



Grassland Monitoring Protocol and Standard Operating Procedures for the Southern Plains I&M Network and Fire Group

Natural Resource Technical Report NPS/SOPN/NRTR—2011/00X



ON THE COVER

Blue grama grass

Photograph by: Dawnelle Malone

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National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Folts-Zettner, T., R. Gatewood, R. Bennetts and K. Cherwin. 2011. Grassland monitoring protocol and standard operating procedures for the Southern Plains I&M Network and Fire Group. Natural Resource Technical Report NPS/SOPN/NRTR—2010/00X. National Park Service, Fort Collins, Colorado.

NPS XXXXXX, Month Year

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

1 Background and Objectives

1.1 Issues Being Addressed and Rationale

The parks of the Southern Plains Network (SOPN) are dominated by mid- and shortgrass prairies that have been impacted by grazing, fire suppression and rowcrop agriculture. Individual restoration efforts of varying techniques and duration have been employed in the past in most of these parks with mixed results. Monitoring of these efforts has been minimal. This grassland vegetation protocol has been developed to inform park management of the status and trends of the overall health of their grasslands. Collaboration with the Southern Plains Fire Group fire effects monitoring program has been developed to address broader issues of vegetation health and to achieve economic efficiencies in both programs. This protocol reflects this collaboration. A separate SOPN protocol currently in development, Exotic Plants Monitoring, will make use of data collected from this Integrated Grassland Protocol.

North American prairie once extended across the mid-continent region from Canada to Texas and from the Rocky Mountains to the Appalachian forest. The vast landscape was nearly continuous grassland, transitioning gradually from shortgrass steppe in the west to tallgrass prairie and savanna in the east. During the last century, large portions of grassland landscapes were plowed for cropland or converted to livestock pasture. Today, Great Plains grasslands are fundamentally altered by the conversion of prairie to cropland and pasture, the removal or disappearance of native ungulates, drainage of wetlands, and an increase in woody vegetation through plantings and fire suppression. Scientists estimate the loss of native prairie ranges from 80 to 99.9%, with the greatest losses occurring in the tallgrass prairie and oak savanna communities. Further, only 71% of shortgrass prairie and 59% of mixed-grass prairie remain (Knopf and Samson 1997). Fragmentation and isolation continues today at an alarming rate. Additionally, ecological driving forces such as fire and the presence of native faunal species including bison (*Bos bison*), elk (*Cervus elaphus*), and wolves (*Canis lupus*), remain largely absent from prairie systems, having been eliminated or placed under human control.

Prairies are dominated by a few matrix-forming grass species that effectively control community structure. A large number of less abundant species, referred to as satellite species, contribute to the diversity of prairie systems (Collins 1987, Collins and Glenn 1988, Collins and Glenn 1990). Distribution patterns of satellite species are inherently bimodal, varying within and between growing seasons (Collins and Glenn 1988, Collins and Gibson 1990). The nature of the above-ground plant community (e.g., the diversity of species and functional guilds) plays an important

role in determining the stability or resistance to disturbance of a prairie system (Wardle et al. 2000).

Fire frequency and seasonality plays a large role in the ecology of the Great Plains. Frequent fire is essential to maintaining native species diversity, and it affects other components, including nutrient cycling and productivity (Collins and Wallace 1990). Historically, lightning and Native Americans were the principal causes of fire. SOPN parks generally average between 40 and 50 days with thunderstorms per year (Bryson and Hare 1974) and fire ignited by summer storms occurred May through September (75% of these between July and August) when storms are most common (Bryson and Hare 1974). In the southern mixed-grass prairie, Native Americans appeared to use fire most frequently in July and August (Moore 1972). The southern mixed-grass prairie has slow litter accumulation and fires probably occurred every 3 to 10 years (Umbanhowar 1996) due to slow litter accumulation. In shortgrass, fires were less frequent, although they were reported from early travelers and were still an ecological driver of the system (Brockway et al. 2002). The majority of SOPN parks have developed fire management plans and implemented prescribed burns over the past decade, although two parks (FOUN, LYJO) employ an alternative (mechanical) control of fuel load.

Long-term ecological monitoring, while contributing to our empirical understanding of prairie communities, is integral to the proper management and protection of the lands entrusted to the National Park Service (NPS). Resource managers of the parks require an effective plant community monitoring protocol to assess their management strategies in maintaining and/or restoring prairie plant community composition, structure, and diversity. Our monitoring strategy attempts to balance the immediate needs of managers for current information and the need for insight into the changes occurring in vegetation communities over time.

1.2 Overview of Vegetation and Monitoring at Southern Plains Parks

The Southern Plains Inventory and Monitoring Network (SOPN) is composed of 11 National Park Service (NPS) units: Bent's Old Fort National Historic Site (BEOL) and Sand Creek Massacre National Historic Site (SAND), Colorado; Fort Larned National Historic Site (FOLS), Kansas; Capulin Volcano National Monument (CAVO), Fort Union National Monument (FOUN), and Pecos National Historical Park (PECO), New Mexico; Chickasaw National Recreation Area (CHIC) and Washita Battlefield National Historic Site (WABA), Oklahoma; and Alibates Flint Quarries National Monument (ALFL), Lake Meredith National Recreation Area (LAMR), and Lyndon B. Johnson National Historical Park (LYJO), Texas (Figure 1.2). Park units within the SOPN are located in shortgrass and mixed-grass ecosystems, and range in size from 326 acres (WABA) to 46,349 acres (LAMR).

The Southern Plains Fire Group (SPFG) is responsible for the majority of these same parks and is headquartered at LAMR. Four parks of the SOPN are overseen by other fire groups: FOUN and PECO are under the Bandelier Fire Group, LYJO under the Big Thicket Fire Group, and FOLS under the Midwest Region.

CHIC, FOLS, LYJO, and WABA are in mixedgrass prairie or savannah. ALFL, BEOL, CAVO, FOUN, LAMR, and SAND are located in shortgrass prairie, and PECO is in the ecotone between shortgrass prairie and piñon-juniper forest. At a finer scale, the SOPN parks can be placed in six

different vegetative zones or biomes (Küchler 1986, Omernik 1987, Bailey 1995) and eight vegetative sections.

The SOPN has a wide range of soil orders present, including dry mollisols through central Texas, central Oklahoma, and central Kansas; wet mollisols in the vicinity of CHIC; entisols and aridisols in southeastern Colorado; and aridisols and alfisols in northeastern New Mexico.

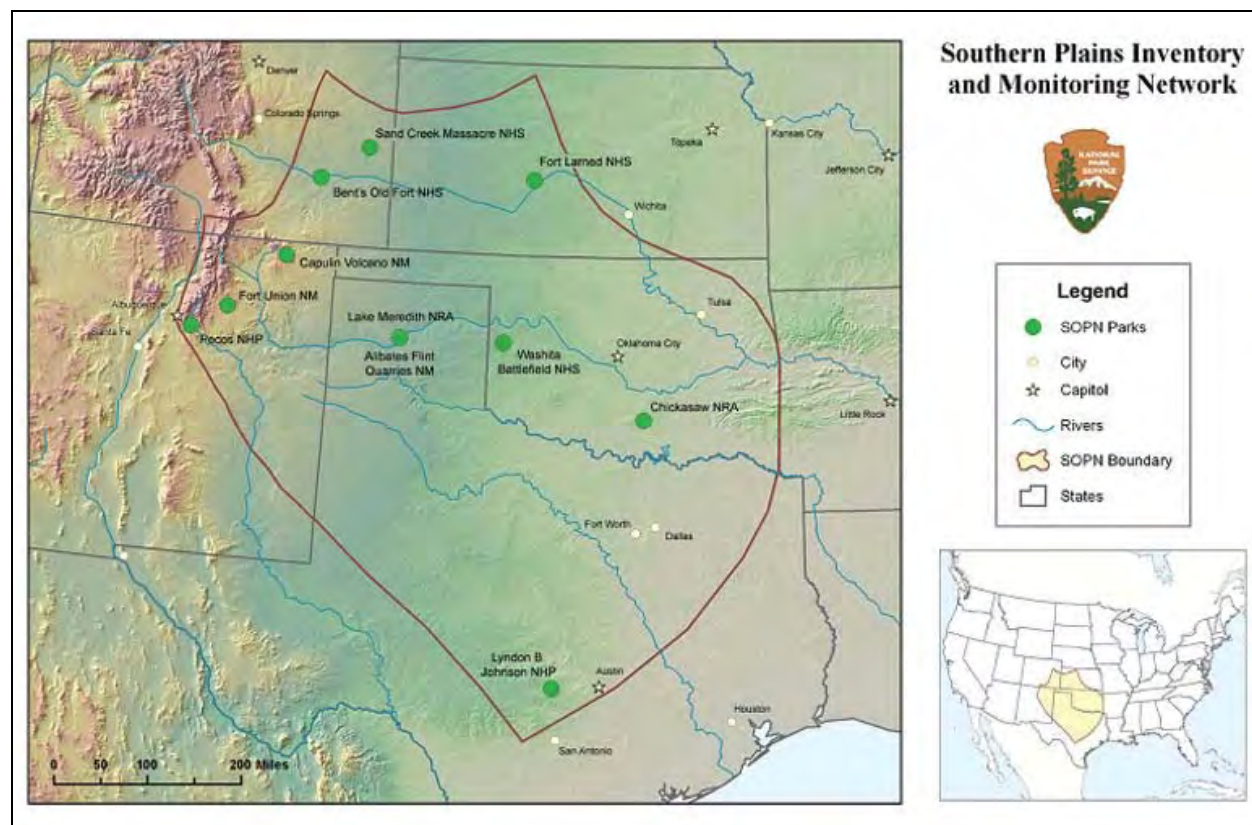


Figure 1.2. The Southern Plains Inventory and Monitoring Network.

1.2.1 Alibates Flint Quarries NM

Alibates Flint Quarries National Monument (1,371 acres [555 ha] in size and adjacent to LAMR) was created in 1965, to preserve the extensive flint quarries that were once used by prehistoric humans as a source of raw material for weapons and tools. ALFL also protects the ruins of several village sites of the Plains Village Indians, who inhabited the area circa 1200–1450 A.D. The land surface at ALFL is nearly flat and slopes to the southeast at approximately 8 to 10 feet (2.4 – 3 m) per mile. In the vicinity of Lake Meredith, this flat surface has been downcut by the Canadian River and its tributaries, causing canyons or “breaks”, some of which are now filled by Lake Meredith. The Alibates Dolomite is Permian in age and contains an abundance of flint, which was used by some of the earliest humans to make tools and points. The flint can often be found in alternating beds of gray and red. The Canadian River Basin climate is characterized as semi-arid with an average annual rainfall of 20 inches (51 cm) per year. Seventy percent of the precipitation falls between April and September, which is the primary growing season. This area has hot summers and cold winters with strong winds that work to increase evaporation rates, which have been estimated to average 60-65% of the total precipitation. Elevation is

approximately 3,200 feet (975 m). A total of 486 species have been documented and supported by vouchers from ALFL and LAMR (Wright and Meador 1981, Nesom et al. 2005). Vegetation at ALFL is dominated by yucca grassland (36%), vegetated cliffs (34%), mixed-grassland (18%), mesquite grassland (8%), and mixed forest (3%) (Lake Meredith National Recreation Area 2002). Bell et al. (2000) also provides a list of plant species from ALFL but it is un-vouchered. Bell and Coffman (2000) identified a number of major introduced plant species at ALFL. There are no known endangered or threatened plants within the boundaries of the parks. Prescribed burning has not yet been applied to the grassland at ALFL and no vegetation monitoring has taken place.

1.2.2 Bent's Old Fort NHS

Bent's Old Fort National Historic Site covers 799 acres (323 ha) along the Arkansas River in southeastern Colorado. The original adobe fort was constructed in 1833, to serve as a trade center on the Santa Fe Trail and became a staging area for the U.S. Army during the U.S.–Mexican War in 1846. The fort was abandoned in 1849, and established as a national historic site in 1960. BEOL is situated on a series of low terraces along three miles of the Arkansas River, within the Great Plains-Palouse Steppe ecological province and the short-grass prairie ecoregion Ladyman (2003). This part of the Central Short-grass physiographic region is dominated by Buffalo grass (*Buchloe dactyloides*) and blue grama grass (*Bouteloua gracilis*). Temperature and rainfall reflect seasonal patterns at BEOL. The average maximum temperature from June to August is 91°F (32°C), while the average minimum temperature from December to February is 15°F (-9.5°C). Annual precipitation averages between 11 and 15 inches (28 to 38 cm). Approximately 70 percent of the precipitation falls in April through August and only about 10 percent falls in November through February. In a 1986 assessment of prairie, James Stubbendieck estimated that approximately 638 acres of Bent's Old Fort National Historic Site was in various successional stages leading to short-grass prairie (Stubbendieck and Wilson 1986). A 2003 restoration management plan (Ladyman 2003) determined that approximately 124 acres (50 ha) were upland prairie, 271 acres (110 ha) were riparian grassland and 300 acres (121 ha) were riparian shrub- and grasslands recovering from tamarisk invasion. Grazing by livestock used in cultural interpretation still occurs (Ladyman 2003). Prairie restoration efforts continue at BEOL. Ladyman's (2003) restoration plan states that all grasslands had varying amounts of the exotic plants, including several listed on Colorado's noxious plant list. Prescribed fire has been used at BEOL since 2002, while vegetation monitoring has been sporadic.

1.2.3 Capulin Volcano

Capulin Volcano National Monument was established to preserve a volcanic cinder cone that formed more than 60,000 years ago. The park includes 793 acres (321 ha) in northeastern New Mexico. CAVO receives 16–20 inches (41 - 51 cm) of rain annually. The average annual temperatures range from 35°F to 62°F (2-17°C). Average maximum temperatures for June to August is 78°F (25.5°C), while average minimum temperatures for December to February is 19°F (-7°C). Reaching an elevation up to 8,182 feet (2,494 m), Capulin Volcano is a cinder cone primarily covered with piñonjuniper woodland and surrounded by shortgrass prairie. CAVO is located in the Arkansas Tablelands section of the Great Plains-Palouse Dry Steppe ecoregion. Six communities are identified by Natural Heritage New Mexico's (NHNM) Vegetation Community Classification system are crater grassland, disturbed grassland, piñon-juniper, lowland grassland, gamble oak and ponderosa (Johnson et al. 2003). No threatened or endangered plants were located during the field survey conducted by NHNM in 2002. Two

hundred and fortythree species (92%) of the 255 potential species were documented, including twenty-two introduced plant species (Johnson et al. 2003). An assessment of the condition of the prairie and recommendations given for management were completed by Stubbendieck and Wilson (1986). A newly instituted Fire Management Plan has introduced prescribed burning to the park. Fire effects monitoring has taken place since 2005, but no other vegetation monitoring has occurred.

1.2.4 Chickasaw NRA

Chickasaw National Recreation Area comprises 9,889 acres (4,002 ha) in south-central Oklahoma. In the late 1800s, the Chickasaw and Choctaw Native American tribal units recognized threats to the freshwater and mineral springs in this area and, consequently, requested that the federal government establish sustainable management practices (Wikle et al. 1998). The juncture of the southern Osage Plains and the Arbuckle Mountains in south-central Oklahoma is a transitional ecotone of Eastern deciduous forest and the Western prairies. Although much of Chickasaw National Recreation Area is in the Arbuckle Mountains physiographic province, the northwestern portion of CHIC is a transitional area to the low rolling hills of the redbed plains (Hoagland and Johnson 1999). The topography of the park is moderately rolling with several steep bluffs in the northern portion and level terrain on the upland areas in the southern portion. Elevations range from 872 feet (266 m) at Lake Arbuckle to 1,082 feet (330 m) at Mount Airy (Chickasaw National Recreation Area 1999). The park is located in the Subtropical Humid climate zone (Hoagland & Johnson 2001), resulting in a warm continental climate. Summers are hot and humid, with an average maximum temperature June–August of (91°F [33°C]) and prevailing winds from the southwest. Winters are mild with an average minimum temperature December–February of (28°F [-2°C]). Snowfall is light and lasts only a few days, resulting in a relatively dry season. Average annual precipitation is 38 inches (97 cm), with 70% falling during the warm months predominately from thunderstorms. Damaging hail is common and tornados not unusual (Chickasaw National Recreation Area 1997). Mixed grasslands (primarily *Schizachyrium scoparium*–*Sorghastrum nutans*) and oak forests cover a large portion of the upland areas, while riparian vegetation dominates the lowlands. There are no federally threatened or endangered plant species known to exist in the recreation area (Chickasaw National Recreation Area 1999). Oklahoma Biological Survey documented 582 taxa during an inventory in 2000 and noted there was a floristic affinity with the Edwards Plateau. Ten species are tracked by the Oklahoma Natural Heritage Inventory. Grazing was allowed throughout much of the park until 1986 (Chickasaw National Recreation Area 1997) but continues today only within a fenced pasture containing reintroduced bison (Chickasaw National Recreation Area 1999). Vegetation management using prescribed fire began in 1998 in an effort to restore habitat health (Chickasaw National Recreation Area 1999) and is the only vegetation monitoring that has taken place.

1.2.5 Fort Larned NHS

Fort Larned National Historical Site encompasses 718 acres (291 ha) along the banks of the Pawnee River, most of which falls within the Pawnee River floodplain. Fort Larned, originally established to protect traffic along the Santa Fe Trail, became a key U.S. military base during the Indian Wars. FOLS is located in the South-central Great Plains section of the Great Plains Steppe Ecological Province at an elevation of approximately 2000 feet (610 m). FOLS has a semi-arid continental climate, generally west of the flow of Gulf moisture and east of the Rocky Mountain rain shadow (Becker et al. 1986), with changeable temperatures and precipitation. The average maximum temperature of 89°F (31.5°C) June through August is made more bearable by a

constant breeze and low humidity. The dry season of winter brings average minimum temperatures of 19°F (-7°C) December through February. Snowfall averages 20 inches (51 cm) annually and seldom persists longer than three days after a snow event (Becker et al. 1986). The average annual precipitation nears 23 inches (58 cm), with most of the moisture falling from intense thunder storms August through October. Winds are constant with only rare periods of calm (National Park Service 1979). The detached Trail Ruts unit is found on gently rolling uplands 4.5 miles (7.2 km) southwest of the Fort unit. It is estimated that at least 400 acres (162 ha) (60%) of FOLS is considered grassland habitat (Becker et al. 1986). Both units lie on the western edge of the mixed-grass prairie region of Kansas, characterized by grama grasses (*Bouteloua* spp.), buffalograss (*Buchloe dactyloides*), big bluestem (*Andropogon gerardii*), indian grass (*Sorghastrum nutans*) and associated species (Choate et al. 1998). The Trail Ruts unit, while never plowed, has had its original prairie vegetation heavily impacted by grazing and prairie dogs. It is estimated that 76% of FOLS is formerly cropped grassland that has undergone continuing prairie restoration since 1964 (Delisle and Busby 2004). There are no known federally threatened or endangered plant or animal species at Fort Larned. Prairie restoration at FOLS began in 1968. The management tool of mowing was augmented in 1983 by the onset of prescribed burning (Stubbendieck and Willson 1986). FOLS falls outside of the Southern Plains Fire Group, requiring that SOPN monitor grasslands independently or form a collaboration with the Midwest Region Fire Group.

1.2.6 Fort Union NM

Fort Union National Monument (721 acres [292 ha]) was established in 1956, to preserve and protect the mid-19th century fort situated on the Santa Fe Trail in New Mexico. The monument, at an elevation of 6,800 feet (2,073 m), is located in a wide valley of Wolf Creek, on the southwestern fringe of the Great Plains. Annual precipitation is 16-20 inches (41 - 51 cm), with the majority of rain falling from May to September, results in a semi-arid climate with notable periods of wind (Muldavin et al. 2004). Fort Union is in a region of the heaviest thunder and lightening regions in the nation (Fort Union National Monument 2000). Temperatures range from an average high of 80°F (27°C) from June to August to an average low of 14°F (-10°C) for December to February, with daily temperature fluctuations of 30°F (16.8°C) or more. FOUN is located in the southern parks and ranges section of the Southern Rocky Mountain Steppe ecoregion. An assessment of prairie carried out by Stubbendieck and Willson (1986) classified the majority of the monument as native prairie “in excellent condition,” with blue grama as the dominant grass, thought to be similar to conditions of 1884. A more recent survey of vegetation by Natural Heritage New Mexico in 2004 described the plant life at FOUN as relatively diverse, with the shortgrass prairie still dominant yet reflecting the impacts of historic use. Drought was prevalent during the three summer seasons of this survey, resulting in the identification of 142 taxa, 16 plant associations and 11 alliances. The vegetation survey carried out by Natural Heritage New Mexico found only twelve species they considered “non-native alien introductions,” with none posing significant threats to native species (Muldavin et al. 2004). Lack of grazing on these prairies, while initially beneficial, may now limit range improvement. FOUN continues to be surrounded by a 96,000-acre (38,850 ha) cattle ranch that pre-dates the 1891 closure of the fort (Johnson et al. 2003a). The reintroduction of fire into this grassland is not feasible at this time. No vegetation monitoring has been carried out at FOUN in the past.

1.2.7 Lake Meredith NRA

Lake Meredith was formed in the 1962, when the U.S. Bureau of Reclamation constructed the Sanford Dam on the Canadian River. LAMR was designated as a national recreation area in 1990, at which time its management was transferred from the U.S. Bureau of Land Management to the NPS. LAMR, covering 46,349 acres (18,757 ha), is located on the High Plains of the Llano Estacado, specifically along the Breaks created by the Canadian River as it meanders west-east across the Texas Panhandle. Much of LAMR is in the category “Rough Broken Land” that can be divided into Mesa Top, Gravelly Slope, Steep Slope, and Bottomland. This area of Texas is comprised of gently rolling to moderately rough topography. Narrow, intermittent stream valleys flowing east to southeast dissect it. The Canadian River Basin climate is characterized as semi-arid with an average annual rainfall of 20 inches (51 cm) per year. Seventy percent of the precipitation falls between April and September, which is the primary growing season. This area has hot summers and cold winters with strong winds that work to increase evaporation rates, which have been estimated to average 60-65% of the total precipitation. The elevation ranges from 2800 to 3320 feet (853-1,012 m). A total of 486 species have been documented and supported by vouchers from the park (Wright and Meador 1981, Nesom et al. 2005). An earlier plant list by Phillips (1997) lists 516 species but there are no voucher specimens to support the list, and Nesom et al. (2005) estimated that 59 of these species were unlikely to occur at LAMR. Much of the terrain surrounding the parks consists of flat grasslands. The predominant vegetative cover is comprised of blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), and buffalo grasses. Nesom et al. (2005) detected 47 exotic species, from the park based on vouchered specimens. There are no known endangered or threatened plants within the boundaries of the parks. Prescribed fire has been used at LAMR since 1998.

