a five-year post-burn density of 19-25 trees/acre of *Pinus ponderosa* in the 16"+ size class.

PRESCRIBED FIRE PROJECT OBJECTIVES—Second Entry Burn

Objectives will be written for this section, once results from first entry burn are known.

PRESCRIBED FIRE PROJECT OBJECTIVES—Third Entry Burn

Objectives will be written for this section, once results from first and second entry burns are known.

FIRE MONITORING OBJECTIVES

1. Install enough plots to be 80% confident that overstory ponderosa pine density figures are within 20% of the true population mean.
2. Install enough plots to be 80% confident that total fuel load estimates are within 20% of the true population mean.
3. Install enough plots to be 80% confident that pole density estimates are within 20% of the true population mean.

DATA ANALYSIS

See FMH-4 Data Analysis Checklist

Literature Cited

Covington, W.W. and M.M. Moore. 1992. Postsettlement changes in natural fire regimes: implications for restoration of old-growth ponderosa pine forest. *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.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecol. Monogr. 11:229-76.

Wolf, J. and J. Mast. 1998. Fire history of mixed-conifer forests on the North Rim, Grand Canyon National Park, Arizona. Physical Geography, 19, 1, pp. 1-14.

Plot Protocols for PIPN

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width	2 x 50 meters		Stakes Installed: All		
	Number of Belts recorded	2				
	Herbaceous Data and Brush Data Collected at: Q4-Q1 and Q3-Q2					
Burn and Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt		√	Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	25 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt		√
Fuel Load	Sampling Plane Length	50 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

Rec = Recommended Opt = Optional

FMH-4 MONITORING TYPE DESCRIPTION SHEET
Grand Canyon National Park

Monitoring Type Code: FPIAB1D09

Monitoring Type Name: Ponderosa Pine with White Fir Encroachment

Prepared by: Tonja Opperman and Ken Kerr

Date: December 18, 1999

PHYSICAL DESCRIPTION

Located at 8000 to 9000 feet elevation on the North Rim with slopes from 0% to 60%, including all aspects. Soils are moderately shallow on ridgetops with silty loams occurring in drainage bottoms. All soils are derived from Kaibab limestone parent material.

BIOLOGICAL DESCRIPTION

Total canopy cover is at least 25% but can near 100%. It is a mixed conifer forest dominated by *Pinus ponderosa, Abies concolor*, and *Populus tremuloides* with the greatest basal area in *Pinus ponderosa* even though there may be more overstory[3] *Abies concolor* stems per acre. Other possible overstory species include *Pseudotsuga menziesii, Picea pungens, Abies lasiocarpa,* and *Picea engelmanni.* The understory is composed of mostly *Abies concolor* (25 to 100%), *Pinus ponderosa, Populus tremuloides*, and *Pseudotsuga menziesii.* Common brush species are *Amelanchier utahensis, Berberis repens,* and *Robinia neomexicana.* Common herbaceous plants include *Bouteloua gracilis, Carex* spp., *Fragaria ovalis, Lotus utahensis, Pedicularis centranthera,* and *Poa fendleriana.*

REJECTION CRITERIA

Large rock outcroppings or barren areas >20% of the plot; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones; areas burned in the last 10 years; areas where majority of basal area is not in ponderosa pine; areas with pole densities that do not include white fir as a major component.

DESIRED FUTURE CONDITION

At this time a literature search has been initiated to determine the desired future condition of North Rim *Pinus ponderosa* forests at Grand Canyon National Park, but it is not complete. Forests in the PIAB monitoring type are at a slightly higher elevation and experience slightly wetter conditions and cooler

[3] Overstory trees are defined in the Fire Monitoring program as trees with a diameter at breast height of 15 cm (6 in) or greater. This definition does not take individual tree dominance or crown position into account.

temperatures than the North Rim Ponderosa Pine (PIPN) monitoring type. *Pinus ponderosa* likely dominated these stands but occasionally other mixed conifer species were present as well as pockets of *Populus tremuloides*. At the 8200' elevation on the North Rim, research suggests the stands were comprised of 51 overstory *Pinus ponderosa* per acre (126 trees/ha) with a mixture of *Abies concolor* and *Populus tremuloides* equally occupying the remaining 40 overstory trees per acre (99 trees/ha) (Covington et. al. 1998). Fire likely occurred in these stands every 4-15 years (Wolf and Mast 1998). Pre-European settlement fuel load estimates are unknown, but are likely greater than the PIPN forest type to the south. A conservative estimate for desired average fuel load is 0.2 to 20 tons/acre, but this figure should be revised as new information is available. Pole density figures for this forest type are also unknown, but again, are likely to be more dense than the drier forests to the south.

BURN PRESCRIPTION

Units will be burned during the growing and dormant seasons from summer (June) to fall (November). In drier years the time period may move into April and/or December. The following values present a range of conditions that may be used to accomplish objectives. Optimal values and relationships exist between these ranges that relate to on-the-ground fire effects achieved as well as resistance to control. Prescription element ranges and objectives were developed using past experience, BEHAVE program, and FOFEM program.

Fire Prescription Elements	
RH = 10-80%	Live Woody Fuel Moisture = 60-250%
Dry Bulb = 40-80 F	Average Flame Length = 0.5 – 30 feet
Mid-flame Winds=0-15mph G30mph	Average Rate of Spread = 1-40 chs/hour
10-hour TLFM = 3-15%	1000-hour TLFM = 9-25%

MONITORING VARIABLES IN ORDER OF IMPORTANCE

1. Overstory density
2. Fuel Load
3. Pole density

PRESCRIBED FIRE PROJECT OBJECTIVES—First Entry Burn

Immediately Post-Burn:

1. Reduce total fuel load by at least 30% on average, as measured across the landscape immediately post-burn (fuel reduction efforts will continue until the Desired Future condition of 0.2 to 20 tons/acre (average) is achieved).
2. Limit crown scorch to 30% on *Pinus ponderosa* with dbh greater than or equal to 16" (40 cm).

Two Years Post-Burn:

1. Reduce *Abies concolor* poles in 1-6" (2.5-15 cm) size class by 20-70% to average less than 100 trees/ac (247 trees/ha). *This is a conservative target until more research indicates a better target. Preburn* Abies concolor *pole densities average 237 trees/ac, and* Pinus ponderosa *poles average 31 trees/ac (77 trees/ha) in this monitoring type on 21 plots.*

Five Years Post-Burn

1. Achieve and maintain a five-year post-burn density of 19-25 trees/acre of *Pinus ponderosa* in the 16"+ size class.

PRESCRIBED FIRE PROJECT OBJECTIVES—Second Entry Burn

Objectives will be written for this section, once results from first entry burn are known.

PRESCRIBED FIRE PROJECT OBJECTIVES—Third Entry Burn

Objectives will be written for this section, once results from first and second entry burns are known.

FIRE MONITORING OBJECTIVES

1. Install enough plots to be 80% confident that overstory ponderosa pine density figures are within 20% of the true population mean.
2. Install enough plots to be 80% confident that total fuel load estimates are within 20% of the true population mean.
3. Install enough plots to be 80% confident that white fir pole density estimates are within 25% of the true population mean.

