National Park Service
Scotts Bluff National Monument, Nebraska
Fire Effects Monitoring Plan

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INTRODUCTION

Scotts Bluff National Monument encompasses approximately 3003 acres in western Nebraska. The most prominent feature of the park is Scotts Bluff, which rises nearly 800 feet above the North Platte River Valley. The Scotts Bluff vegetation map (USGS 1998) shows six principal land cover types. Nearly 50% of the park is covered by native mixed-grass prairie. Dominant species of the mixed-grass prairie include needle-and-thread (*Hesperostipa comata*), blue grama (*Bouteloua gracilis*), threadleaf sedge (*Carex filifolia*), western wheatgrass (*Pascopyrum smithii*), prairie sandreed (*Calamovilfa longifolia*), and sand bluestem (*Andropogon hallii*). The other principal land cover types are sparsely vegetated badlands (18%), non-native grasslands (15%), native shrublands (7%), native conifer stands (6%), and North Platte River floodplain (2%). Mixed-grass prairie dominated by western wheatgrass, needle-and-thread, grama grasses (*Bouteloua* spp.), and threadleaf sedge is believed to be the major pre-settlement vegetation type for the area, although the exact composition of the communities before settlement is unknown. Kuchler (1964) described the potential vegetation for the Scotts Bluff area as wheatgrass-needlegrass prairie.

Large and small-scale disturbances shaped the landscape of Scotts Bluff and surrounding areas. Historically, disturbances included seasonal bison grazing, extended wet and dry periods, soil disturbance (buffalo wallows and prairie dog towns) and fire. Many of these disturbances continue in Scotts Bluff today. Fires started both by lightning and Native Americans maintained the prairies and kept shrubs and trees limited to wetter areas or areas of broken topography until the area was settled in the 1880s. Fire suppression, overgrazing and plowing for farming broke up the areas of continuous fuels and significantly reduced the number of fires and acres burned. The lack of trees with fire scars make interpreting fire history for the area difficult. Wendtland and Dodd (1990) considered historical accounts and fire scar data from the edges of the Black Hills. They estimated fire return intervals from as short as 5 years in level to gently rolling topography to 15-30 years in more broken topography at Scotts Bluff.

Collins and Gibson (1990) documented the need for an interaction of four different disturbance types to maintain diverse community structure in mixed grass prairie. The interaction of drought, grazing, fire and soil disturbance--both buffalo wallows and prairie dog towns--alters community structure. In the absence of any one of these disturbances, species richness (the number of species per unit area), evenness (the distribution between dominance among species), and patch structure (the association of species at various spatial scales) will change. The absence of fire tends to increase woody species and reduce species richness and patch structure. The absence of grazing by large ungulates and/or soil disturbance reduces species diversity and decreases community heterogeneity. Management actions that include all disturbance types should be considered to maintain diverse community structure.

Prescribed fire will be used to maintain and restore the fire adapted ecosystems at Scotts Bluff. 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.

There are four communities at Scotts Bluff that will be monitored: (1) native mixed-grass prairie, (2) restored prairie, (3) native shrubland, and (4) Rocky Mountain juniper stands. Before the prescribed fire program began in 1983, much of the park had not burned since its establishment in 1939. Fire will be used to help restore these communities to more native conditions and then used to maintain systems by burning within the predicted range of return intervals. A more complete discussion of fire effects and management follows.

ECOLOGICAL MODEL

The vegetation of Scotts Bluff is predominantly mixed-grass prairie. Mixed-grass prairie is characterized as having a mixture of mid-height and shortgrasses as well as a mixture of grasses with different photosynthetic pathway types (C_3: cool-season and C_4: warm-season) (Singh et al. 1983). This diversity of species found on the Northern Great Plains is a result of great and repeated migrations of species that responded to changes in climate during periods of glaciation (Weaver and Albertson 1956, Wells 1970). One of the unique traits of the Northern Great Plains mixed-grass prairie is the dominance of cool-season grasses (Singh et al. 1983). A complex disturbance regime of biotic and abiotic disturbances (including periodic drought, grazing, fire, and soil disturbances) have interacted to form and continue to maintain grasslands of the Northern Great Plains (Anderson 1990, Collins and Gibson 1990). These disturbances also interact with climate, topography, soils, and competition among plant species to influence grassland composition (Fig. 1) (Wells 1970, Wright and Bailey 1980, Collins and Gibson 1990).

Although cool-season species tend to dominate northern mixed-grass prairies, warm-season species co-dominate on more xeric sites since these species are generally better adapted to warm, dry conditions (Singh et al. 1983). Light to moderate grazing also favors warm-season species while heavy grazing can shift composition toward warm-season shortgrasses such as buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*) (Weaver and Albertson 1956, Ode et al. 1980, Singh et al. 1983). Native ungulates generally favor graminoids over forbs which may lead to increases in occurrence of forb species (Krueger 1986). Annual forbs colonize small-scale soil disturbances such as prairie dog mounds or buffalo wallows (Collins and Gibson 1990).

FIRE ECOLOGY

Historically, fire was a frequent and large-scale disturbance on northern mixed-grass prairies and continues to be a tool that managers use. Historic fire frequencies are very difficult to determine largely due to a lack of trees on the plains to record fire scars (Wright and Bailey 1980). Most fire frequency estimates have been based on accounts of early settlers or known fire frequencies

needed to prevent woody plant encroachment into grasslands. Mean fire return intervals have been estimated at 4 to 9 years for the sandhills of north-central Nebraska (Steinauer and Bragg 1987), 10 to 12 years for the forest-prairie ecotone of the Black Hills of South Dakota (Brown and Sieg 1999), and 15 to 30 years for the broken topography of Scotts Bluff National Monument, Nebraska (Wendtland and Dodd 1990).

Ignition sources for fires in presettlement times are believed to be mainly lightning and ignition by American Indians (both intentional and unintentional). A study of lightning-ignited fires in the Northern Great Plains over the past five decades indicates that nearly 75% of lightning-ignited fires occurred during July and August and lightning-ignited fires were recorded every month from April to September (Higgins 1984). It is presumed that this pattern has not changed significantly for at least a few centuries. Historical documents and accounts of early settlers suggest that there were two seasonal periods for fires ignited by American Indians, one during the spring with a peak in April and one during the fall with a peak in October (Higgins 1986).

Effects of fire can vary depending on the season burn occurred, time since last burned, grazing history, precipitation before and after burn, vegetation composition, fire intensity and severity, and topography (Anderson 1990, Collins and Gibson 1990). Fire can influence both plant community productivity and structure. Productivity may be increased following fire as a result of reduction in the litter layer and grazing may have similar effects (Anderson 1990). In mixed-grass prairie, with both warm- and cool-season species, season of burn can strongly affect species composition. Generally, spring and fall burns favor warm-season grasses while summer burns tend to favor cool-season grasses (Steuter 1987, Howe 1994).

FIRE HISTORY OF SCOTTS BLUFF NATIONAL MONUMENT

Wendtland and Dodd (1990) and Wendtland (1993) described the fire history of Scotts Bluff National Monument by reviewing published literature, historical records and NPS fire records. Postsettlement fire return intervals were estimated by comparing locations and dates of fires occurring at Scotts Bluff. They concluded that fires occurred about every five years on smooth and gently rolling topography and 15 to 20 years on areas with more broken topography. Historically fires were most common in July and August, but since 1935 fires have more often occurred between March and June. They attributed this change to the introduction of prescribed fire in the latter part of the twentieth century.

VEGETATION OF SCOTTS BLUFF NATIONAL MONUMENT

There are six principal land cover types at Scotts Bluff. These cover types are simplified from the Scotts Bluff vegetation map (USGS 1998) and include native mixed-grass prairie, sparsely vegetated badlands, non-native grasslands, native shrublands, native conifer stands, and North Platte River floodplain (Fig. 2). The management history of Scotts Bluff is complex, but the prairie vegetation is generally considered in excellent condition (Stubbendieck and Willson 1986).

Native mixed-grass prairie

This cover type is dominated by needle-and-thread, blue grama, threadleaf sedge, and western wheatgrass. Prairie sandreed, green needlegrass (*Nassella viridula*), sand bluestem, scarlet gaura (*Gaura coccinea*), scarlet globemallow (*Sphaeralcea coccinea*), winterfat (*Krashkinninikovia*

lanata), and fringed sagewort (*Artemisia frigida*) are common constituents. Non-native, annual bromes (*Bromus* spp.) are also found on these sites.

Sparsely vegetated badlands

As the name implies, vegetation in this cover type is sparse and patchy. It mainly consists of rock outcrops and eroding cliffs. Shrubs, such as western snowberry (*Symphoricarpos occidentalis*) and skunkbush sumac (*Rhus aromatica*), and native grasses are found in the draws and ravines, but generally at moderate to low density.