1.2.8 Lyndon B. Johnson NHP

Lyndon B. Johnson National Historical Park preserves the birthplace, boyhood home, ranch, and final resting place of the 36th president of the United States. The two districts of LYJO, one consisting of the LBJ Ranch and the other of properties in Johnson City, Texas, total 674 acres (273 ha). The park is classified as southwest plateau and plains dry steppe and shrub according to Bailey (1994). Elevations range from 1190 to 1565 feet (363-477 m). The subtropical, subhumid character of the Edwards Plateau results in a sunny, mild climate, except for summer’s high humidity and 100°F (38°C) temperatures. Winter temperatures are usually in the 50s°F (10°C); snow and ice are rare. Annual precipitation averages about 32 inches (81 cm), with May and September the wetter months and November, December and January the driest months. LYJO lies in the Hill Country of south-central Texas, and has a landscape of forested hills and grasslands. The majority of the Ranch District is managed as improved range with exotic plant species. The Johnson City District has approximately 39 acres that can be classified as prairie or semi-natural prairie (Stubbendieck and Willson 1986), however these areas also contain a large number of exotic species. Two floristic inventories have documented 609 native and cultivated species (including distinct varieties, cultivars, and hybrids) occurring (Sanders and Gallyoun 2004, Sanders 2005). The first intensive inventory was conducted in 2002 and was completed at the end of a drought. An additional 2005 inventory was done in a year with normal or slightly above normal precipitation and documented 51 additional species. Sanders (2005) documented two new introduced naturalized species that had not been reported from Texas. Prescribed burning at LYJO has been determined to be inappropriate at this time. LYJO falls within the Big Thicket Fire Group, requiring that SOPN monitor grasslands independently.

1.2.9 Pecos NHP

Pecos National Historical Park (6,670 acres [2,699 ha]) was designated in 1965, to preserve an exceptional cultural and natural area with a long human history. Paleo-Indians, archaic people, basket makers, and Puebloan peoples all left evidence of early use in the valley, followed by Spanish and Anglo settlement. Most of PECO lies in the upper Pecos River valley. This narrow valley is bordered by the 13,000-foot (3,962 m) Sangre de Cristo Mountains to the north, the rugged hills of the Tecolote Range to the east, and the steep Glorieta Mesa to the west. The 8,200-foot (2,499 m) Glorieta Mesa escarpment is the most prominent geologic feature in the area, rising abruptly above the 7,000-foot (2,134 m) valley floor. Annual precipitation varies from 16 to 20 inches (41-51 cm) per year, with the majority falling during the summer season. Temperatures range from an average high of 80°F (27°C) June to August to an average low of 15°F (-9°C) December through February. The spring season tends to be windy. The southern Rocky Mountain Steppe geographic province, southern parks and ranges ecoregion gives way to the Mexican Highlands in this area, producing a climate and vegetation unique for this elevation. Major habitats found within PECO include riparian corridors, grasslands of old pastures, and predominant piñon/juniper woodland (Parmenter and Lightfoot 1996). Approximately 40 acres (of the original monument) is classified as Grama-Galleta Steppe prairie. A vegetation survey conducted by PECO between 1992 and 1994 resulted in 354 species of vascular plants, 57 of which were exotics (Reed et al. 1999). There are no threatened or endangered plants or animals documented at PECO. Grazing generally ceased in June 1967 when the boundary fence was completed. The 64-acre core of the monument has been closed to grazing since the 1940s, while the newest acreage was protected from grazing in 1978 (Stubendieck and Willson 1986). Naturally occurring fire has been suppressed for at least 50 years but a prescribed burn program is now in place. PECO falls outside of the Southern Plains Fire Group, however a collaboration with the Bandelier Fire Group for monitoring at this one park is underway.

1.2.10 Sand Creek Massacre NHS

The recently formed Sand Creek Massacre National Historic Site (2,400 acres [971 ha]) lies along a 5.5-mile (8.85 km) stretch of Big Sandy Creek in southeastern Colorado. Established in 2007, SAND commemorates the Sand Creek Massacre of November 1864. SAND is located within the High Plains section of the Great Plains-Palouse Dry Steppe Province ecoregion, at an elevation of approximately 4,000 feet (1,219 m). The climate at SAND is fairly typical of the eastern Colorado Plains – predominately clear and dry with moderate winds out of the southeast. Average annual precipitation is 13-14 inches (33-36 cm), falling fairly evenly throughout the year. Summer thunderstorms can bring heavy rains and hail, while winter snowfalls average 27 inches (69 cm) annually (Anderson et al. 1981). Temperatures range from an average of 87°F (31°C) from June through August, to an average minimum of 14°F (-10°C) December through February. There are three types of habitat identified: riparian cottonwood along sections of the creek, short-grass prairie north of Big Sandy Creek; and the sand sage (*Artemisia filifolia*) community to the south. Within these grassland communities there are pockets of grasslands with tall-grass species due to the sandy soils. The blue grama (*Bouteloua gracilis*) and buffalo grasses (*Buchloe dactyloides*) of the short-grass prairie dominate at SAND. Sand sage has gained a foothold on drier slopes and where grazing has been excessive (National Park Service 2000). As a newly-formed park, a Fire Management Plan will be developed, with a goal of introducing prescribed fire.

1.2.11 Washita Battlefield NHS

Washita Battlefield National Historic Site (326 acres [132-ha]), located on the banks of the Washita River, protects and interprets the site where the 7th U.S. Cavalry, led by George Armstrong Custer, attacked the Southern Cheyenne village of Chief Black Kettle in November 1868. WABA is in the Rolling Plains, near the western limit of the Redbed Plains physiographic region of the Great Plains Steppe and Shrub Province. The Washita River winds west to northeast for 1.25 miles (2 km) across the park, dividing WABA into a floodplain bounded to the north and south by wooded “benches” at an approximate 2000 foot (610 m) elevation. The climate at Washita Battlefield is sub humid, temperate and continental. It is characterized by hot summers, mild winters, relatively high wind velocities and wide fluctuations in rainfall. Average maximum temperature June through August is 91°F (33°C), while average minimum temperatures December through February is 23°F (-5°C). Average annual precipitation is 25 inches (64 cm) with most of this falling between April and August. Severe thunderstorms are common and can produce tornados (National Park Service 2001). The surrounding landscape is classified as dry plains, steppe with moderate valley slopes (2–20%), and a gently rolling topography (Bergey 2003). The area was once continuous mixed and shortgrass prairie amid red sandstone and gypsum outcroppings. It is estimated that historically, riparian areas covered 19 acres (8 ha) of park, while grassland dominated 316 acres (128 ha) (Hoagland et al. 2005). Baseline vegetation data was collected under drought conditions by Stotts and DuBey (1998). Their analysis suggested that the southern riparian area was the most “pristine,” the upland prairie in the southeast sector was the most ecologically healthy, and that the wooded “bench” to the north, although heavily grazed, had never been plowed (Stotts and DuBey 1998; Milner 2003). The Oklahoma Biological Survey conducted a vascular flora inventory in 2002, collecting over eight months. They documented 272 species of vascular plants, 32 of which were trees, shrubs or vines. Five species tracked by the Oklahoma Natural Heritage Inventory were found (Hoagland et al. 2005). Thirty-two exotic species were documented, representing 11.8% of the flora collected at Washita Battlefield (Hoagland et al. 2005), several of which are listed by the State of Oklahoma as noxious weeds. There are no endangered or threatened species found at WABA. Prescribed fire has been in use at the park since 2003 with the only plant monitoring being conducted through fire effects monitoring.

1.3 Measurable Objectives for the Grassland Monitoring Protocol

SOPN has developed the following objectives for grassland vegetation monitoring:

1. Determine status and trends in plant species composition (richness and diversity) and community structure (relative abundance, frequency, distribution, ground cover) of remnant, disturbed and/or restored grasslands

Justification: In the Great Plains, grasslands have been converted to agricultural land and urban areas, their hydrology has been altered, and they have been degraded due to overgrazing, increased land fragmentation, fire suppression, and exotic species invasion. Changes in the vegetation communities can lead to subsequent changes in the faunal communities and natural processes. Land fragmentation, exotic species, and altered fire regimes with subsequent invasion by native woody species are major threats to SOPN grasslands. Land fragmentation can increase the chances of exotic plant species invasion and alters landscape-scale processes including species immigration and emigration in SOPN grasslands. Exotic plants can greatly alter ecosystem processes and displace native communities. Moreover, even native woody species

such as Eastern red cedar, mesquite, Ashe juniper, and pinion juniper represent a threat to SOPN parks as they invade/encroach and convert native grasslands to wood- and shrublands.

2. Determine relationship between status and trends of species composition and community structure and environmental variables including such things as long-term management actions, climate, and atmospheric deposition.

Justification: The structure of the vegetation is a primary identifying characteristic of the ecosystem; changes in structure may be rapid or gradual and are indicative of ecologically important trends. In addition, grassland vegetation structure can be used to evaluate the effectiveness of management practices (prairie restoration, grazing, and fire).

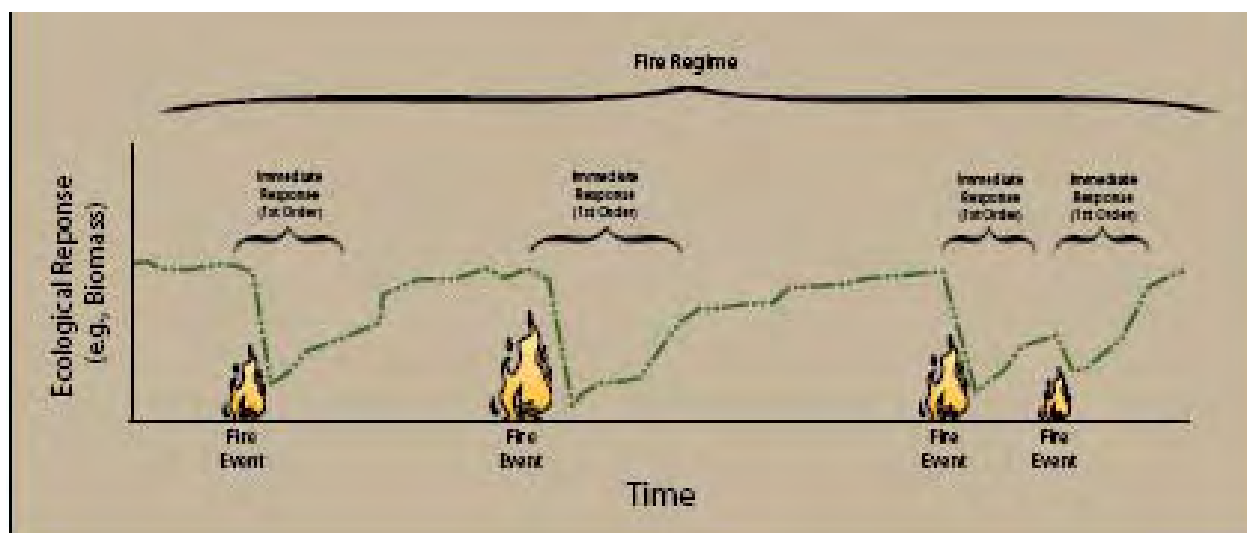
2. Sampling Design

The Inventory and Monitoring Program and the Fire Program both monitor grassland ecosystems; however, the emphasis has differed among the two programs. The fire program has historically had a greater emphasis on monitoring immediately before, during and after fire events, with a goal of understanding the response of grasslands to fire. These effects, sometimes referred to as first order fire effects (Key and Benson 2006) relate to the change in living biomass, energy, etc as a direct result of the fire (Fig. 2). In contrast, the emphasis of the Inventory and Monitoring Program has been on long-term ecosystem health; thus, tends to focus more on the cumulative effects of a fire regime, including secondary effects from fire events that manifest themselves over a more extended period time. This is not to say that the Fire Program is not interested in longer term effects of fire regimes, or that the I & M Program is not interested in the immediate effects of an individual fire events.

[Understand what you are trying to say below, but needs to have better structure for clarification]

Rather, it implies that with limited resources, there may be areas where the information needs require an emphasis for the resources allotted to be directed toward those aspects of fire ecology and management that provide the greatest benefit. From the perspective of both fire management and ecological health, it is important to understand the effects of fire as a process that shapes our grassland communities, and given the high overlap in our respective programmatic goals in monitoring these ecosystems, it only makes sense for a collaborative effort between the Fire Effects Monitoring Program and the Inventory and Monitoring Program. The design we have developed reflects both areas of emphasis with an intention to gain mutual benefit of a more comprehensive and coherent collaborative program.

Figure 2. The Southern Plains Inventory and Monitoring Network and Fire Group have historically emphasized different components of a comprehensive assessment of fire effects and ecosystem health.



2.1 Target Population, Sample Frame, and Sample Units

2.1.1. Target Population

The target population of this effort is the grassland communities of each park within the Southern Plains Network. For the purposes of this project, grasslands are defined as areas with > 60% graminoid, or areas that are targeted for habitat management within the intention of achieving 60% graminoid.

2.1.2. Sample Frame

Using vegetation types alone as a basis for defining the sample frame can be problematic if the intended scope of inference is broader than the vegetation classes themselves. In such cases, the dynamic nature of vegetation can result in a shifting population for which inference becomes nebulous. However, for the purposes of this protocol, we are interested in changes in grassland and riparian community classes which include both the current and potential state. As such, our sample frame is somewhat analogous to an ecotype based on a combination of habitat types, soils, and general land form such that it includes existing grassland or riparian habitat types as well as areas that have a reasonable potential for such types either through management or natural processes. For example some pinyon-juniper savannahs (CAVO) or honey mesquite shrublands (LAMR, ALFL) are included in the sample frame, even though the current habitat type may not be strictly considered a grassland.

Thus, the sampling frame for this protocol is defined in terms of mapped habitat types using the criteria described above. A few areas are excluded from the sample frame due to high disturbance areas that will continue to undergo disturbance and slopes >35%.

2.1.3. Sample Units

The sample units consist of 50 m permanent transects within which 5 divided quadrats are located every 10 m (beginning at 0 m) (Fig. 3.3.1).

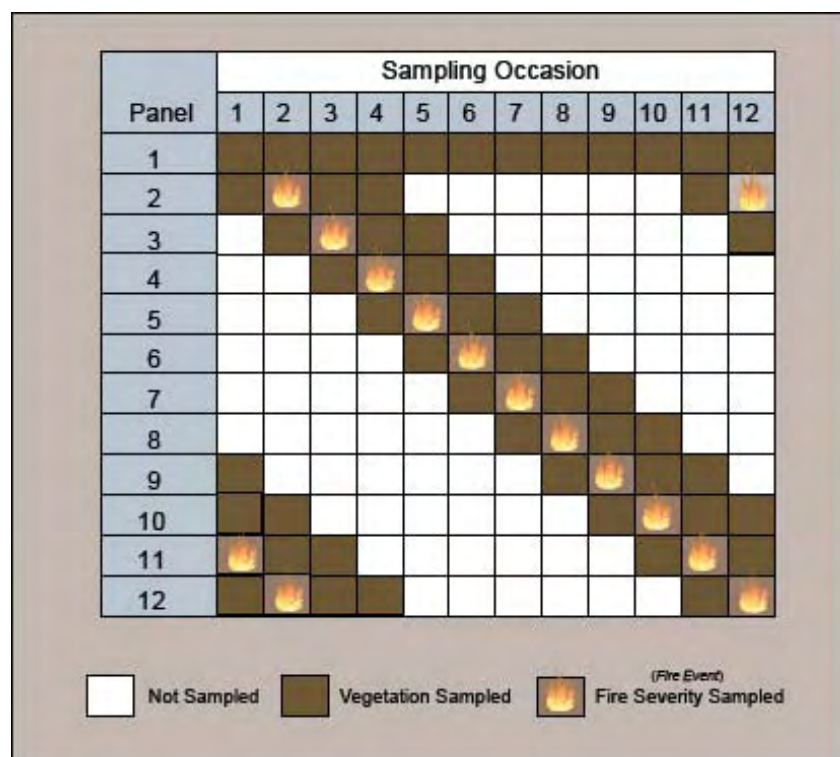
2.2 Spatial Design

The overall spatial design for this protocol is a stratified random sample with unequal inclusion probabilities to ensure samples in particular specific habitats of interest. In most cases, fire plots already existed from previous efforts. These plots were initially selected using a stratified random sample based on burn units. However, these plots were selected and sampled for the purpose of monitoring fire effects; thus were sampled in conjunction (before and after) with burns. The intention of our design was to compliment this sampling with plots intended to monitoring long-term changes in these communities. As such, we augmented the existing plots through the selection (building upon the original stratified random sample) of additional plots where the temporal revisit design (see below) was not restricted to burn events. In cases where no fire plots existed in a habitat of interest, we supplemented the existing sample using an unequal inclusion probability to select samples in those habitats of interest.

2.3 Temporal Revisit Design

The temporal revisit design, like the rest of this protocol, is intended to reflect our two programs and their corresponding objectives in such a way that the sum is greater than its parts. The fire plots focus on the more immediate response of the vegetation to fire; whereas the annual plots emphasize the long-term changes in the grasslands. The overall approach is a split panel design where the fire plot panels are a rotating panel based on burn frequencies (Fig.2.3). It is important to note however, that in those parks which use prescribed fire (currently all but FOUN, SAND and LYJO), all areas are burned over time unless excluded for archeological resource protection. Therefore, no areas can be considered a “control” with respect to fire as an unburned treatment. Rather, any inference derived between burned and unburned areas are based on what is burned within a given year.

Figure 2-3. Temporal revisit design.



It is important to note that the panel of samples that are visited every year does not constitute a “control” in the sense that these sites do not experience fire events. Virtually all of the sites experience fire events. Rather, these units are sampled every year regardless of whether or not a fire event has occurred. These units help to ensure that we have samples from all successional stages relative to fire (or other treatment) events and help to interpret the potential confounding effects of year (e.g., environmental effects) and fire events. The time since the previous fire event will typically always be considered as an explanatory variable in our analyses.

3. Field Methods

SOPN Grassland Monitoring has been integrated into SPFG fire effects monitoring efforts and takes advantage of many of the field methods used by this group. The divided frequency quadrat method of vegetation measurement has been added to this suite of field methods to meet SOPN needs. For the immediate future, vegetation methods using the point-line intercept currently employed by the fire effects monitoring program will continue along the same transect used for collecting divided frequency, so that we can compare methods to determine both the most robust method for detecting species richness and to provide a cross-walk for historic vegetation data. Once this determination has been made, a single best method will be chosen for use in future monitoring..

3.1 Field Season Preparation, Schedule and Equipment

Prior to the field season each year, beginning in April or May, the field crew must review this entire protocol, including all of the SOPs. It is important that each member of the field crew is thoroughly familiar with the elements of the design and standard operating procedures for this program. There are numerous tasks that must be performed to ensure a smooth and efficient field season, including generating and copying sufficient data sheets for the year, making appropriate logistical plans, and purchasing necessary equipment and supplies to provision the field effort. These procedures are described in SOP #1.

Due to the number of procedures performed as part of the vegetation monitoring field sampling effort, considerable preparations are necessary in order to effectively accomplish this suite of tasks. All materials and equipment must be brought on sampling trips with the crew. The suite of tasks involved in preparing for a field sampling bout include:

1. Acquisition of a list of plots to be monitored from the Project Manager. Some plots may be first-time visits, requiring establishment, while others may already exist, requiring only data collection. The UTM coordinates, general description of the plot (in terms of ecological site), appropriate field forms, existing plot data, travel directions (if a re-visit), and geographic data should also be acquired from the PI.
2. Review of species lists from previous monitoring efforts to identify any unique plants that may be encountered. Prior knowledge of at least the dominant species at a site will facilitate faster recognition and data collection in the field. Each member of the field crew should review the lists and use reference manuals to identify species that will likely be encountered. Certified species lists from NPSpecies available from the SOPN data manager and/or the PI should be used to generate species lists for the field. Copies of these combined species list should be carried into the field for quick reference.
3. Scheduling of sampling dates and organization of logistics prior to the start of each field season. Monitoring will be conducted during the growing season across the Southern Plains. A preliminary schedule should be approved by the PI. Upon approval, resource staff of park units being visited should be notified (via an email message) of the dates the monitoring field crew will be in their parks. Collection permits have been established with the individual parks being sampled and should be carried into the field by the crew leader. Just prior to the time the field crew enters a park unit the resource staff of the park is to be provided with the actual dates field-

crew members will be working in the park, a list of their names, and approximate locations of monitoring activity.

4. All equipment should be organized and prepared for the field season at least one month in advance of the field season. This allows time to make needed repairs and order equipment. Equipment needed for each four-person crew (SOP #1) should be prepared and taken to the field, even if all plots are already established, to replace any monuments removed since the last visit. However, at most, only 1-2 pieces of rebar should be carried to existing plots. This should be sufficient to cover replacement needs without undue burden to field crews.

3.2 Establishing and Marking Permanent Monitoring Sites

These procedures will only be completed during initial transect establishment (refer to SOP #3).

3.2.1 Locate Plot Origin Point

Using a map of numbered random points and associated UTM coordinates, use a GPS unit to navigate to each. To eliminate bias, visit potential plot locations in the order in which they were randomly selected within each portion of the strata. This will eliminate any tendency to avoid plots located in difficult terrain or that are otherwise operationally less desirable. Once you have navigated to the selected point, select a random azimuth. This is done by selecting a random compass direction (0° to 359°) from a list of random azimuths. Make sure that each random number used is deleted from the list.

