National Park Service

Wind Cave National Park, South Dakota

Fire Effects Monitoring Plan

INTRODUCTION

Prescribed fire will be used to maintain and restore the fire adapted ecosystems at Wind Cave. National Park Service (NPS) Reference Manual 18 states, "Monitoring is a critical component of fire management and the Fire Monitoring Plan is important to identify why monitoring will be done, what will be monitored, how it will be monitored, where it will be done, and how often it will be completed." Monitoring of these fires is mandated in Director's Order #18: Wildland Fire Management issued in 1998. Section 5.2, *Fire Management Plans* (no. 10) states, "Include procedure for short and long term monitoring to document that overall program objectives are being met and undesired effects are not occurring". Section 5.8 directly addresses *Prescribed Fire Monitoring*:

a) Fire effects monitoring must be done to evaluate the degree to which objectives are accomplished.
b) Long-term monitoring is required to document that overall programmatic objectives are being met and undesired effects are not occurring.
c) Evaluation of fire effects data is the joint responsibility of fire management and natural resource management personnel.

MONITORING DESIGN

SAMPLING DESIGN

Most plots established at Wind Cave follow standard Fire Monitoring Handbook (FMH) (2003) protocols. The sampling design for the FMH plots are contained in the individual monitoring unit description sheets found in Appendix 1. Long-term photo monitoring points have also been established (see Appendix 2). Protocols have been established for collecting short-term tree data. Descriptions and sample data sheets can be found in Appendix 3.

FIELD MEASUREMENT

The individual variables to be measured are defined in the monitoring unit descriptions found in Appendix 1. All plots are marked with steel rebar approximately half a meter in height. Each piece of rebar has a brass tag indicating its location within the plot. The rebar at the zero end of each plot has a tag with complete plot data as specified by the handbook. All locations have been georeferenced with a GPS unit. A hard copy of each plot location is retained in the Northern Great Plains Fire Management Office (NGP) at Wind Cave National Park. A digital text file with UTM coordinates and ArcView 'shape' file are also on file at the NGP. The Northern Great Plains Fire Monitoring Crew will retain copies and backups and will be responsible for providing updated versions to Wind Cave as needed.

MONITORING LOCATION

Currently there are thirty-one monitoring plots and four photo points at Wind Cave (Fig. 1).

PRESCRIBED FIRE MONITORING PARAMETERS

Wind Cave has adopted the NPS FMH (2003) as a guide for fire effects monitoring. The handbook identifies four monitoring levels:

Level 1 – Reconnaissance	Fire Cause, location, size, fuel and vegetation types, relative fire activity, potential for spread, current and forecasted weather, resource or safety threats and constraints, and smoke volume and movement
Level 2 – Fire Conditions	Fire monitoring period, ambient conditions – topographic and fire weather, fuel model, fire characteristic, and smoke characteristic
Level 3 – Immediate Post fire Effects	Fuel reduction, vegetative change or other objective dependent variables with in 1 to 5 years after a prescribed fire
Level 4 – Long-term Change	Continued monitoring of Level 3 variables to measure trends and change over time

The FMH plots that have been described in this document thus far are being used to examine levels 3 and 4.

Wildland fires that are suppressed will be monitored at levels 1 and 2 with observations entered into the park's monitoring database. In the event that long-term fire effects plots are burned in a wildland fire, they will be read by the NGP Fire Monitoring Crew, according to the schedule of plot rereads following a prescribed fire treatment. Level 1 and 2 monitoring observations will be filed with the final fire package and a copy placed with the records for the Fire Management Unit that was burned.

Prescribed fires will meet at least the Level 1 and 2 recommended standards. If there are FMH plots in a unit, information on Level 3 and 4 Variables will be collected.

Level 1 variables

Reconnaissance monitoring provides a basic overview of the fire event. The following variables will be collected on all fires.

- Fire cause (origin), location and size
- Fuels and vegetation type
- Relative fire activity
- Potential for further spread
- Current and forecasted weather
- Resource or safety threats and constraints
- Smoke volume and movement

Specific information on the collection of these variables can be found in the NPS Fire Monitoring Handbook (2003) or the RX-91 – 'Monitoring Prescribed and Wildland Fire' text.

Level 2 variables

Fire conditions monitoring provides information on fire weather, fire behavior and resource values at risk. The following variables will be collected and summarized in a monitoring report on all prescribed fires.

- Fire monitoring period
  - fire number and name
  - observations data and time
  - monitor's name
- Ambient conditions
  - topographic variables
  - slope (%)
  - aspect
- Fire weather variables
  - dry bulb temperature
  - relative humidity
  - wind speed
  - wind direction
  - fuel shading and/or cloud cover
  - time-lag fuel moisture
  - live fuel moisture
- Soil moisture
- Fuel model
- Fire characteristics
  - linear rate of spread
  - perimeter or area growth
  - flame length
  - fire spread directions
- Smoke characteristics (based on state and local requirements)

INTENDED DATA ANALYSIS

Plot installations will be based on prescribed fire priorities and with the intention of achieving a statistically valid sample size within five years for the priority monitoring units. The Northern Great Plains Fire Ecologist will be responsible for checking the minimum plot numbers in all units that have more than five plots installed. Each monitoring unit description delineates the variables that will be analyzed. When minimum plot numbers have been reached, objectives will be evaluated after the data have been checked to meet the assumptions of the statistical test. If the data meet the assumptions, including normality, then confidence intervals will be used for change over time comparisons. If data do not meet the assumptions, a statistician will be consulted. Correlation of Level 2 data with vegetation data can be done with either regression or multivariate analysis.

The Northern Great Plains Fire Ecologist will compare data with fire effects research that has been completed in the park and area. Inconsistencies should lead the ecologist to examine different methodologies, data interpretation, and potential research questions.

MONITORING IMPLEMENTATION SCHEDULE

Timing of monitoring

All plots are currently monitored at peak diversity for the native vegetation approximately halfway between the peak in cool and warm season grasses. This will need to be examined after pilot sampling. All plots are currently being read pre-burn, immediately post-burn, and 1, 2, 5, 10, and 20 years post-burn.

Pre-burn Sampling

Pre-burn sampling will be done during peak phenology. Plots should be installed the growing season before prescribed fires. All plots that have not burned within 2 years of installation will not be reread until that unit is again scheduled to burn. These plots can also be considered for control plots depending on long-term prescribed fire planning.