Non-native grasslands

This cover type occurs mainly in areas that have experienced some type of previous disturbance. Non-native species generally dominate these areas, although native species are present. Non-native grasses include Japanese brome (*Bromus japonicus*), cheatgrass (*B. tectorum*), smooth brome (*B. inermis*), crested wheatgrass (*Agropyron cristatum*), and Kentucky bluegrass (*Poa pratensis*). Non-native forbs such as tumble mustard (*Sisymbrium altissimum*), Russian thistle (*Salsola tragus*), kochia (*Kochia scoparia*) and goatsbeard (*Tragopogon dubius*) also occur throughout this cover type.

A few disturbed areas that have undergone restoration treatments are included in this cover type. These areas were seeded with a native seed mix, but sideoats grama (*Bouteloua curtipendula*) tended to dominate these sites following restoration.

Native shrublands

Native shrublands are scattered throughout the park, largely associated with draws, ravines and bluff slopes but also found in patches within prairie areas and bluff tops. Shrub species include western snowberry, skunkbush sumac, winterfat, yucca (*Yucca glauca*), western red current (*Ribes cereum*) and mountain mahogany (*Cercocarpus montanus*).

Native conifer stands

Conifer stands are restricted to bluff tops and ravine areas on the bluff slopes. Rocky Mountain juniper (*Juniperus scopulorum*) and ponderosa pine (*Pinus ponderosa*) occur in dense to open stands. The understory of the more open woodlands vary from grass to shrub and grass.

North Platte River floodplain

The floodplain forms a relatively narrow band parallel to the North Platte River on the northern boundary of Scotts Bluff. Broadleaf cattail (*Typha latifolia*) and some narrowleaf willow (*Salix exigua*) are found in the more mesic areas along the river. The lower floodplain terrace contains an open woodland of plains cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*) with a dense understory of graminoids and forbs.

FIRE EFFECTS

Cheatgrass and Japanese brome

Cheatgrass and Japanese brome are both members of the genus *Bromus*. They are very similar in growth, reproduction, and habitat. Both are cool season annuals that germinate primarily during

the fall from the previous year's seed crop (Baskin and Baskin 1981). They reproduce entirely from seeds and are prolific seed producers. Little research has been carried out regarding the effects of fire on cheatgrass in the Northern Great Plains. Response of Japanese brome to burning appears to be highly correlated with litter reduction by fire and the amount of autumn precipitation following the fire. Germination and establishment of Japanese brome tends to decrease as litter accumulation is reduced and when autumn precipitation is low.

At Wind Cave National Park, Japanese brome density was reduced the first growing season after both fall (Sept. 18) and spring (Apr. 10) burns, with slightly better reduction following the fall burn (Gartner 1975). Yield of Japanese brome was reduced following both spring (May 15) and fall (Nov. 7) burns in a study near Rapid City, SD (Gartner et al. 1978). A fall burn (2nd week of October) near Miles City, Montana resulted in a reduction in cheatgrass and Japanese brome cover of nearly 70%; while reduction was only 50% following a spring (Apr. 9) burn (White and Currie 1983). Significant reduction in Japanese brome density and yield was reported following a spring (April 20) burn at Badlands National Park, but this reduction appeared to persist for only one growing season unless burning was followed by dry weather (Whisenant and Uresk 1990).

MANAGEMENT OBJECTIVES

Four vegetation communities or monitoring units have been selected for monitoring. They either closely correspond to or are subsets of the land cover types described above. Included are: 1) needlegrass/sedge mixed-grass prairie, 2) restored prairie, 3) western snowberry shrubland, and 4) juniper woodlands. Vegetation descriptions, desired future conditions, and management objectives for each monitoring unit follow below.

NEEDLEGRASS/SEDGE MIXED-GRASS PRAIRIE

This monitoring unit is largely native mixed-grass prairie dominated by needle-and-thread and threadleaf sedge. Other grasses include western wheatgrass, blue grama, prairie sandreed, and sideoats grama. Ponderosa pine and Rocky Mountain juniper occur on the bluff summits, slopes and sheltered ravines. Riparian areas contain plains cottonwoods, boxelder, and Siberian elm. Non-native species include crested wheatgrass, dwarf alyssum (*Alyssum desertorum*), cheatgrass, Japanese brome, kochia, and Russian thistle.

It is desired to have a community with reduced amounts of exotic cool season grasses and weedy annuals while maintaining or increasing native grass cover. The natural diversity of associated native species would be preserved or increased. There could be short-term (2-4 years) increases in native forbs following prescribed fire.

<u>Immediate post-burn</u>

- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3)* as defined in the Fire Monitoring Handbook (2001)

* Litter charred to partially consumed, soil not visibly altered, grass stubble remains, foliage and smaller twigs consumed.

Two years post-burn
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Five years post-burn
- Maintain increase in native species
- Maintain reduction in non-native species

RESTORED PRAIRIE

This monitoring unit occurs where native species have been seeded in previously disturbed areas. The areas of disturbance are located on flat to rolling terrain that were used as farmland or as a golf course. These areas are currently dominated by sideoats grama and green needlegrass. Other graminoids include threadleaf sedge, needle-and-thread, western wheatgrass, blue grama, and prairie sandreed. Non-native species include crested wheatgrass, dwarf alyssum, cheatgrass, Japanese brome, kochia, Russian thistle, and tumble mustard.

It is desired to have a community with reduced amounts of exotic cool season grasses and weedy annuals while maintaining or increasing native grass cover. Restoring a more "natural" diversity in the grass community is also desired. A gradual increase in the number and types of native forbs is anticipated as these species spread into these areas from adjacent native prairie.

Immediate post-burn
- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3)* as defined in the Fire Monitoring Handbook

Two years post-burn
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Five years post-burn
- Maintain increase in native species
- Maintain reduction in non-native species

WESTERN SNOWBERRY SHRUBLAND

Shrublands are dominated by western snowberry, winterfat, skunkbush sumac, and lesser amounts of common chokecherry (*Prunus virginiana*), wild rose (*Rosa woodsii*), silver buffaloberry (*Shepherdia argentea*), rubber rabbitbrush (*Chrysothamnus nauseosus*), yucca, and prickly pear (*Opuntia* spp.). The herbaceous layer consists of western wheatgrass, sideoats grama, smooth brome, Japanese brome, needle-and-thread, goatsbeard, prickly lettuce (*Lactuca serriola*), sunflower (*Helianthus* spp.), and prairie coneflower (*Ratibida columnifera*).

* Litter charred to partially consumed, soil not visibly altered, grass stubble remains, foliage and smaller twigs consumed.

The desired future condition of this community is to have increased availability of browse for deer. Snowberry, skunkbush sumac, and poison ivy (*Toxicodendron rydbergii*) are all common shrubs in this community. These shrub species tend to sprout vigorously following fire. The historical pictures of the area show less shrub cover than is now present. Shrub cover is not likely to decrease without the presence of large ungulates.

Immediate post-burn
- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3)* as defined in the Fire Monitoring Handbook

One year post-burn
- Shrub density of snowberry resprouts at least 40% of pre-burn snowberry density

Two years post-burn
- Limit change in shrub density to no more than ± 30% of pre-burn shrub density
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Five years post-burn
- Maintain shrub density change to no more than ± 30% of pre-burn shrub density
- Maintain increase in native species
- Maintain reduction in non-native species

JUNIPER WOODLANDS

Overstory dominated by Rocky Mountain juniper occurring mainly on steep north aspects of drainages and bluffs accounting for greater than 20% of canopy cover. Understory is predominantly blue grama and littleseed ricegrass under the juniper canopy and needle-and-thread and threadleaf sedge in the open. Shrubs include western snowberry, skunkbush sumac, wild rose and winterfat. Common forbs are milkweed and spiderwort.

Fire will be used in this community to reduce density of overstory juniper, while limiting overstory mortality to less than 30% with each prescribed fire. This will help maintain shelter, cover and structure for deer, birds, and small mammals. High mortality for the juvenile trees encroaching in the prairie is anticipated and desirable. Understory vegetation is very sparse. Annual exotic brome species, cheatgrass and Japanese brome, both occur in this system and can be expected to increase in the short term (1-5 years) after prescribed fire.

Immediate post-burn
- Burn at least 80% of the burnable project area
- Mortality of overstory juniper 10 to 30%
- Reduce litter and duff fuel load by at least 25%

* Litter charred to partially consumed, foliage and smaller twigs partially to completely consumed, less than 60% of the shrub canopy is consumed.

Two years post-burn
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%
- Limit change in shrub density to no more than ± 30% of pre-burn shrub density

Five years post-burn
- Maintain increase in native species
- Maintain reduction in non-native species
- Maintain shrub density change to no more than ± 30% of pre-burn shrub density

MONITORING DESIGN

MONITORING OBJECTIVES

Needlegrass/sedge mixed-grass prairie
- Install enough plots to be 80% confident that relative cover of native perennial grass and forb species is within 25% of the true population mean.
- Install enough plots to be 80% confident that relative cover of non-native grass and forb species is within 25% of the true population mean.

Restored prairie
- Install enough plots to be 80% confident that relative cover of native perennial grass and forb species is within 25% of the true population mean.
- Install enough plots to be 80% confident that relative cover of non-native grass and forb species is within 25% of the true population mean.