3.2.2 Assess Plot Suitability & Mark Plot Origin Point

From the plot origin point, check the area against the monitoring type description and selection criteria (SOP #3) on FMH-4 (Monitoring type description sheet). If the monitoring plot origin point and the area roughly within a 50 m radius of that point meet the criteria for the monitoring type, install a stake, which serves as the plot origin point (the 0 point). If the origin point and surrounding area meet one or more rejection criteria for the monitoring type, return to the origin point, orient 180° away from the previous randomly selected azimuth, and move a distance of 50 m to a new plot origin point. If the second location meets one or more rejection criteria, reject the random point and proceed to the next oversample point within the monitoring type in numerical order (return to Step 1).

3.2.3. Laying Out & Installing Monitoring Plots

Once the origin stake is installed (see below), select a random azimuth and lay out a 50 m+ tape from the origin stake along this azimuth. Suspend the transect line, defined by the tape, tautly through the vegetation. The entire 50 m line on either side of it must lie within the identified monitoring type.

Mark the transect dimension by installing two 0.5 in diameter rebar stakes at 0 and 50.3 m. Installing a stake at 50.3 m minimizes stake interference in the transect at the 50 m data point. Stake height above the ground should allow easy relocation of the stakes. Stakes should be installed deep enough to provide adequate basal stability relative to the height necessary to bring the stake into view. Suggested stake lengths are 0.5 to 1 m for grassland transects. It is generally best to overestimate the stake heights needed, to compensate for snow creep and vegetation growth.

Install permanent plot identification tags on each stake, using rectangular or oblong brass tags. Each tag should include the monitoring stake location code, plot purpose, plot identification code, and date of initial installation.

3.2.4 Photographing the Plot

Once the tape is laid out, take a minimum of two photos at each plot, one from the beginning of the transect toward the end and the second from the end of the transect toward the beginning (SOP #4). If necessary to better characterize the vegetation at the site, take additional photos from a well-documented location. To minimize the effect of vegetation trampling on the photo, photograph the monitoring plot before you sample other variables, staying outside the plot as much as possible.

A coded photograph identification “card” should be prepared and made visible in every photograph. The card should display, in large black letters, the plot identification code, date, subject code and any other information that may be useful. Place a flagged rangepole or other tall marker at the midpoint of the line being photographed. The pole should be located at the same point each time the plot is rephotographed. This can provide for clearer comparisons over time.

3.2.5 Complete Plot Establishment Data Sheet

Assign and record the plot identification code consisting of the monitoring type code and a two digit plot number. Record the date the form was completed, the people on the team, the azimuth of the transect, and the declination used for all azimuths. Record Universal Transverse Mercator values, Estimated Horizontal Error, and the datum used. Record the average percent slope, the aspect, and elevation of the plot location. Record the travel route used to access the monitoring plot. Identify permanent or semi-permanent reference features on the site in case the origin stake is hard to find or disappears. Record the true compass bearing (including declination) and distance in meters from the reference feature to the origin stake.

3.3 Field Sampling Methods

Grassland sampling consists of a variety of measurements. Primary vegetation data will be collected using a series of permanent transects consisting of 5 divided quadrats located every 10 m (beginning at 0 m) along a 50 m transect (figure 3.3-1). Quadrat sampling requires at minimum a two person team: one “observer” to call out frequency, cover, and density and one “recorder” to write down these data. The sampling team should keep their same roles for frequency, cover, and density on a given transect.

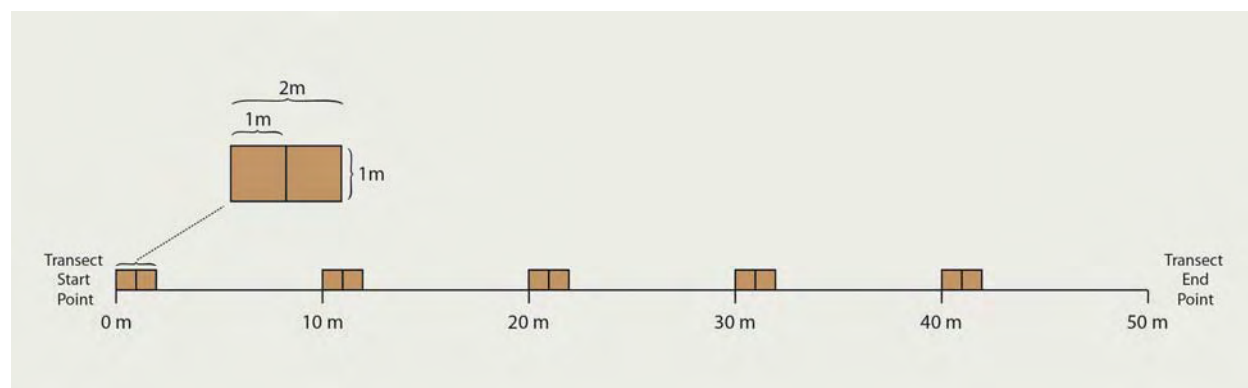


Figure 3.3-1. General plot layout for sampling grasslands.

3.3.1 Set up the transect

Use a GPS to locate the coordinates of the start and end points of the transect (SOP #2). Relocate the rebar posts marking the start and end of each transect, using a metal detector if necessary. Avoid trampling the sampling area on the left side of transect (from the start point). Anchor the beginning end of the tape to the plot origin stake and walk on the right side of the transect towards the ending stake. Fasten the tape so that the 50 m transect tape is taut and as close to the ground as possible to avoid curvature in the line. If necessary, use additional steel pins to hold the tape in place at other points along the transect.

3.3.2 Photograph the transect

Photos should be taken each time the permanent plot is revisited (SOP #4). Every attempt should be made to duplicate the establishing photos. A copy of establishing photos can be taken into the field to facilitate replication of earlier shots. Photos will be more useful if they show primarily the vegetation, with space taken up by the board and crew person minimized.

3.3.3 Prepare Data Collection Sheet(s)

Record relevant information in the header of the Field Data Form in preparation for data collection.

3.3.4 Sample divided plots for cover and frequency

Frequency and cover data are collected in five divided quadrats located along each transect, spaced 10 meters apart. Along all transects, plots begin at 0 m, 10 m, 20 m, 30 m, and 40 m on the left side of the tape. For the first quadrat, align the 1m² sampling frame so that the quadrat begins at 0 m and ends at 1 m.

The variable scale plot design is effective for assessing changes in frequency when sampling multiple species simultaneously. Plot size determines frequency values and frequency values between 30% and 70% allow the greatest potential for detecting increases or declines in species frequency (Elzinga et al. 1998). The various sized plots are useful for detecting changes in frequency of dominant prairie grasses and some ubiquitous forb species.

The observer first lists the individual plant species found in each of the divided quadrats and then estimates foliar cover for each species using the ocular estimation techniques (SOP #5). Each individual percentage value alone cannot exceed 100%, but when combined the cover value for a plot may be greater than 100% due to layering. Only species rooted >50% in the plot are included in estimates of foliar cover. A reference list provided for each plot lists the names, but not the associated cover values, of species previously collected in a plot for comparison to those being recorded. If any species from the previous year was missed, the plot is searched again for the species. Comparison with the previous year's species list maintains consistency in species identification and creates a check for missing species.

After collecting foliar cover in a given plot, the ground-level cover of bare soil, litter and other attributes (Table 3.3.4-1) is estimated using the same ocular estimation techniques (SOP #5) in only the 1x2 m plot. Two measures of bare soil are estimated: bare soil exposed to wind and rain erosion and bare soil below standing live vegetation that receives some protection from erosion. When percentages are combined the cover value for a plot may not be greater than 100%. These attributes are measured in plots to describe changes in ground cover, and allow for exploration of the correlative relationships between compositional changes and environmental attributes. For

example, changes in bare ground and litter cover are directly affected by fire spread and intensity (Knapp and Seastedt 1986). These changes have been correlated with changes in species composition and the dominance of certain guilds of species following a fire (Collins et al. 1998).

Soil surface type	Definition
Bare soil, no overhead vegetation	Loose soil particles (0-2 mm diameter) exposed to erosion
Bare soil, under vegetation	Loose soil particles (0-2 mm diameter) protected by vegetation overhead
Litter	Embedded litter that is less than 2.5 cm in diameter, where removal of the litter would leave an indentation in the soil surface or would disturb the soil surface
Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and in direct contact with soil
Small rock	Rock fragments 2-20 mm in diameter
Large rock	Rock fragments >20 mm in diameter
Lichen	Lichen crust on soil (lichen on rock is recorded as the appropriate rock type)
Moss	Moss on soil (moss on rock is recorded as the appropriate rock type)
Crust, undifferentiated	Anything from physical crust to weak biological crust but NOT including lichen, or moss
Scat, livestock	Any type of livestock scat

Table 3.3.4-1. Definitions of soil surface features for quadrat sampling.

3.3.5 Complete sampling at all quadrats along the transect

After you finish sampling the first quadrat, repeat Step 3.3.4 to sample the remaining quadrats along the transect. Sample quadrats every 10 m as you move down the transect, making sure to sample all divided plots.

3.3.6 Point-Line Intercept Sampling

During the first few years of vegetation sampling, additional measurement data will be collected using the Point-Line Intercept method currently employed by the SPFG fire effects monitoring program. This data will be collected along the first 30 m of the 50 m transect used to collect divided frequency data. This method of data collection requires that a vertical pole be placed at every 0.3 m point along the transect, starting at 0 m, and the following data collected at each point:

Height and species ID of tallest vegetation touching the pole; species ID of additional lower-growing vegetation in decreasing height order; and ground layer condition (bare ground, litter, bedrock, etc.). Detailed instructions on collection of this data can be found in SOP #6.

3.3.7 Fine Fuel Load (Biomass) Collection

The fine fuel load and biomass of grassland will be collected using the established protocol of the SPFG monitoring program. Detailed instructions for this sampling can be found in SOP #8. In brief, this sampling will be done by clipping all above ground vegetation found within five 0.25m² quadrats located systematically within 10 m of the established vegetation transect.

Clipped vegetation from each of the quadrats will be placed in separate bags, weighed, dried, and weighed again to extrapolate the biomass and moisture content of the grassland area.

3.3.8 Fuels Data

Fire fuels data will be collected at each transect using the standard protocol of the fire effects monitoring program. Detailed instructions for this sampling can be found in SOP #9. This data is collected using the Browns Transect method.

3.4 Ancillary Data Collection

3.4.1 Shrub Transect Sampling

When the sampling transect falls within areas containing shrubs and other woody vegetation, it will be necessary to collect data on the plant species present and the number of living stems contained within a 10 meter radius from the 25 m point on the transect. This sampling method follows the standard sampling methods employed by the SPFG fire effects monitoring protocol. Detailed instructions for the collection of this data can be found in SOP #7.

3.4.2 Site Impact Assessment

Should a disturbance be observed either on the transect or surrounding area that could potentially impact the site, use the following guidelines to record disturbances on the Site Impact Assessment data sheet. Conditions that would be classified as a disturbance include: social roads or trails, campsites, livestock grazing, wildfire, burrowing and wind or water erosion.

A. On-site disturbances

The purpose of this section is to document the occurrence of on-site factors which may affect ecological processes within the transect. Examples include land uses or natural or anthropogenic landscape alterations which alter hillslope hydrological processes or wind- or water-driven erosional processes. Such alterations may affect runoff patterns or sediment deposition within the transect. Common types of disturbances are listed on the bottom of the data sheet. Include any other type of disturbance that appears significant at a site.

Walk along the transect and note any disturbances. Make sure you are walking on the right side of the transect and not trampling the areas sampled by quadrats. Also walk around the perimeter of the transect to examine the 25 m bordering the transects on all sides. For each disturbance encountered, describe the size of the area affected in m², the position of the disturbance relative to the transect and the severity of the impact. Additionally, you may use the space at the bottom of the data sheet to sketch the approximate size and location of the disturbance. Answer the questions on the data sheet to assess potential effects of the disturbance and provide additional information to help describe the disturbance. Each data sheet only has space to record one on-site and one off-site disturbance. Use additional data sheets as necessary.

Disturbance type	Definition
Ant mound	Holes and mounds created by ants
Bicycle	Disturbances caused by non-motorized bicycles
Human track/trail	Tracks or trails created by humans

Livestock track/trail	Tracks, marks, or trails created by livestock
Motor vehicle	Disturbances caused by any motorized vehicle
Wildlife excavation	Holes and mounds created by wildlife
Wildlife track/trail	Tracks, marks, or trails created by wildlife
Other anthropogenic	Any human disturbance other than tracks and trails
Undifferentiated	Any disturbance not classified as one of the other categories

Table 3.4-1. Definitions of soil-surface disturbances.

B. Off-site disturbances

Upslope - The purpose of this section is to document the occurrence of off-site (i.e. outside the transect), upslope (gravitational) factors which may affect ecological processes within the transect. Concepts and examples are the same as for on-site influences. Observe the area to the hilltop or 500 m upslope of and perpendicular to the transect for any sign of disturbance. For each disturbance encountered, describe the type of disturbance, the size of the area affected in m², the distance upslope from the transect, and the severity of the impact. Answer the questions on the data sheet to assess potential effects of the disturbance and provide additional information to help describe the disturbance. Use additional data sheets as necessary.

C. Off-site disturbances

Other than Upslope - Assessment of disturbances at orientations other than upslope is more general and is conducted without leaving the transect area. Looking down slope and across slope, record noticeable disturbances, the approximate direction and distance from the transect edge, and the approximate aerial extent of the disturbance.

3.4.3. Unknown Plant Species

It may be difficult or impossible to determine the specific identify of individual plants encountered during sampling. When this situation occurs, search the immediate area surrounding the transect, looking for specimens of the unknown plant that are more readily identifiable (e.g., due to the presence of flowers or fruits from current or previous seasons). These may assist in correctly identifying the species in the transect. Collect a sample of the plant with leaves, flower and/or fruit, place it in a press or field notebook, attach a sample label it and fill in the requested information. Assign an unknown code that is unique from all other unknown codes in the park. This specific code will be used whenever the same plant is encountered again during monitoring in that park.

Use the Unknown Plant Species Tracking Log (SOP #10) to manage the record number assignments and identification of unknowns. When digital data entry is performed in the field on a laptop computer, the field crew will need to add codes for these unknowns to the database species list. The field crew assigns a code that has meaning only to the field crew to each unidentified taxon (e.g., UNKWHITEFLOWER for an unidentified plant with white flowers). Suspected Family or Genus names and/or numbers may also be used. The same assigned code is used for every record of each unknown taxon entered into the database.

Unknown plant material should be examined and identified as rapidly as possible. This can be facilitated by using the park specific species list as a starting point. Rapid identification is necessary due to the temporary nature of the sample collected; an un-pressed specimen will deteriorate rapidly, making identification more difficult. This situation can be avoided by performing a high-resolution (600 dpi) scan of the specimen upon return from the field each day. Each scan should be labeled with the park name + unknown code. Thumbnails of these scans can be printed out and carried into the field on subsequent days to ensure proper unknown code assignments when these species are encountered again within a given park. When an unknown is identified at a later date, the code must be corrected globally on all data lists, species lists and in the database.

There may be rare occasions when it will be necessary to collect a voucher specimen off the transect for verification of presence. This will occur at the request of the PI for a specific species or when a new (to the park) species has been found. There are specific directions to follow in the collection of a voucher specimen, outlined in SOP #11. Collected material is mounted on acid-free herbarium paper, kept in insect proof containers, and becomes reference specimens. Rare, threatened, and endangered species are not collected. Voucher specimens are housed in the appropriate herbarium for each park. Kartez/ITIS is used as the first system for standardizing taxonomy.

3.5 End-of-Season Procedures

3.5.1 Equipment maintenance

Make certain that all equipment is in good working order, or repair or replace if necessary.

3.5.2 Supplies inventory.

To ensure that adequate supplies are on hand for the next field season, order supplies if needed.

3.5.3 Complete ID of unknowns.

The field-crew leader is responsible to ensure complete resolution of all unknown plants. Plants are identified to species, genus or family. Should the crew leader encounter difficulty with identification, the Project Manager will assign a botanist to handle identification.

3.5.4 Data management

The field crew leader is responsible to ensure that all data sheets are completed properly, and that all digital photos are labeled and stored (SOPs #XX and #XX).

3.5.5 New Species

The crew leader is responsible to ensure that plant species not on the current park list are submitted to the Project Manager to update NPSpecies. This requires a voucher specimen which the crew leader is responsible to acquire.

3.5.6 Protocol review procedures

Prior to the departure of the field crew, the Project Manager will implement the annual Protocol Review procedures, which queries the field crew for problems, issues, and recommendations regarding the extant grassland protocol.

4. Data Management

The grassland monitoring staff annually makes thousands of observations about plant communities and their environments. Taken together, these observations can form a statistical representation of our sampling universe. To ensure that an accurate and complete record is maintained in perpetuity a coordinated data management plan must be in place early in the monitoring process. Specific data management objectives relate to three themes: database design, data entry, and long-term data integrity and security.

4.1 Collaboration with Fire Effects Monitoring

It was determined during the development of this protocols that SOPN would work to integrate SOPN grassland monitoring with the regional fire effects vegetation monitoring program. This is mainly due to the overlap of the objectives of both programs and that they both collect similar data. Fire is a natural process in all of the vegetated area within SOPN's parks, although frequencies differ among vegetation types. Based on this, the combined resources of the two programs would produce a much stronger vegetation monitoring program for the NPS Southern Plains parks than would two separate programs.

4.2 FFI Database Overview

As part of the collaboration with the fire program, data will be entered into FFI, a SQL database that has been developed as an integration of integration of FEAT and FIREMON fire monitoring databases. Although initially designed for use in fire effects monitoring, FFI includes a robust protocol manager and can easily be modified to record data for grassland vegetation monitoring.

Please note that this section will be filled out in more detail once I finish building the protocols into FFI

4.3 Data Entry, Verification and Editing

Data entry is the initial set of operations in which raw data from paper field forms or field notebooks are transcribed into a computerized form (i.e., within a database). Data entry is best performed by a person who is familiar with the data and ideally takes place as soon as data collection is complete. Inevitably, the process of transcribing data from field forms to a digital format introduces error. FFI uses data entry forms with quality assurance and quality control (QA/QC) features in order to minimize such errors. Data entry forms reduce transcription errors through pick lists and value limits. Standardized identifiers (e.g. sample period or location) are selected from a list generated from a look-up table. Look-up tables contain project specific data and prohibit entry of data into a field if a corresponding value is not included in the look-up table. Consequently, only valid names or measures may be entered and spelling mistakes are eliminated.

If a species name does not appear in the dropdown pick list, a series of quality control measures will prevent the entry of an erroneous species name into the database. Without a species name or habitat measure listed in the pick list, it cannot be typed in. Sequential procedures within the database structure determine if it is the result of a name change or a new species or habitat measure. Synonymous names (i.e. two or more different names referring to the same taxon), common for plant species, are searched for prior to entering a new species name, thereby preventing the duplicate entry of synonyms. To check the current nomenclature for a taxon, a

nomenclature update form is attached to the data entry form via a button. If the species or habitat measure name has changed, the form will indicate the current accepted name. If the species name is valid, but not currently in the database, a form is provided to update the species table with the new species name and attribute data.

Data verification is the process of checking the accuracy of the digital data against copies of the original paper data sheets, and it should immediately follow data entry. To minimize transcription errors in the final dataset, personnel familiar with the project's field and data collection methods should verify 100% of the records to the source documents. After any required corrections have been made, the project manager will review 10% of the records a second time. The results of that comparison will be reported in the metadata. If the project manager finds any errors, the entire dataset will be verified again. The paper data sheets will be archived after the project manager verifies that the digital data accurately reflects the original field data.

Data validation is the process of reviewing digital data for range and logic errors. Even when data are correctly transcribed from field-data sheets, some values may not be logical or accurate. Although some validation features, such as range limits, are built into the database itself via data-entry forms (see above) and queries, the project manager or another person familiar with the data will further review the dataset for these types of range and logic errors.

Data certification is the process of ensuring that the dataset (i.e., portion of the database related to all of the records for that year) has been verified and validated for accuracy, is complete, and that metadata/documentation for the dataset is finalized. Data certification will be completed annually for all tabular and spatial project data sets. The project manager will complete the certification form (in development) and notify the data manager that the data are ready for archiving and storage. Once the dataset is certified, it can be used in analyses and reports.

Validation of spatial data is accomplished using ArcGIS 9.x (ESRI, Inc.). FFI includes a GIS module capable of directly connecting to Arc- GIS via a toolbar. As such, data can directly be imported into ArcGIS to create a shapefile. The UTM coordinate values stored in the database for point locations will then be compared to the original GPS coordinates. The process of verifying, editing, validating, and certifying spatial data will follow the same process as for other electronic data.

4.4 Data Archival Procedures

Secure data storage and archiving is essential for protecting data files from corruption. The FFI database is maintained on the SOPN snap server. Backup copies of all data will be maintained at (to be determined, possibly with Richard?) A complete copy of the database also will be archived prior to any database version changes.

Data sets are rarely static. Changes, improvements, or updates to the data may be made following the archival of a data set. There are three main caveats to this process: 1) data integrity must be maintained; 2) once archived, all changes to the data set must be documented; and 3) mistakes made during editing must be recoverable. Any editing of archived data is accomplished jointly by the project manager and data manager. Every change must be documented in an edit log and accompanied by an explanation that includes pre- and post-edit data descriptions.

Prior to any major changes in an archived data set, a copy is exported with the appropriate version number, which allows for the tracking of changes over time. With proper controls and communication, versioning ensures that only the most current version is used in any analysis. Versioning of archived data sets is handled by adding floating-point number to the file name, with the first version being numbered 1.00. Each major version is assigned a sequentially higher whole number. Each minor version is assigned a sequentially higher 0.1 number. Frequent users of the data are notified of the updates and provided with a copy of the most recent archived version. Once the data are archived, any changes made to the data must be documented in an edit and original field forms are not altered. Field forms can be reconciled to the database through the use of the edit log.

Certified and archived non-sensitive data will be posted to the NPS Data Store and LCAS website where they may be downloaded for research and management applications. Other datasets, including those containing sensitive data, may be requested in writing from the SOPN data manager. Sensitive data will be released only with a signed confidentiality agreement.

4.5 Metadata Procedures

All tabular datasets in FFI, including all database objects (e.g., tables, fields) will be defined and documented using the database's built-in metadata functionality. FGDC-compliant metadata (including the NPS profile) for all spatial data will be created using the Metadata Tools and Editor. Both spatial and non-spatial metadata records for non-sensitive data will be uploaded to the NPS Data Store where they will be available to the public. All metadata records will be updated as needed whenever additional data are collected and added to the database.