Post-burn sampling

Post-burn sampling will be done immediately post-burn and 1, 2, 5, 10, and 20 years after the prescribed fire. Plots that burn in the spring will be read at peak phenology that summer, and then at the regular schedule (1, 2, 5, 10, and 20 year). The 1-Year reads for grassland plots burned in the spring are during the growing season the same year as the prescribed fire, and the 2-year read occurs in the following year. The 1-year reads for forest plots burned in the spring are during the growing season one year after the prescribed fire. Fall prescribed fires will be read the following summer as 1 year post-burn reads. If a unit is scheduled to be burned for a second or third time between reads, an additional pre-burn read will be added. For example, a unit burned in the spring of 2000 would be sampled within a week following the fire, 1 year read summer 2000, 2 year read summer 2001, and 5 year read summer 2004. The unit is then scheduled to burn again in 2008. A second pre-burn read should be added summer 2007.

DATA MANAGEMENT

Other monitoring programs have shown that between 25-40% of the time associated with monitoring should be on data management. The data for Wind Cave is collected and managed by the Northern Great Plains Fire Monitoring Crew located at Wind Cave National Park, Hot Springs, South Dakota. All data collected at Wind Cave will be entered and checked by this crew at their office. Generally the seasonal field staff enters and checks data. This process is supervised the NGP Lead Monitor and Fire Ecologist. Original copies of all data will be kept at the crew's office. Hard copies of the Plot Location Data Sheets will be archived at Wind Cave in the Resource Management files. The Lead Monitor will provide monitoring data to the Wind Cave Resource Management staff annually on CD for archiving. Data are currently entered and analyzed in the FMH software. It is backed up to the server at Wind Cave. It will be sent annually to Wind Cave and the Midwest Regional Ecologist in conjunction with the annual report. Global positioning data of plot locations are stored on CD at the Fire Monitoring Office at Wind Cave.

QUALITY CONTROL

Data quality will be ensured through proper training of the crew in data collection and a system of checks in the data entry process. All data sheets will be checked by the lead crewmember

before leaving a plot for data accuracy and completeness. Data will be summarized annually and results reported to the park and regional fire ecologist. A program review should happen every 3-5 years to maintain consistency of data collection and analysis and re-assessment of program requirements. More frequent review may be necessary if there are significant staffing changes, additional ecological concerns, or by request of the park or monitoring crew.

SOURCES OF DATA ERRORS

Errors in recording can be reduced by checking all data sheets for completeness and accuracy before leaving the plot. Standardized crew training at the beginning of the season will insure all data are being collected in the same manner by all crewmembers. Transcription errors will be corrected by checking all data once entered in the computer. Collecting voucher specimens and using the study collection to verify plant identifications can minimize incorrect identification of plant species. All unknown plant species will be photographed and added to the unknown plant database. These photos can be used as a field reference to insure that all unknowns are consistently observed. Wind Cave Resource Management personnel will be notified of unknowns of particular concern so special attention can be given to identify it. Undersampling of less-frequently occurring species is a large problem in the grass types. An additional sampling technique, nested frequency, will be added after consulting with the regional fire ecologist to better sample the species richness found in these types.

The impacts of monitoring include compacting of fuels and vegetation and the collection of voucher plant specimens. Compaction can be minimized by crew awareness as to where data are collected. Voucher specimens are not collected in the plot – if no other specimen is found, the unknown plant will be photographed and added to the unknown plant photo database. Accurate plot locations including GPS data will aid in plot location and minimize vegetative compaction. Test all directions by having new crewmembers use previously written directions to ensure accuracy. Incomplete or missing data will be corrected as soon as possible. Plot protocols need to be reviewed annually with the seasonal crew prior to beginning work to insure that data are accurately collected. Problems encountered by the field crew must be brought to the attention of the lead monitor and fire ecologist.

RESPONSIBLE PARTIES

Administrative duties will be assigned as follows:

- *Northern Great Plains Fire Ecologist*: Plan revision, crew supervision, data management and data analysis
- *Superintendent, Wind Cave National Park*: Park liaison
- *Northern Great Plains Lead Monitor*: Data collection, data entry, data management and field crew supervision
- *Midwest Regional Fire Ecologist*: Coordinate program reviews

MANAGEMENT IMPLICATIONS OF MONITORING RESULTS

Monitoring results will be summarized and presented to the park in the fall meeting of the Fire Committee with the NGP Fire management Officer, Prescribed Fire Specialist and Fire

Ecologist. This meeting helps coordinate fire activities including prescribed fire for the park in the coming year. The annual report information can be conveyed to Wind Cave Resource Management in an additional meeting as requested.

Review of the data summary and analysis by the NGP Fire Ecologist, Prescribed Fire Specialist, and Wind Cave Resource Management staff should determine if the current program is moving the vegetation towards the desired conditions and/or having unwanted results. Targets should be reviewed and refined, and prescribed fire prescriptions and other vegetation management techniques could be adjusted to compensate. This review could also generate questions that may lead to fire effects research being conducted in the park. Information from the Wind Cave program could be analyzed with other parks from the NGP group as appropriate and should be presented to other parks and at scientific meetings and publications.

CONSULTATION AND COORDINATION

The Northern Great Plains Fire Monitoring Crew is responsible for coordination and consultation with other parks in the group, fire management personnel, and the Midwest Regional Fire Ecologist. Wind Cave Resource Management staff will be responsible for coordination and consultation with the park and all other cooperators.