DATA ANALYSIS

See FMH-4 Data Analysis Checklist

Literature Cited

Covington, W.W., M.M. Moore, P.Z. Fule, H.B. Smith. 1998. Grand Canyon Forest Ecosystem Restoration Report on Pre-treatment measurements of experimental blocks. Northern Arizona University unpublished manuscript.

Wolf, J. and J. Mast. 1998. Fire history of mixed-conifer forests on the North Rim, Grand Canyon National Park, Arizona. Physical Geography, 19, 1, pp. 1-14.

Plot Protocols for PIAB

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width	2 x 50 meters		Stakes Installed: All		
	Number of Belts recorded	2				
	Herbaceous Data and Brush Data Collected at: Q4-Q1 and Q3-Q2					
Burn and Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt		√	Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	5 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt		√
Fuel Load	Sampling Plane Length	50 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

Rec = Recommended Opt = Optional

FMH-4 Data Analysis Checklist

The following analyses should be performed at the end of each field season for the Prescribed Fire Annual summary, or more often if necessary.

	PIED	PIPO	PIPN	PIAB	PIEN	Graphics
Overstory density PRE-YR05 all species combined	x					stacked bar by species
Overstory density for PIPO by size class (6-15.9" and 16"+) for each year (not POST).		x	x	x		stacked bar by size class
Overstory density at PRE and YR05 (minimum), all species combined	x					bar graph
Scorch percent, live PIPO overstory only, avg and range, by burn unit and monitoring type		x	x	x		bar graph(?) for avg with line for min/max?
Overstory snag density by size class (6-15.9" and 16"+) for each year.		x	x	x		stacked bar by size class
Total fuel load by year in all size classes, PRE through YR05; calculate % change for text portion	x	x	x	x		stacked bar and notations in text
Pole density, 1-6", PRE-YR02 each year.		PIPO only	PIPO only	ABCO only		bar graph
Changes in herbaceous layer species composition; show species; native v. non-native.		x	x	x		??? need to determine how to do this with FMH database
Seedling density by species		x	x	x		stacked bar

Appendix D. FMH Checklists

D-1: Things to Check in all Plot Folders

D-2: What to cover in crew training

D-3: Backing up database

D-4: Data processing

D-5: Field checklist

D-7: Locating and installing new plots

D-9: Before you leave the plot

D-10: Reading plots

D-12: Data Entry Checklist

Things to Check in All Plot Folders

Plot ID_____ Date(M/D/Y)_____ Initials:____

Tabs—are they inserted with correct labels? Field Copy, Directions, PR01, PR02, PRE, POST, YR01, YR02, YR05, Slides & Old Photos (in this order).	Yes No—find some tabs, label them, insert.
Tabs—are data sheets located BEHIND each tab?	Yes No—fix it.
Directions—Are the most current and correct FMH-5, hand drawn map, and other existing location maps behind this tab? No FMH-5s or location maps should exist under individual plot reads.	Yes No—Update and print the FMH-5, toss all old FMH-5s in the folder. Keep maps under the Directions tab. If no hand drawn map, indicate here:
Field Copy—are ALL most recent data sheets included, including all tree maps, most recent photographs, and copy of FMH-5?	Yes No—update it now.
Field Copy—are reference photos included with the field copy?	Yes No—are they in the back of the binder; print them if they're on disk; or make a note that they need to be taken during the next visit:
Data—are all forms entered in fmh.exe? Check the file/data form summary menu in fmh.exe to check that they exist in database.	Yes No—enter the form now or highlight missing form on master copy of entered forms.
Is there a copy of the FMH-6 (species code list) for all the plants in this monitoring type? It should be in the field copy section.	Yes No—photocopy it and put it in the field copy section.
Is this plot mapped on the wall map?	Yes No—map it now.
What are the PLGR-determined UTM coordinates for this plot? If they were obtained without use of PLGR, ignore.	Northing_____ Easting_____
Date of the Post read(s) Season of burn—actual or estimate?	date: season:
Is there a 1:24000 scale ArcView map?	Yes No
Is there a 1:100,000 scale ArcView map?	Yes No
Are old slides archived on CD-ROM?	Yes No

Other Problems with this Plot Folder:

T[illegible]ered in [illegible]aining:

- Overview of FMH program, nationwide and in park.
- Administrative overview: uniform policy, radio policy, vehicles, crew log, fitness, IA gear, OT sheets.
- FMH ops: The List, Monday Duties, office tour, other facilities, park tour.
- Methods--classroom: FMH-4's,field protocols, data sheets.
- Install practice plots: how to write directions, chaining and pacing, squaring a plot, filling out headers, and "what's your DBH?"
- Everyone should read plot as a group, so measurements can be compared.
- Practice data entry and introduction to FMH software.

Backing up the Database

- After every data entry session, back up the database to an external disk!
- Go to the File menu in the FMH software and click on Zip data.
- Enter the drive and name the file (max 8 letters). For example: a:grca1299 would mean it's a zipped file from December of 1999.
- Keep the disk in the a: drive and open ccmail.
- Address a new message to Opperman, Tonja. Click on the paper clip icon. Add the grca1299.zip file from the a: drive. Send mail. This will put a backup on another computer in another building.

THERE IS NO OTHER DATA BACKUP THAN THE ONE YOU PERFORM! IT IS VERY IMPORTANT THAT DATA ARE BACKED UP AFTER EVERY DATA ENTRY SESSION! IF DATA CANNOT BE RECOVERED IT WILL TAKE MONTHS OF DATA ENTRY TO RESTORE THE DATABASE!

A new backup system involving up to 15 diskettes may be started soon...

Data Processing

South Rim:

1. Make 2 copies of raw data sheets and staple them.
2. Put used film in FMH Inbox.
3. Put 1 copy in Data Backup Box in helibase.
4. Put 1 copy in temporary plot folder (use to update field copy later).
5. Put temporary plot folder in "data to be entered" rack.

North Rim:

1. Double-check the "Before you leave the plot" checklist.
2. Make 2 copies of raw data sheets and put in a holey envelope to us on South Rim.
3. Put raw data sheets and film in a holey envelope - 1 plot per envelope - and keep in a Box.
4. Bring the Box to South Rim.
5. Go to South Rim Step 2.

6. Enter data - finish entering any sheet started - NO HALF SHEETS!
7. Initial your work on the Data Entry Checklist.
8. Move file to "data to be checked" on rack when all sheets have been entered.
9. Check database against data sheets - LINE BY LINE!
10. Initial your work on the Data Entry Checklist.
11. Update Field Copy: keep most recent copies of hand-drawn map, topo map, FMH-5, FMH-6, and all data sheets. Discard old copies.
12. File new Field Copy in plot binder under field copy tab.
13. File new data sheets in plot binder under new tab.
14. Put the Data Entry Checklist in the FMH inbox.

Field Checklist...

- **Check plot folder for:**
- Photos
- field copy
- species code list
- map, and blank sheets.