Western snowberry shrublands
- Install enough plots to be 80% confident that shrub density of all species is within 25% of the population mean.
- Install enough plots to be 80% confident that relative cover of perennial grasses and forbs is within 25% of the population mean.
- Install enough plots to be 80% confident that relative cover of non-native annual grass species is within 25% of the population mean.

Juniper woodlands
- Install enough plots to be 80% confident that density of overstory trees is within 25% of the true population mean.
- Install enough plots to be 80% confident that litter and duff fuel load is within 25% of the true population mean.
- Install enough plots to be 80% confident that relative cover of native and non-native herbaceous species is within 25% of the true population mean.
- Install enough plots to be 80% confident that shrub density is within 25% of the true population mean.

SAMPLING DESIGN

All plots established at Scotts Bluff follow standard Fire Monitoring Handbook (FMH) (2001) 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 will also be established in the future.

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 Team will retain copies and backups and will be responsible for providing updated versions to Scotts Bluff as needed.

MONITORING LOCATION

Currently there are 17 monitoring plots in 5 prescribed fire units (Fig. 3).

PRESCRIBED FIRE MONITORING PARAMETERS

Scotts Bluff has adopted the NPS Fire Monitoring Handbook (2001) 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 Team, 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 (2001) 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 wildland fires for resource benefit and 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
  - drought index
- 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

Prescribed fire unit schedule

Appendix G of the Fire Management Plan identifies the planned prescribe fire schedule for the next several years. The unit rotation is based on a 5 to 15 year fire return interval. Units dominated by non-native species may require shorter burn intervals to meet desired objectives. A map of the prescribed fire units is also included (Fig. 4).

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. With the addition of nested frequency monitoring the vegetative data may need to be read twice a year because of the two different peaks. 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 1, 2, 5, 10, and 20 year schedule. 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.

ADDITIONAL VEGETATION MONITORING

Vegetation monitoring plots were established at Scotts Bluff in 1998 by the Prairie Cluster Long-Term Ecological Monitoring (LTEM) Program to detect and describe long-term changes in grassland and juniper communities. Thirteen sample sites, covering four vegetation types, were chosen. The LTEM group identified sampling localities within a designated plant community using a random numbers table. If the random number placed the paired transects on a vegetation boundary (e.g. a transition zone between a disturbed prairie remnant and a high-quality prairie remnant), they moved the paired transects into the habitat type to be sampled. Within each plant community identified for sampling, they randomly located two or more 50-m paired transects. The paired transects are 20-m apart and run parallel to each other and to the elevation contours. Along each transect they established five 10 m^2 circular plots at 10-m intervals (see Appendix 3). Within each 10-m^2 circular plot, they nested a 0.1 m^2 circular plot and a 1.0-m^2 circular plot. In small communities where the sample site encompasses a large proportion of the total area (e.g., bluff top communities), they placed a single transect pair. They marked each transect at both ends with rebar. Using a global positioning system (GPS) unit, they recorded the coordinates for the end points of each transect. During sampling, they took photos of each transect from the permanent transect endpoints to have visual documentation of vegetation change. Within these plots, foliar cover, species frequency, species diversity, and species composition are measured. The fire effects monitoring program will coordinate with the LTEM program to minimize duplication and develop an efficient monitoring program for Scotts Bluff

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 Scotts Bluff is collected and managed by the Northern Great Plains Fire Monitoring Team located at Wind Cave National Park, Hot Springs, South Dakota. All data collected at Scotts Bluff will be entered and checked by this team 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 team's office. Hard copies of the Plot Location Data Sheets will be archived at Scotts Bluff in the Resource Management files. The Lead Monitor will provide monitoring data to the Scotts Bluff Resource Management Specialist 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 Scotts Bluff 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 ensure 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 ensure that all unknowns are consistently observed. Scotts Bluff 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 ensure 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

This **Fire Monitoring Plan** was written by Cody Wienk, Northern Great Plains Fire Ecologist

Administrative duties will be assigned as follows:

- *Northern Great Plains Fire Ecologist*: Plan revision, crew supervision, data management and data analysis
- *Resource Management Specialist, Scotts Bluff National Monument*: 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 the Badlands Resource Management Division in an additional meeting as requested.

Review of the data summary and analysis by the NGP Fire Ecologist, Prescribed Fire Specialist, and Scotts Bluff 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 Scotts Bluff 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 Team is responsible for coordination and consultation with other parks in the group, fire management personnel, and the Midwest Regional Fire Ecologist. Scotts Bluff Resource Management staff will be responsible for coordination and consultation with the park and all other cooperators.

The Scotts Bluff Resource Management Division participated in shaping and preparing this plan. The following provided assistance with, or review of, this plan:

Robert Manasek, Resource Management Specialist, Scotts Bluff NM
Ralph Moore, Superintendent, Scotts Bluff NM
Andy Thorstenson, Lead Monitor, NPS, Northern Great Plains Fire Monitoring Crew
Kevin Rehman, Assistant Lead Monitor, NPS, NGP Fire Monitoring Crew
Doug Alexander, Fire Management Officer, NPS, NGP Fire Management Office
Bill Gabbert, Fire Management Officer (former), NPS, NGP Fire Management Office
Jim DeCoster, Regional Fire Ecologist, NPS, Midwest Region, Omaha
Cody Wienk, Fire Ecologist, NPS, NGP Fire Management Office

PEER REVIEW

Peer/technical review for this plan was provided by:

Diane Abendroth, Fire Ecologist, Grand Teton National Park

LITERATURE CITED

Anderson, R. C. 1990. The historic role of fire in the North American grassland. Pages 8-18 *in* S. L. Collins and L. L. Wallace, editors. Fire in North American tallgrass prairies. University of Oklahoma Press, Norman, Oklahoma.

Baskin, J.M. and C.C. Baskin. 1981. Ecology of germination and flowering in the weedy winter annual grass *Bromus japonicus*. Journal of Range Management. 34(5):369-372.

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.

Collins, S. L., and D. J. Gibson. 1990. Effect of fire on community structure in tallgrass and mixed-grass prairie. Pages 81-98 *in* S. L. Collins and L. L. Wallace editors. Fire in North American tallgrass prairies, University of Oklahoma Press, Norman, Oklahoma.

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.

Higgins, K. F. 1984. Lightning fires in North Dakota grasslands and in pine-savanna lands of South Dakota and Montana. Journal of Range Management 37(2):100-103.

Higgins, K. F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. USDI Fish and Wildlife Service Resource Publication 161, Washington, D. C., USA.

Howe, H. F. 1994. Response of early- and late-flowering plants to fire season in experimental prairies. Ecological Applications 4:121-133.

Krueger, K. 1986. Feeding relationships among bison, pronghorn and prairie dogs: an experimental analysis. Ecology 67:760-770.

Kuchler, A. W. 1964. Potential natural vegetation of the coterminous United States: manual to accompany the map. American Geographical Society Special Publication 36, New York, New York.

Ode, D. J., L. L. Tieszen, and J. D. Lerman. 1980. The seasonal contribution of C_3 and C_4 plant species to primary production in a mixed prairie. Ecology 61:1304-1311.

Singh, J. S., W. K. Lauenroth, R. K. Heitschmidt, and J. L. Dodd. 1983. Structural and functional attributes of the vegetation of northern mixed prairie of North America. The Botanical Review 49(1):117-149.

Steinauer, E. M., and T. B. Bragg. 1987. Ponderosa pine (*Pinus ponderosa*) invasion of Nebraska sandhills prairie. American Midland Naturalist 118(2):358-365.

Steuter, A. A. 1987. C_3/C_4 production shift on seasonal burns—northern mixed prairie. Journal of Range Management 40(1):27-31.

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, D. C., USA.

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

USDI National Park Service. 1999. Reference manual 18.

USDI National Park Service. 2001. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 288 pp.

USGS. 1998. Scotts Bluff National Monument, USGS-NPS Vegetation Mapping Program Products (http://biology.usgs.gov/npsveg/scbl/index.html). USGS-NPS Vegetation Mapping Program, USGS Center for Biological Informatics, Denver, CO.

Weaver, J. E. and F. W. Albertson. 1956. Grasslands of the Great Plains: their nature and use. Johnsen Publishing Company, Lincoln, Nebraska, USA.

Wells, P. V. 1970. Postglacial vegetational history of the Great Plains. Science 167:1574-1582.

Wendtland, K.J. and J.L. Dodd. 1990. The fire history of Scotts Bluff National Monument. Pages 141-143 *in* D. D. Smith and C. A. Jacobs, editors. Recapturing a vanishing heritage: Twelfth North American Prairie Conference. University of Northern Iowa, Cedar Falls, Iowa.

Wendtland, K.J. 1993. Fire history and effects of seasonal prescribed burning on northern mixed prairie, Scotts Bluff National Monument, Nebraska. Thesis. University of Wyoming, Laramie, WY.

Whisenant, S. G. and D. W. Uresk. 1990. Spring burning Japanese brome in a western wheatgrass community. Journal of Range Management **43**(3):205-208.

White, R. S. and P. O. Currie. 1983. Prescribed burning in the Northern Great Plains: yield and cover responses of 3 forage species in the mixed grass prairie. Journal of Range Management **36**(2):179-183.