LITERATURE CITED

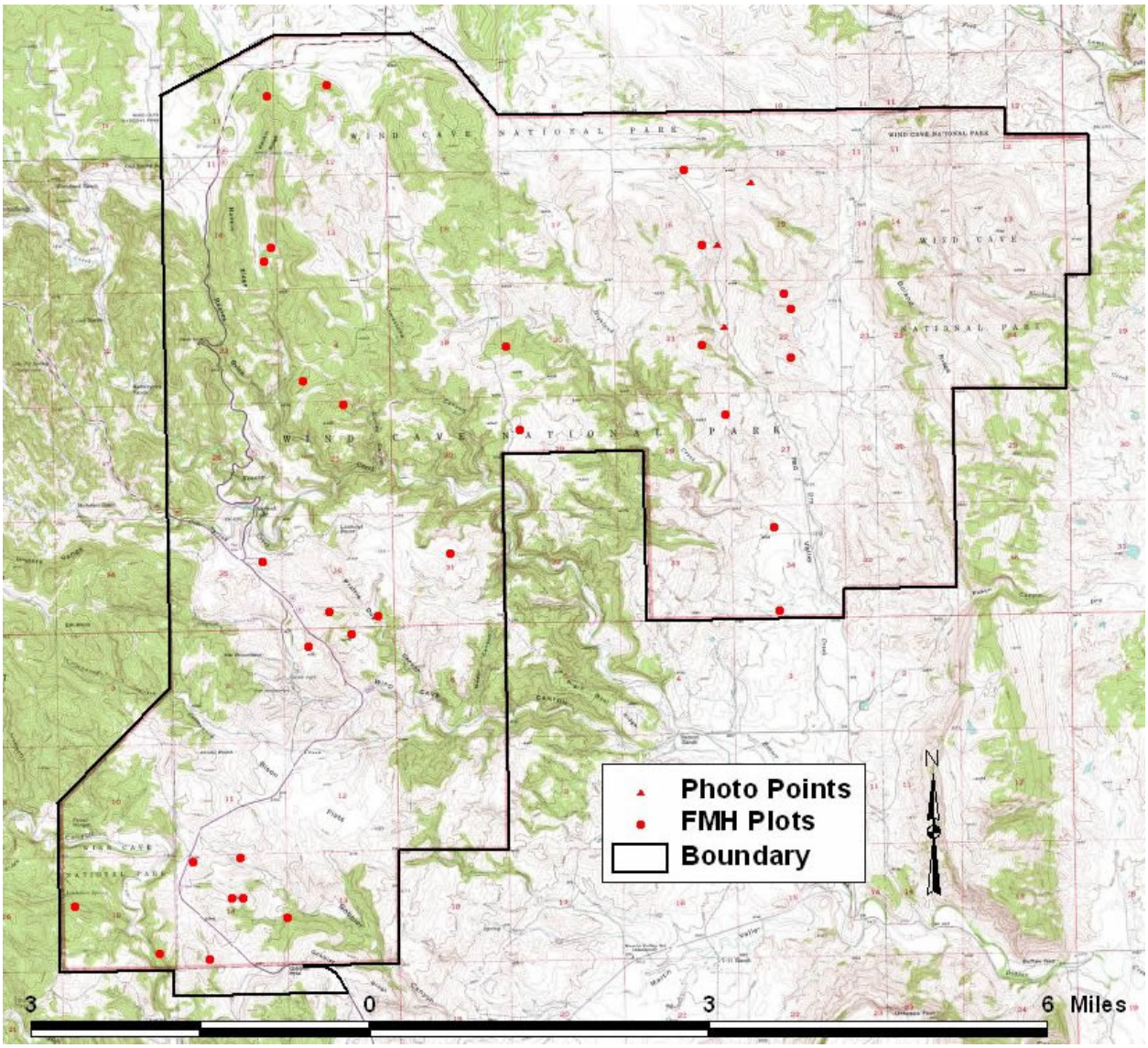
USDI National Park Service. 1998. Directors order #18: wildland fire management.

USDI National Park Service. 1999. Reference manual 18.

USDI National Park Service. 2003. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 274 pp.

FIGURES

FIGURE 1. LOCATION OF FIRE EFFECTS MONITORING PLOTS.



APPENDICES

APPENDIX 1 – MONITORING UNIT DESCRIPTION SHEETS

FMH-4 MONITORING TYPE DESCRIPTION SHEET Park: **WICA**

Monitoring Type Code: GAGSM1D01 **Date Described:** 6 /21/96

Monitoring Type Name: Wheatgrass-Needlegrass Mixed-grass Prairie

Prepared by: R. Rice, D. Kinney, B. Adams, C. Hull Sieg, G. Kemp, P. Reeberg

Updated: November 2000 – D. Roddy, A. Thorstenson, K. Rehman, J. DeCoster

Physical Description

Level to hilly uplands. All aspects are acceptable, slopes <40%, elevation 3,500 to 5,000 feet. Soils are loamy, shallow to deep, and well drained. Soil types include: Canyon-Rockoa Rock Outcrop, Nevee-Gypnevee-Rekop, Vanocker-Sawdust-Paunsaugunt, and Buska-Mocmont-Rock Outcrop Associations

Biological Description

A blend of tall-grass and short-grass prairies, typical dominant grasses include: western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), downy brome (*Bromus tectorum*), Japanese brome (*B. japonicus*), buffalo grass (*Buchloe dactyloides*), and Kentucky bluegrass (*Poa pratensis*). Sedges such as threadleaf sedge (*Carex filifolia), needleleaf sedge (Carex duriuscula*) may also be present. Forbs such as: sageworts (*Artemisia* spp.), scurfpea (*Psoralidium tenuiflorum*), dotted gayfeather (*Liatris punctata*), purple coneflower (*Echinacea angustifolia*), and upright prairie coneflower (*Ratibida columnifera*), are common. Low shrubs include: leadplant (*Amorpha canescens*) and Woods' rose (*Rosa woodsii*).

Rejection Criteria

Large outcroppings or barren areas >20% of the plot; areas with anomalous vegetation; monitoring type boundaries; riparian areas or areas dominated by trees; bio-control areas; areas within 20 meters of roads, man-made trails, or human created clearings are to be rejected.
Notes: Brush density will be collected for rhizomatous brush species, (lead plant, snowberry, wild rose) by stem count and for non-rhizomatous species by individual count to determine brush density.

Desired Future Condition

The community when maintained by fire would have reduced numbers of exotic species, particularly cool-season non-native grasses. The natural diversity of associated native species would be preserved or increased. The forage value for large ungulates (and small rodents) would be improved with periodic burning. There would be short-term (2-4 years post burn) increase in native forbs, especially milkweed and other target species for butterflies. With continued burning we will improve knowledge of fire effects in this community.

The community would have 25-50% of the area burned with in 7-10 years depending on topography to generate a mosaic of different aged stands across the type. Generate a fire disturbance pattern of varying intervals and differing seasons.

Burn Prescription
Units will be burned between late winter until green-up, or late summer through late fall

Fire Prescription Elements	
RH - **25 - 55%**	Average Rate of Spread - **0 - 40 ch/hr**
Bulb - **30°- 85°F**	Average Flame Length – **0.4-1.5 ft**
Average Mid-flame Winds - **0-15 mph**	1 hour TLFM - **6-14%**
Fuel Loading - **1.5-4 tons/acre**	10 hour TLFM – **n/a**
Live Fuel Moisture - n/a	100 hour TLFM **– n/a**

Monitoring Variables
- Cover of native grasses and forbs
- Cover of non-native grasses and forbs
- Shrub Density

Prescribed Fire Objectives
Immediate Post Burn
- Burn 60-80% of the burnable project area.

Two Years Post Burn
- Reduce cover of non-native grasses by at least 20%
- Increase cover of native grasses by at least 10%
- Increase cover of native forbs by at least 30%

Fire Monitoring Objectives
- Install enough plots to be 80% confident that the cover for native grasses and forbs, and non-native grasses and forbs is within 25% of the true population mean.
- Install enough plots to be 80% confident that the average density of all shrub species is within 25% of the true population mean.

Data Analysis
- Assess cover of native grasses and forbs after sampling years 1, 2, and 5.
- Assess cover of non-native grasses and forbs after sampling years 1, 2, and 5.
- Assess shrub density after sampling years 1,2, and 5.

Relevant Literature

Brown, P. M. and C. H. Sieg. 1996. Fire history of interior ponderosa pine communities of the Black Hills, South Dakota, USA. International Journal of Wildland Fire **6**(3):97-105.