- **Make rebar tags, if installing new plot.**

- Bring personal items:
- IA gear
- Tatum
- pens and pencils
- compass
- hand lens
- vest.

- **Put Plant ID Kit in truck. Should include:**
- Press
- field guides
- plastic bags

Check FMH pack for:

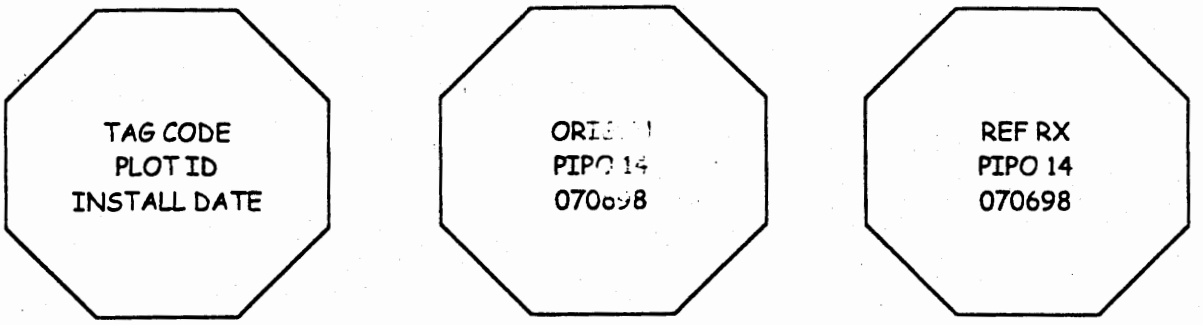
- Red, blue, and orange spray paint
- Plastic bags and trowel for plant collection
- Camera, tripod, fat range pole, and film (one roll per plot, plus 2 extra)
- Crew notebook
- Flagging
- Photo reference sheets, dry erase markers, clean rags, rubbing alcohol
- Skinny (1/4") range pole for herb transects
- Tags: pole tags, overstory tags, blank tags, stamp kit, wire, nails
- Hammers: claw and small sledge
- Tapes: 50m (3), 30m (3), 100 ft (1 or 2 for Brown's)
- DBH tapes: at least 1 large, and 1 or 2 small
- Go-no-go gauge and 12" ruler

- **Put Extra Stuff in truck. Should include:**
- Rebar (25)
- film
- tags, nails, and wire
- spray paint
- 50 m + tape
- 100 foot tape for Brown's
- flagging
- blank data sheets
- dry erase pen
- camera battery

Locating and Installing New Plots

- Random plot locations must be *accepted* or *rejected* in the order that they were plotted.
- Take notes on new plot directions and acceptability in crew notebook.
- Detailed instructions on field-locating plots are on pages 71-79 of FMH.
- At plot location point (PLP), look around a 30m radius to determine if plot matches FMH-4.
- If so, use random azimuth and distance (0-20m) to locate new plot origin point (POP).
- Re-evaluate this point against FMH-4 selection *and* rejection criteria.
- If OK, install plot origin stake.
- If NOT OK, go back to PLP, orient 180 degrees from previous azimuth and go 50m to second POP. Check criteria again.
- If OK, install plot origin stake. If NOT OK, abandon plot.
- From origin stake, measure 25m along plot orient random azimuth, and also 25m along the back azimuth.
- Pound stakes at each end of this 50m center line. Note which is OP and which is 50P.

- Place 3 20m tapes perpendicular to the center, at 0P, Origin, and 50P. Do this using 3-4-5 right triangle method.
- When these 3 tapes are SQUARE, lay 2 tapes parallel to center line at the edges of plot.
- Be sure all long tapes have zero end at 0P end of plot.
- Install A-end Brown's transect stakes - every 10m along center line.
- Install B-end Brown's transect stakes at 50 or 100 feet (see FMH-4) along random azimuths.
- Tag all 17 pieces of rebar correctly. Origin and reference tags are done as shown below—all others just with "Q1", "A1", etc.



Before you leave the plot...

- Are plot directions clear and up to standard?
- Is there a hand-drawn map from reference stake to plot center?
- Are all data sheets complete? No blanks! Record zero values or "no data"
- Are headers completely filled out? Date, plot ID, azimuths, slopes, etc.
- Are all sheets legible?
- Do all stakes have fresh paint?
- Did you collect and label unknown plant specimens?
- Did you take the plot photos?
- Did you take the reference photo?
- Did you label the film?
- Did you pick up all of the plot gear?
- Did you note any replacement or refill items in the crew notebook?

Reading Plots

- If directions are wrong, or incomplete, FIX THEM.
- If plot is not square, FIX IT.
- If any tags are wrong, FIX THEM.
- If Brown's transects are at wrong distance (check FMH-4), FIX THEM.
- Avoid trampling vegetation needlessly. Don't walk directly down transects to lay out tapes.
- Drop gear well away from plot, and outside possible Brown's transects.
- Do first things first: photos, herb transects, Brown's transects, and seedlings.
- Do second things second: overstory, poles, brush.

For immediate post reads, 2 things are different from other reads:

1. Do not use FMH-8 overstory sheet – use FMH-21 (overstory postfire assessment) instead.
2. Also do FMH-22 (burn severity).

Photo Guidelines:

- Take comparable photos by looking at previous photos—BUT—be sure the previous photos were taken correctly.
- Fill in necessary info on laminated sheets. Use legible, large, block letters.
- Start at OP. Move clockwise, as shown on FMH photo record form.
- Lean laminated photo sheet against rebar stake.
- Set tripod about 2m (3 steps) from stake, with height at about 1m (2 leg sections).
- Set range pole about 12m from foreground stake.
- Set lens to widest angle possible (28mm). Use the good camera.
- Use the "P" setting on top left dial.
- Use the "one shot" setting on top right dial.
- Make sure databack feature is turned on (a bar shows under "rec"), and that the date is in the correct format (ex: m d 'yr)
- Center field of view on transect being photographed.

- Center range pole in photo, and focus on it.
- Make sure "AEB" (bracketing) mode is on, and that bracketing is at one step. This is shown on display panel.
- Take 3 shots in a row to bracket photos automatically.
- Take all shots horizontally, never vertically.
- Be sure to fill out FMH photo record form.
- Don't forget to take reference photos with reference photo camera (Sure Shot) using 12-exposure print film.
- Use a GRCA fire monitoring photo record sheet for each reference photo roll to record plot ID, and description of where stake is in photo.
- Store used film in camera case until placing it in a Holey envelope at the office. Don't put it in the vehicle, FMH pack, or any other secret location.