5. Analysis

5.1 Routine Data Summaries and Analyses

Routine data summary reports are available through the Reports and Analysis section of the FFI ecological monitoring utilities, version 1.02. The following section is extracted from the FFI Users Manual (XXXXX). Each report type is summarized below.

5.1.1 Cover/Frequency

The Cover/Frequency summary displays the average percent cover for a macro plot and the average frequency of each species within divided plots. It also displays an average species height for each species sampled. To calculate the percent cover for each species sampled on a macro plot, the mid-point of the estimate range for the species' cover in each quadrat is summed by transect (this midpoint is actually entered when you use the drop-down box during data entry). The transect sums are divided by the number of quadrats to give an average percent cover for the species on that particular transect. The averages for each transect are summed and then divided by the number of transect lines to give an Average Cover (%) for the macro plot in the summary report. Average height is computed by summing all measured heights (by species and status) and dividing by the number of species' entries on each transect line. These average heights are summed and divided by the number of transect lines to get the Average height for each species in the macro plot.

The Average Frequency for the divided samples in the Cover/Frequency summary is obtained by first determining where each species is located within each quadrat (see the Cover/Frequency

description of subplots in FIREMON method descriptions at <http://frames.nbii.gov/firemon>). If the species is located only in a small corner of the quadrat, the plant is located in subplot “1.” If it is located in the right half of the quadrat, the plant is located in subplot “4.” The average divided-root frequency for subplot 1 is calculated by counting the number of times the species is in subplot “1” in the quadrats and dividing by the total number of quadrats in the macro plot. For the frequency of plants in subplot 2, the numbers of occurrences in subplot 2 and subplot 1 are summed and the total is then divided by the total number of quadrats in the macro plot. The process for calculating the frequency in For subplots 3 and 4 is the same as curs in the desired group, add the number of times it occurs in all lower groups, and divide by the total number of quadrats). Results are displayed as a percent.

5.1.2 Density - Shrubs

The Density summary report displays a summary by macro plot and monitoring status for each species that is sampled using the density method. The total count of each species in the circular plot is divided by the number of transects to get an average count. The average counts are converted to an average per unit area (per ft² (m²) or per acre (hectare)) by dividing the average count by the sample area and applying the appropriate conversion factors. The average height in feet (m) is also calculated for each item.

5.1.3 Cover - Line Intercept

The Cover - Line Intercept summary report displays (1) the average percent cover for each species by macro plot and monitoring event; and (2) the average height values for each plant species sampled using the line intercept method.

The percent cover of each species on an individual transect is calculated by totaling the species' intercepts on one transect and dividing by the total transect length. The Average Cover % for the macro plot, however, is calculated by adding the percent cover values (by species) for all transects and dividing by the total number of transects in the macro plot. The Average Height value is obtained by totaling the species heights by status and size class. The totals are then divided by the number entries in each class to obtain an average. Average height is displayed in feet or meters depending on the output units selected.

5.1.4 Cover - Points

The Cover - Points summary report displays the average count, average hits, average cover percent, and average height values for plant species sampled on a macro plot using the point intercept method. The average count and average hits calculations take into consideration that multiple hits may occur at each point. The percent cover on an individual transect is computed for each plant species and substrate item by dividing the number of hits for an item by the total number of points sampled. The average cover for the macro plot is computed by summing the individual transect-cover values and dividing by the total number of transects. Average heights for each species in feet (m) are calculated for the macro plot if they were estimated. Plant species and ground cover values for point frames are calculated by dividing the number of hits for an item by the total number of points per frame. The frame cover values are used to calculate an average cover value for the plot.

5.1.5 Cover - Points by Transect

The Cover - Points by Transect summary displays the average cover and average height of each species or substrate item by macro plot and monitoring status. Unlike the Cover – Points summary, this summary report uses the only the summary of total hits for each species or substrate item. Percent cover for each transect is calculated by dividing the total number of hits for a species/substrate by the total number of points sampled on the transect. Average cover for the macro plot is computed by summing all percent covers by species or substrate and dividing by the number of transect lines.

5.1.6 Post Burn Severity

The Post Burn Severity summary report gives separate assessments of burn effects for the substrate and vegetation strata. The severity rating for each assessment is an average obtained by adding all values and dividing by the number of points on a transect and by the total number of transects. The percent severity values are determined by counting the number of hits within each substrate category (i.e., how many hits in substrate 1) and dividing each by the total number of points per transect. If more than one transect is taken at a macro plot, all subplot totals are averaged by the total number of points on the multiple transects.

5.1.7 Cover - Species Composition

The Cover - Species Composition summary report displays the species cover and height data just as it is entered in the data entry/edit. No calculations are made within this report.

5.1.8 Surface Fuels

The Surface Fuels summary report displays the average fuel loadings in tons per acre (or kg per m²) for each macro plot. The loadings are calculated from fuel counts and duff/litter estimates on the fuels transects along with average vegetation cover and heights. Down woody loadings are calculated for 1-hr, 10-hr, 100-hr, 1-100-hr, 1000-hr sound, 1000-hr rotten, and 1-1000-hr fuels. Biomass is calculated based on the equations presented in the Handbook for Inventorying Downed Woody Material (Brown, 1974).

Non-slash, composite values are used for quadratic mean diameter, non-horizontal correction and specific gravity of fine woody debris. Pieces of coarse woody debris in decay class 1, 2, and 3 are considered sound and assigned a specific gravity of 0.40. Decay class 4 and 5 pieces are considered rotten and assigned a specific gravity of 0.30. Loading of litter and duff is calculated using bulk densities of 2.75 lbs/ft³ and 5.5 lbs/ft³, respectively. Duff and litter depth summaries are provided. Averages for live shrub cover, dead shrub cover, live herbaceous cover, and dead herbaceous cover are also calculated. Average shrub height and herbaceous height are calculated in feet (m). Biomass of live and dead shrubs and biomass of live and dead herbaceous plants are calculated using the equation:

$$B = H * C * BD$$

where B = biomass (kg/m²), H = height (m), C = percent cover/100, and BD = bulk density (kg/m³).

Bulk density used for the herbaceous and shrub components are 0.8 kg/m³ and 1.8 kg/m³, respectively.

5.1.9 Trees; Trees by Species

The Trees summary report displays tree densities (i.e. trees per unit area) for mature trees, saplings, seedlings, and snags by macro plot. For mature trees, it also displays the calculated basal area, average live crown base height, average height, and quadratic mean diameter (QMD) for each macro plot and monitoring unit. The Trees by Species summary report displays the same elements as the Tree Data report except that each element is displayed by species for the macro plot. Within this report are the densities, basal area, average live crown base height, average height, and quadratic mean diameter for each mature tree separated by species. Densities of each species for in the sapling, seedling, and snag classes are also computed.

6. Reporting

Reporting will be hierarchical and intended for multiple audiences and media. The primary delivery system will be the Internet, via the Learning Center of the American Southwest (LCAS), <http://www.southwestlearning.org>. However, the individual products available on the web site will also be available in a format (pdf) that will facilitate easy printing or enable us to deliver a printed version to appropriate audiences.

The LCAS is a partnership between the 48 parks of four monitoring networks (Southern Plains, Sonoran Desert, Southern Colorado Plateau, and Chihuahuan Desert), three Cooperative Ecosystem Studies Units (Desert Southwest, Colorado Plateau, and Rocky Mountain), and currently two non-profit organizations (Sonoran Institute and Big Sky Institute) (Folts-Zettner et al. 2008). Its purpose is to build stronger relationships between national parks and scientists and better communicate science results to interested park audiences. The hub of the Learning Center is a web page that gathers information about a number of resource topics in one place (Figure 6.1-1).

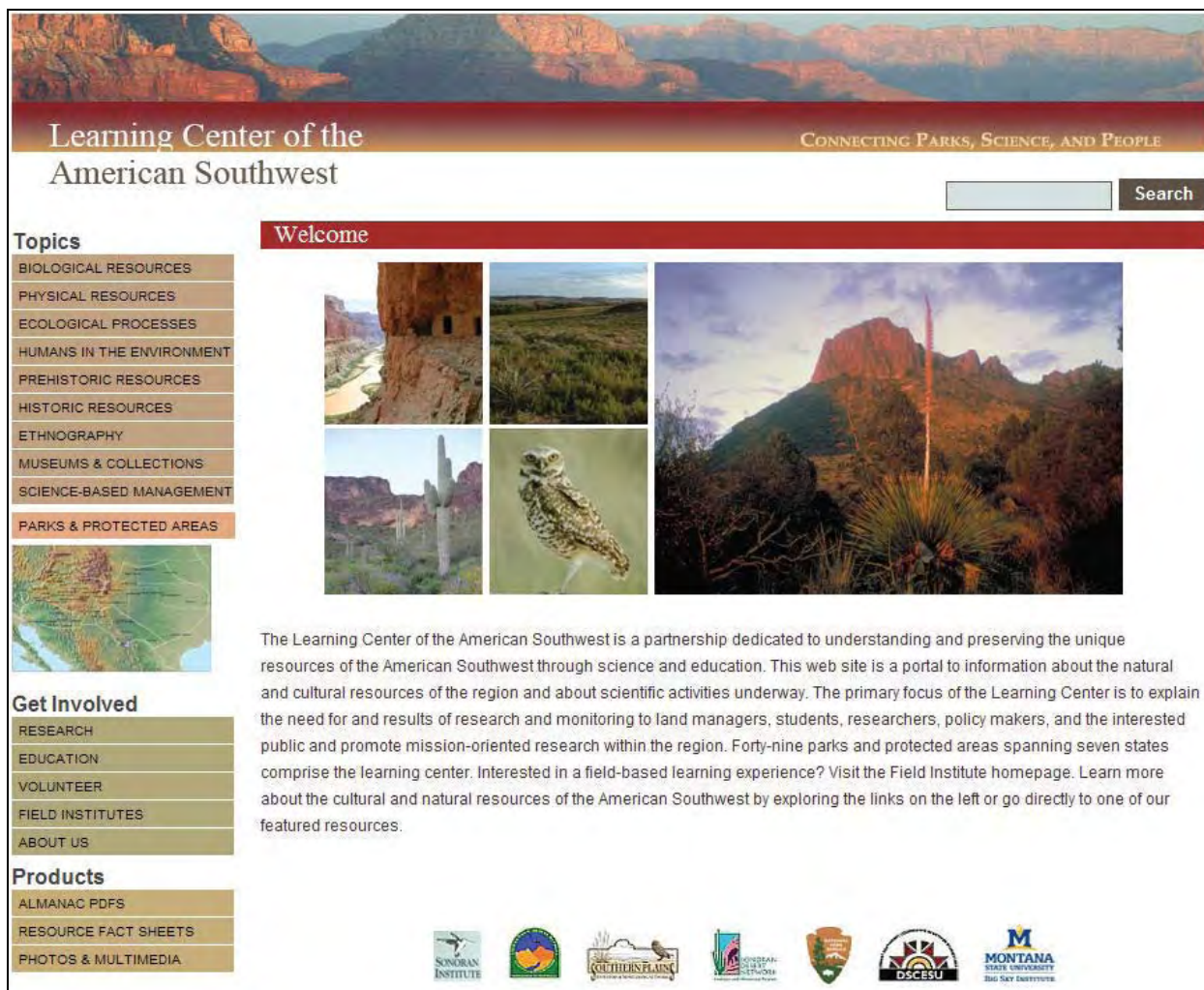


Figure 6.1. The home page of the Learning Center of the American Southwest enables navigation via a given resource or via a given park unit or network.

Information within LCAS is organized hierarchically, as a series of products within two major levels, the resource level and the project level. Resource-level products report on the condition of the resource, regardless of the source of information. This is the level that best synthesizes the available information regarding the status and trends of the resource. In contrast, project-level products report the available information from a given project, whether it be monitoring, research, etc. Thus, someone looking for the most comprehensive information about status and trend of a resource would find it at the resource level, while someone looking for the specific results from a given project would find it at the project level. I&M monitoring data will contribute to, and sometimes be the only source of information for, resource-level products, and will also be reported at the project level.

For this monitoring effort, we anticipate products at both the resource and project level each of which are described below and summarized in (Table 6-1). At the resource level we expect to

produce a resource brief annually. At the project level, we anticipate producing a project report and summary annually and a synthesis report approximately every five years.

Table 6-1. Hierarchy of primary products produced for the Learning Center of the American Southwest.

Product	Primary Purpose/Scope	Primary Target Audience(s)	Scale	Length	Frequency
Resource Brief	Status and Trend of Grassland Habitat	Superintendents/ Resource Managers	Park	1 Page	Annual
Project Summary	Summary of Project Accomplishments and Results for a given year. Extracted from Annual Report	Resource Managers	Park	2 Pages	Annual
Annual Report	Project Accomplishments and Results for a given year.	Resource Managers	SOPN with individual Park Sections	5-20 Pages	Annual
Synthesis Report	In depth synthesis of data and supporting evidence. Primary focus on Trends and Influences on those trends.	Resource Managers/ Science Community	SOPN with individual Park Sections	Variable	Every 5 Years

6.1 Resource Brief

The resource brief is a one-page synthesis document that explains the importance of a resource, describes its status and trend, and discusses its stressors and drivers. Relevant photos, maps, and/or graphs complement the text. The resource brief page contains three parts:

- Importance. A one-paragraph description of why the resource is important that may include information on the ecological role or historical significance of the resource.
- Status and Trends. A one-paragraph summary of the status of the resource and how the resource has changed over a specified period of time.
- Discussion. A one-paragraph discussion of the key drivers and stressors for a resource. If this is not applicable or unknown, describe the issues faced in managing this resource.

6.2 Project summary

The project summary is a two-page synthesis of the current status and results, if applicable, of a given project. The pdf provides the user with a summary of a project and includes an introduction as well as sections on methods, results, and project contacts. Relevant graphs, photos, and/ or maps complement the text.

6.3 Project report

Project reports will be produced annually or as appropriate, and will synthesize the results of a given period's effort for that project. It is more limited that the synthesizes report (below) in that its emphasis is on a data summary and estimates of the primary parameters being assessed. The two-page project report provides additional detail not included within the project summary, and includes the following sections:

- Introduction. Explains the purpose and background of the project.
- Methods. A brief description of the methods with reference to the full monitoring protocol.
- Results. The results of the current period's effort and trend information where appropriate.
- Discussion. A short narrative putting the current year's results into context, a discussion of patterns or trends, and a description of possible implications to management.

6.4 Synthesis Report

The synthesis report is a more in depth assessment of the status and trend of the resource. The annual report, while also synthesizing project results, is generally limited to a data summary and estimates of the core parameters. In contrast, the synthesis report will provide a much more in depth assessment, including more comprehensive analyses and broader interpretation of the implications of the results to other resources.

7. Personnel and Training

7.1 Collaborative Model

The collaboration between the fire and monitoring programs is intended to gain efficiency from our respective strengths, programmatic goals, and legacy (Table 7-1). The Inventory and Monitoring Program approaches grassland monitoring with an emphasis on long-term ecosystem health. In contrast, but not mutually exclusive, the Fire Program approaches monitoring with an emphasis on understanding the effects of wildland or prescribed fire as a management or "natural" treatment on the ecosystem. Not surprising, the parameters that would be monitored from each of these perspectives overlap considerably. Furthermore, most of the park lands are subject to fire or other treatments at some point in time. Consequently, there is no inherent difference between lands being managed with fire or other treatments and the lands for which ecosystem health is being assessed. It also follows that there is considerable efficiency to be gained from a combined effort whereas complimentary types of sampling can add value to the sampling designs that might otherwise occur independently.

7.2 Roles and Responsibilities

The SOPN project manager and the Fire Ecologist for the Southern Plains Fire Group are the lead ecologists for implementing the vegetation community monitoring protocol, and are supervised by the network coordinator for the SOPN Program. Because of the need for a high level of consistency in implementing the protocol, the project manager will be responsible for training the seasonal and permanent personnel assisting with the monitoring efforts. The data management aspect of the monitoring effort is the shared responsibility of the project manager and the data manager. Typically, the project manager is responsible for data collection, data entry, data verification and validation, as well as data summary, analysis, and reporting. The data manager is responsible for data archiving, data security, dissemination, and database design. The data manager, in collaboration with the project manager, also develops data entry forms and other database features as part of quality assurance and automates report generation. The data manager is ultimately responsible for ensuring that adequate QA/QC procedures are built into the database management system and that appropriate data handling procedures are followed. The Crew Leader will be responsible for, among other activities, day-to-day scheduling and field

operations over the Crew Members. It is anticipated that there will be two to three Crew Members responsible for efficient data collection.

Table 7-1. Primary roles and contributions of the Fire and Inventory and Monitoring Programs toward the collaborative effort.

Contribution	Description	Lead Group
Field Crew	Oversight	Fire
Field Crew	Day to Day	Fire*
Data Analysis	As per Fire & I&M Needs	I & M
Data Management	Maintain Database with Shared	I & M
* I & M will contribute to the cost of one or two field technicians		

7.3 Qualifications and Training

A competent, detail-oriented observer is essential for collecting credible, high-quality data in vegetation communities. Observer bias in the estimation of cover and misidentification of species will affect the ability to detect valid trends or changes in vegetation communities through time (Elzinga et al. 1998). Field observers must be proficient at accurately identifying plants and estimating plant coverage. Observers should also have good organizational skills, memory retention and an ability to work methodically and consistently under difficult conditions.

Training is essential for developing competent observers. Herbarium specimens and comparative notes on difficult or uncommon species should be provided for field observers. Observers should be tested frequently on their ability to identify plant species, tailoring the testing for the more problematic look-alike species. Time should also be invested in training personnel on cover estimation. Estimating cover is best taught at the start of the season in the field with all crew members present and then reviewed periodically throughout the summer to reduce within-year observer differences in cover estimation. Refer to the following instructions for training observers in both plant identification and cover estimation.

Table 7-2. Roles, responsibilities, and minimum qualifications of the primary positions of this project.

Position	Roles	Responsibilities	Minimum Qualifications
Project Managers (SOPN & SPFG)	-Serves as a liaison among project cooperators (cooperating agencies), other related projects (i.e., monitoring by other groups or in neighboring locales), and between other staff (crew leader and members) and the SOPN (and its cooperators)	-To hire other staff members (crew leader and members) -To coordinate field schedules and availability of supplies with the crew leader -To participate in the creation of (and possibly lead) training for crew leader and members -To inform SOPN & SPFG staff and cooperators of the progress of monitoring and any areas where	-Excellence in identifying (and explaining the identification of) native and exotic plant species found in SOPN parks. -Experience hiring personnel -Experience managing projects and communicating results in a clear and concise manner to all interested parties through a variety of media

		adjustments may be needed -To act as a direct channel of communication between this project and others of this nature, thus building relationships and cooperation among this project and other similar projects -To be the party responsible for providing data from fieldwork to SOPN & SPFG staff for analysis in a quality checked format, along with copies of all original data, and to be available for any questions pertaining to the data	-Experience collecting and quality checking reliable data -Experience training crews and performing field work
Crew Leader	-Serves as the leader of the field crew members and is the primary liaison between the project manager and the crew members	-To participate in field training -To act as the primary coordinator with respect to field schedules and supplies -To serve as the party who is primarily responsible for the safety of crew members and to conduct safety training for crew members -To accompany crew members in the field -To act as a direct liaison between the project manager and the crew members -To enter and quality check all data before submitting for analysis	-Experience performing field work -Experience training, leading and coordinating crews -Experience with data collection, entry and quality assurance -Experience communicating with a variety of audiences -Experience with teaching outdoor safety and route finding - Excellence in identifying (and explaining the identification of) native and exotic plant species found in SOPN parks. -Experience using a GPS unit -Must be able to hike long distances and carry a heavy backpack
Crew Members	-Serve as the back bone of the field operation by performing all field work related to the monitoring project	-To participate in field training -To alert crew leader of any scheduling conflicts or needed supplies -To account for safety of yourself and others at all times -To be responsible for all loaned equipment and use it properly -To collect reliable, accurate data and submit it to the crew leader in a timely manner	-Capability to learn to identify native and exotic plant species -Capability to learn safety and route finding -Capability to learn the use of a GPS unit and undergo training if necessary -Experience communicating and working with a variety of personalities in close settings under arduous conditions -Must be able to hike long distances to and carry a heavy backpack -Preferably have experience performing field work in vegetation measurements, have experience working with dichotomous keys and identifying species, and have extensive hiking/backpacking experience

7.3.1 Training Observers

Necessary skills to be acquired or honed before data collection begins each field season are reviewed below.

1 Knowledge of the use of a GPS is essential. GPS is used to navigate to transects, and in the future, may be employed to record key site information. SOP #2 (Use of a GPS) should be thoroughly reviewed. Training sessions described below will require field crew members to exercise the use of a GPS.

2 Plant identification skills are critical. Only field crew members with demonstrated plant ID skills should be hired. Even so, fine-tuning ID skills for SOPN plant species is still important. The SOPN Integrated Grassland Ecologist or designee (e.g., lead bio-tech) will provide training for all crew members. Training will consist of fieldbased identification of plants anticipated to be observed during the field season, with emphasis on difficult-to-ID species. Additionally, field crews will be instructed in the use of taxonomic keys and reference materials which will be available to all crew members.

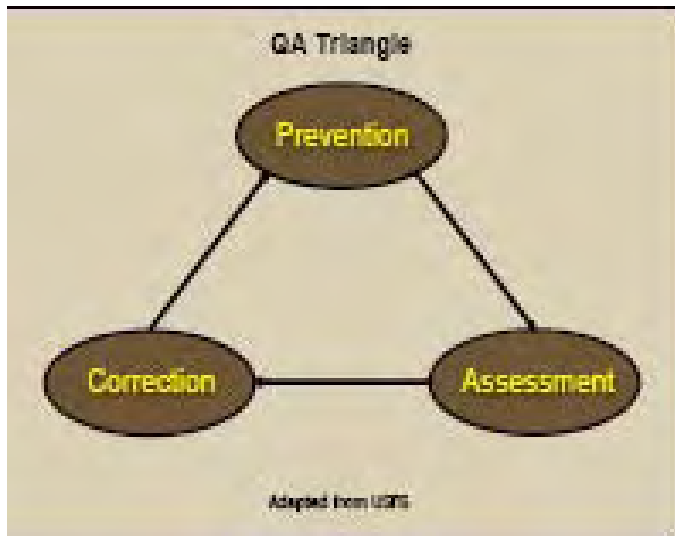
3 Identifying Ecological Site types is critical during transect-establishment. Establishing new transects requires determining if the preselected transect corresponds to the targeted ecological site. Ecological site is an underlying strata in SOPN grassland monitoring, and it is important that the computer- selected transects actually represent the intended ecological-site stratum.