Gartner, F. R. 1975. Final report: Wind Cave National Park grassland ecology. Unpublished paper on file at: USDI, National Park Service, Wind Cave National Park, Hot Springs, SD.

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FMH-4 **PLOT PROTOCOLS**

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots		•	Herb Height	•	
	Herbaceous Density		•	Belt Transect Width: **5m**		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens	•		Stakes Installed: **0P & 30P**		
	Stereo Photography		•	Crown Intercept		•
	Brush Individuals	•		Herb. Fuel Load	•	
	Herbaceous Data Collected at: **0P-30P**					
Burn	Duff Moisture		•	Flame Zone Depth	•	
Postburn	Herbaceous Data: Not Collected			Herb. Fuel Load	•	
	100 Pt. Burn Severity		•			

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **WICA**

Monitoring Type Code: GANSCD01 **Date Described:** 6 /12/97

Monitoring Type Name: Bluestem-Needlegrass Mixed-grass Prairie

Preparer: A. Powers, G. Bradshaw, B. Braudis, D. Roddy, B. Adams, G. Kemp, P. Reeberg

Physical Description
Level to hilly uplands. All aspects are acceptable, slopes <40%, elevation 3,500 to 5,000 feet. Soils are loamy, shallow to deep, and well drained. Soil types include the: Canyon-Rockoa-Rock Outcrop Outcrop, Nevee-Gypnevee-Rekop, Vanocker-Sawdust-Paunsaugunt, and Buska-Mocmont-Rock Outcrop Associations

Biological Description
A blend of tall-grass and short-grass prairies, typical dominant grasses include: little bluestem (*Schizachyrium scoparium*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), buffalo grass (*Buchloe dactyloides*), and Kentucky bluegrass (*Poa pratensis*). Sedges such as threadleaf sedge (*Carex filifolia)*, needleleaf sedge (*Carex duriuscula*) may also be present. Forbs such as: sageworts (*Artemisia* spp.), scurfpea (*Psoralidium tenuiflorum*), dotted gayfeather (*Liatris punctata*), purple coneflower (*Echinacea angustifolia*), and upright prairie coneflower (*Ratibida columnifera*), are common. Low shrubs include: leadplant (*Amorpha canescens*) and Woods' rose (*Rosa woodsii*).

Rejection Criteria
Large outcroppings or barren areas >20% of the plot; areas with anomalous vegetation; monitoring type boundaries; riparian areas or areas dominated by trees; bio-control areas; areas within 20 meters of roads, man-made trails, or human created clearings are to be rejected.

Desired Future Condition
The community when maintained by fire would have reduced numbers of exotic species, particularly cool-season non-native grasses. The natural diversity of associated native species would be preserved or increased. The forage value for large ungulates (and small rodents) would be improved with periodic burning. There would be short-term (2-4 years post burn) increase in native forbs, especially milkweed and other target species for butterflies. With continued burning we will improve knowledge of fire effects in this community.

The community would have 25-50% of the area burned with in 7-10 years depending on topography to generate a mosaic of different aged stands across the type. Generate a fire disturbance pattern of varying intervals and differing seasons.

Burn Prescription
This monitoring type will be burned between early-April and green-up, or late-August to the end of September.

Fire Prescription Elements	
RH - **25 - 55%**	Average Flame Length - **0.4-1.5 ft**
Bulb - **30°- 85°F**	Average Rate of Spread - **0 - 3 ch/hr**
Average Mid-flame Winds - **0-20 mph**	1 hour TLFM - **6-14 %**
Fuel Loading - **3-5 tons/acre**	10 hour TLFM – **n/a**
Live Fuel Moisture – **n/a**	100 hour TLFM – **n/a**

Fire Monitoring Variables
- Cover of native grasses and forbs
- Cover of non-native grasses and forbs
- Total shrub density

Prescribed Fire Objectives
Immediate Post Burn
- Burn 60-80% of the burnable project area.

Two Years Post Burn
- Reduce cover of non-native grasses by at least 20%
- Increase cover of native grasses by at least 10%
- Increase cover of native forbs by at least 30%

Fire Monitoring Objectives
- Install enough plots to be 80% confident that the cover for native grasses and forbs, and non-native grasses and forbs is within 25% of the true population mean.
- Install enough plots to be 80% confident that the average density of all shrub species is within 25% of the true population mean.

Data Analysis
- Assess cover of native grasses and forbs after sampling years 1, 2, and 5.
- Assess cover of non-native grasses and forbs after sampling years 1, 2, and 5.
- Assess shrub density after sampling years 1,2, and 5.

Notes: Shrub density will not be collected for *Opuntia polyacantha,* lead plant, wild rose, or snowberry because they are rhizomatous.

Relevant Literature

Brown, P. M. and C. H. Sieg. 1996. Fire history of interior ponderosa pine communities of the Black Hills, South Dakota, USA. International Journal of Wildland Fire **6**(3):97-105.

Gartner, F. R. 1975. Final report: Wind Cave National Park grassland ecology. Unpublished paper on file at: USDI, National Park Service, Wind Cave National Park, Hot Springs, SD.

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GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots		•	Herb Height	•	
	Herbaceous Density		•	Belt Transect Width: **5 m**		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens	•		Stakes Installed: **0P & 30P**		
	Stereo Photography		•	Crown Intercept		•
	Brush Individuals		•	Herb. Fuel Load		•
	Herbaceous Data Collected at: **0P-30P**					
Burn	Duff Moisture		•	Flame Zone Depth	•	
Postburn	Herbaceous Data: Not collected.			Herb. Fuel Load		•
	100 Pt. Burn Severity		•			

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **WICA**

Monitoring Type Code: FPIPO1D02 **Date Described:** 6/11/97

Monitoring Type Name: Ponderosa Pine/Mixed-grass Savannah

Prepared by: Brian Braudis, B. Adams, G. Kemp, Andrea Powers, Ginger Bradshaw, Dan Roddy.

Physical Description
Soils include: Alice fine sandy loam, Alice Theda Lund complex, Lakoa-Butche complex, Nunn clay loam and Samsil-Gaynor complex. Characteristic soils consist of loamy soils, shallow to deep, well drained, alluvial fans, uplands and terraces, slopes >40%, elevation 3,500 to 5,000 feet, with lower to mid slopes and valleys

Biological Description
Open canopy ponderosa pine (*Pinus ponderosa*) with occasional Rocky Mountain juniper (*Juniperus scopulorum*). Understory trees include bur oak (*Quercus macrocarpa*), chokecherry (*Prunus virginiana*), and American plum (*Prunus americana*). Shrubs include: Oregon grape (*Mahonia repens*), common juniper (*Juniperus communis*), western red current (*Ribes cereum*). Herbaceous species include: poverty oat grass (*Danthonia spicata*), needle-and-thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), and Kentucky bluegrass (*Poa pratensis*).