Data Entry Checklist

Enter Date and Initials for Each Entry

Items	Data Gathered	Data Entry	Data Checked
Topo Map			
Hand Drawn Map			
Location FMH-5		Save as *.doc in c:\crewdocs\fmh5	
Species FMH-6			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Photos FMH-7		N/A	
PRE		N/A	
POST		N/A	
YEAR 1		N/A	
YEAR 2		N/A	
YEAR 5		N/A	
Overstory FMH-8			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Overstory FMH-9			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Pole Data FMH-11			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Pole Map FMH-12			
PRE			

Plot ID - _____

Data Entry Checklist

Enter Date and Initials for Each Entry

POST			
YEAR 1			
YEAR 2			
YEAR 5			
Seedling FMH-14			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
FMH-17 Q4-Q1			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
FMH-17 Q3-Q2			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Brush FMH-18			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Brown's FMH-20			
PRE			
POST			
YEAR 1			
YEAR 2			
YEAR 5			
Post Fire FMH-21	Post-burn Only	Post-burn Only	Post-burn Only
Severity FMH-22	Post-burn Only	Post-burn Only	Post-burn Only

Appendix E. Modified FMH Forms for Plots

E-1: FMH-5 Template, Index Plot Location Data Sheet

E-2: FMH-8 Overstory Tree Data Sheet

E-4: FMH-9 Pole Tree Data Sheet

E-6: FMH-10 Seedling Tree Data Sheet

E-7: FMH-11 Overstory Tree Map

E-8: FMH-12 Quarter 1 Pole-sized Tree Map

E-9 FMH-12a Quarter 2 Pole-sized Tree Map

E-10 FMH-15 50-Meter Transect Data Sheet

E-12 FMH-16 Belt Transect Data Sheet for Brush Density

E-14 FMH-18 Forest Index Plot Fuels Inventory Data Sheet (front for 100')

E-15 FMH-18 Forest Index Plot Fuels Inventory Data Sheet (back for 50')

E-16 FMH-19 Overstory Tree Postfire Assessment Data Sheet

E-17 FMH-20 Forest Plot Burn Severity Data Sheet

FMH-5 INDEX PLOT LOCATION DATA SHEET

Plot ID _____ Today's Date __/__/__ Installation Date ___/___/___

Burn Unit _____

Recorders _____

Topo Quad _____ Transect Azimuth (from OP->50P) _____

Declination 13.5 UTM Zone 12 UTME _____ UTMN _____

Township _____ Range _____ Section _____

Slope(%) _____ Aspect _____ Elevation _____

Date of Last Known Fire _____

Fire History of the Plot _____

_____

Deviations from protocols? If yes, describe: _____

_____

VERY SPECIFIC DIRECTIONS TO PLOT ORIGIN

- **Did you remember:**
  - ❑ Which road(s) to drive on to get to the plot?
  - ❑ Which side of the road is the reference stake on?
  - ❑ What significant feature is the reference stake near or by?
  - ❑ Did you get an accurate azimuth from the reference stake to the plot origin?
  - ❑ Did more than one person compass and chain?
  - ❑ Is the plot mapped on the appropriate topo map?
  - ❑ Are all plots for a burn unit on the same map?
  - ❑ Did you draw a hand drawn map on the back of this sheet?
  - ❑ Are the directions easy enough for a firefighter to follow and comprehend?
  - ❑ Was a picture of the reference stake taken and recorded on FMH-7?
  - ❑ Does your hand drawn map **STAND** (Scale, Title, Author, North Arrow, Date)?

FMH-8 **OVERSTORY TREE DATA SHEET** Page__ of __

Plot ID: ____________________ B / C (circle one) Date ___/___/___

Burn Unit ____________________ Recorders ____________________

Burn Status: PRE POST mo _____ yr1 yr2 yr5 yr10 yr20 (circle one)

QTR	TAG	SPP	DBH	LIVE?	CROWN	DAMAGE (codes below)	COMMENTS
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			

Crown Position Codes: (See back of FMH 9 for illustration)

1 = Dominant
2 = Codominant
3 = Intermediate
4 = Subcanopy
5 = Open Growth
6 = Recent Snag
7 = Loose Bark Snag
8 = Clean Snag
9 = Broken above DBH
10*= Broken below DBH
11*= Dead and down
12*= Cut Stump
*10-12 only used postburn

Damage Codes:

ABGR	abnormal growth pattern
BIRD	bird (woodpecker holes)
BLIG	blight
BROK	broken top
BROM	witches broom
BURL	burl
CONK	conk, large shelf fungus
CROK	crooked or twisted bole
DTOP	dead top
EPIC	sprouting from bole or limbs
EPIP	epiphytes
FIRE	fire scar or cambial damage
FORK	forked top
FRST	frost crack
GALL	galls
HOLW	goose pen
INSE	insects or their sign
LEAN	tree is leaning
LICH	Lichen
LIGT	lightning scar
MAMM	mammal-caused damage
MISL	mistletoe present
MOSS	moss
OZON	ozone
ROOT	large roots exposed
ROTT	rot, fungus other than conk
SNAG	snag
SPAR	unusually sparse foliage
SPRT	sprouting from base
TWIN	twinned tree-below DBH
UMAN	human-caused damage
WOND	wound-cracks, etc.

QTR	TAG	SPP	DBH	LI'	CROWN	DAMAGE (codes be')	COMMENTS
				Y			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			
				Y N			

- ☐ An overstory tree is >= 15.1cm.
- ☐ Measure overstory in all quarters for all monitoring types.
- ☐ For new installations, tags should be 1 - 100. Re-nail incorrect tags.
- ☐ Place nails angled down so tags hang away from tree and make sure all TAGS FACE THE ORIGIN.
- ☐ ROUND DOWN to the nearest tenth of a centimeter.
  DBH perpendicular to bole, and if on a slope, stand at the middle of the slope.
- ☐ Make sure DBH tape is level and tight. DBH is 4.5 feet along bole, not from ground level.
- ☐ If tree is forked below DBH, tag the most prominent stem. DON'T TAG BRANCHES!!
- ☐ Use special protocols for junipers.
- ☐ Write note for DBH-ing unusual trees.

FMH-9

POLE SIZED TREE DATA SHEET

Page__ of __

Plot ID: ________________ B / C (circle one) Date ___/___/___

Burn Unit ________________ Recorders ____________________________

Burn Status: PRE POST mo ____ yr1 yr2 yr5 yr10 yr20 (circle one)

Area Sampled: Q1 & Q2

QTR	SPP	TAG	DBH	LIVE	HGT	QTR	SPP	TAG	DBH	LIVE	HGT
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	

Height[1] class codes (in centimeters):

1 = 0 - 15	4 = 60.1 - 100	7 = 300.1 - 400	10 = 600.1 - 700	13 = 900.1+
2 = 15.1 - 30	5 = 100.1 - 200	8 = 400.1 - 500	11 = 700.1 - 800	
3 = 30.1 - 60	6 = 200.1 - 300	9 = 500.1 - 600	12 = 800.1 - 900	

[1]Height is measured from ground level to the highest point of growth on the tree. A bent tree can have its highest point below the growing apex.