Wright, H. A. and A. W. Bailey. 1980. Fire ecology and prescribed burning in the Great Plains—a research review. USDA Forest Service General Technical Report INT-77. Intermountain Forest and Range Experiment Station, Ogden, Utah.

FIGURES

FIGURE 1. ECOLOGICAL MODEL The Northern Great Plains mixed-grass prairie is characterized as having a mixture of mid-height and shortgrasses with different photosynthetic pathway types (cool- and warm-season). Cool-season grasses are dominant. A complex disturbance regime of biotic and abiotic disturbances (including periodic drought, grazing, fire, and soil disturbances) have interacted to form and continue to maintain grasslands of the Northern Great Plains. These disturbances also interact with climate, topography, soils, and competition among plant species to influence grassland composition.

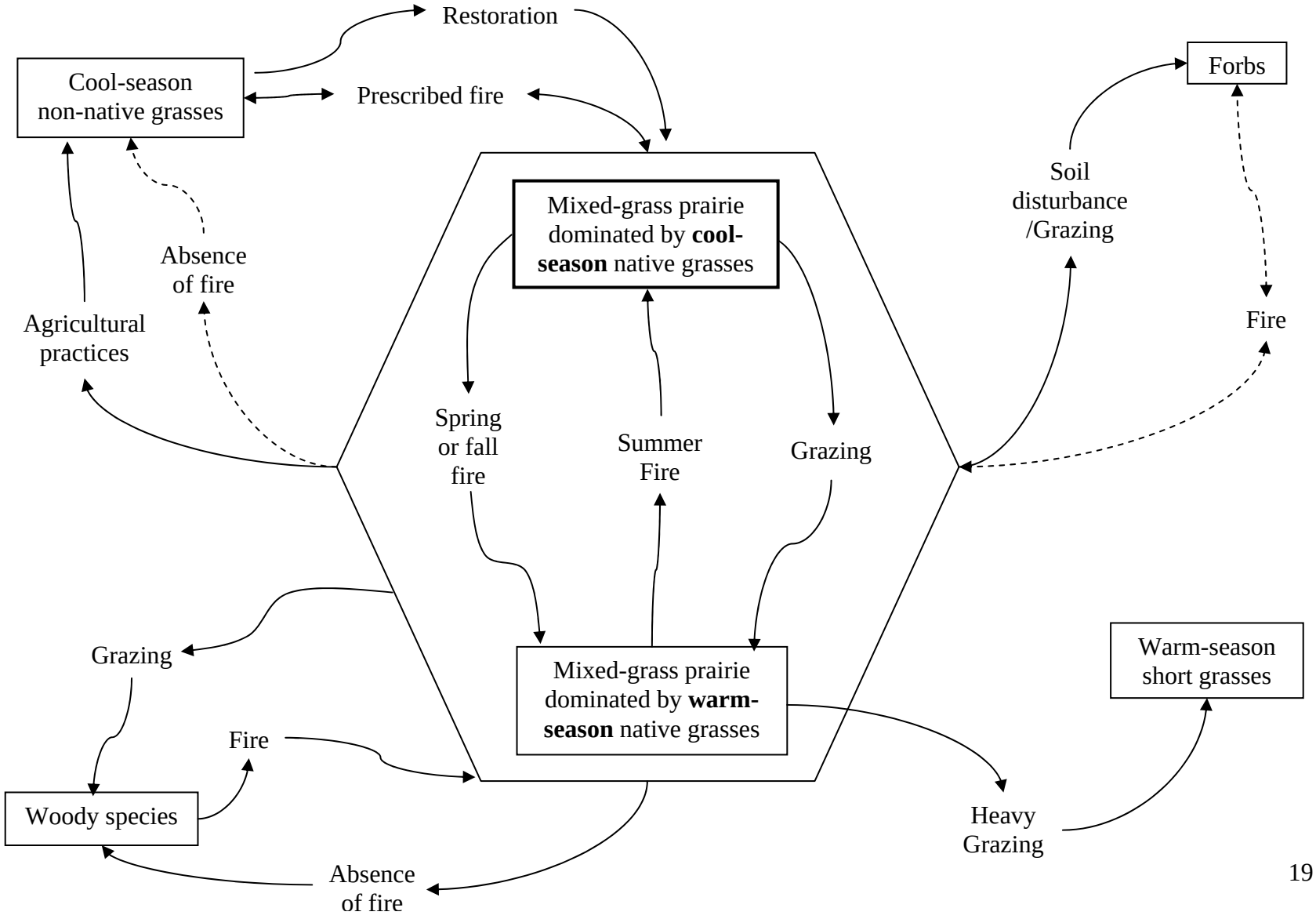


FIGURE 2. VEGETATION MAP OF SCOTTS BLUFF NATIONAL MONUMENT. Product of the USGS-NPS Vegetation Mapping Program (USGS 1998). JUSC = *Juniperus scopulorum*, ORMI = *Oryzopsis micrantha*, PIPO = *Pinus ponderosa*, PODE = *Populus deltoides*, Salix = *Salix exigua*, ANHA = *Andropogon hallii*, CALO = *Calamovilfa longifolia*, CEMO = *Cercocarpus montanus*, BOCU = *Bouteloua curtipendula*, SYOC = *Symphoricarpos occidentalis*, Typha = *Typha* spp., Kochia = *Kochia scoparia*, Brome = *Bromus* spp., PASM = *Pascopyrum smithii*, STCO = *Hesperostipa comata*, BOGR = *Bouteloua gracilis*, ANGE = *Andropogon gerardii*.

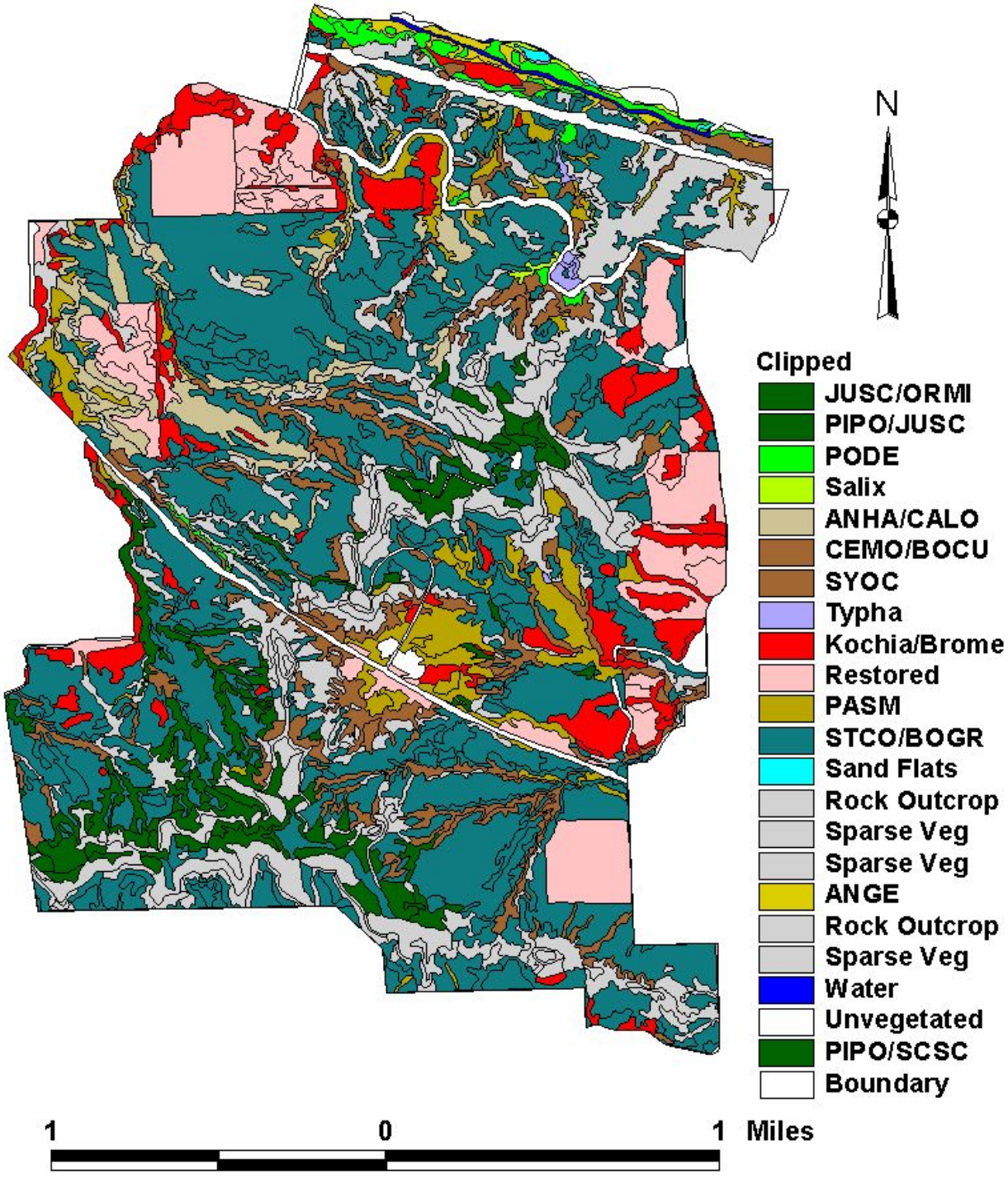


FIGURE 3. LOCATION OF FIRE EFFECTS MONITORING PLOTS.