Rejection Criteria
Large outcroppings or barren areas >20% of the plot; areas with anomalous vegetation; monitoring type boundaries; riparian areas or areas dominated by deciduous trees (> 30% cover); areas within 30 meters of roads, man-made trails, or human created clearings.

Desired Future Condition
- Decrease non-native species.
- Maintain open-canopy ponderosa pine stands with overstory tree density in a range of 150-250 stems/ha (60-100 stems/acre).
- Fuel load levels that are consistent with frequent, low intensity fires
- Decrease density of seedling and pole-sized trees.
- The community would have 50-80% of the area burned within 7-15 years depending on topography to generate a mosaic of different aged stands across the type.
- Generate a fire disturbance pattern of varying intervals and differing seasons.

Burn Prescription:
Units will be burned from April to green-up, or Labor Day to the end of September.

Fire Prescription Elements	
RH: **25-55%**	Average Rate of Spread: **0-3 ch/hr**
Temp: **50-85°F**	Live Fuel Moisture: **n/a**
Average Mid-flame Winds: **0-20 mph**	1-hour TLFM: **6-14%**
Fuel Loading: **3-5 tons/acre**	10-hour TLFM: **8-15%**
Average Flame Length: **0.4-1.5 ft**	100-hour TLFM: **10-30%**

Monitoring Variables

- Density of overstory, pole-size, and seedling ponderosa pine
- Cover of native herbaceous species
- Cover of non-native herbaceous species
- Total dead and down fuel load

Prescribed Fire Project Objectives

Immediate Post-burn

- Reduce dead and down fuel loading by at least 30%
- Burn at least 80% of the project area

One Year Post-burn

- Achieve at least 70% mortality on seedling ponderosa pine

Two Years Post-burn

- Achieve at least 30% mortality in overstory ponderosa pine
- Achieve at least 50% mortality in pole-size ponderosa pine
- Increase relative cover of native herbaceous species by at least 25%
- Reduce relative cover of non-native herbaceous species by at least 25%

Five Year Post Burn

- Maintain increase in relative cover of native herbaceous species
- Maintain decrease in relative cover of non-native species
- Monitor accumulation of dead and down fuels

Fire Monitoring Objectives:

- Install enough plots to be 80% confident that density of overstory, pole-size, and seedling ponderosa pine are within 20% of the true population mean.
- Install enough plots to be 80% confident that relative cover of native and non-native herbaceous species is within 20% of the true population mean.
- Install enough plots to be 80% confident that the total dead and down fuel load is within 20% of the true population mean.

Data Analysis

- Assess density of overstory and pole-size ponderosa pine after sampling years 1, 2, and 5.
- Assess cover of native herbaceous species after sampling years 2 and 5.
- Assess total dead and down fuel load after sampling immediate post-burn, years 2 and 5.

Relevant Literature

Arno, S. F. 1988. Fire ecology and its management implications in ponderosa pine forests. Pages 133-139 *in* D. M. Baumgartner and J. E. Lotan, editors. Ponderosa pine: the species and its management. Symposium Proceedings, Washington State University, Spokane.

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Covington, W. W., and M. M. Moore. 1994. Southwestern ponderosa forest structure: changes since Euro-American settlement. Journal of Forestry **92**(1):39-47.

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Grafe, E. and P. Horsted. 2002. Exploring with Custer: The 1874 Blacks Hills Expedition. Golden Valley Press, Custer, South Dakota, USA.

Kuchler, A.W. 1964. Potential natural vegetation of the coterminous Untied States. Am. Geogr. Soc. Spec. Publ. 36 (Manual), New York.

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USDI National Park Service. 2003. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 288 pp.

USGS. 1999. Wind Cave National Park, USGS-NPS Vegetation Mapping Program Products (http://biology.usgs.gov/npsveg/wica/index.html). USGS-NPS Vegetation Mapping Program, USGS Center for Biological Informatics, Denver, CO.

FMH- 4 PLOT PROTOCOLS

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots		•	Herb Height	•	
	Herbaceous Density		•	Belt Transect Width:	**2 meters ***	
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens	•		Stakes Installed: All		
	Stereo Photography		•	Crown Intercept		•
	Brush Individuals		•	Herb. Fuel Load		•
	Herbaceous Data Collected at: **Q4-Q1**					
	* *Symphoricarpos occidentalis* is measured in 0.5 m belt transect.					
Burn	Duff Moisture		•	Flame Zone Depth	•	
Postburn	Herbaceous Data: Not Recorded			Herb. Fuel Load		•
	100 Pt. Burn Severity		•			

FOREST PLOT PROTOCOLS		YES	NO		YES	NO
Overstory	Area sampled: **50 x 20m**			Quarters Sampled: **Q1-Q4**		
	Tree Damage	•		Crown Position	•	
	Dead Tree Damage		•	Dead Crown Position		•
Pole-size	Area Sampled: **25 x 10m**			Quarters Sampled: **Q1**		
	Height	•		Poles Tagged		•
Seedling	Area Sampled: **5 x 10m**			Quarters Sampled: **Subset of Q1**		
	Height	•		Seedlings Mapped		•
Fuel Load	Sampling Plane Length: **6, 6, 12, 100, 100**			Fuel Continuity		•
	Aerial Fuel Load		•			
Postburn	Char Height	•		Mortality	•	

Notes: Brush density will not be collected for *Opuntia polyacantha*.

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **WICA**

Monitoring Type Code: FPIPO1D09 **Date Described:** 6/11/97

Monitoring Type Name: Ponderosa Pine Forest

Preparer: Dan Roddy, Brian Braudis, B. Adams, G. Kemp, Andrea Powers, Ginger Bradshaw.

Updated: 25 January 2005 – C. Wienk

Physical Description
Strongly sloping areas to steep canyons. Elevation 3,500-6,200 ft. Soils are loamy fine sand, shallow to deep, well to excessively drained. Soil types include: Sawdust-Hopdraw-Paunsaugunt, Citadel, Vanocker and areas of rock outcrop.

Biological Description
Overstory dominated by ponderosa pine (*Pinus ponderosa*). Understory is predominantly little bluestem (*Schizachyrium scoparium*), western snowberry (*Symphoricarpos occidentalis*), mountain mahogany (*Cercocarpus montanus*), golden currant (*Ribes aureum*), skunkbush sumac (*Rhus trilobata* Nutt. var. *trilobata*), Woods' rose (*Rosa woodsii*) and common chokecherry (*Prunus virginiana*). Common forbs include downy paintbrush (*Castilleja sessiliflora*), Hood's phlox (*Phlox hoodii*), prairie groundsel (*Packera plattensis*), stemless four-nerve daisy (*Tetraneuris acaulis* [Pursh] Greene var. *acaulis*), common starlily (*Leucocrinum montanum*) and darkthroat shootingstar (*Dodecatheon pulchellum*).