QTR	SPP	TAG	DBH	L	HGT	QTR	SPP	T	DBH	LIVE	HGT
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	
				Y N						Y N	

- ☐ A pole is ∆ 2.5 cm and Ω 15.0 cm.
- ☐ Measure poles in Quarters 1 & 2 for all monitoring types.
- ☐ For new installations tags should be numbered P101 - P200. Re-nail incorrect tags.
- ☐ Place nails angled down so tags hang away from tree and make sure all TAGS FACE THE ORIGIN.
- ☐ ROUND DOWN to the nearest tenth of a centimeter for DBH.
- ☐ DBH perpendicular to bole, and if on a slope stand at the middle of the slope.
- ☐ Make sure DBH tape is level and tight. DBH is 4.5 feet along bole, not from ground level.
- ☐ If tree is forked below DBH tag the most prominent stem. DON'T TAG BRANCHES!!
- ☐ Use special protocols for junipers.
- ☐ Sprouters (QUGA) get multiple tags.
- ☐ If tree is too small to tag at DBH, tag at base and make note.
- ☐ Write note for DBHing unusual trees.

Height[1] class codes (in centimeters):

0 - 15	**4** = 60.1 - 100	**7** = 300.1 - 400	**10** = 600.1 - 700	**13** = 900.1+
15.1 - 30	**5** = 100.1 - 200	**8** = 400.1 - 500	**11** = 700.1 - 800	
3 = 30.1 - 60	**6** = 200.1 - 300	**9** = 500.1 - 600	**12** = 800.1 - 900	

[1]Height is measured from ground level to the highest point of growth on the tree. A bent tree can have its highest point below the growing apex.

FMH-10

SEEDLING TREE DATA SHEET

Page___of___

Plot ID____________________ B / C (circle one) Date ___/___/___

Burn Unit ____________________ Recorders ______________________________

Burn Status: PRE POST mo ___ yr1 yr2 yr5 yr10 yr20 (circle one)

Record: species by code (SPP), # of species by height (TALLY), alive (LIVE), and height by code (HGT).

Seedlings are less than 2.5 cm in diameter.

Area Sampled: 10X25 in Quarter 1 for PIED, PIPO, PIPN.

Area Sampled: 5X10 in Quarter 1 from P1-OR line for PIAB.

SPP	TALLY	TOTAL	LIVE	RSPRT	HGT	SPP	TALLY	TOTAL	LIVE	RSPRT	HGT
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	
			Y N	YN					Y N	YN	

Height[1] class codes (in centimeters):

1 = 0 - 15
2 = 15.1 - 30
3 = 30.1 - 60
4 = 60.1 - 100
5 = 100.1 - 200
6 = 200.1 - 300
7 = 300.1 - 400
8 = 400.1 - 500
9 = 500.1 - 600
10 = 600.1 - 700
11 = 700.1 - 800
12 = 800.1 - 900
13 = 900.1+

[1] Height is measured from ground level to the highest point of growth on the tree. A bent tree can have its highest point below the growing apex.

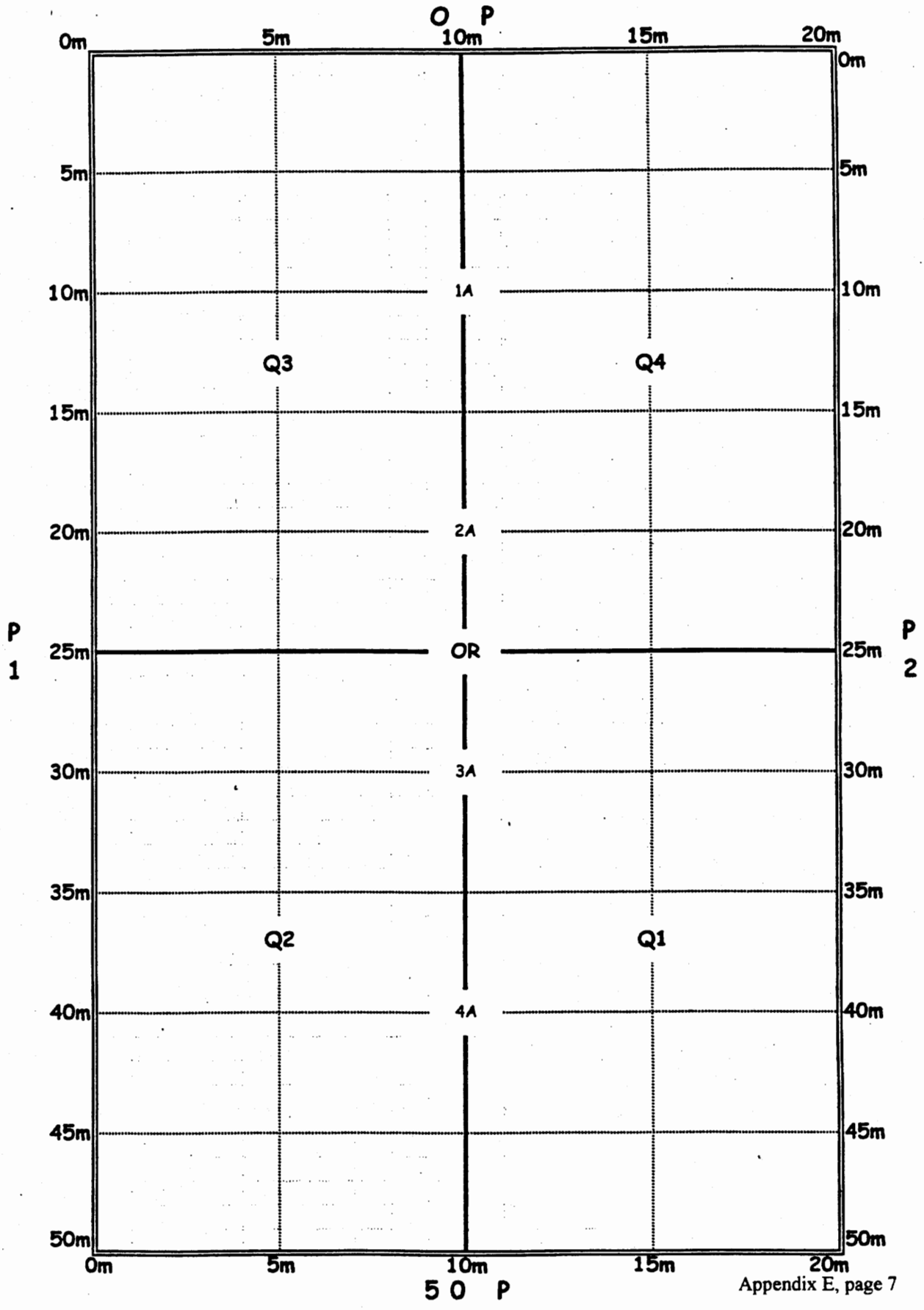
FMH-11

VERSTORY TREE M.