4 Transect Establishment and Marking procedures will be exercised prior to operational monitoring efforts. The PI or designee will provide several days of instruction covering the operational procedures of all field methods. Practice procedures will commence with using a GPS to locate a pre-determined point. Each crew member will need to find specified points using a GPS. Site Characterization procedures will be explained and demonstrated, which includes evaluation of Ecological Site conditions. Transect Establishment, on-site measurement methods, and site-impact procedures will be explained and demonstrated. For each of these categories of activities, field crew members will be paired, and required to exercise all procedures under the supervision of the PI. All procedures will be exercised to the full extent, including actual recording of observations on data sheets.

8. Continual Improvement

Quality assurance extends beyond data management and must be an integral component of all aspects of the SOPN program. The USFS Forest Inventory and Analysis Program (FIA) identified three aspects of quality assurance (prevention, assessment and correction), which are referred to as the QA triangle (Figure 8-1). In the context of the overall SOPN program, prevention is addressed through sound development of sampling design, data management and analysis. Although prevention is extremely important, it is not sufficient by itself, due to changing programs, funding, environments, technologies, etc. Thus, this protocol includes the following section for assessment (i.e., the review process) and correction.

Figure 8-1. The quality assurance triangle. Adapted from the USFS.



8.1 Review Process

Reviews may be periodic (planned at a predefined interval) or episodic (resulting from changing mandates, funding, priorities, etc). The review process should permeate through all phases of our monitoring. It also should permeate through all of our thematic elements (i.e., applicability, reliability and feasibility), although it may not be the same review process for each element. Rather, the details of a given review should reflect which element(s) is being targeted. For example, a review intended to assess the scientific reliability is likely to be conducted by qualified scientists. In contrast, a scientific review panel may have little insight if a review is intended to assess whether or not the monitoring meets the needs of managers. Consequently, the review strategy should also clearly specify the purpose of the review and, at least in general terms, who should conduct the review.

8.2 Process for Change

Determining the status and trends of selected indicators of the condition of park ecosystems is an essential and critical goal of the I&M Program. Understanding the spatial and temporal scales over which change occurs is paramount to achieving this goal. We have considered the spatial and temporal scale in several elements of this report, including sampling design and implementation. However, many ecosystem attributes of interest operate at such long time scales that implementing a temporal sampling design requires a long-term commitment that enables teasing apart true change from environmental noise (i.e., variation). Thus, one of the key values of the I&M program is its longterm prospect. Frequent changes in monitoring protocols in the attributes being monitored and how they are being monitored would likely lead to an ever-weakening ability to meet the program goals, leading to erosion of support, further weakening the program, etc. Thus, at the outset the SOPN needs to be vigilant about disruptive change in our monitoring, while at the same time recognizing that changing resources and management regimes may require some degree of flexibility. The difficulty lies in finding the right balance between maintaining the necessary consistency to meet our program goals with enough flexibility to meet the challenges of changing natural and political environments. Thus, when making changes in protocols, the following questions should be addressed:

1. What are the criteria for determining whether or not a change is warranted? These should reflect the general themes identified above:

- Reliability - The data are not reliable in their present form
- Applicability- The data are not applicable to managers, the public, etc. in their present form
- Feasibility- The data are not feasible to obtain in their present form (e.g., funding, logistics, priorities, etc).

2. If it is determined that a change is required, what programmatic element needs to be changed?

- Objectives?
- Design?
- Field Methods?
- Data Management?
- Analysis?
- Reporting?

Note: Changing a vital sign or an objective is far more drastic than changing a reporting method. Thus the criteria for making changes to different elements may reflect their relative degree of severity.

3. What is the procedure for making the change?

4. What precautions will be taken to ensure that the revised protocol will be acceptable?

- Pre-change reviews (based on planned changes)?
- Post-change reviews (based on results from implemented changes)?
- Testing concurrent with existing protocol?
- Post-change analyses

5. How will the transition to the revised protocol be accomplished?

- Will there be a period of overlap; if so, how?

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Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) #01

Field Preparation and Equipment List

Version 1.0 (March 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure reviews tasks to be accomplished in preparation for a field season and itemizes the equipment needed to perform grassland monitoring in all parks of the Southern Plains. There are numerous tasks that must be performed to ensure a smooth and efficient field season, including generating and copying sufficient data sheets for the year, making appropriate logistical plans, and purchasing necessary equipment and supplies to provision the field effort. The equipment list can also be used at the end of field session to verify that all equipment is present and accounted for. Information contained in this SOP is augmented by procedures described in the 2003 USDI-National Park Service Fire Monitoring Handbook.

Prior to the field season each year, beginning in April or May, the field workers must review this entire protocol, including all of the SOPs. It is important that each member of the field crew is thoroughly familiar with the elements of the design and standard operating procedures for this program. These procedures are described in SOP'S # 2 through 12.

Due to the number of procedures performed as part of the vegetation monitoring field sampling effort, considerable preparations are necessary in order to effectively accomplish this suite of tasks. All materials and equipment must be brought on sampling trips with the crew. The suite of tasks involved in preparing for a field sampling bout include:

1. Preparation of Data Sheets

- Acquire a list of plots to be monitored for each park from the Project Manager. Some plots may be first-time visits, requiring establishment, while others may already exist, requiring only data collection.
- Review previous field forms for these plots and assemble copies of the existing data needed for the upcoming season. These will include UTM coordinates, general description of the plot (in terms of ecological site), travel directions (if a re-visit), and geographic data.

- Prepare appropriate data files for uploading into GPS units. NOTE: *Additional detail for this procedure will be added once we know which GPS units are being used and exactly which data can be uploaded.*
- Prepare copies of blank field forms needed to collect new data for each plot. These will include Plot Maintenance Logs, Quadrat Data forms, Point-Line Intercept forms, Biomass Collection forms, and Fuels Data forms. Additional blank forms to be copied include Shrub Transect forms, Site Impacts forms, and Unknown Plant Species forms. If the crew will be establishing new monitoring points, they will also need blank Plot Suitability forms, Transect Establishment Data forms, Plot Location Data forms, and Photo Logs.
- For each plot to be installed, generate two or three sets of random numbers, six random azimuths (0–359) (two for the plot azimuth and four for the fuel transects) ahead of time. An excellent idea is to generate all the random azimuths and distances that you will need for the entire season at once, using a spreadsheet program.
- Prepare packets of the compiled information and forms for each park to be sampled. These packets should also contain the necessary collection permits (see below).

2. Prepare Plant Species Lists

- Certified species lists from NPSpecies available from the SOPN Data Manager and/or the Project Manager should be used to generate species lists for the field. Review of species lists and previously unidentified plant species from previous monitoring efforts to identify any unique plants that may be encountered. Compile and generate a copy of comprehensive species list for each park and for each previously established plot.
- Prior knowledge of at least the dominant species at a site will facilitate faster recognition and data collection in the field. Each member of the field crew should review the lists and use reference manuals to identify species that will likely be encountered. Copies of these combined species list should be carried into the field for quick reference.

3. Prepare Schedules and Notify Parks

- Monitoring will be conducted during the growing season across the Southern Plains. A preliminary schedule should be approved by the PI. Upon approval, resource staff of park units being visited should be notified (via an email message) of the dates the monitoring field crew will be in their parks.
- In addition to submitting the preliminary field schedule, the project manager should also submit requests for park housing and permits (camping) any other special requests (e.g., boat transportation).
- Collection permits have been established with the individual parks being sampled and should be carried into the field by the crew leader.
- Just prior to the time the field crew enters a park unit the resource staff of the park is to be provided with the actual dates field-crew members will be working in the park, a list of their names, and approximate locations of monitoring activity.

4. Prepare Equipment

- All equipment (see list below) should be organized and prepared for the field season at least two months in advance of the field season. This allows time to make needed repairs and ordering/replenishing equipment.
- Equipment needed for sampling crew should be prepared and taken to the field, even if all plots are already established, to replace any monuments removed since the last visit. However, at most, only 1-2 pieces of rebar should be carried to existing plots. This should be sufficient to cover replacement needs without undue burden to field crews.

FIELD EQUIPMENT LIST

Activity	Equipment
Plot establishment or re-visit	Digital Camera Photo board Compass Clinometer GPS unit Maps Daubenmire Sampling Frame (1m ²) constructed of PVC Biomass clipping frame Paper sacks for biomass collection Measuring Tapes – 4 - 50meter Survey pins Rangepole for Point-Line Intercept & photos Batteries for electronics Bug spray/sulphur sock/clothes treatment
Plot Establishment	Aluminum tags Die stamps Pliers/wire cutters Rebar ½ meter long Hammer or mallet Wire for attaching tags to rebar Metal nails for 10 m marking
Data collection	Clip boards Data Sheet for all field-based procedures Handlens Pencils/Pens/Markers Plant Press Species Identification Manuals and Taxonomy Books Species lists (previous observations, potential observations) Species Master Names and Codes list Unknown Specimen Forms
Required Miscellaneous Items	Backpacks Duct Tape First-Aid Kit Nourishment Cellular Phone or Radio for communicating Sun Screen Towels Water

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 2

Using a GPS, Navigation & Measuring Techniques

Version 1.0 (March 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains how to use a GPS as well as navigational and measurement techniques necessary for the specialized equipment used during grassland monitoring in the parks of the Southern Plains. As field personnel, monitors must be able to use a GPS to navigate over open terrain, determine distances traveled and plot transect locations on a map. The following sections discuss the correct use of three of the basic tools used by monitors in the field—A GPS, a compass and a clinometer— as well as some basic mapping techniques for locating and mapping transect locations in the field. Information for this SOP has been taken from the 2003 USDI-National Park Service Fire Monitoring Handbook.

USING A GPS

NOTE: This section will be completed once we know what type of unit is being used in the fire program.

All GPS measurements should be set to:

- UTM coordinates
- NAD83 datum
- Meters

All crew members should be familiar with the operation of their GPS unit. Each network will supply the appropriate Users Guide for their equipment and this guide should be reviewed by all crew members and carried while on sampling events. Prior to the beginning of field season, all crew members should participate in field training in the use of their respective GPS unit.

As field personnel, monitors must be able to use a GPS to navigate to specific monitoring points and mark the beginning/ending points of a transect. This is achieved by marking waypoints. When paper data sheets are used, both the UTM coordinates and the waypoint number should also be recorded on the data sheet.

COMPASS

The compass is probably the instrument most frequently used by field personnel. Accurate compass bearings are essential for navigating over open terrain and for finding and mapping plot locations.

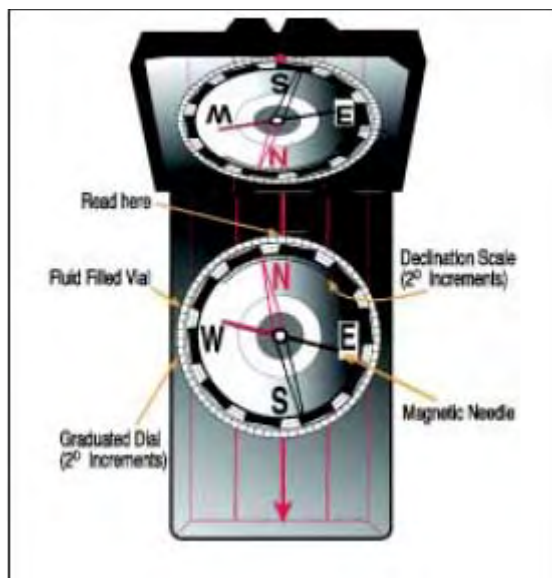


Figure 1. Graphic of a compass

Parts of a Compass

A multitude of compass models exist with different features; however, all compasses have at minimum the following:

Magnetic needle—The magnetic needle, drawn by the pull of the magnetic north pole, always points to magnetic north. The north end of the needle is usually marked by an arrow, or painted red.

Revolving 360° dial—The dial is marked with the cardinal points, N, E, S, W and is graduated into degrees. Within the dial is a transparent plate with parallel orienting lines and an orienting arrow.

Transparent base plate—Has a line of travel arrow and ruled edges.

Obtaining Accurate Compass Bearings

Always hold the compass level, so the magnetic needle can swing freely. Hold the compass away from magnetic objects such as rebar, watches, mechanical pencils, cameras, and belt buckles that can draw the magnetic needle off line.

Setting a Bearing

If you know the bearing in degrees from your current position to an object, turn the dial until the degree is aligned with the index point and line of travel arrow. In Figure 1, the bearing is set at 356°.

Taking a Bearing

- Aim the line of travel arrow on the compass towards the object.
- Turn the revolving dial until the magnetic needle is aligned within the orienting arrow in the compass dial.
- Read the bearing on the compass dial at the index point.

Facing a Bearing (Direction of Travel)

Hold compass with the base plate level and line of travel arrow pointing forward. Turn your body with the compass until the red north end of the magnetic needle point is aligned within the orienting arrow in the compass dial. You are now facing in the direction of the bearing.

Walking a Bearing

Look straight ahead in the direction of travel. Choose a landmark that lies in line with the direction of travel. Walk to the landmark. Continue in this manner until you reach your destination.

USING A COMPASS IN CONJUNCTION WITH A MAP

You may use a compass in conjunction with a map in either of two ways:

- Determine a bearing from a map and then travel that direction in the field (map to terrain), or
- Take a bearing in the field and plot that bearing on a map (terrain to map).

Whenever combining compass (field) bearings with map (true) bearings, you must account for declination.

Declination

Declination is the degree of difference between true north and magnetic north. True north is where all lines of longitude meet on a map. Magnetic north is the location of the world's magnetic region (in the upper Hudson Bay region of Canada). Declination is east or west, depending upon where magnetic north lies in relation to your position. If magnetic north lies to the east of your position, declination is east. If magnetic north lies to the west of your position, declination is west. In North America, zero declination runs roughly from west of Hudson Bay down along Lake Michigan to the gulf in western Florida.

Declination diagrams are located in the bottom margin of USGS topographic maps. Keep in mind that declination changes slightly over time as magnetic north moves slowly west; therefore, the current declination in your area may be slightly different than the declination at the time the map was printed. Declination maps are re-mapped every five years by the USGS; the most recent declination map is for 1995 (see Figure 2). On some maps the annual rate of change may be printed and thus you can calculate the current declination. USGS also produces a Magnetic Declination Map of the United States. This map shows the rate of change throughout the US so that the current declination in any area can be calculated. You may also obtain the current declination in your area from your county surveyor.

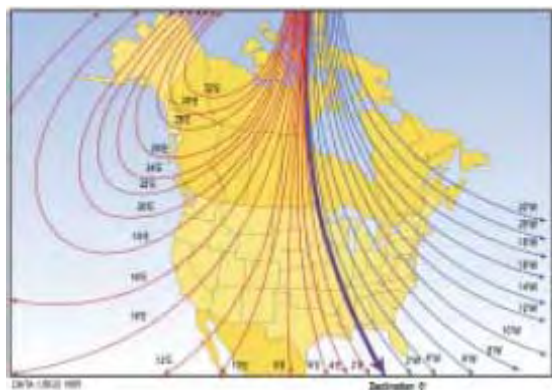


Figure 2. Map showing declination in North America. East of the zero line, declination is “west.” West of the zero line, declination is “east.”

If you need to be more precise, try using a geomagnetic calculator (e.g., NOAA 2000) that will calculate the declination for any year (1900–2005) given the latitude/ longitude or UTM coordinates.

Setting declination on your compass

Some compass models have a declination adjustment screw. The set screw key is usually attached to a nylon cord that hangs from the compass. Using the key, turn the set screw to the appropriate declination. Once you have set the proper declination you do not need to change it until you move to a different area. If you move to a new area, remember to reset the declination

on your compass. If you do not have a compass with a declination adjustment screw, you must add or subtract declination to determine the correct bearing. Whether you add or subtract declination depends on whether you are working from map to terrain or terrain to map.

Map to terrain

If you have determined a bearing between two positions from a map, and you are going to walk the bearing, you must convert that bearing to a magnetic bearing. The rules for converting from map to field bearings are as follows:

- For declination west, turn dial west (add number of degrees of declination)
- For declination east, turn dial east (subtract number of degrees of declination)

Terrain to map

If you have taken a field bearing and want to plot the position on a map, you must convert the bearing from a magnetic bearing to a map (true) bearing. The rules are simply the reverse of the map to terrain rules:

- For declination west, turn dial east (subtract)
- For declination east, turn dial west (add)

CLINOMETER

A second important field tool is a clinometer, which measures slope in degrees and/or percent. Slope is one of the most important topographic influences on fire behavior. In addition, recording the slope along the plot azimuth is another aid in defining (and thus relocating) plots.

Measuring Slope Using a Clinometer

The model of clinometer most commonly used in fire effects monitoring has both a degree scale and a percent scale. When you look through the lens, you will see the percent slope scale on the right side and the degree scale on the left (see Figure 3). Slope can be measured in degrees or as a percent. For our purposes, measurements are made in percent slope rather than in degrees; degrees slope is not used in this handbook. Percent slope measures the degree of incline over a horizontal distance; a +1% slope indicates the rise is very gradual over a given distance. A +60% slope indicates the rise is very rapid over a given distance.

The degree scale gives the angle of slope in degrees from the horizontal plane at eye level. The percent scale measures the height of the point of sight from the same horizontal eye level and expresses it as a percent of the horizontal distance (i.e., % slope); percent slope is used throughout this protocol.

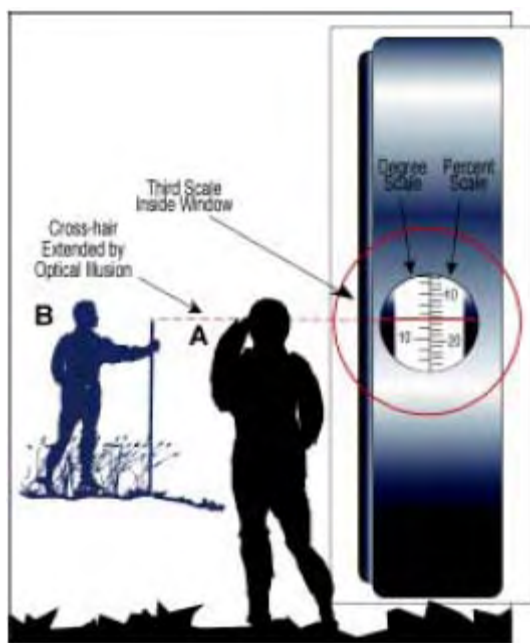


Figure 3. Graphic of a clinometer.

Note: The rangepole at B is the same height as the viewer's (A) eye level. Also note that you can find clinometers with percent on either the right or left side; percent being the larger number.

To use a clinometer:

- Hold the clinometer so that the round side-window faces to the left.
- Hold the clinometer up to your right eye but keep both eyes open (you can hold the instrument up to your left eye, if that is more comfortable).
- Aim the clinometer in the direction of the slope you want to measure.
- Fix the hair line of the clinometer on an object in your line of sight and at the same height as your eye level, a rangepole may be useful.
- Look into the viewing case, and read where the hair line intersects the percent scale (on the right).

DETERMINING DISTANCES IN THE FIELD

Distances along the ground can be measured by various means. You can measure distances along a road in a vehicle with an odometer. In the field you can use a meter tape, though over long distances this method is often impractical. Pacing is a common means of measuring distance in the field. By knowing the length of your pace you can measure the distance over ground simply by walking. A pace is defined as the distance between the heel of one foot and the heel of the same foot in the next stride. Therefore, one pace equals two steps—one step of each leg.

Determining Your Pace on Level Ground

- On level ground, lay out a course of known distance (e.g., 50 m or 1 chain).
- Walk the length of the course counting each pace (two steps). Take the first step with your left foot, then count each time your right foot touches the ground.
- Repeat the process several times to obtain an average number of paces per length.
- Divide the number of paces into the measured distance to arrive at the length of your pace.

To determine the distance you have paced in the field, multiply the number of paces by your distance per pace.

Example:

50 m/32 pace = 1.6 m/pace

66 ft/20 pace = 3.3 ft/pace

Example:

The distance between the reference feature and OP is 30 paces. Your pace distance is 1.6 m.

30 paces × 1.6 m/p = 48 m

Determining Your Pace on Sloping Ground

Walking on a slope, either uphill or downhill, your paces will be shorter; consequently you will take more paces to cover the same distance on a slope as on level ground. To determine your pace on sloping ground:

- Lay out a course of the same distance used on level ground with moderately steep slope.
- Walk upward on this course, counting the number of paces as before.
- Divide the total distance by the total number of paces.
- This is the length of one pace on a slope.

Example:

On level ground: 50 m = 32 paces = 1.60 m/pace

On sloping ground: 50 m = 40 paces = 1.25 m/pace

Walk the course several times both uphill and downhill until you have an average length of a pace on sloping ground. Your upslope pace may be different than your downslope pace.

SOME BASIC MAP TECHNIQUES

Working with Scale

You will inevitably use maps with many different scales during your monitoring work. If you enlarge or reduce a map, the scale of the map will change and you must determine the new scale. Scale on a map is determined by the formula:

$$\text{Scale} = \frac{\text{Map Distance (MD)}}{\text{Ground Distance (GD)}}$$

Map distance equals the distance measured between two points on a map. Ground distance equals the distance on the ground between the same two points.

To determine the new scale of a map that was enlarged or reduced, follow these steps:

- On the original map of known scale, measure the map distance between two points that are separated horizontally and two points that are separated vertically. (The reason to measure two distances is that copy machines are not precision instruments and may skew the map.)
- Compare the distances to the original map scale to determine the four ground distances.
- On the enlarged (or reduced) map, measure the distances between the same four points. (Although the map distance has changed, the ground distances between the four points are still the same.)
- Calculate the scale of the enlarged (or reduced) map with the scale formula, using each of the four distances.
- Average all four scales, and use this for determining ground distances on the enlarged (or reduced) map.