Rejection Criteria
Large outcroppings or barren areas >20% of the plot; slopes >60%; areas with anomalous vegetation; monitoring type boundaries; riparian areas or areas dominated by deciduous trees (> 30% cover); areas within 30 meters of roads, man-made trails, or human created clearings; and areas within 20 meters of Woodlands Research exclosures are to be rejected.

Desired Future Condition
- Decrease non-native species.
- Maintain open-canopy ponderosa pine stands with overstory tree density in a range of 200-350 stems/ha (80-140 stems/acre).
- Decrease density of seedling and pole-sized trees.
- Fuel load levels that are consistent with frequent, low intensity fires
- The community would have 50-80% of the area burned within 7-15 years depending on topography to generate a mosaic of different aged stands across the type.
- Generate a fire disturbance pattern of varying intervals and differing seasons.

Burn Prescription:
Units will be burned from April to green-up, or Labor Day to the end of September.

Fire Prescription Elements	
RH: **25-55%**	Average Rate of Spread: **0-3 ch/hr**
Temp: **50-85°F**	Live Fuel Moisture: **n/a**
Average Mid-flame Winds: **0-20 mph**	1-hour TLFM: **6-14%**
Fuel Loading: **3-5 tons/acre**	10-hour TLFM: **8-15%**
Average Flame Length: **0.4-1.5 ft**	100-hour TLFM: **10-30%**

Fire Monitoring Variables
- Density of overstory, pole-size, and seedling ponderosa pine
- Cover of native and non-native herbaceous species
- Shrub Density
- Total dead and down fuel load

Prescribed Fire Project Objectives
Immediate Post-burn
- Reduce dead and down fuel loading by at least 60%
- Burn at least 80% of the project area

Two Years Post-burn
- Achieve at least 30% mortality in overstory ponderosa pine
- Achieve at least 50% mortality in pole-size ponderosa pine
- Achieve at least 70% mortality on seedling ponderosa pine
- Increase relative cover of native herbaceous species by at least 25%
- Reduce relative cover of non-native herbaceous species by at least 25%

Five Year Post Burn
- Maintain increase in relative cover of native herbaceous species
- Maintain decrease in relative cover of non-native species
- Monitor accumulation of dead and down fuels

Fire Monitoring Objectives:
- Install enough plots to be 80% confident that density of overstory, pole-size, and seedling ponderosa pine are within 20% of the true population mean.
- Install enough plots to be 80% confident that relative cover of native and non-native herbaceous species is within 20% of the true population mean.
- Install enough plots to be 80% confident that the total dead and down fuel load is within 20% of the true population mean.

Data Analysis
- Assess density of overstory and pole-size ponderosa pine after sampling years 1, 2, and 5.
- Assess cover of native herbaceous species after sampling years 2 and 5.
- Assess total dead and down fuel load after sampling immediate post-burn, years 2 and 5.

Relevant Literature

Arno, S. F. 1988. Fire ecology and its management implications in ponderosa pine forests. Pages 133-139 *in* D. M. Baumgartner and J. E. Lotan, editors. Ponderosa pine: the species and its management. Symposium Proceedings, Washington State University, Spokane.

Brown, P. M., and C. H. Sieg. 1999. Historical variability in fire at the ponderosa pine - Northern Great Plains prairie ecotone, southeastern Black Hills, South Dakota. Ecoscience **6**(4):539-547.

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Gartner, F. R., and W. W. Thompson. 1972. Fire in the Black Hills forest-grass ecotone. Pages 37-68 *in* Proceedings of the 12th annual Tall Timbers Fire Ecology Conference. Tall Timbers Research Station, Tallahassee, Florida, USA.

Grafe, E. and P. Horsted. 2002. Exploring with Custer: The 1874 Blacks Hills Expedition. Golden Valley Press, Custer, South Dakota, USA.

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FMH- 4 PLOT PROTOCOLS

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots		•	Herb Height	•	
	Herbaceous Density		•	Belt Transect Width: **2 meters ***		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens	•		Stakes Installed: All		
	Stereo Photography		•	Crown Intercept		•
	Brush Individuals		•	Herb. Fuel Load		•
	Herbaceous Data Collected at: **Q4-Q1**					
	* *Symphoricarpos occidentalis* is measured in 0.5 m belt transect.					
Burn	Duff Moisture		•	Flame Zone Depth	•	
Postburn	Herbaceous Data: Not Recorded			Herb. Fuel Load		•
	100 Pt. Burn Severity		•			

FOREST PLOT PROTOCOLS		YES	NO		YES	NO
Overstory	Area sampled: **50 x 20m**			Quarters Sampled: **Q1-Q4**		
	Tree Damage	•		Crown Position	•	
	Dead Tree Damage		•	Dead Crown Position		•
Pole-size	Area Sampled: **25 x 10m**			Quarters Sampled: **Q1**		
	Height	•		Poles Tagged		•
Seedling	Area Sampled: **5 x 10m**			Quarters Sampled: **Subset of Q1**		
	Height	•		Seedlings Mapped		•
Fuel Load	Sampling Plane Length: **6, 6, 12, 100, 100**			Fuel Continuity		•
	Aerial Fuel Load		•			
Postburn	Char Height	•		Mortality	•	

Notes: Brush density will not be collected for *Opuntia polyacantha*, lead plant, wild rose, and snowberry because they are all rhizomatous.

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **WICA**

Monitoring Type Code: GPOPR1D01 **Date Described:** 5/11/99

Monitoring Type Name: Non-native Perennial Grass

Prepared by: A. Thorstenson, A. Powers, B. Kobza, K. Paintner

Physical Description
Level to hilly uplands. All aspects are acceptable, slopes <40%, elevation 3,500 to 5,000 feet. Soils are loamy, shallow to deep, and well drained. Soil types include the: Canyon-Rockoa-Rock Outcrop Outcrop, Nevee-Gypnevee-Rekop, Vanocker-Sawdust-Paunsaugunt, and Buska-Mocmont-Rock Outcrop Associations

Biological Description
Grassy areas dominated by Kentucky bluegrass (*Poa pratensis*) with some native intermingled. Native grasses include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), buffalo grass (*Buchloe dactyloides*), and western wheatgrass (*Pascopyrum smithii*). Sedges such as threadleaf sedge (*Carex filifolia*) may also be present. Forbs such as sageworts (*Artemisia* spp.), slimflower scurfpea (*Psoralidium tenuiflorum*), dotted blazing star (*Liatris punctata*), purple coneflower (*Echinacea angustifolia*), and upright prairie coneflower (*Ratibida columnifera*), are common. Low shrubs include leadplant (*Amorpha canescens*) and Woods' rose (*Rosa woodsii*).