Plot ID _____ B / C (circle one) Date ___/___/___

Burn Unit _____ Recorders _____

Burn Status: PRE POST mo___ yr1 yr2 yr5 yr10 yr20 (circle one)

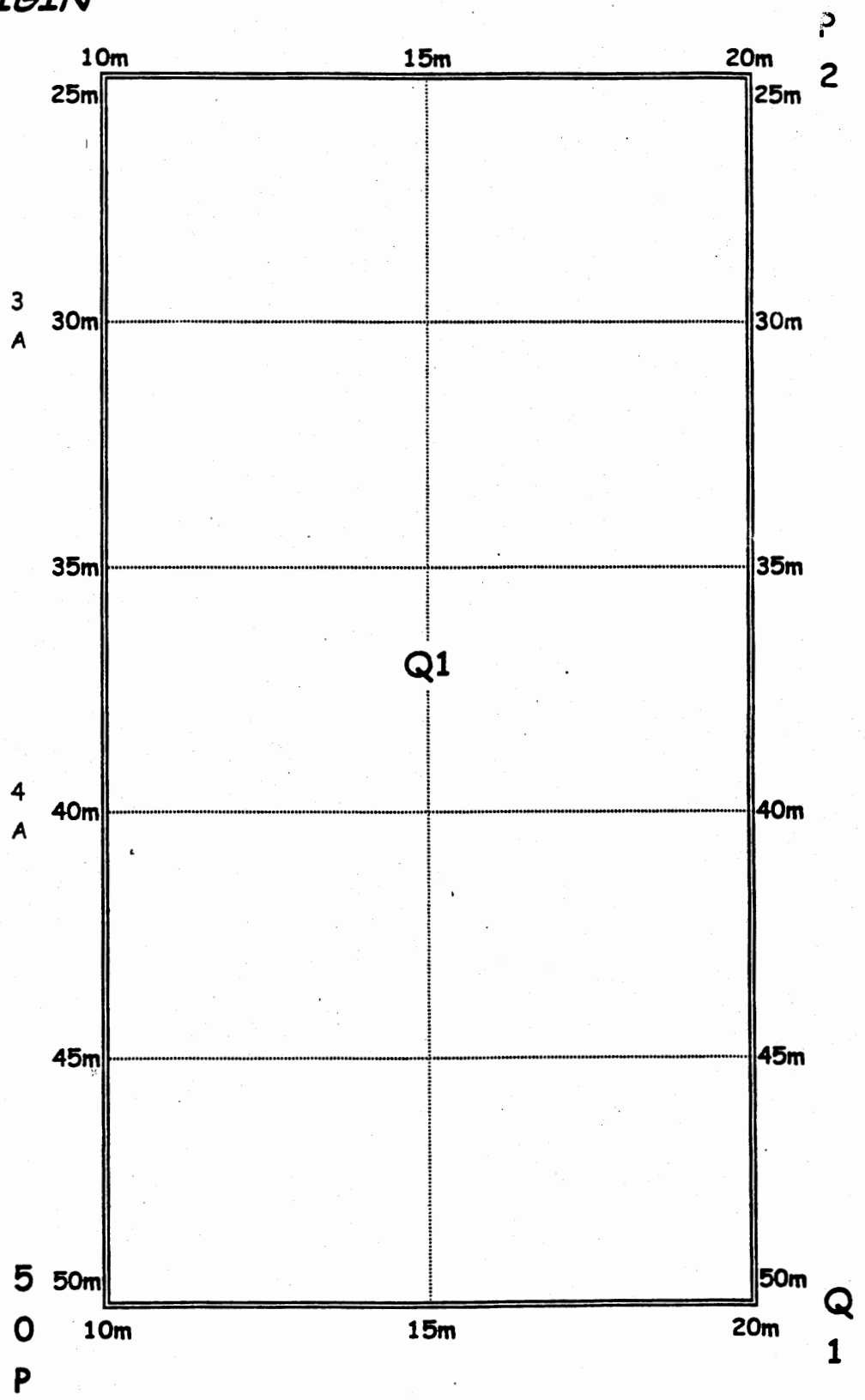


FMH-12 **QUA ʼER 1 POLE-SIZED ʻREE MAP**

Plot ID _____ B / C (circle one) Date ___/___/___

Burn Unit _____ Recorders _____

Burn Status: PRE POST mo___ yr1 yr2 yr5 yr10 yr20 (circle one)



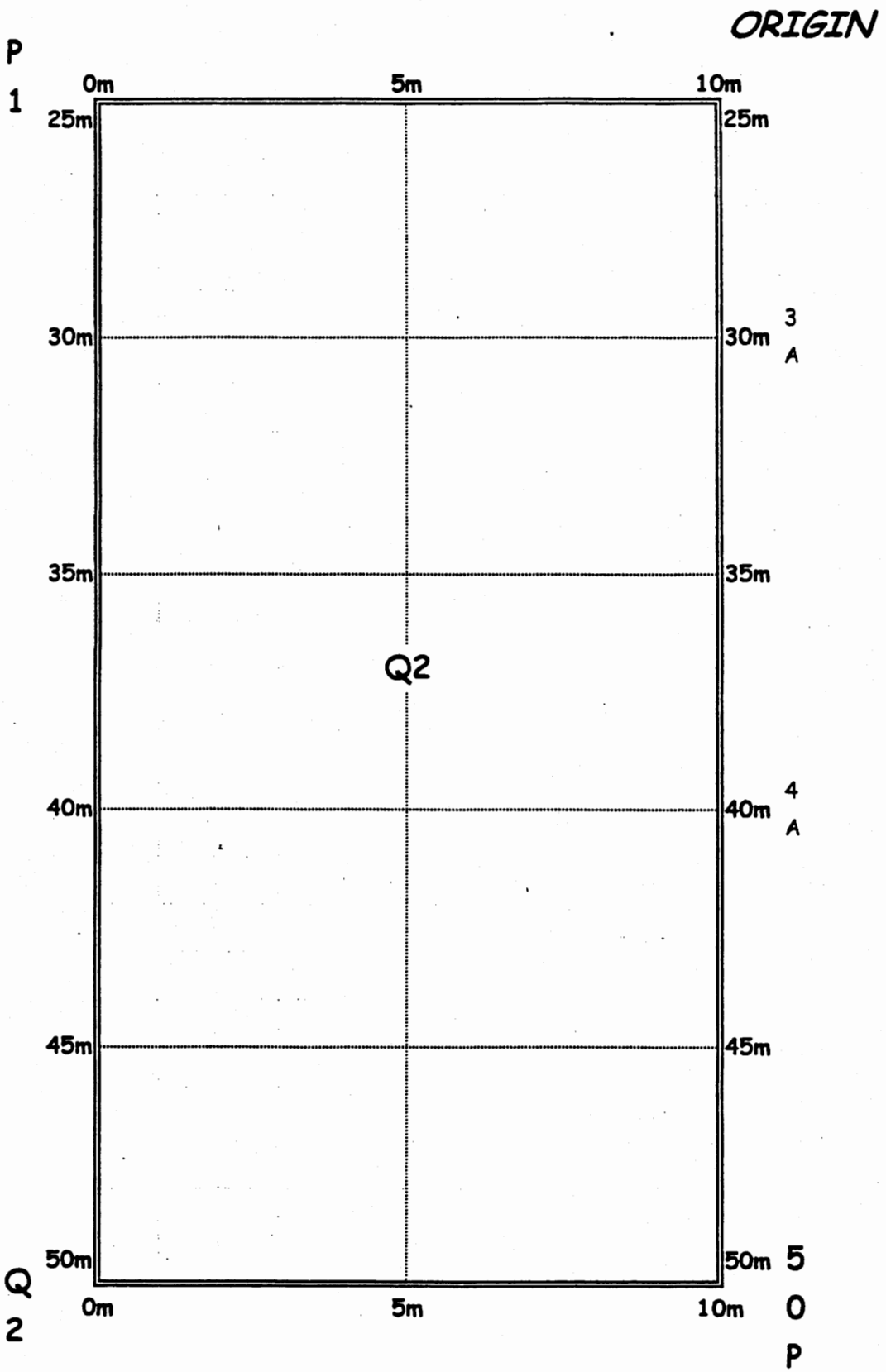
FMH-12a

QUARTER 2 POLE-SIZED TREE MAP

Plot ID _____ B / C (circle one) Date ___/___/___

Burn Unit _____ Recorders _____

Burn Status: PRE POST mo___ yr1 yr2 yr5 yr10 yr20 (circle one)