Example:

You calculate the scale of a map from an original map at the scale of 1:24,000. On the original map, you measure two separate horizontal distances, 5.6 and 11.1 cm, and two vertical distances 4.15 and 6.5 cm. For a 1:24,000 map, 1 cm = 240 m, so the corresponding ground distances are 1,344, 2,644, 996, and 1,560 m respectively.

Using the enlarged map, now measure the same four distances. Using the first map distance-ground distance combination, we get the following scale:

$$Scale = \frac{MD}{GD} = \frac{13.2cm}{1344m} = \frac{1cm}{101.82m}$$

Continuing on for the three remaining distances, the four resulting scales would be 1:10,182; 1:10,129; 1:10,163; and 1:10,163. Taking the average of these four numbers, the scale of the enlarged map is determined to be 1 cm = 101.59 m, or 1:10,159.

Determining the Direction and Distance Between Two Map Points

You will have to determine the direction and distance between two map points when you use a map to get to your Plot Location Points (PLP).

Determining the direction between two map points

To determine the direction between two points on a map, follow these steps:

- Draw a line connecting the two points (A B).
- Place your compass with the edge of the base plate along the line.
- Orient the compass with the line of travel arrow pointing towards point B.
- Turn the revolving dial of the compass until the orienting lines within the compass dial are parallel with the north-south meridian lines on the map, and the North (N) arrow points to north on the map.

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 3

Determining Site Suitability, Establishing and Marking Permanent Monitoring Plots

Version 1.0 (March 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes step-by-step instructions for determining site suitability, establishing and marking permanent monitoring plots for parks units in the Southern Plains. This procedure is carried out on the first iteration of sampling for a point after the transect origin point is located. This SOP has been adapted from the 2003 USDI-National Park Service Fire Monitoring Handbook.

DETERMINING SITE SUITABILITY

Potential sampling sites will be selected prior to actual fieldwork and will be limited to areas where less than 10% cover by tree species occurs. These potential sites will be generated by a computer following a stratified random sample.

Prior to field work, all potential sites will be viewed using geographic information systems by overlaying the location on aerial photography or satellite imagery. This will eliminate many sites beforehand that are not in appropriate habitat (e.g., those potential sites on ponds, parking lots, or forested habitats). The remaining sites will be presented to the park's natural resource manager for final comments.

All potential sites that are not eliminated by the process described above will be visited for plot establishment and data collection. While at the site, the sampling crew will perform a final check with additional criteria as outlined below.

Criteria for Accepting or Rejecting Sampling Sites in the Field

Once a site is located in the field, it must be checked to ensure that the plot falls within acceptable sampling criteria.

- 1) All areas of the sampling point must fall within the designated habitat type. From the plot origin point, check the area against the monitoring type description on the Monitoring Type Description sheet. If the monitoring plot origin point and the area roughly within a 50 m radius of that point meet the criteria for the monitoring type, install a stake, which serves as the plot origin point (the 0 point).

- 2) There must not be any obstacles that present a safety hazard to the crew. This includes, but is not limited to, steep slopes (> 40%) within the sampling area, known high density of rattlesnake habitat, etc;
- 3) The sampling area must be > 50 m away from roads, trails, potential development and ecotones;

If the origin point and surrounding area meet one or more rejection criteria for the monitoring type, return to the origin point and orient 180° away from the previous randomly selected azimuth. If the second location meets one or more rejection criteria, reject the random point and proceed to the next one (in numerical order) and begin site assessment anew.

ESTABLISHING AND MARKING PERMANENT PLOTS

1. Locate Transect Origin Point

Locate the transect origin point by using your GPS (see also SOP # 2 Using a GPS) and predetermined UTM coordinates for the origin point. Care must be taken during origin point installation to prevent trampling of the surrounding vegetation, which will be sampled following transect establishment. Crew members and equipment should wait a minimum of 15 m away from the origin point until transect azimuth has been determined.

2. Install Origin Point Monument

A permanent monument consists of a rebar stake (0.5" x 18") pounded firmly into the ground and labeled. Ideally, the stake will protrude less than 30 cm above-ground. There are special requirements for rebar placement whenever a plot is highly visible to park visitors. If a piece of rebar is easily detectable from a road or trail, only leave about 10-cm of the bar above ground, or sink a stake to ground level, and note this in the comments of the data form. In high-use areas it may be necessary to partially camouflage stakes, or to mark beginning and end points with buried metal markers that can be relocated with a metal detector (or a magnetic locator).

At times rebar cannot be satisfactorily pounded into the ground. If this is the case at one of your plot points, try installing the rebar out a little further along the tape. Note the distance along the transect where the rebar is placed (i.e., at the start, the distance is 0). Another option is to sink the stake in at an angle so that the top is in the correct location. You can also pile up rocks around the rebar, but only if that won't affect the variable you are sampling and the cairn has a reasonable chance of remaining undisturbed.

3. Label Transect Origin Point

Install permanent plot identification tags on each stake as described below.

- Use rectangular or oblong brass tags; aluminum tags are likely to melt in areas of prescribed burns.
- Each tag should include the monitoring stake location code, plot purpose, plot identification code (see Step 9 below), and date of initial installation. An abbreviated format may be used to reduce the amount of minting. It includes the monitoring stake location code, plot purpose, vegetation code from the plot identification code, plot number and date.

Stamping the tags using a die set produces the most wear-resistant results, but is very time-consuming. Stamp the tags (except the date and the plot number, which can be added once the plot has been accepted) before going into the field.

4. Determine Azimuth of Transect

Using the random table in the field materials, select an azimuth for the transect. If the azimuth chosen is unsuitable for the transect (hazards, boulders, etc.), reorient 180 degrees at the origin point.

5. Establish Transect and Monument End Point

Anchor the beginning end of the tape to the plot origin stake and walk to the right side of the transect azimuth for 50 m. Once 50 m have been measured, pull the tape taut along the transect azimuth. If necessary, use steel pins to hold the tape in place at other points along the transect. Mark the end point of the transect with another rebar monument, following instructions in Step 1. Fasten the tape so that the 50 m transect tape is taut and as close to the ground as possible to avoid curvature in the line. Once the transect line has been established, measure 10 meters to the left of the tape establish a second 50 meter tape to delineate the area to be monitored.

6. Photograph Sampling Site

Once the tape is laid out, take a minimum of two photos at each plot, following the “Subject” sequence listed below (see also SOP #04 Photographing Plots). If necessary to better characterize the vegetation at the site, take additional photos from a well-documented location. Place a flagged rangepole or other tall marker at the midpoint of the line being photographed. To minimize the effect of vegetation trampling on the photo, photograph the monitoring plot before you sample other variables, staying outside the plot as much as possible.

Subject	Code
1. From 0P toward 50P	0P–50P
2. From 50P toward 0P	50P–0P
3. From 0P toward reference feature	0P–REF
4. From reference feature toward 0P	REF–0P

A coded photograph identification “card” should be prepared and made visible in every photograph. The card should display, in large black letters, the plot identification code, date (if camera is not equipped with a date stamp), subject code and any other information that may be useful, e.g., park code, unit, or burn status.

7. Place Nails Along Transect

To insure the proper alignment of the sampling frame at each 10 meter mark along the transect, insert a metal nail flush with the ground at the 10 m, 20 m, 30 m and 40 m tape marks along the transect tape, and at all the above plus the 0 m mark along the secondary tape.

8. Collect Environmental Data

Determine the Aspect and Elevation of the sampling site. Using a clinometer (Refer to SOP # 02 – Navigation & Measurement Aids), determine 1) the percentage of slope along the transect azimuth, and 2) percentage of slope of hillside. Record this data on the Plot Location Data sheet.

9. Complete Plot Location Data Sheet

Complete the Plot Location Data Sheet by adding detailed directions to the plot. Detailed directions are those adequate for someone unfamiliar with the site to locate it. Begin with road travel, where to park, describe (and photograph) landmarks used in navigating the start of the center transect. Note particular obstacles or hazards to be avoided at (and en route to) this particular site.

- Assign and record the plot identification code. The plot ID number consists of the monitoring type code and the pre-assigned two digit plot number.
- Record the date you established the plot, the unit name or number, crew member names, the azimuth of the transect and the declination used (See SOP #02 – Navigation Aids & Techniques).

- Record the Universal Transverse Mercator values, Estimated Horizontal Error, and datum used.
- Record the average percent slope that the transect azimuth follows, the aspect, and elevation of the plot location.
- Record the road and trail used to travel to the plot.
- Record the compass bearing (including declination) followed from the road or trail (or other relatively permanent reference point) to locate the monitoring plot. Mark on the topographic map where you left this well-known trail or road, and photograph this location if necessary
- Describe how to get to the monitoring plot, referring to the hand-drawn map to illustrate the written directions by including all your geographic references. Include the highly visible features from which you took your bearings.
- Identify permanent or semi-permanent reference features on the site in case the origin stake is hard to find or disappears. The reference feature should be easy to relocate.
- Record the true compass bearing and distance in meters from the reference feature to the origin stake.
- Describe the plot location accurately and thoroughly, referring to the hand-drawn map.
- Complete the history of site visits every time you visit the plot.

Transect Establishment Data Sheet

Park: _____ Transect ID: _____ Date : _____ Page ____ of ____

Observer : _____ Community: _____

Transect Coordinates (UTM): _____ m E _____ m N

Datum_____ UTM Zone_____

Slope (%): _____ Aspect (°): _____ Transect Azimuth (°): _____ Declination: _____

TRANSECT LOCATION:

Rebar at transect origin		Rebar location (m)	Rebar at transect end		Rebar location (m)	Elevation m
UTM E	UTM N		UTM E	UTM N		

Directions to Transect: _____

[illegible]

PLOT LOCATION DATA SHEET

Plot ID: _____ B / C (Circle One) Park Code: _____ Date: _____

Burn Unit: _____ Recorders: _____

Topo Quad: _____ Transect Azimuth: _____ Declination: _____

UTM Zone: _____ Lat: _____ Section: _____ Trans Slope (%): _____

UTM E (x): _____ Long: _____ Township: _____ Hill Slope (%) _____

UTM N (y): _____ Range: _____ Aspect: _____ Elev: _____

Location information determined by ___ Map & Compass / ___ GPS

If determined by GPS: Datum used: ___ PDOP / ___ EHE

Fire History of Plot (including date of last known fire)

Road and trail used to travel to plot:

True compass bearing at point where road/trail is left to hike to plot: _____ °

Describe the route to the plot; include or attach a hand-drawn map illustrating these directions, including the plot layout, plot reference stake and other significant features. In addition, attach a topo, orthophoto, and/or trail map.

Describe reference feature:

True compass bearing from plot reference feature to plot reference stake: _____ °

Distance from reference feature to reference stake: _____ m

Problems, comments, notes:

Date Entered: _____

FMH-4**MONITORING TYPE DESCRIPTION SHEET**

Monitoring Type Code: _____

Date Described: ____/____/____

Monitoring Type Name: _____

FGDC Association(s): _____

Preparer(s) (FEMO/RMS/FMO): _____

Burn Prescription (including other treatments: _____

Management Objective(s): _____

Monitoring Objective(s): _____

Objective Variable(s): _____

Physical Description: _____

Biological Description: _____

Rejection Criteria: _____

Notes: _____

Date Entered: ____/____/____

FMH-4

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 4

Photographing Plots

Version 1.0 (March 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revisio n Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains the methods for photo-documentation of permanent plots and has been adopted from the 2003 USDI-National Park Service Fire Monitoring Handbook. There is a set of minimum requirements for the photo-documentation for each plot. However, each plot area is also different, and creativity is encouraged in crew members (especially the Lead Technician for this SOP) in deciding the best ways to add to these minimum requirements. Keep in mind that landscape photo-pairs repeated from identical points over time are extremely valuable tools for documenting changes through time in vegetation and landscape variables. Photo-documentation provides the following benefits to the program:

1. A graphical depiction of aspects of the vegetation mosaic and the landscape context of each plot – a snapshot in time.
2. A graphical depiction of any nearby features that might prove significant in understanding changes that could occur within a plot, such as ecotones, potential sources of disturbance, and conspicuous landmarks.
3. After the first iteration of sampling, the images are an invaluable tool for accurately setting- up plots and placing quadrats, thereby increasing the accuracy and overall repeatability of our measurements.
4. Once out of the field, plot photographs allow us a way to 'revisit' a plot if questions arise during data entry or analysis – that is, if something seems amiss or unusual with some aspect of the data, the photographs should allow us to assess whether this is a mistake, or that the plot truly was an "outlier" of some sort.
5. A method to actually analyze and graphically display apparent changes in the vegetation cover of a plot – sometimes a picture will capture changes that have occurred when other sampling measurements do not capture the change.

In general, one technician will be assigned the lead role for photo-documentation. Often other technicians will shoot some of the required photos, but the lead technician for this role is responsible for ensuring all required photos for the plot are taken, and any good photo opportunities to illustrate the overall grid or individual plots are utilized. As of this version (1.0), the model of the digital camera is Canon PowerShot S45, 4.0 megapixel resolution. Future models will be recorded in the revision log.

Procedures:

I. Responsibilities of the lead technician

1. The lead technician for the photo-documentation protocol will need to become proficient in the operation and features of the digital cameras prior to going into the field.
2. The lead technician will be skilled at the following functions of the camera: image resolution, image file size, zoom or wide-angle capabilities, the 'stitch' feature that allows multi-image panoramic photos to be stored and stitched together, and the 'macro' feature. The lead technician also makes sure that the photo-log is completely and correctly filled out, which is crucial to the photo-documentation process. All photograph notes are entered into the project database.
3. The lead technician ensures the proper gear is assembled and packed for sampling trips (see equipment list below). They also ensure that a sufficient number of charged batteries and storage cards are brought into the field each day.
4. The lead technician ensures that the equipment is well-cared for, and that the camera is stored in dry conditions during inclement weather.
5. The lead technician must be familiar with the methods, hardware and software required to download the images following a trip, and is responsible for recharging the batteries such that they will be ready for use during the subsequent field excursion.
6. The lead technician will make recommendations at the end of the field season about lessons learned and improvements to this procedure.

II. Shooting Photos

1. Plot photos are taken immediately after the plot is installed (SOP #3). It is essential that you take the plot photos before the measurements are made, so that images of the plot represent its most natural, undisturbed state.
2. Every photo that is taken must be recorded in the photo log. The camera automatically assigns a number to each image. Each number in the sequence for a particular grid must be recorded in the data sheet. If you delete an image, the camera will not re-assign that number to another image. Therefore, if you delete a photo for any reason, record it as a deleted image next to the associated number, so that all numbers in the sequence are accounted for.
3. Use a medium resolution format for photos. The typical file size of photos ranges between 400 KB – 1 MB. Rarely will you need to store images in the highest resolution format for routine photo-documentation.
4. Once all the tapes are laid out, take a minimum of two photos at each plot, following the "Subject" sequence listed below:

Subject	Code
1. From 0P toward 50P	0P–50P
2. From 50P toward 0P	50P–0P
3. From 0P toward reference feature	0P–REF
4. From reference feature toward 0P	REF–0P

5. A coded photograph identification "card" should be prepared and made visible in every photograph. A convenient photo board can be fashioned out of a piece of white paper (or card stock) laminated with 10 mil plastic; dry erase markers can then be used to mark the board. Such a board will last one field season. The card should display, in large black letters, the plot identification code, date,

subject code and any other information that may be useful, e.g., park code, unit, or burn status. Photos will be more useful if they show primarily the vegetation, and space taken up by the board and monitor is minimized. Have someone hold the board so that the codes are just visible in each photograph, but the board itself is as unobtrusive as possible. While it would make for great reminiscing, the person holding the board and the other data collectors should not be visible in the photo.

6. Place a range pole or other tall marker at the midpoint of the line being photographed. The pole should be located at the same point each time the plot is rephotographed. This can provide for clearer comparisons over time.

7. If the closest stake that should be in the photo is obstructed by a shrub or tree limbs, take the photo anyway, flagging the stake and moving as little vegetation as possible. You may then take an oblique shot of the photo transect if desired, noting the exact location from which this shot was taken and that this photo should always be repeated on subsequent visits. If obtrusive vegetation prevents you from placing the camera in such a spot that you can get the closest stake in the picture, it may be acceptable to take the photo while standing at the stake itself, or from a different height (but not above 5 ft), as long as this is noted and repeated on all subsequent visits. Never prune vegetation from a plot.

III. Rephotographing Plots

Remember that when you are photographing plots that have already been documented, you should make every attempt to duplicate the previous photos, no matter what technique was used, unless the previous photos are poor, e.g., pictures of plot stakes, but not the plot itself. If possible, bring a reference photo (a color photocopy of the original) along to facilitate duplication of earlier shots.

1. Always bring a copy of the establishing photos into the field to facilitate replication of earlier shots. This can be a set of photographic prints, scanned images, or color photocopies generated for this purpose and included in the “field packet” (see SOP #1).
2. Retake the photo when the shrub and herbaceous species are at the same phenological stage as they were in the original photos whenever possible.
3. If you find that the Photographic record sheet is too large, or if you use multiple cameras, keep a small notebook with appropriately labeled pages in the camera bag at all times. Attaching the notebook to the camera bag will reduce the risk of losing the entire notebook and all the data with it.

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 5

Method for Collecting Divided Quadrat Data

Version 1.0 (March 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains the procedures that are performed to collect data using the divided quadrat method in all parks of the Southern Plains. Following these procedures is important to collect valid data used in monitoring grassland health.

Primary vegetation data will be collected using a series of permanent transects consisting of 5 divided quadrats located every 10 m (beginning at 0 m) along a 50 m transect (figure 1). Quadrat sampling requires a two person team: one “observer” to call out frequency, cover, and density and one “recorder” to write down these data. The sampling team should keep their same roles for frequency, cover, and density on a given transect.

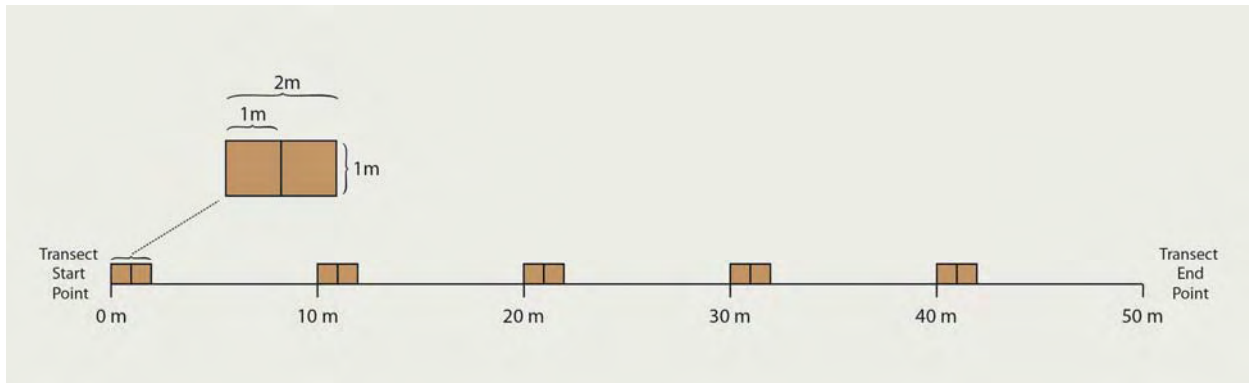


Figure 1. General plot layout for sampling grasslands.

Set up the transect

Use a GPS to locate the coordinates of the start and end points of the transect (SOP #3). If a revisit, relocate the rebar posts marking the start and end of each transect using a metal detector if necessary. Avoid trampling the sampling area on the left side of transect (from the start point). Anchor the beginning end of the tape to the plot origin stake and walk on the right side of the transect towards the ending stake. Fasten the tape so that the 50 m transect tape is taut and as close to the ground as possible to avoid curvature in the line. If necessary, use additional steel pins to hold the tape in place at other points along the transect. Set up a second 50 m tape parallel and 10 m to the left of the transect tape to delineate to sampling area, being careful to align both tapes with the metal pins placed at the sampling marks.

Photograph the transect

Photos should be taken each time the permanent plot is revisited (SOP #4). Every attempt should be made to duplicate the establishing photos. A copy of establishing photos can be taken into the field to facilitate replication of earlier shots. Photos will be more useful if they show primarily the vegetation, and space taken up by the board and the crew is minimized.

Prepare Data Collection Sheet(s)

Record relevant information in the header of the Field Data Form in preparation for data collection. These data sheets can be printed both front and back, using one side of the sheet for each of the five quadrats.

Sample divided plots for cover and frequency

Care should be taken while performing the actions below so that vegetation along the transect tape is not trampled. Point-line intercept readings of the vegetation on the tape line should be taken prior to the divided quadrat readings.

Frequency and cover data are collected in five 2x1 m quadrats located along each transect, spaced 10 meters apart. Along all transects, plots begin at 0 m, 10 m, 20 m, 30 m, and 40 m on the left side of the tape. For the first quadrat, align the PVC sampling frame so that the quadrat begins at 0 m and ends at 2 m. Begin by sampling a 1 m² area (0m – 1m), followed by a 2x1 area (0m – 2m) that includes the previously sampled area.

Record Species Codes

Species codes are assigned in a systematic way. Originally, they were assigned following Natural Resource Conservation Service methodology, as used in the USDA PLANTS Database (USDA NRCS 2001). This naming convention used a 4+ character alpha code beginning with the first two letters of the genus name and the first two letters of the species name. The following 0–2 characters were assigned as needed to avoid confusion of plants with duplicate codes. If there was no subspecies or variety, the next character(s) may not be needed or would be a one or two digit number representing the alphabetical ranking of that plant on the national list.

The many numbers following the four letter code has proven to be quite confusing and an easy vector for mistakes when entering data into the database. Therefore, a change has been made to the species code for the purpose of this protocol. The species code will now be a six-letter code +characters, consisting of the first three letters of the genus and the first three letters of the species, followed by a number if duplicate codes exist. While numbering may still be involved, there are normally no more than two numbers involved, decreasing the possibility of mistakes.

Examples:

Original	Current	
DACA	DALCAL	Dalea californica
DACA3	DANCAL	Danthonia californica
DACA13	DASCAL	Dasistoma calycosa

If the plant is a subspecies or variety, then the character in the seventh position will be the first letter of that infraspecific name, and if there are duplicates, a number will follow.