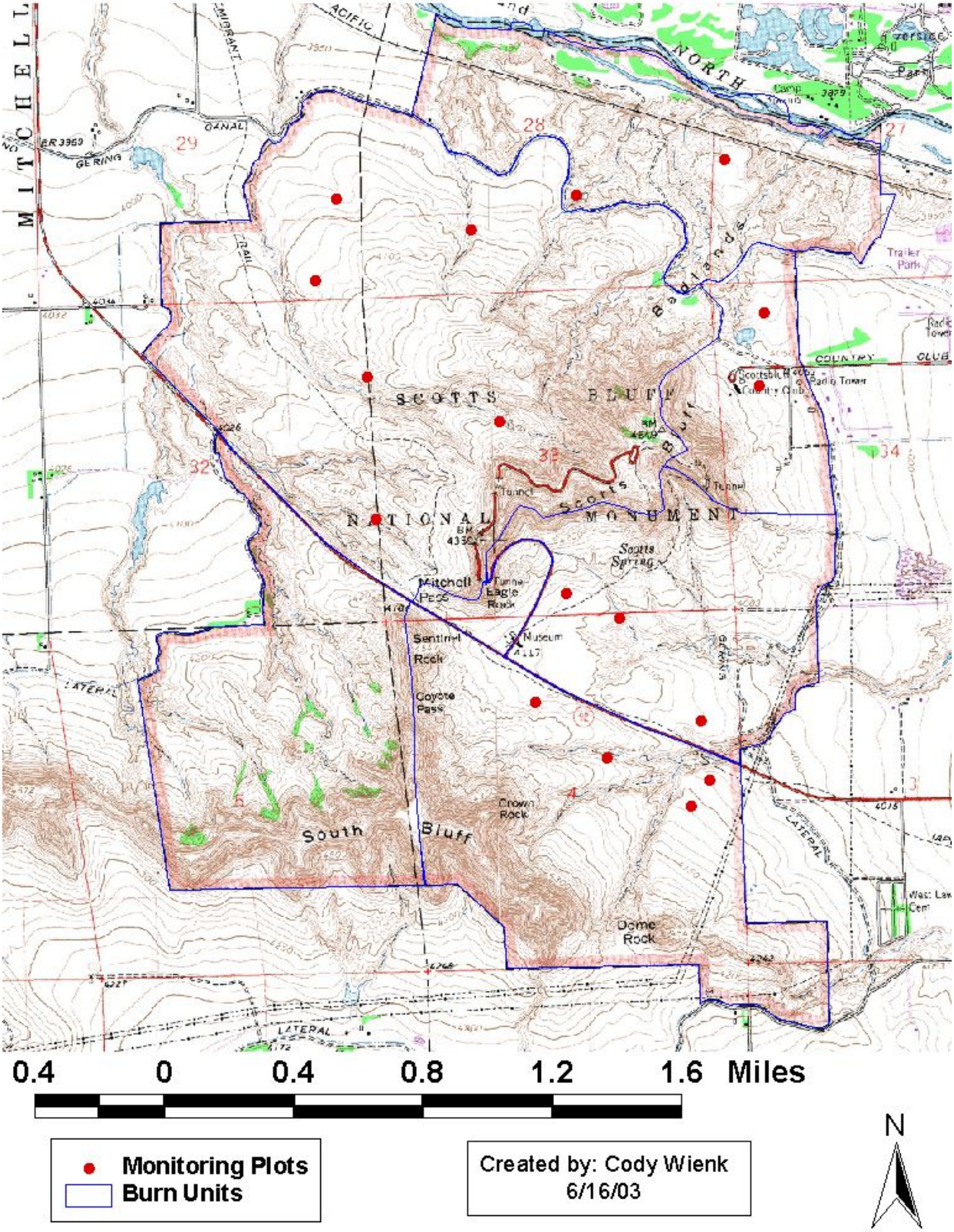
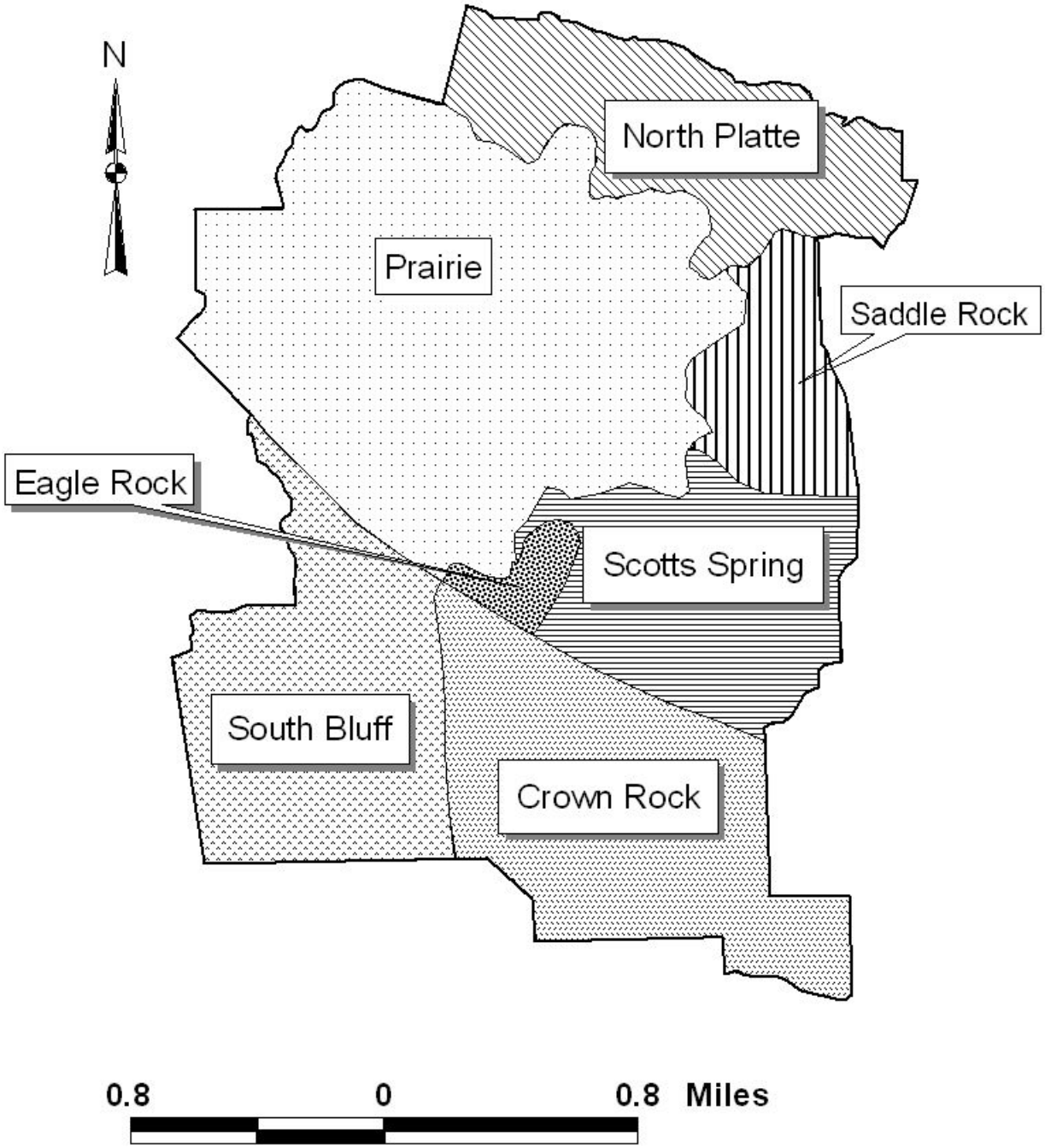


FIGURE 4. PRESCRIBED FIRE UNITS OF SCOTTS BLUFF NATIONAL MONUMENT.



APPENDICES

APPENDIX 1 – MONITORING UNIT DESCRIPTION SHEETS

FMH-4 MONITORING UNIT DESCRIPTION SHEET Park: **SCBL**

Monitoring Unit Code: GBOCU1D01 **Date Described:** 6/12/97

Monitoring Unit Name: Sideoats grama/needlegrass mixed grass prairie

Prepared by: A. Powers, G. Bradshaw, B. Braudis, B. Adams, G. Kemp, P. Reeberg, R. Manasek

Physical Description
Area includes Summits and Badlands, elevation 4,000-4,600 ft. Soils range from sandy loam to silt loam, with rock outcroppings and are well to excessively drained. Soil types include: Otero fine sandy loam, Mitchell-Epping complex and Mitchell silt loam.