FMH-15 50 METER HERB TRANSECT DATA SHEET

Plot ID _____ B / C (circle one) Date ___/___/___

Burn unit _____ Recorders _____

Burn Status: PRE POST mo ___ yr1 yr2 yr5 yr10 yr20 (circle one)

Transect Azimuth: _____ Transect: Q4-Q1 Q3-Q2 (circle one)

Record: height to nearest 0.01 m (HGT)
species or substrate by 4-letter code (SPP)

PNT	m	HGT,m	SPP (tallest to lowest)			
1	0.3					
2	0.6					
3	0.9					
4	1.2					
5	1.5					
6	1.8					
7	2.1					
8	2.4					
9	2.7					
10	3.0					
11	3.3					
12	3.6					
13	3.9					
14	4.2					
15	4.5					
16	4.8					
17	5.1					
18	5.4					
19	5.7					
20	6.0					
21	6.3					
22	6.6					
23	6.9					
24	7.2					
25	7.5					
26	7.8					
27	8.1					
28	8.4					
29	8.7					
30	9.0					
31	9.3					
32	9.6					
33	9.9					
34	10.2					
35	10.5					
36	10.8					
37	11.1					
38	11.4					
39	11.7					
40	12.0					
41	12.3					
42	12.6					
43	12.9					
44	13.2					
45	13.5					
46	13.8					
47	14.1					
48	14.4					
49	14.7					
50	15.0					
51	15.3					
52	15.6					
53	15.9					
54	16.2					
55	16.5					
56	16.8					
57	17.1					
58	17.4					
59	17.7					
60	18.0					
61	18.3					
62	18.6					
63	18.9					
64	19.2					
65	19.5					
66	19.8					
67	20.1					
68	20.4					
69	20.7					
70	21.0					
71	21.3					
72	21.6					
73	21.9					
74	22.2					
75	22.5					
76	22.8					
77	23.1					
78	23.4					
79	23.7					
80	24.0					
81	24.3					
82	24.6					
83	24.9					
84	25.2					
85	25.5					
86	25.8					

PNT	m	HGT,m	SPP (tallest		lowest)
87	26.1				
88	26.4				
89	26.7				
90	27.0				
1	27.3				
92	27.6				
93	27.9				
94	28.2				
95	28.5				
96	28.8				
97	29.1				
98	29.4				
99	29.7				
100	30.0				
101	30.3				
102	30.6				
103	30.9				
104	31.2				
105	31.5				
106	31.8				
107	32.1				
108	32.4				
109	32.7				
110	33.0				
111	33.3				
12	33.6				
13	33.9				
114	34.2				
115	34.5				
116	34.8				
117	35.1				
118	35.4				
119	35.7				
120	36.0				
121	36.3				
122	36.6				
123	36.9				
124	37.2				
125	37.5				
126	37.8				

PNT	m	HE	SPP (tallest to lowest)		
127	38.1				
128	38.4				
129	38.7				
130	39.0				
131	39.3				
132	39.6				
133	39.9				
134	40.2				
135	40.5				
136	40.8				
137	41.1				
138	41.4				
139	41.7				
140	42.0				
141	42.3				
142	42.6				
143	42.9				
144	43.2				
145	43.5				
146	43.8				
147	44.1				
148	44.4				
149	44.7				
150	45.0				
151	45.3				
152	45.6				
153	45.9				
154	46.2				
155	46.5				
156	46.8				
157	47.1				
158	47.4				
159	47.7				
160	48.0				
161	48.3				
162	48.6				
163	48.9				
164	49.2				
165	49.5				
166	49.8				

Species observed within 5 m of either side of the transect but not intercepted (write out full name):

_____

_____

_____

- Drop range pole plumb every 30 cm's. Record each species just once.
  Record only vegetation under 2 meters in height. Record height to nearest cm.
- Record height for tallest veg. spp touching. Record species for all hits **regardless of where veg. is rooted.**
- "D" after code for all dead perennial veg.--**ignore dead annual veg.**
- If pole does not intercept veg. record substrate.
- Substrates: BARE, BOLE, DUFF, LITT, ROCK, ROOT, SCAT, WOOD (only wood on ground—not elevated).

FMH-16

BRUSH DENSITY DATA SHEET

Plot ID ______________________ B / C (circle one) Date ___/___/___

Burn Unit ______________________ Recorders ______________________________________

Burn Status: PRE POST mo ____ yr1 yr2 yr5 yr10 yr20 Transect Azimuth:______

Belt sampling width 2 m on "inside" edge of transect (side toward origin)

Count all living and dead brush or cactus having 50% of base rooted in the belt

Record AGE code: S = Seedling/immature R = Resprout M = Mature/adult

Record INT code: 1: 0-5 3: 10.1-15 5: 20.1-25 7: 30.1-35 9: 40.1-45

2: 5.1-10 4: 15.1-20 6: 25.1-30 8: 35.1-40 10: 45.1-50

Transect Q4-Q1

INT	SPP	AGE	TALLY	TOTAL	LIVE
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N

Transect Q3-Q2

INT	SPP	AGE	TALLY	TOTAL	LIVE
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N

Record INT code: 1: 0-5 3: 10.1-15 5: 20.1-25 7: 30.1-35 9: 40.1-45
2: 5.1-10 4: 15.1-20 6: 25.1-30 8: 35.1-40 10: 45.1-50

Transect Q4-Q1 cont.

INT	SPP	AGE	TALLY	TOTAL	LIVE
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N

Transect Q3-Q2 cont.