Examples:

Original	Current	
ACRUT	(ACERUBT)	Acer rubrum var. trilobum
ACRUT3	(ACERUBT2)	Acer rubrum var. tridens
DACAP	(DALCARP)	Dalea carthagenensis var. portoricana
DACAP3	(DANCALP)	Danthonia californica var. palousensis

Vegetative Cover:

The observer estimates the cover of individual species in each of the divided quadrats using ocular estimation techniques (see below). Each individual percentage value alone cannot exceed 100%, but when combined the cover value for a plot may be greater than 100% due to layering. Only species rooted >50% in the plot are included in estimates of foliar cover. A reference list provided for each plot lists the names, but not the associated cover values, of species previously collected in a plot for comparison to those being recorded. If any species from the previous year was missed, the plot is searched again for the species. Comparison with the previous year's species list maintains consistency in species identification and creates a check for missing species.

Ground Cover:

After vegetative cover is estimated, for each 2x1 m plot, the ground-level cover of bare soil, litter and other attributes (Table 1) is estimated using the same ocular estimation techniques (see below). When percentages are combined the cover value for a plot may not be greater than 100%.

Soil surface type	Definition	
Bare soil, no overhead vegetation	Loose soil particles (0-2 mm diameter) exposed to erosion	
Bare soil, under vegetation	Loose soil particles (0-2 mm diameter) protected by vegetation overhead	
Litter	Embedded litter that is less than 2.5 cm in diameter, where removal of the litter would leave an indentation in the soil surface or would disturb the soil surface	
Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and in direct contact with soil	
Small rock	Rock fragments 2-20 mm in diameter	
Large rock	Rock fragments >20 mm in diameter	
Lichen	Lichen crust on soil (lichen on rock is recorded as the appropriate rock type)	
Moss	Moss on soil (moss on rock is recorded as the appropriate rock type)	
Crust, undifferentiated	Anything from physical crust to weak biological crust but NOT including lichen, or moss	
Scat, livestock	Any type of livestock scat	

Table 1 Definitions of soil surface features for quadrat sampling.

Complete sampling at all quadrats along the transect.

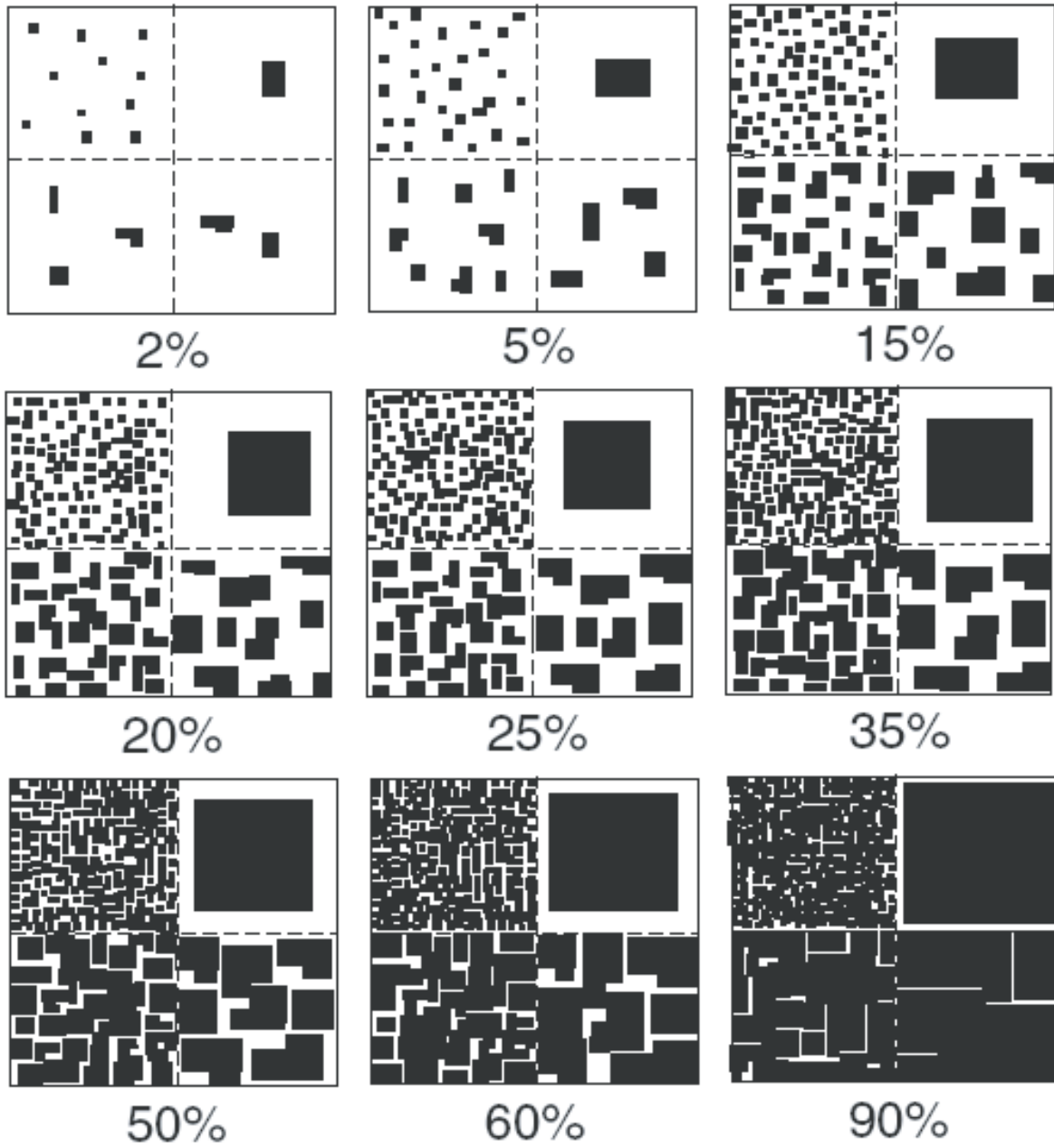
After you finish sampling the first quadrat, repeat the above efforts to sample the remaining quadrats along the transect. Sample quadrats every 10 m as you move down the transect, making sure to sample all divided plots.

AID FOR OCULAR ESTIMATION

The validity of ocular estimation has come into question due to observer variability both within and across seasons. It is of critical importance that observers be well trained at the beginning of the season and recalibrate their estimations monthly during the field season. The best consistency will be achieved within a season's readings if they are made by the same person all season. During the first three field seasons implemented under this protocol, cover will be estimated using two different procedures: by ocular estimate and through Point-Line Intercept, which currently has greater validity within the scientific community. Comparisons of these two estimates will be made to determine the degree of observer error for future monitoring effort.

When cover estimates are made using the Divided Frequency method, vegetation cover estimates will be made for each divided quadrat (1 m² and 2x1 m) at the species level. Ground surface estimates will be made only for each 2x1 m quadrat.

Use the following visual aid to calibrate observer estimation.



Presence, Cover, and Density Data Sheet

Park: _____ Plot #: _____ Date _____ Page _____ of _____

Observer: _____ Recorder _____

[illegible]

Surface Feature % Cover	2x1 m
Bare soil, no overhead vegetation	
Bare soil, under vegetation	
Litter	
Woody debris	
Small rock	
Large rock	
Lichen	
Moss	
Crust, undifferentiated	

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 06

Point-Line Intercept Procedures

Version 1.0 (March 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains the procedures that are used to collect Point-Line Intercept data from monitoring transects. This SOP is adapted from the 2003 USDI-National Park Service Fire Monitoring Handbook.

Procedures

Use the appropriate form for 30 m transects or 50 m transects. Use a point intercept method to record the number of transect hits and to obtain relative and percent cover by species over time.

Locate the 0 point on the point intercept transect

The data collection starting point is at the OP (origin stake) on grassland plots and follows the same tape transect used for obtaining nested quadrat data.

Collect number of transect hits

Drop a ¼ in diameter pole (a rigid plumb bob), graduated in decimeters, gently so that the sampling rod is plumb to the ground (on slopes this will not be perpendicular to the ground), every 30 cm along the transect line. Where the transect length is 30 m, there will be 100 points (50 m transects will be 166 points).

At each “point intercept” (Pnt), gently drop the pole to the ground, and record each species (Spp) that touches the pole on the Point-Line Intercept data sheet. Count each species only once at each point intercept even if the pole touches it more than once. Record the species from tallest to the shortest. If the pole fails to intercept any vegetation, record the substrate (bare soil, rock, forest litter, etc). Note: You can occasionally find vegetation under a substrate type; in this case you would ignore the substrate and record the vegetation. If the rod encounters multiple types of substrate, record only that which the pole hits first.

Do not count foliage or branches intercepted for trees over 2 m tall, but count all other vegetation, including shrubs, no matter its height. (This is because trees are better sampled using other procedures, and the target variables using the point intercept transect are shrubs and herbs.) If the sampling rod intersects the bole of a tree that is over 2 m tall, record “2BOLE,” or “2SDED” if the tree is dead. Note: Record species not intercepted but seen in the vicinity on the bottom of the data sheet.

Tall Vegetation Sampling Problems

When recording vegetation height, if vegetation is unexpectedly taller than the sampling rod, try dropping the rod at the sampling point, then placing your hand at the 1 or 1.5 m point on the rod and sliding the rod up (without looking up), elevating it by 1 or 1.5 m and recording where it touches the vegetation above you. If the vegetation is consistently taller, find a taller sampling rod.

Dead Herbaceous and Shrub Species Sampling Problems

You may encounter dead standing vegetation along your transects. Always record dead annual vegetation in the same way you record live individuals. Record dead biennial and perennial vegetation (except dead branches of living plants) by placing a “D” at the end of the species code. This permits dead vegetation to be treated separately from live vegetation. Dead perennials may not be included in species abundance indices, but their presence may provide information for estimating fire behavior and determining mortality. In general count dead branches of living plants as a live intercept. In the case of shrub and herbaceous species, this also applies if the main plant is dead but sprouting, and the dead part is encountered.

Sprouting Dead Trees

Trees under 2 m tall: If the bole (>2 m tall) is dead but sprouting at the base, consider any live sprout (<2 m tall) you encounter as live. Trees over 2 m tall: If you encounter a live basal sprout over 2 m tall, the sprout should be considered a tree (2BOLE) in its own right.

Shrub and herbaceous layer height

At every sampling point, measure the height of the tallest living or dead individual of each species (to the nearest decimeter, in meters) at the highest place on the sampling rod touched by vegetation. Record this height (Hgt) on the data sheet. A ¼ in wide sampling rod graduated in decimeters should make this measurement relatively easy. Do not record data for aerial substrate such as the leaves or stems attached to a dead and downed tree.

Record Species Codes

Species codes are assigned in a systematic way. Originally, they were assigned following Natural Resource Conservation Service methodology, as used in the USDA PLANTS Database (USDA NRCS 2001). This naming convention used a 4+ character alpha code beginning with the first two letters of the genus name and the first two letters of the species name. The following 0–2 characters were assigned as needed to avoid confusion of plants with duplicate codes. If there was no subspecies or variety, the next character(s) may not be needed or would be a one or two digit number representing the alphabetical ranking of that plant on the national list.

The many numbers following the four letter code has proven to be quite confusing and an easy vector for mistakes when entering data into the database. Therefore, a change has been made to the species code for the purpose of this protocol. The species code will now be a six-letter code +characters, consisting of the first three letters of the genus and the first three letters of the species, followed by a number if duplicate codes exist. While numbering may still be involved, there are normally no more than two numbers involved, decreasing the possibility of mistakes.

Examples:

Original	Current	
DACA	DALCAL	Dalea californica
DACA3	DANCAL	Danthonia californica
DACA13	DASCAL	Dasistoma calycosa

If the plant is a subspecies or variety, then the character in the seventh position will be the first letter of that infraspecific name, and if there are duplicates, a number will follow.

Examples:

<i>Original</i>	<i>Current</i>	
ACRUT	(ACERUBT)	Acer rubrum var. trilobum
ACRUT3	(ACERUBT2)	Acer rubrum var. tridens
DACAP	(DALCARP)	Dalea carthagenensis var. portoricana
DACAP3	(DANCALP)	Danthonia californica var. palousensis

FMH-16**30 m TRANSECT DATA SHEET**

Plot ID: _____

B/C (Circle One)

Date: ____ / ____ / ____

Burn Unit: _____

Recorders: _____

Burn Status: Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ____-yr02 ____-yr05 ____-yr10 ____-yr20 Other: ____-yr____; ____-mo____

Phenological Stage: _____ (Circle One) Q4–30 m w 0P–30P

Pnt	Tape	Hgt (m)	Spp; Species or Substrate Codes (tallest to lowest)					
1	0.3							
2	0.6							
3	0.9							
4	1.2							
5	1.5							
6	1.8							
7	2.1							
8	2.4							
9	2.7							
10	3.0							
11	3.3							
12	3.6							
13	3.9							
14	4.2							
15	4.5							
16	4.8							
17	5.1							
18	5.4							
19	5.7							
20	6.0							
21	6.3							
22	6.6							
23	6.9							
24	7.2							
25	7.5							
26	7.8							
27	8.1							
28	8.4							
29	8.7							
30	9.0							
31	9.3							
32	9.6							
33	9.9							
34	10.2							
35	10.5							
36	10.8							
37	11.1							
38	11.4							
39	11.7							
40	12.0							
41	12.3							
42	12.6							
43	12.9							
44	13.2							
45	13.5							
46	13.8							
47	14.1							

Date Entered: ____ / ____ / ____

Pnt	Tape	Hgt (m)	Spp; Species or Substrate Codes (tallest to lowest)					
48	14.4							
49	14.7							
50	15.0							
51	15.3							
52	15.6							
53	15.9							
54	16.2							
55	16.5							
56	16.8							
57	17.1							
58	17.4							
59	17.7							
60	18.0							
61	18.3							
62	18.6							
63	18.9							
64	19.2							
65	19.5							
66	19.8							
67	20.1							
68	20.4							
69	20.7							
70	21.0							
71	21.3							
72	21.6							
73	21.9							
74	22.2							
75	22.5							
76	22.8							
77	23.1							
78	23.4							
79	23.7							
80	24.0							
81	24.3							
82	24.6							
83	24.9							
84	25.2							
85	25.5							
86	25.8							
87	26.1							
88	26.4							
89	26.7							
90	27.0							
91	27.3							
92	27.6							
93	27.9							
94	28.2							
95	28.5							
96	28.8							
97	29.1							
98	29.4							
99	29.7							
100	30.0							

Species observed within ____ m of either side of the transect but not intercepted: _____

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 7

Shrub Transect Procedures

Version 1.0 (April 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains the procedures that are performed to collect data in shrub belt transects. This SOP is adapted from the 2003 USDI-National Park Service Fire Monitoring Handbook.

Collect and Record Shrub Density Data

Record shrub density within a circle bisected by the divided quadrat and the point intercept transect. The size of this circle is 20 m, using the 25 m main transect point as the center and a 10 m radius. Count each individual having >50% of its rooted base within the circle. Use the Shrub density data sheet to record the data. You may divide the circle into sections (pie slices) to facilitate counts. For this protocol, it is not necessary to record the interval (Int). Record data by species (Spp), age class (Age), whether it is living (Live), and number of individuals (Num) of that species. Tally any change in species, age, or live-dead as a separate entry on the data sheet (e.g., ARTTRI, M, L, would be tallied separately from ARTTRI, M, D). Under age class, identify each plant as either a immature-seedling (I), a resprout (R), or as a mature-adult (M) (see definitions below). Shrub density data should also include data on subshrubs (primarily *Cactaceae*).

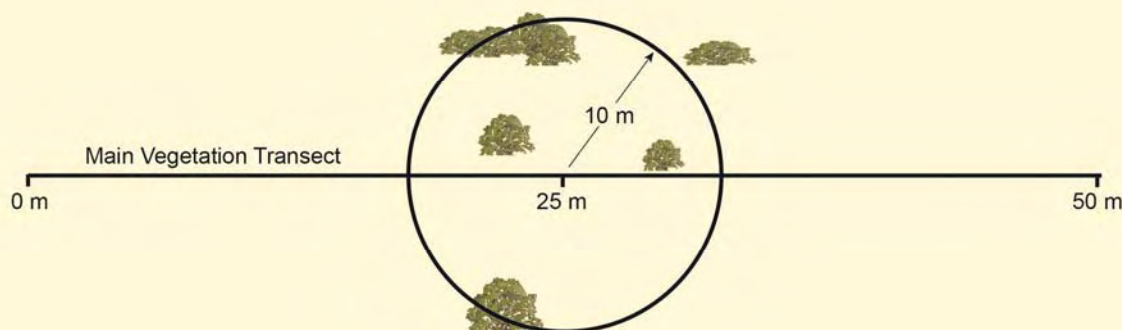


Figure 7-1. Plot layout for monitoring shrub density.

Definitions of Age Classes and Subshrub:

Immature/Seedling (Shrubs). An age class for shrubs without burls that have emerged since the time of the last disturbance, or a shrub (with or without a burl) too immature to flower. This definition will vary by shrub, by ecosystem and by the time since the last disturbance.

Mature. An age class for shrubs able to produce flowers and seeds. Also called Adult.

Resprout. A shrub or seedling tree age class of shrubs or seedling trees that have resprouted after being top-killed by a fire or any other disturbance. Sprouting can be epicormic (from the stem) or basal (from the base of the plant).

Subshrub. Multi-stemmed woody plant species with a height of less than 0.5 m due either to genetic or environmental constraints. Also called dwarf shrubs.

Troubleshooting Shrub Data Collection

Dead burls

After dead burls have been counted at least once since dying, you can omit them from density sampling, but it may be useful to note them on the form in case they sprout again in another year.

Clonal or rhizomatous species

Shrub individuals may be very difficult to define in some species, and monitors may get very different numbers depending on their perception of what an individual is. Relative or percent cover may be a more accurate way to describe these species. However, it may be appropriate to count something other than the individual in this case, e.g., a surrogate plant part such as culm groups, inflorescences, or stems.

Examples:

Arctostaphylos spp. stems are often easy to trace to a basal burl. This usually defines the individual. The “burl unit” may be an appropriate delineator of individuals, even when two or more individuals have grown together.

Rubus spp. are often rhizomatous, making it difficult to distinguish an “individual.” The recommended response for dealing with rhizomatous or clonal species is to ignore these species when you collect shrub density data. Note: If these species are ecologically significant (e.g., for wildlife habitat), count stem density instead of individual density. The “stem unit,” in this case, becomes the basis for quantifying density.

The usefulness of these surrogates depends on the biological significance of changes within these surrogates. Consult with the project manager before you use a surrogate, or omit a species from shrub density sampling. Note any species for which you plan to use surrogates, or omit from monitoring.

Resprouts

Once a disturbance has caused a plant to die back and resprout, the plant should be considered a resprout for the first year, and then an immature until it is once again reproductive (mature).

Anticipated dramatic increases in postburn shrub density

It may be advantageous to establish a protocol to count seedlings in density plots only after their second or third year of survivorship. However, you should at least estimate seedling presence in all cases, with estimates such as 10/m² or 50/m². You may wish to subsample the density plot during temporary high density periods. To subsample, grid the plot and randomly select an appropriate subsample (i.e., 10%, 20%) of the area. Then proceed to count the individuals in the subsample area and extrapolate to the sample area. Again, this should be done only in consultation with the project manager.

Page _____ of _____

Plot ID:

Burn Unit:

Date: / /

Recorders: _____

Treatment Type: Rx Fire, Wildfire, Mechanical, Herbicide, None (Circle One)

If multiple treatment types indicate all that apply.

Mechanical 00-PRE _____-Post ____-YR01 _____-YR02 ____-YR05 ____-YR10 Other: _____YR ____mo

Herbicide 00-PRE _____-Post _____-YR01 _____-YR02 _____-YR05 _____-YR10 Other: _____YR _____mo

Circular Plot Radius (m):

[illegible]

Date entered / /

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 8

Fine Fuel Load Sampling

Version 1.0 (April 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This sampling protocol is used to estimate fine fuel loading (standing biomass and litter) on a dry weight basis. The fuel loading is sampled by individually clipping and weighing forbs, grasses, subshrubs and litter of the vegetation community and expressed in tons acre⁻¹ or kg hectare⁻¹. The primary use of this data is as variable to model fire behavior and as an indicator of ecosystem recovery following fire disturbance. This provides a measure of how quickly fine fuel accumulates (standing biomass and litter) to levels observed prior to burning or some other disturbance that alters above ground biomass such as grazing or drought. Generally, sampling is conducted without regard to species composition but by life form. Species composition is obtained from nested frequency or point intercept data.

Equipment Needed:

For the field

- **Sheers:** Suggested Corona [Forged Thinning Shear Model number FS 4350](#)



- **2- Bundles of Paper Grocery Bags (500):** 9-3/4 x 6-1/4 x 16-3/8" (Available online from GSAAAdvantage.
- **4 - 6 Black Markers** (for labeling bags)
- **3 - 0.25 m² Square Frame:** Frame is constructed of ½ inch schedule 40 pvc pipe with the inside dimensions of 50 cm x 50 cm.
- **1 - 50-m Tape:** For collecting fine fuel loading data and runs parallel to the permanently placed vegetation transect (Nested frequency or Point-Intercept).
- **2 – 30-m Tapes:** Used to measure the offset distance from the permanent vegetation transect at 0 and 50m.
- **2 - 3 100g Scale** (i.e. Pesola Micro-Line Spring Scale, 100g x 1g)
- **2 - 2 300g Scale** (i.e. Pesola Medio-Line Spring Scale, 300g x 2g)
- **2 - 600g Scale** (i.e. Pesola Medio-Line Spring Scale, 600g x 5g)
- **2 - Staplers** for closing sacks retained for drying.
- **2 – PDAs** (HP Ipaqs or Trimble Nomads)

For the lab:

- **1 - Electronic Balance** measure two decimal places
- **1 - Bench Top Drying Oven:** Must be able to be set to 100°C (212°F)

Preparing for the Field

Prior to going to the field label the paper sacks in which biomass samples are to be returned to the office for further processing. There should be two samples per transect of grasses, forbs, subshrubs (*Gutierrezia sarothrae*, etc) and litter. The label should contain:

- the park code,
- the date,
- the transect number,
- the location along the transect from which the sample was taken, 20 or 40 meters, and
- contents of sack: grasses, forbs, subshrubs or litter.