Rejection Criteria
Large outcroppings or barren areas greater than 25% of the plot; slopes >15%; areas with anomalous vegetation; areas dominated by deciduous trees (> 30% cover); areas within 30 meters of roads, man-made trails, or human created clearings.

Desired Future Condition
Areas currently dominated by non-native cool-season grasses are thought to have been mixed-grass prairie, though the exact pre-settlement vegetative composition is not known. The vision for this community is to reduce the cover of non-native grasses and forbs and increase the cover of native grasses and forbs.

Burn Prescription:
Units will be burned between early spring and green-up.

Fire Prescription Elements	
RH: **25 - 55%**	Average Flame Length: **0.4 - 1.5 ft**.
Temperature: **50 – 85 °F**	Average Rate of Spread: **0 - 3 ch/hr**
Average Mid-flame Winds: **0 - 20 mph**	1 hour TLFM: **6-14 %**
Fuel Loading: **3 - 5 tons/acre**	10 hour TLFM: **n/a**
Live Fuel Moisture: **n/a**	1000 hour TLFM: **n/a**

Monitoring Variables
- Cover of non-native grass and forbs
- Cover of native grass and forbs

Prescribed Fire Objectives

Immediate Post-burn
- Burn at least 60% of the burnable project area.

Two Years Post-burn
- Reduce relative cover of non-native grasses by at least 30%.
- Increase relative cover of native grasses by at least 20%.
- Increase relative cover of native forbs by at least 20%.

Fire Monitoring Objectives
- Install enough plots to be 80% confident that relative cover of native and non-native grasses will be within 25% of the population mean.

Data Analysis
- Assess cover of native grasses and forbs after sampling years 1, 2, and 5.
- Assess cover of non-native grasses and forbs after sampling years 1, 2, and 5.

Relevant Literature

Gartner, F. R. 1975. Final report: Wind Cave National Park grassland ecology. Unpublished paper on file at: USDI, National Park Service, Wind Cave National Park, Hot Springs, SD.

Gartner, F. R., R. I. Butterfield, W. W. Thompson, and L. R. Roath. 1978. Prescribed burning range ecosystems in South Dakota. Pages 687-690 *in* D. N. Hyder, editor. Proceedings of the First International Rangeland Congress. Society for Range Management, Denver, CO.

Gartner, F. R., and W. W. Thompson. 1972. Fire in the Black Hills forest-grass ecotone. Pages 37-68 *in* Proceedings of the 12th annual Tall Timbers Fire Ecology Conference. Tall Timbers Research Station, Tallahassee, Florida, USA.

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Stubbendieck, J., and G. Willson. 1986. An identification of prairie in National Park units in the Great Plains. USDI National Park Service Occasional Paper No. 7, Washington, DC.

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FMH-4 PLOT PROTOCOLS

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots		•	Herb Height	•	
	Herbaceous Density		•	Belt Transect Width: **5m**		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens	•		Stakes Installed: **0P & 30P**		
	Stereo Photography		•	Crown Intercept		•
	Brush Individuals	•		Herb. Fuel Load	•	
	Herbaceous Data Collected at: **0P-30P**					
Burn	Duff Moisture		•	Flame Zone Depth	•	
Postburn	Herbaceous Data: Not Collected			Herb. Fuel Load	•	
	100 Pt. Burn Severity		•			

Notes: Shrub density will not be collected for *Opuntia polyacantha*.

LONG TERM PHOTO MONITORING SHEET

Plot # _____ **Park: _____** **Date: _____**

Burn Unit: _____ **Recorders: _____**

UTM Zone:_____	**Camera height: _____ft.**	**Elevation: _____ft**
UTMN:_____	**Lens size: _____mm**	**Slope along transect: _____%**
UTME:_____	**Distance from pole: _____ft.**	**Slope of terrain: _____%**
Datum:_____	**Azimuth from camera to pole: ____**	**No. of Photos Taken: _____**
EPE:_____	**Height on pole used for shot: _____ft**	**Compass Bearing(s):**

Describe the route to the plot, include or attach a hand drawn map illustrating these directions, including the plot layout, and significant features:

Visit	Initial/ Date	Comments
Install/Pre		
Immediate Post		
1 Year Post		
2 Year Post		
5 Year Post		
10 Year Post		

APPENDIX 3 – ALTERNATIVE PROTOCOLS

Protocols for PIPO Seedling Monitoring in Northwest

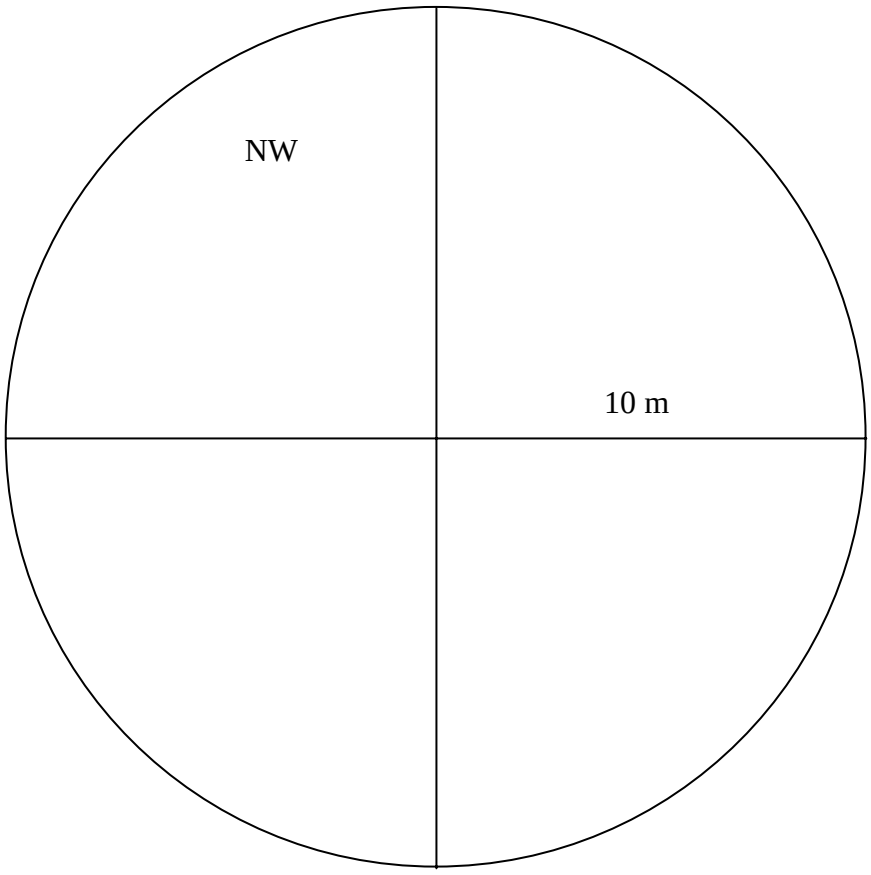
Circular plots with 10 m radius will be randomly located within areas of seedling establishment in the Northwest prescribed fire unit. Within these circular plots, the number of ponderosa pine seedlings will be tallied and recorded. Seedlings are defined as those trees with dbh <2.5 cm. Seedling densities pre- and post-burn will be summarized from this data. UTM coordinates and datum used will be recorded. Photos will be taken from two end points looking toward the center.