Biological Description
This monitoring unit occurs where native species have been seeded in previously disturbed areas. The areas of disturbance are located on flat to rolling terrain that were used as farmland or as a golf course. These areas are currently dominated by sideoats grama (*Bouteloua curtipendula*) and green needlegrass (*Nassella viridula*). Other graminoids include threadleaf sedge *(Carex filifolia)*, needle-and-thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), and prairie sandreed (*Calamovilfa longifolia*). Ponderosa pine (*Pinus ponderosa*), and Rocky Mountain juniper (*Juniperus scopulorum*) occur on the bluff summits, slopes and sheltered ravines. Riparian areas contain plains cottonwoods (*Populus deltoides*), boxelder (*Acer negundo*), and Siberian elm (*Ulmus pumila*). Non-native species include crested wheatgrass (*Agropyron cristatum*), dwarf alyssum (*Alyssum desertorum*), cheatgrass (*Bromus tectorum*), Japanese brome (*Bromus japonicus*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*), and tumble mustard (*Sisymbrium altissimum*).

Rejection Criteria
Large outcroppings or barren areas >20% of the plot; areas with anomalous vegetation; monitoring unit 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
Mixed-grass prairie dominated by western wheatgrass, needle-and-thread, and grama grasses (*Bouteloua* spp.) is believed to be the major pre-settlement vegetation type for the area, although the exact composition of the communities before settlement is unknown. Kuchler (1964) described the potential vegetation for the Scotts Bluff area as wheatgrass-needlegrass prairie. The fire return intervals reported vary from as short as five years in level to gently rolling topography to 15-30 years in more broken topography (e.g. badlands) at Scotts Bluff National Monument, Nebraska (Wendtland and Dodd 1992). It is believed that the fire return interval in these areas would have been short.

It is desired to have a community with reduced amounts of exotic cool season grasses and weedy

annuals while maintaining or increasing native grass cover. The natural diversity of associated native species would be preserved or increased. A gradual increase in the number and types of native forbs is anticipated as these species spread into these areas from adjacent native prairie.

Burn Prescription
This prairie will be burned when vegetation is cured, preferably early spring or late summer to early fall.

Fire Prescription Elements	
RH: **25-55%**	Average Flame Length: **0.4-1.5 feet**
Bulb: **30-85 °F**	Live Fuel Moisture: **NA**
Average Mid-flame winds: **0-20 mph**	1-hour TLFM: **6-14%**
Fuel loading: **3-5 tons/acre**	10-hour TLFM: **8-15%**
Average Rate of Spread: **0-3 ch/hr.**	100-hour TLFM: **10-30%**

Monitoring Variables (in order of importance)
- Native Perennial Grass Relative Cover
- Non-native Grass Relative Cover
- Native Forb Relative Cover

Prescribed Fire Objectives*
Immediate post-burn
- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3) as defined in the Fire Monitoring Handbook

Two years post-burn
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Five years post-burn
- Maintain increase in native species
- Maintain reduction in non-native species

Fire Monitoring Objectives
- Install enough plots to be 80% confident that relative cover of native perennial grass and forb species is within 25% of the true population mean.
- Install enough plots to be 80% confident that relative cover of non-native grass and forb species is within 25% of the true population mean.

Data Analysis
- Assess relative and absolute cover of native grass and forb species after sampling years 1, 2, and 5.

* Objectives intended for first prescribed fire treatment and are subject to change as information becomes available through fire monitoring activities.

- Assess relative and absolute cover of non-native grass and forb species after sampling years 1, 2 & 5.

Relevant Literature

Kuchler, A.W. 1964. Potential natural vegetation of the coterminous United States. Special Publication 36 (Manual), American Geographical Society, New York, NY.

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.

Stumpf, J. A., J. Stubbendieck, C. H. Butterfield, and R. D. Hiebert. 1996. An assessment of prairie restoration at two national monuments. In: Warwick, C. (ed) Proceedings of the Fifteenth North American Prairie Conference.

USDA, NRCS. 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA.

USDI National Park Service. 2001. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 288 pp.

USGS. 1998. Scotts Bluff National Monument, USGS-NPS Vegetation Mapping Program Products (http://biology.usgs.gov/npsveg/scbl/index.html). USGS-NPS Vegetation Mapping Program, USGS Center for Biological Informatics, Denver, CO.

Wendtland, K.J. 1993. Fire history and effects of seasonal prescribed burning on northern mixed prairie, Scotts Bluff National Monument, Nebraska. Thesis. University of Wyoming, Laramie, WY.

Wendtland, K. J., and J. L. Dodd. 1990. The fire history of Scotts Bluff National Monument. In: Smith, D. and C. Jacobs (eds) Proceedings of the Twelfth North American Prairie Conference. Cedar Falls, Iowa.

Plot Protocols

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots/Opt		•	Herb Height/Rec	•	
	Herbaceous Density/Opt		•	Belt Transect Width: 2 meters *		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens/Rec	•		Stakes Installed: 0P & 30P		
	Stereo Photography/Opt		•	Crown Intercept/Opt		•
	Brush Individuals/Rec		•	Herb. Fuel Load/Opt		•
	Herbaceous Data Collected at: 0P-30P					
Burn	Duff Moisture/Rec		•	Flame Zone Depth/Rec	•	
Postburn	Herbaceous Data/Opt: Not collected.			Herb. Fuel Load/Opt		•
	100 Pt. Burn Severity/Opt		•			

Rec = Recommended; Opt = Optional

* belt transect width for *Symphoricarpos occidentalis* is 0.5 meters

FMH-4 MONITORING UNIT DESCRIPTION SHEET Park**: SCBL**

Monitoring Unit Code: FJUSC1D02 **Date Described:** 6/25/98

Monitoring Unit Name: Juniper Slopes and Draws

Prepared by: A. Thorstenson, A. Powers, B. Manasek

Physical Description
Steep slopes, narrow ravines and draws with mostly north aspects over outcrops of barren rocky slopes. Soils poorly developed, shallow loamy sands, sandy loams, and clay loams. Slopes ranged from 15-75%. Elevations are from 4,000-4,600 ft. Soils range from sandy loam to silt loam, with rock outcroppings and are well to excessively drained. Soil types include; Otero fine sandy loam, Mitchell-Epping complex and Mitchell silt loam

Biological Description
Overstory dominated by Rocky Mountain juniper (*Juniperus scopulorum*) occurring mainly on steep north aspects of drainages and bluffs accounting for greater than 20% of canopy cover. Understory is predominantly blue grama (*Bouteloua gracilis*) and littleseed ricegrass (*Oryzopsis micrantha*) under the juniper canopy and needle-and-thread (*Hesperostipa comata*) and threadleaf sedge (*Carex filifolia*) in the open. Shrubs include western snowberry (*Symphoricarpos occidentalis)*, skunkbush sumac, (*Rhus aromatica*) wild rose (*Rosa woodsii*) and winterfat (*Krascheninnikovia lanata*). Common forbs are milkweed (*Asclepias speciosa*) and spiderwort (*Tradescantia occidentalis*).

Selection Criteria
At least 20% canopy cover of juniper and 7 overstory juniper with in the plot.

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.

Future Desired Conditions
Mixed-grass prairie dominated by western wheatgrass (*Pascopyrum smithii*), needle-and-thread, and grama grasses (*Bouteloua* spp.) is believed to be the major pre-settlement vegetation type for the area, although the exact composition of the communities before settlement is unknown. Kuchler (1964) described the potential vegetation for the Scotts Bluff area as wheatgrass-needlegrass prairie. The juniper occupies narrow draws of steep (15-45% upper- and mid-slopes of escarpments. On the southwestern part of the monument, this community can be found in steep-sided ravines cutting through grassy uplands. Sites are often quite eroded and soils are poorly developed loose, loamy sands. The exact composition of these communities before settlement is unknown. The fire return intervals reported vary from as short as 5 years in level to gently rolling topography to 15-30 years in more broken topography at Scotts Bluff National Monument, Nebraska (Wendtland and Dodd 1992). These areas would have burned less frequently due to the broken topography and bare ground present in the community.

Fire will be used in this community to reduce density of overstory juniper, while limiting overstory mortality to less than 30% with each burn. This will help maintain shelter, cover and structure for deer, birds, and small mammals. High mortality for the juvenile trees encroaching in the prairie is anticipated and desirable. Understory vegetation is very sparse. Annual exotic brome species, cheatgrass (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*), both occur in this system and can be expected to increase in the short term (1-5 years) after prescribed fire.

Burn Prescription.
These areas will be burned in concert with the surrounding prairie. Typically the prairie will be burned between April until green-up, or mid-august through a season ending event in the fall.

Fire Prescription Elements	
RH: **25-55%**	Average Rate of Spread: **0-3 chains/hr**
Temperature: **30-85 °F**	Live Fuel Moisture: **NA**
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 feet**	100-hour TLFM: **10-30%**

Monitoring Variables (in order of importance)
- Density of overstory juniper
- Litter and duff fuel load
- Relative cover of native and non-native herbaceous species
- Shrub density

Prescribed Fire Objectives*
Immediate post-burn
- Burn at least 80% of the burnable project area
- Mortality of overstory juniper 10 to 30%
- Reduce litter and duff fuel load by at least 25%

Two years post-burn
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%
- Limit change in shrub density to no more than ± 30% of pre-burn shrub density

Five years post-burn
- Maintain increase in native species
- Maintain reduction in non-native species
- Maintain shrub density change to no more than ± 30% of pre-burn shrub density

* Objectives intended for first prescribed fire treatment and are subject to change as information becomes available through fire monitoring activities.