INT	SPP	AGE	TALLY	TOTAL	LIVE
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N
					Y N

Common Brush Species

Amelanchier utahensis	Utah Serviceberry
Arctostaphylus pungens	Pointleaf Manizanita
Artemisia nova	Black Sage
Artemisia tridentata	Big Sage
Berberis fremontii	Fremont Barberry
Berberis repens	Oregon Grape
Ceanothus fendleri	Buckbrush
Ceanothus integerrimus	Deerbrush
Cercocarpus ledifolius	Curlyleaf Mt-Mahogany
Chamaebatiaria millefolium	Fernbush
Chrysothamnus nauseosus	Rabbitbrush
Chrysothamnus spp.	Rabbitbrush
[illegible]ryphantha vivapara	Barrel Cactus
[illegible]wania mexicana	Cliffrose
Fallugia paradoxa	Apahce Plume
Fendlera repicole	False mockorange
Gutierrezia sarothrae	Snakeweed
Juniperus communis	Common Juniper
Opuntia sp	Prickly Pear
Pachystima myrsinites	Mountain lover
Purshia tridentata	Antelope Brush
Rhus trilobata	Squawbrush
Ribes cereum	Wax currant
Ribes inebrians	Wax currant
Robinia neomexicana	New Mexican Locust
Rosa arizonica	Arizona Rose
Rosa fendleri	Rose
Rubus strigosus	American Red Raspberry
Sorbus dumosa	Arizona Mountain-ash
Symphoricarpos oreophilus	Snowberry
Symphoricarpos longiflora	Snowberry
Tetradymis canescens	Horsebrush
Yucca angustissima	Yucca
Yucca baccata	Yucca

FMH-18 **FU_S INVENTORY DAT . SHEET**

Plot ID _____ B / C (circle one) Date ___/___/___

Burn Unit _____ Recorders _____

Burn Status: PRE POST mo ___ yrl yr2 yr5 yr10 yr20 Transect Azimuth:_____

THIS SIDE FOR PIED, PIPO only! 100 foot transects.

Transect lengths, in feet: 1 hr-6' 10 hr-6' 100 hr-12' 1000 hr S-100' 1000 hr R-100'

	1hr hits 0 - ¼"	10hr hits ¼" - 1"	100hr hits 1" - 3"	1000hr hits S 3"+ nearest 0.5"	1000hr hits R 3"+ nearest 0.5"	Litter and Duff Depths, nearest 0.1"					
							L	D		L	D
Transect 1 Azimuth ____ Slope ____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		
Transect 2 Azimuth ____ Slope ____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		
Transect 3 Azimuth ____ Slope ____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		
Transect 4 Azimuth ____ Slope ____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		

- ☐ Measure all dead and down wood along vertical 6 foot plane over the transect.
- ☐ Litter is considered the top, unconsolidated layer.
- ☐ Duff is the fibrous, consolidated, decomposed layer above mineral soil.
- ☐ Take 1000 hr measurements perpendicular to long length.
- ☐ If a rock is encountered enter 0 litt, 0 duff.
- ☐ If a log is encountered offset, looking from A to B, 1' right, 2' R, 3' R. If still unreadable then 1' left, 2' L etc...
- ☐ Record slopes in % (45 degrees = 100%). Average litt/duff over a 20 X 20 cm area.

FMH-18

FUEL INVENTORY DATA SHEET

Plot ID _____ B / C (circle one) Date ___/___/___

Burn Unit _____ Recorders _____

Burn Status: PRE POST mo ___ yr1 yr2 yr5 yr10 yr20 Transect Azimuth:_____

THIS SIDE FOR PIAB, PIPN, PIEN only! 50 foot transects.

Transect lengths, in feet: 1 hr-6' 10 hr-6' 100 hr-12' 1000 hr S-50' 1000 hr R-50'

	1hr hits 0 - ¼"	10hr hits ¼" - 1"	100hr hits 1" - 3"	1000hr hits S 3"+ nearest 0.5"		1000hr hits R 3"+ nearest 0.5"		Litter and Duff Depths, nearest 0.1"					
									L	D		L	D
Transect 1 Azimuth ____ Slope ____%								1			25		
								5			30		
								10			35		
								15			40		
								20			45		
Transect 2 Azimuth ____ Slope ____%								1			25		
								5			30		
								10			35		
								15			40		
								20			45		
Transect 3 Azimuth ____ Slope ____%								1			25		
								5			30		
								10			35		
								15			40		
								20			45		
Transect 4 Azimuth ____ Slope ____%								1			25		
								5			30		
								10			35		
								15			40		
								20			45		

- ☐ Measure all dead and down wood along vertical 6 foot plane over the transect.
- ☐ Litter is considered the top, unconsolidated layer.
  Duff is the fibrous, consolidated, decomposed layer above mineral soil.
  Take 1000 hr measurements perpendicular to long length.
- ☐ If a rock is encountered enter 0 litt, 0 duff.
- ☐ If a log is encountered offset, looking from A to B, 1' right, 2' R, 3' R. If still unreadable then 1' left, 2' L etc..
- ☐ Record slopes in % (45 degrees = 100%). Average litt/duff over a 20 X 20 cm area.

FMH-19 OVERSTORY TREE POSTFIRE DATA SHEET

Plot ID ____________________ Date ___/___/___ Page____ of ____

Burn Unit____________________ Recorders ______________________________

Burn Status: PRE POST mo ____ yr1 yr2 yr5 yr10 yr20 (circle one)

For each tagged overstory tree record: TAG #; tree status (LIVE- alive (L), dead(D) if dead tree remains, resprouting (R) or completely consumed (C) if nothing is left); maximum scorch height in meters (SCHGT); % crown scorched (SCPER); and char height in meters (CHAR).

USE ONLY FOR IMMEDIATE POST READ. DON'T USE FMH 8 FOR IMMEDIATE POST!!

QTR	TAG	LIVE	SCHGT (m)	SCPER	CHAR (m)	QTR	TAG	LIVE	SCHGT (m)	SCPER	CHAR (m)

FMH-20

BURN SEVERITY DATA SHEET

Plot ID _____ Date ___/___/___

Burn Unit _____ Recorders _____

Burn Status: PRE POST mo ___ yr1 yr2 yr5 yr10 yr20 (circle one)

Postfire burn severity ratings are made at the Brown's transects duff measurement points using the Coding Matrix at the bottom of this form.

Each observation is from a 20 cm x 20 cm area.

ORGANIC SUBSTRATE

Transect	Sample Point 1'	5'	10'	15'	20'	25'	30'	35'	40'	45'
1	S	S	S	S	S	S	S	S	S	S
2	S	S	S	S	S	S	S	S	S	S
3	S	S	S	S	S	S	S	S	S	S
4	S	S	S	S	S	S	S	S	S	S

VEGETATION

Transect	Sample Point 1'	5'	10'	15'	20'	25'	30'	35'	40'	45'
1	V	V	V	V	V	V	V	V	V	V
2	V	V	V	V	V	V	V	V	V	V
3	V	V	V	V	V	V	V	V	V	V
4	V	V	V	V	V	V	V	V	V	V

Burn Severity Coding Matrix

	Unburned (5)	Scorched (4)	Lightly Burned (3)	Moderately Burned (2)	Heavily Burned (1)	(0)
Substrate (litt/duff) (S)	Not burned	Litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged	Litter charred to partially consumed; upper duff layer may be charred but the duff later is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned	Litter mostly to entirely consumed, leaving coarse light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred; burned-out stump holes are common	Litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas	INORGANIC PREBURN
Vegetation (understory/ brush/herbs) (V)	Not burned	Foliage scorched and attached to supporting twigs	Foliage & smaller twigs partially to completely consumed; branches mostly intact	Foliage, twigs and small stems consumed; some branches still present	All plant parts consumed leaving some or no major stems/trunks; any left are deeply charred	NONE PRESENT PREBURN