Plots will be divided into quadrants using 2 tapes laid out on cardinal directions. One 36" rebar will be located at the center of the plot and tagged with the plot identifier. Seedlings will be tallied by quadrant (i.e. NE, SE, SW, NW). Analysis of density and resulting mortality will be done at Year 2. Rebar will be removed after Year 2.

Rejection criteria: If a random point falls adjacent to a rock outcrop the point will be moved ten meters in a direction perpendicular to the face of the rock outcrop. If the location is still not suitable, the point will be rejected. Other areas that would justify rejection of random points include drainages dominated by deciduous trees and shrubs, man-made features such as roads, and areas that have recently been thinned or other human-caused disturbance.

Equipment:

____ GPS unit
____ map of random points
____ UTM coordinates
____ 2 30-m tapes
____ 4 chaining pins
____ DBH tape
____ 1 rebar
____ Hammer
____ compass
____ clinometer
____ data sheets
____ clipboard
____ pencils



Seedling Mortality Data Sheet – WICA

Burn Unit: _____ Date: _____

Burn Status: _____ Recorders: _____

Plot ID: _____ Plot Radius: _____

UTM Coordinates: Datum: _____ N _____ E _____

Live Ponderosa Pine Seedling Tally

Quarter 1:	Quarter 2:
Quarter 3:	Quarter 3:
Comments:	

Plot ID: _____ Plot Radius: _____

UTM Coordinates: Datum: _____ N _____ E _____

Live Ponderosa Pine Seedling Tally

Quarter 1:	Quarter 2:
Quarter 3:	Quarter 3:
Comments:	

Protocols for Tree Monitoring in Red Valley

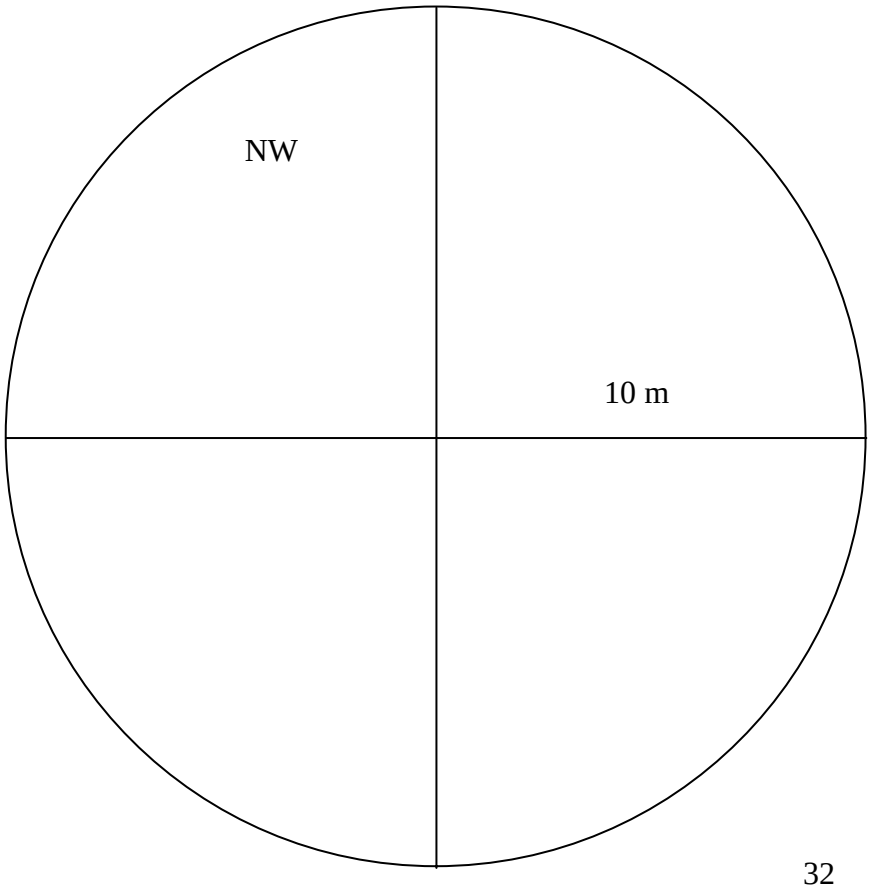
Circular plots with 10 m radius will be randomly located within the forested areas of the Red Valley unit. Within this circular plot, size class and live or dead will be measured and recorded for all ponderosa pine trees. Trees will be separated into 3 classes based on diameter at breast height (dbh). Seedlings with dbh <2.5 cm, Poles with dbh $\geq$ 2.5 cm and $\leq$15.0 cm, and Overstory trees with dbh > 15.0 cm. Basic stand structure information, such as number of trees per size class, will be summarized from this data. UTM coordinates and datum used will be recorded. Photos will be taken from two end points looking toward the center, and an overview photo will be taken at a location that best captures the sampling area.

Plots will be divided into quadrants using 2 tapes laid out on cardinal directions. One 36" rebar will be located at the center of the plot and tagged with the plot identifier. Trees will be located by quadrant (i.e. NE, SE, SW, NW), by size class and live or dead. Analysis of density by size class and resulting mortality by size class will be done at Year 2. Rebar will be removed after Year 2.

Rejection criteria: If a random point falls adjacent to a rock outcrop the point will be moved ten meters in a direction perpendicular to the face of the rock outcrop. If the location is still not suitable, the point will be rejected. Other areas that would justify rejection of random points include drainages dominated by deciduous trees and shrubs, man-made features such as roads, and areas that have recently been thinned or other human-caused disturbance.

Equipment:

____ GPS unit
____ map of random points
____ UTM coordinates
____ 2 30-m tapes
____ 4 chaining pins
____ DBH tape
____ 1 rebar
____ Hammer
____ compass
____ clinometer
____ data sheets
____ clipboard
____ pencils



Park _____

Plot I.D._____ Install Date _____

Burn Unit _____ Location UTMN _____
UTME _____
Recorders_____ Datum _____

2003 Pre				2004 Year 1				2005 Year 2			
Qtr	**Size Class S, P, O**	**Live or Dead**	**Tally**	**Qtr**	**Size Class S, P, O**	**Live or Dead**	**Tally**	**Qtr**	**Size Class S, P, O**	**Live or Dead**	**Tally**