Fire Monitoring Objectives

- Install enough plots to be 80% confident that density of overstory trees is within 25% of the true population mean.
- Install enough plots to be 80% confident that litter and duff fuel load is within 25% of the true population mean.
- Install enough plots to be 80% confident that relative cover of native and non-native herbaceous species is within 25% of the true population mean.
- Install enough plots to be 80% confident that shrub density is within 25% of the true population mean.

Data Analysis

- Assess density of overstory trees after sampling years 1, 2 and 5.
- Assess liter and duff fuel load after sampling immediate post-burn and year 1.
- Assess relative and percent cover of native and non-native herbaceous species after sampling years 1, 2, and 5.
- Assess shrub density after sampling year 1, 2, and 5.

Relevant Literature

Kuchler, A.W. 1964. Potential natural vegetation of the coterminous United States. Special Publication 36 (Manual), American Geographical Society, New York, NY.

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.

Stumpf, J. A., J. Stubbendieck, C. H. Butterfield, and R. D. Hiebert. 1996. An assessment of prairie restoration at two national monuments. In: Warwick, C. (ed) Proceedings of the Fifteenth North American Prairie Conference.

USDA, NRCS. 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA.

USDI National Park Service. 2001. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 288 pp.

USGS. 1998. Scotts Bluff National Monument, USGS-NPS Vegetation Mapping Program Products (http://biology.usgs.gov/npsveg/scbl/index.html). USGS-NPS Vegetation Mapping Program, USGS Center for Biological Informatics, Denver, CO.

Wendtland, K.J. 1993. Fire history and effects of seasonal prescribed burning on northern mixed prairie, Scotts Bluff National Monument, Nebraska. Thesis. University of Wyoming, Laramie, WY.

Wendtland, K.J., and J.L. Dodd. 1990. The fire history of Scotts Bluff National Monument. In: Smith, D. and C. Jacobs (eds) Twelfth North American Prairie Conference. Cedar Falls, Iowa.

Plot Protocols

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots/Opt		•	Herb Height/Rec	•	
	Herbaceous Density/Opt		•	Belt Transect Width: 5 meters *		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens/Rec	•		Stakes Installed: All		
	Stereo Photography/Opt		•	Crown Intercept/Opt		•
	Brush Individuals/Rec		•	Herb. Fuel Load/Opt		•
	Herbaceous Data Collected at: **Q4-Q1**					
Burn	Duff Moisture/Rec		•	Flame Zone Depth/Rec	•	
Postburn	Herbaceous Data/Opt: FMH - 17			Herb. Fuel Load/Opt		•
	100 Pt. Burn Severity/Opt		•			

FOREST PLOT PROTOCOLS		YES	NO		YES	NO
Overstory	Area sampled: 50 x20m			Quarters Sampled: Q1-Q4		
	Tree Damage/Rec	•		Crown Position/Rec	•	
	Dead Tree Damage/Opt		•	Dead Crown Position/Opt		•
Pole-size	Area Sampled: 25 x10m			Quarters Sampled: Q1		
	Height/Rec	•		Poles Tagged/Rec		•
Seedling	Area Sampled: 5 x 10m			Quarters Sampled: Subset of Q1		
	Height/Rec	•		Seedlings Mapped/Opt		•
Fuel Load	Sampling Plane Length: 6, 6, 12, 100, 100			Fuel Continuity/Opt		•
	Aerial Fuel Load/Opt		•			
Postburn	Char Height/Rec	•		Mortality/Rec	•	

Rec = Recommended Opt = Optional
* see notes section.

FMH-4 **MONITORING UNIT DESCRIPTION SHEET** Park: **SCBL**

Monitoring Unit Code: GSTCO1DO1 **Date Described:** 6/12/97

Monitoring Unit Name: Needlegrass/Sedge Mixed-grass Prairie

Prepared by: A. Powers, G. Bradshaw, B. Braudis, R. Manasek, B. Adams, G. Kemp, P. Reeberg

Physical Description
Area includes Summits and Badlands, elevation 4,000-4,600 ft. Soils range from sandy loam to silt loam, with rock outcroppings and are well to excessively drained. Soil types include: Otero fine sandy loam, Mitchell-Epping complex and Mitchell silt loam.

Biological Description
A mixed-grass prairie dominated by threadleaf sedge (*Carex filifolia*) and needle-and-thread (*Hesperostipa comata*). Other grasses include western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), prairie sandreed (*Calamovilfa longifolia*), and sideoats grama (*Bouteloua curtipendula*). Ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*) occur on the bluff summits, slopes and sheltered ravines. Riparian areas contain plains cottonwoods (*Populus deltoides*), boxelder (*Acer negundo*), and Siberian elm (*Ulmus pumila*). Non-native species include crested wheatgrass (*Agropyron cristatum*), dwarf alyssum (*Alyssum desertorum*), cheatgrass (*Bromus tectorum*), Japanese brome (*Bromus japonicus*), kochia (*Kochia scoparia*), and Russian thistle (*Salsola tragus*).

Rejection Criteria
Large outcroppings or barren areas >20% of the plot; areas with anomalous vegetation; monitoring unit 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 Conditions
Mixed-grass prairie dominated by western wheatgrass, needle-and-thread, and grama grasses (*Bouteloua* spp.) is believed to be the major pre-settlement vegetation type for the area, although the exact composition of the communities before settlement is unknown. Kuchler (1964) described the potential vegetation for the Scotts Bluff area as wheatgrass-needlegrass prairie. The fire return intervals reported vary from as short as five years in level to gently rolling topography to 15-30 years in more broken topography (e.g. badlands) at Scotts Bluff National Monument, Nebraska (Wendtland and Dodd 1992).

Most areas at the base of the bluff would have had a shorter fire return interval. The North Platte burn unit contains badlands topography around it and it would probably have had longer intervals between prescribed fires, see the Fire Management Plan (FMP) for details.

It is desired to have a community with reduced amounts of exotic cool season grasses and weedy annuals while maintaining or increasing native grass cover. The natural diversity of associated native species would be preserved or increased. There could be short-term (2-4 years) increases

in native forbs following prescribed fire.

Burn Prescription
This prairie will be burned when vegetation is cured, preferably late summer to early fall.

Fire Prescription Elements	
RH: **25-55%**	Average Flame Length: **0.4-1.5 feet**
Temp: **30-85 °F**	Live Fuel Moisture: **NA**
Average Mid-flame winds: **0-20 mph**	1-hour TLFM: **6-14%**
Fuel loading: **3-5 tons/acre**	10-hour TLFM: **8-15%**
Average Rate of Spread: **0-3 chains/hr.**	100-hour TLFM: **10-30%**

Monitoring Variables (in order of importance)
- Relative cover of native perennial grass and native forb species
- Relative cover of non-native grass and forb species

Prescribed Fire Objectives*
Immediate post-burn
- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3) as defined in the Fire Monitoring Handbook

Two years post-burn
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Five years post-burn
- Maintain increase in native species
- Maintain reduction in non-native species

Fire Monitoring Objectives
- Install enough plots to be 80% confident that relative cover of native perennial grass and forb species is within 25% of the true population mean.
- Install enough plots to be 80% confident that relative cover of non-native grass and forb species is within 25% of the true population mean.

Data Analysis
- Assess relative and absolute cover of native grass and forb species after sampling years 1, 2, and 5.
- Assess relative and absolute cover of non-native grass and forb species after sampling years 1, 2 & 5.

* Objectives intended for first prescribed fire treatment and are subject to change as information becomes available through fire monitoring activities.

Relevant Literature

Kuchler, A.W. 1964. Potential natural vegetation of the coterminous United States. Special Publication 36 (Manual), American Geographical Society, New York, NY.

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.

Stumpf, J. A., J. Stubbendieck, C. H. Butterfield, and R. D. Hiebert. 1996. An assessment of prairie restoration at two national monuments. In: Warwick, C. (ed) Proceedings of the Fifteenth North American Prairie Conference.

USDA, NRCS. 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA.

USDI National Park Service. 2001. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 288 pp.

USGS. 1998. Scotts Bluff National Monument, USGS-NPS Vegetation Mapping Program Products (http://biology.usgs.gov/npsveg/scbl/index.html). USGS-NPS Vegetation Mapping Program, USGS Center for Biological Informatics, Denver, CO.

Wendtland, K.J. 1993. Fire history and effects of seasonal prescribed burning on northern mixed prairie, Scotts Bluff National Monument, Nebraska. Thesis. University of Wyoming, Laramie, WY.

Wendtland, K.J., and J.L. Dodd. 1990. The fire history of Scotts Bluff National Monument. In: Smith, D. and C. Jacobs (eds) Twelfth North American Prairie Conference. Cedar Falls, Iowa.

Plot Protocols

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots/Opt		•	Herb Height/Rec	•	
	Herbaceous Density/Opt		•	Belt Transect Width: 2 meters *		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens/Rec	•		Stakes Installed: 0P & 30P		
	Stereo Photography/Opt		•	Crown Intercept/Opt		•
	Brush Individuals/Rec		•	Herb. Fuel Load/Opt		•
	Herbaceous Data Collected at: 0P-30P					
Burn	Duff Moisture/Rec		•	Flame Zone Depth/Rec	•	
Postburn	Herbaceous Data/Opt: Not collected.			Herb. Fuel Load/Opt		•
	100 Pt. Burn Severity/Opt		•			

Rec = Recommended, Opt = Optional

* belt transect width for *Symphoricarpos occidentalis* is 0.5 meters

FMH-4 **MONITORING UNIT DESCRIPTION SHEET** Park: **SCBL**

Monitoring Unit Code: BSYOC1D01 **Date Described:** 6 /12/97

Monitoring Unit Name: Western Snowberry Shrubland Alliance

Prepared by: A. Powers, G. Bradshaw, B. Braudis, R. Manasek, B. Adams, G. Kemp, P. Reeberg

Physical Description
Area includes Summits and Badlands, elevation 4,000-4,600 ft.. Soils range from sandy loam to silt loam, with rock outcroppings and are well to excessively drained. Soil types include Otero fine sandy loam, Mitchell-Epping complex and Mitchell silt loam.

Biological Description
Shrublands are dominated by western snowberry (*Symphoricarpos occidentalis*), winterfat (*Krascheninnikovia lanata*), skunkbush sumac (*Rhus aromatica*), and lesser amounts of common chokecherry (*Prunus virginiana*), wild rose (*Rosa woodsii*), silver buffaloberry (*Shepherdia argentea*), rubber rabbitbrush (*Chrysothamnus nauseosus*), yucca (*Yucca glauca*), and prickly pear (*Opuntia* spp.). The herbaceous layer consists of western wheatgrass (*Pascopyrum smithii*), sideoats grama (*Bouteloua curtipendula*), smooth brome (*Bromus inermis*), Japanese brome (*Bromus japonicus*), needle-and-thread (*Hesperostipa comata*), goatsbeard (*Tragopogon dubius*), prickly lettuce (*Lactuca serriola*), sunflower (*Helianthus* spp.), and prairie coneflower (*Ratibida columnifera*).

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

Desired Future Conditions
Mixed-grass prairie dominated by western wheatgrass, needle-and-thread, and grama grasses (*Bouteloua* spp.) is believed to be the major pre-settlement vegetation type for the area, although the exact composition of the communities before settlement is unknown. Kuchler (1964) described the potential vegetation for the Scotts Bluff area as wheatgrass-needlegrass prairie. The shrubland normally occupies lower slopes of escarpments and walls, and beds of draws and channels on the plains. Soils are colluvial silt and sandy loam and not rapidly drained. The fire return intervals reported vary from as short as 5 years in level to gently rolling topography to 15-30 years in more broken topography at Scotts Bluff National Monument (Wendtland and Dodd 1992). These areas would have burned less frequently due to the mesic nature of the sites compared to the surrounding prairie.

The desired future condition of this community is to have increased availability of browse for deer. Snowberry, skunkbush sumac, and poison ivy (*Toxicodendron rydbergii*) are all common shrubs in this community. These shrub species tend to sprout vigorously following fire. The

historical pictures of the area show less shrub cover than is now present. Without the presence of large ungulates, the shrub cover will not likely decrease, but the area that this community covers will stay the same or increase in size.

Burn Prescription
This prairie will be burned when vegetation is cured, preferably late summer to early fall.

Fire Prescription Elements	
RH: **25-55%**	Average Rate of Spread: **0-3 chains/hr**
Bulb: **30-85 °F**	Live Fuel Moisture: **NA**
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 feet**	100-hour TLFM: **10-30%**

Monitoring Variables (in order of importance)
- Shrub density by species and age class
- Relative cover of native perennial grasses
- Relative cover of non-native annual grasses
- Relative cover of forbs

Prescribed Fire Objectives[*]
Immediate post-burn
- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3) as defined in the Fire Monitoring Handbook

One year post-burn
- Shrub density of snowberry resprouts at least 40% of pre-burn snowberry density

Two years post-burn
- Limit change in shrub density to no more than ± 30% of pre-burn shrub density
- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Five years post-burn
- Maintain shrub density change to no more than ± 30% of pre-burn shrub density
- Maintain increase in native species
- Maintain reduction in non-native species

Fire Monitoring Objectives
- Install enough plots to be 80% confident that shrub density of all species is within 25% of the population mean.
- Install enough plots to be 80% confident that relative cover of perennial grasses and forbs is

[*] Objectives intended for first prescribed fire treatment and are subject to change as information becomes available through fire monitoring activities.

within 25% of the population mean.
- Install enough plots to be 80% confident that relative cover of non-native annual grass species is within 25% of the population mean.

Data Analysis
- Assess shrub density, by species, after sampling years 1, 2, and 5.
- Assess relative and absolute cover of native grass and forb species after sampling years 1, 2, and 5.
- Assess relative and absolute cover of non-native grass and forb species after sampling years 1, 2, and 5.

Relevant Literature

Kuchler, A.W. 1964. Potential natural vegetation of the coterminous United States. Special Publication 36 (Manual), American Geographical Society, New York, NY.

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.

Stumpf, J. A., J. Stubbendieck, C. H. Butterfield, and R. D. Hiebert. 1996. An assessment of prairie restoration at two national monuments. In: Warwick, C. (ed) Proceedings of the Fifteenth North American Prairie Conference.

USDA, NRCS. 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA.

USDI National Park Service. 2001. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 288 pp.

USGS. 1998. Scotts Bluff National Monument, USGS-NPS Vegetation Mapping Program Products (http://biology.usgs.gov/npsveg/scbl/index.html). USGS-NPS Vegetation Mapping Program, USGS Center for Biological Informatics, Denver, CO.

Wendtland, K.J. 1993. Fire history and effects of seasonal prescribed burning on northern mixed prairie, Scotts Bluff National Monument, Nebraska. Thesis. University of Wyoming, Laramie, WY.

Wendtland, K.J., and J.L. Dodd. 1990. The fire history of Scotts Bluff National Monument. In: Smith, D. and C. Jacobs (eds) Twelfth North American Prairie Conference. Cedar Falls, IA.

Plot Protocols

GENERAL PROTOCOLS		YES	NO		YES	NO
Preburn	Control Plots/Opt		•	Herb Height/Rec	•	
	Herbaceous Density/Opt		•	Belt Transect Width: 2 meter width *		
	OP/Origin Buried		•	Abbreviated Tags	•	
	Voucher Specimens/Rec	•		Stakes Installed: 0P & 30P		
	Stereo Photography/Opt		•	Crown Intercept/Opt		•
	Brush Individuals/Rec		•	Herb. Fuel Load/Opt		•
	Herbaceous Data Collected at: 0P-30P					
Burn	Duff Moisture/Rec		•	Flame Zone Depth/Rec	•	
Postburn	Herbaceous Data/Opt: Not collected.			Herb. Fuel Load/Opt		•
	100 Pt. Burn Severity/Opt		•			

Rec = Recommended, Opt = Optional
* belt transect width for *Symphoricarpos occidentalis* is 0.5 meters

APPENDIX 2 – LONG-TERM PHOTO MONITORING

LONG TERM PHOTO MONITORING SHEET

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

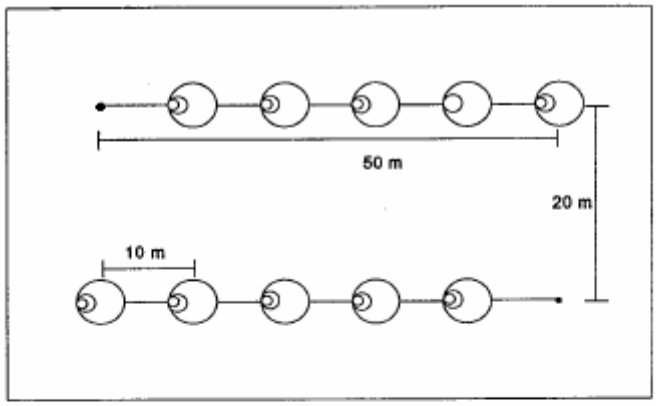
Burn Unit: _____ **Recorders: _____**

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 – PRAIRIE CLUSTER LONG-TERM ECOLOGICAL MONITORING: SAMPLING PROTOCOLS AND PLOT LOCATIONS



Plot sizes	Vegetation component sampled
0.1 m^2	Herbaceous and shrub species presence recorded
1 m^2	Herbaceous and shrub species presence recorded
10 m^2	1. Foliar cover of all herbaceous and shrub species estimated using cover class values; 2. Stems of woody seedlings (< 0.5 m tall), large seedlings (> 0.5 m tall and < 2.5 cm dbh), and saplings (> 2.5 cm DBH and < 5.0 cm dbh) counted.

Prairie Cluster LTEM Plots