Ten empty sacks should be dried at 100°C (212°F) for 24 hours and weighed on an electronic balance to obtain a mean tare weight for each of the sack sizes used. If possible be consistent in the size of the sack used when sampling a transect. Record the tare weight in the FFL spreadsheet. A copy of this spreadsheet will be loaded onto the pda (Trimble Nomad or HP IPaq) for field entry. Extra blank sample sacks should be taken for quadrats with large samples. These sacks should be labeled accordingly and the number of the sack with the total number of sacks used per sample for example 1 of 2, 2 of 2, etc. If the sample is being discarded fill as many bags as needed, weigh each bag as they are filled; don't wait until all the bags are full. Enter values and then discard the sample. Keep the sacks for further use.

Transect Placement

The fine fuel load (ffl) transect is offset and parallel to the permanent vegetation transect and can be placed on either side depending if it's an odd or even decade (the third number in the year i.e 20[1]1). The origin (OP) of the ffl transect is on the same end as the vegetation transect. The offset distance varies annually to avoid clipping the same area from year to year. The offset distance ranges from 1 to 10m depending on the last number of the year. So for 2011 the offset is 1m, for 2015 it would be 5m and 2020 it would be 10m (0=10m). If the third number of the year is odd the ffl transect is placed on the left side of the vegetation transect (standing at transect origin (Op) and facing the end of the transect 50p) and if it's even, on the right side. So for the decade 2010 to 2019, the third number, being odd, dictates that sampling occur on the left side. In the next decade, 2020 to 2029, the third number is even, therefore sample on the right side. Following this pattern an area is not sampled more than once every twenty years. Refer to Figure 8.1 for transect/quad diagram.

Quadrat Placement

The 0.25m² quadrat frame (50cm x 50cm) is placed at five locations at 10m meter intervals along the 50m ffl transect; at 10 to 10.5m, 20 to 20.5m, 30 to 30.5m, 40 to 40.5m, and 50 to 50.5m. When the third number in the year is odd, the quadrat is placed on the left side of the ffl transect and when even, on the right side, similar to placement of the fine fuel transect.

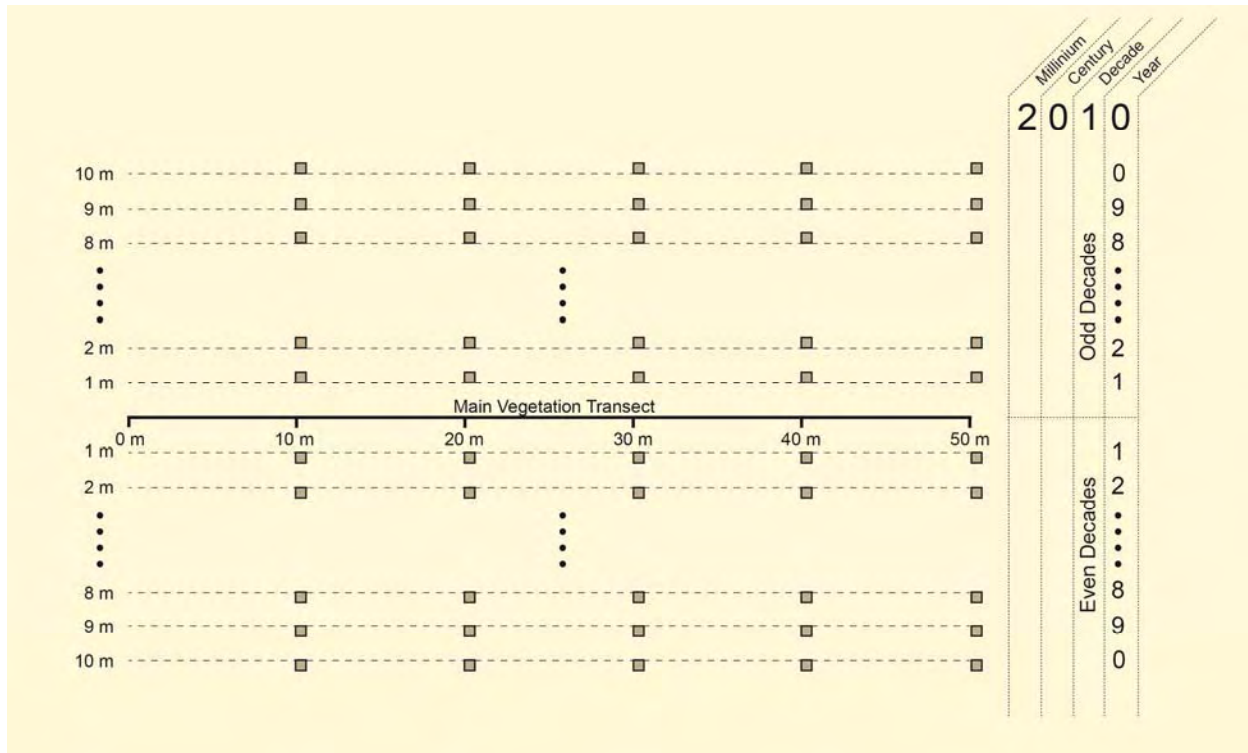


Figure 8.1. Transect/quadrat placement diagram for Fine Fuel Loading sampling.

Sampling

Prior sampling, it may be necessary to reweigh the sample sacks to determine if there is a departure (+1g for small sacks and +2g for large sacks) from the tare weight on the ffl spreadsheet on the pda. If there is, reweigh 10 empty sacks in the field, determine the mean and replace the wet mean lab tare weight with the new field wet tare weight. It may be necessary to frequently check (30 minutes to an hour) sack tare weights, particularly when the relative humidity is high.

Clip all grasses, forbs and subshrubs rooted within the 0.25m² quadrat frame to within 1 cm of the soil surface. Clip, bag and weight subshrubs first, forbs second and, grasses third. Standing dead from previous growing season is sampled with the current years standing biomass. Pick up as much litter as possible with as little soil as possible. Cacti are not clipped. Once sack is filled, **do not wait too long before weighing the sample (>5 min)**. Enter the value into the pda on the ffl excel spreadsheet. Samples collected at 10, 30 and 50m are discarded after the weights are recorded. Samples from 20m and 40m are retained to determine moisture content when processed in the lab. The sacks are sealed by folding and stapling the top closed. Use additional sacks as needed.

Sample Processing

Two samples from the transect, 20m and 40m, are retained for further processing to account for the moisture in the field weighed samples in order to express fuel loadings on a dry weight basis. This is obtained by oven drying the retained samples for a minimum of 24 hours at 100°C. After 24 hours the samples are removed from the oven and weighed on the electronic balance and the values are entered in the ffl spreadsheet. Within the spreadsheet the oven dry weight is then divided by the wet (field weight) minus the tare weights to obtain the moisture correction factor (mcf) for each sample.

$$\text{Moisture Correction Factor} = \frac{\text{Dry wt} - \text{Tare wt}}{\text{Wet wt} - \text{Tare wt}}$$

The two samples for each transect are then averaged so that one mfc is obtained for grasses, one for forbs, one subshrubs and one for litter. Each mfc is then multiplied by the five samples along the transect so that the fuel load is expressed on a dry weight basis for the four fine fuel components: grasses, forbs, subshrubs and litter. Once the five samples have been corrected they can then be averaged resulting in one mean value for grasses, forbs, subshrubs and litter for the transect, which can then be summed to obtain a total fine fuel loading in grams per 0.25m². This value is converted to kg per hectare by the following equation

$$\text{kg ha}^{-1} = \left(\frac{x \text{ g}}{0.25 \text{ m}^2} \right) \times \left(\frac{10,000 \text{ m}^2}{1 \text{ ha}} \right) \times \left(\frac{1 \text{ kg}}{1000 \text{ g}} \right)$$

where:

x = the moisture corrected average fuel load values.
 g = grams
 kg = kilograms
 ha = hectares
 m^2 = meters squared

And into tons per acre by the following:

$$\text{t ac}^{-1} = \left(\frac{x \text{ kg}}{1.0 \text{ ha}} \right) \times \left(\frac{0.001102 \text{ t}}{1.0 \text{ kg}} \right) \times \left(\frac{1.0 \text{ ha}}{2.471 \text{ ac}} \right)$$

where:

x = the fuel loading values in kg per ha.
 t = tons
 ac = acres
 kg = kilograms
 ha = hectares

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 9

Collecting Fuels Data

Version 1.0 (March 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains the procedures that are performed to collect data in shrub belt transects. This SOP is adapted from the 2003 USDI-National Park Service Fire Monitoring Handbook.

On all monitoring plots, measure dead and detached woody fuel as well as duff and litter depths. These measurements are taken along fuel inventory transects, which must be relocatable to allow evaluation of postburn fuel load. Transects extend in random directions originating from the main transect at 10, 20, 30, and 40 m. Unlike herbaceous transects, fuel load transects can cross each other (Brown 1996). Each transect length is 50 ft.

Lay out the appropriate length tape along the transect in a random direction (Appendix B). Place a labeled tag at each end of the transect. Measure the percent slope of the transect (from end to end) in percent.

Working along the transect, tally each particle intersected along a preselected side of the tape, categorized by size class. Measurement of all particles is taken perpendicular to the point where the tape crosses the central axis (Figure 9.1). Count intercepts along the transect plane up to 6 ft from the ground. Count dead and down woody material, but not cones, bark, needles and leaves. Do not count stems and branches attached to standing shrubs or trees (Brown 1974; Brown and others 1982). For additional details on tallying downed woody material, refer to the notes on the reverse side of the Forest Plot Fuels Inventory Data Sheet.

Differentiate between 3 in (or larger) diameter particles that are sound and those that are rotten. Rotten wood is that which is obviously deteriorating or punky. Measure the particle diameter to the nearest 0.5 in with a diameter tape or ruler. Ignore particles buried more than halfway into the duff at the point of intersection. Visually reconstruct rotten logs as a cylinder and estimate the diameter. This reconstructed diameter should reflect the existing wood mass, not the original sound diameter.

Take depth measurements for litter and duff at 10 points along each fuel transect—that is at 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 ft. Do not take measurements at the stake (0 point); it is an unnatural structure that traps materials. At each sampling point, gently insert a trowel or knife into the ground until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Vertically measure the litter and duff to the nearest tenth of an inch. Refill holes created by this monitoring technique. Do not include twigs and larger stems in litter depth measurements. Record the above dead and downed fuel data on the Forest plot fuels inventory data sheet

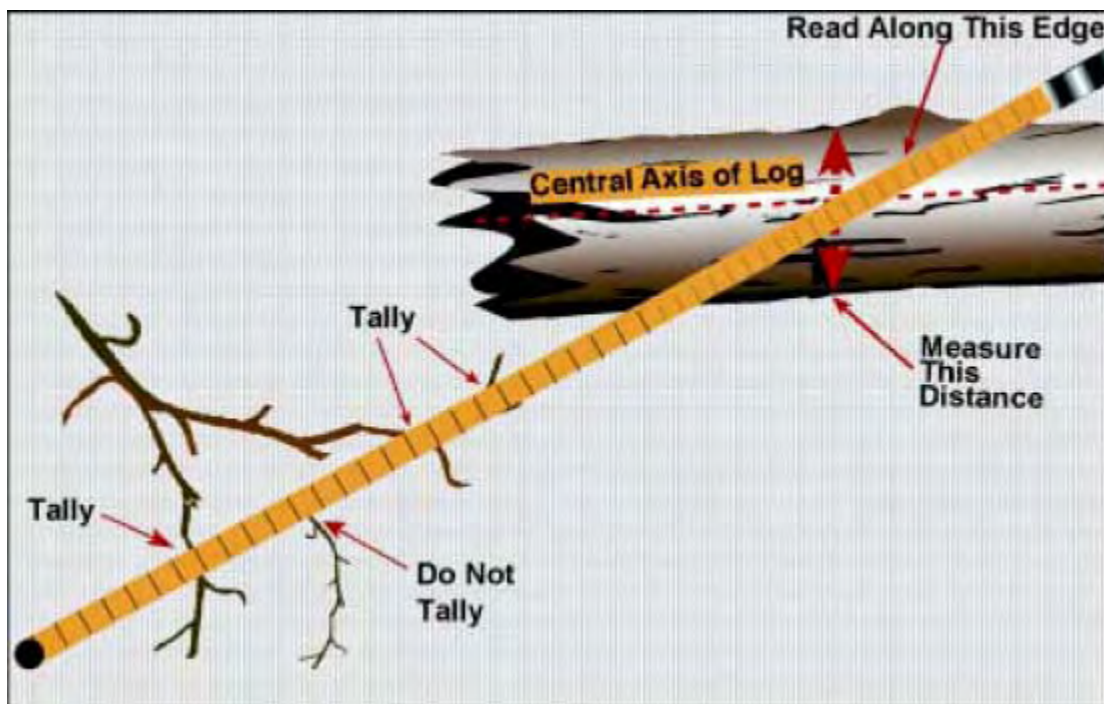


Figure 9.1. Tally rules for dead and down fuel. Count all intersections, even curved pieces. All intersections must include the central axis in order to be tallied.

Size Class	Suggested Length
0–0.25" (0–0.62 cm) diameter (1 hour)	tally from 0–6 ft
0.25–1" (0.62–2.54 cm) diameter (10 hour)	tally from 0–6 ft
1–3" (2.54–7.62 cm) diameter (100 hour)	tally from 0–12 ft
>3" (>7.62 cm) diameter (1,000 hour)	measure each log from 0–50 ft

Table 9-1. Suggested lengths of transect lines to tally fuels by size class.

When an Obstruction is Encountered Along the Fuel Transect

If the fuel transect azimuth goes directly through a rock or stump, in most cases you can run the tape up and over it. If the obstruction is a tree, go around it and pick up the correct azimuth on the other side. Be sure to note on the FMH-19 on which side of the bole the tape deviated so that it will be strung the same way in the future.

Occasionally moss, a tree trunk, stump, log, or large rock will occur at a litter or duff depth data collection point. If moss is present, measure the duff from the base of the green portion of the moss. If a tree, stump or large rock is on the point, record the litter or duff depth as zero, even if there is litter or duff on top of the stump or rock. If a log is in the middle of the litter or duff measuring point, move the data collection point 1 ft over to the right, perpendicular to the sampling plane.

FMH-19**FOREST PLOT FUELS INVENTORY DATA SHEET**

Page ____ of ____

Plot ID: _____

B / C (Circle One)

Date: ____ / ____ / ____

Burn Unit: _____

Recorders: _____

Burn Status: Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ____-yr02 ____-yr05 ____-yr10 ____-yr20 Other: ____-yr ____; ____-mo ____

Transect lengths, in feet: 0-0.25: ____ 0.25-1: ____ 1-3: ____ 3+s: ____ 3+r: ____

	# of intercepts					Diameter (in)		Litter and Duff Depths (in)			
	0-.25"	.25-1"	1-3"	3+s	3+r	L	D	L	D		
	(1-hr)	(10-hr)	(100-hr)	(1,000-hr)							
Transect 1						1			25		
Compass						5			30		
Dir. _____°						10			35		
Slope ____%						15			40		
Tag 1A						20			45		
& 1B											
Transect 2						1			25		
Compass						5			30		
Dir. _____°						10			35		
Slope ____%						15			40		
Tag 2A						20			45		
& 2B											
Transect 3						1			25		
Compass						5			30		
Dir. _____°						10			35		
Slope ____%						15			40		
Tag 3A						20			45		
& 3B											
Transect 4						1			25		
Compass						5			30		
Dir. _____°						10			35		
Slope ____%						15			40		
Tag 4A						20			45		
& 4B											

Note: See reverse for definitions and tally rules

Date Entered: ____ / ____ / ____

FMH-19

Definitions

Litter—Includes freshly fallen leaves, needles, bark, flakes, fruits (e.g., acorns, cones), cone scales, dead matted grass, and a variety of miscellaneous vegetative parts. Does not include twigs and larger stems.

Duff—The fermentation and humus layers; does not include the freshly cast material in the litter layer, nor in the postburn environment, ash. The top of the duff is where needles, leaves, fruits and other cast-off vegetative material have noticeably begun to decompose. Individual particles usually are bound by fungal mycelia. The bottom of the duff is mineral soil.

Downed Woody Material—Dead twigs, branches, stems and boles of trees and shrubs that have fallen and lie on or above the ground.

Obstructions Encountered Along Fuel Transects—If the fuel transect azimuth goes directly through a rock or stump, in most cases you can run the tape up and over it. If the obstruction is a tree, go around it and pick up the correct azimuth on the other side. Be sure to note on the FMH-19 on which side of the bole the tape deviated so that it will be strung the same way in the future.

Litter and Duff Measurement Rules

- If the transect is longer than 50 ft, do not take additional litter and duff measurements.
- Do not take measurements at the stake (0 point); it is an unnatural structure that traps materials.
- At each sampling point, gently insert a trowel or knife into the ground, until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Vertically measure the litter and duff to the nearest tenth of an inch.
- Refill holes created by this monitoring technique.
- Do not include twigs and larger stems in litter depth measurements.
- Occasionally moss, a tree trunk, stump, log, or large rock will occur at a litter or duff depth data collection point. If moss is present, measure the duff from the base of the green portion of the moss. If a tree, stump or large rock is on the point, record the litter or duff depth as zero, even if there is litter or duff on top of the stump or rock.
- If a log is in the middle of the litter or duff measuring point, move the data collection point one foot over to the right, perpendicular to the sampling plane.

Tally Rules for Downed Woody Material

- Measure woody material first to avoid disturbing it and biasing your estimates.
- Do not count dead woody stems and branches still attached to standing shrubs and trees.
- Do not count twigs and branches when the intersection between the central axis of the particle and the sampling plane lies in the duff.
- If the sampling plane intersects the end of a piece, tally only if the central axis is crossed.
- Do not tally any particle having a central axis that coincides perfectly with the sampling plane.
- If the sampling plane intersects a curved piece more than once, tally each intersection.
- Tally uprooted stumps and roots not encased in dirt. Do not tally undisturbed stumps.
- For rotten logs that have fallen apart, visually construct a cylinder containing the rotten material and estimate its diameter.
- When stumps, logs, and trees occur at the point of measurement, offset 1 ft (0.3 m) perpendicular to the right side of the sampling plane.
- Measure through rotten logs whose central axis is in the duff layer.

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) #10

Management of Unidentified Taxa (Unknowns)

Version 1.0 (March 2011)

REVISION HISTORY LOG:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This global standardized operating procedure (GOP) gives step-by-step instructions on how to collect field samples, enter unidentified taxa (referred to hereafter as “unknowns”) into the protocol database and how to edit the records once the unknowns have been identified. This SOP will also provide directions on how to manage the unknown records created in the protocol’s field database species list.

1. Collect field sample of unknown plants

It may be difficult or impossible to determine the specific identify of individual plants encountered during sampling. When this situation occurs, search the immediate area surrounding the transect, looking for specimens of the unknown plant that are more readily identifiable (e.g., due to the presence of flowers or fruits from current or previous seasons). These may assist in correctly identifying the species in the transect. Collect a sample of the plant with leaves, flower and/or fruit, place it in a press or field notebook, attach a sample label it and fill in the requested information. Assign an unknown code that is unique from all other unknown codes in the park. This specific code will be used whenever the same plant is encountered again during monitoring in that park

2. Assign/create an unknown taxonomic record

Use the attached Unknown Plant Species Tracking Log to manage the record number assignments and identification of unknowns. When digital data entry is performed in the field on a laptop computer, the field crew will need to add codes for these unknowns to the database species list. The field crew assigns a code that has meaning only to the field crew to each unidentified taxon (e.g., UNKWHITEFLOWER for an unidentified plant with white flowers). Suspected Family or Genus names and/or numbers may also be used. The same assigned code is used for every record of each unknown taxon entered into the database.

3. Identify unknowns from the field

As soon as possible following collection, the field crew identifies the unknowns collected from the field. When possible, digital scans of the fresh specimen should be made at 600 dpi to preserve the specimen’s identifying features. Scans should be labeled as PARKCODE_UNKCODE_DATE(mmddyyyy). Further identification is done either at the network office with the assistance of the plant ecologist or at the local approved herbarium.

4. Edit the unknown taxonomic records

4.1. Unknowns identified to species (or sub-species)

- 4.1.1. The species matches an existing record in the protocol's species list – Go to step 4.1.4.
- 4.1.2. The species does not exist in the protocol's species list – Go to step 4.1.3.
- 4.1.3. Add the appropriate scientific nomenclature and associated information for the new species into the database species table.
- 4.1.4. Use the *Edit* function in the protocol database to change the field-assigned unknown code to the correct species code.
- 4.1.5. Notify the project lead that the **Field** database is ready to be appended to the **Current** database.

4.2. Unknowns identified to general unknown categories

- 4.2.1. Use the *Edit* function in the protocol database to change the field-assigned unknown code to the general unknown code already available in the protocol database (*e.g.*, UNKSHR for an unknown shrub).
- 4.2.2. Notify the project lead that the **Field** database is ready to be appended to the **Current** database.

5. Manage the protocol species list

This section will be written when SQL Server is up and running.

Exotic Plant Monitoring

Unknown Plant Species List, Daily Tracking

Datasheet Version: 1.0

Proofread by: _____
 Copied by: _____
 Edits to DB date: _____
 Edits to Datsh. date: _____
 Edits to Copies date: _____

Location and Event Information

Park Code:		Date (mm/dd/yyyy):	
Plots/Polygons/Transect:			Observer Name(s):
Protocol Name: Multi-Network Exotic Plant Monitoring		Protocol Version: 1.0	

[illegible]

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) #11

Collecting Plant Voucher Specimen

Version 1.0 (March 2011)

Revision History

Ver. #	Revision Date	Author	Description of Change	Effective Date

This document details the appropriate collection and curation protocol for voucher specimen collections made in the course of research activities conducted by the Integrated Southern Plains grassland monitoring team. Plant collections provide primary documentary evidence for the presence of a vascular plant species at the park unit. This document details the appropriate protocol for voucher specimen collections from collection in the field, through identification, to curation at appropriate herbaria.

Field Data Collection

Voucher specimen collection is a necessary component of any integrated data collection system for research on vascular plants. For Southern Plains researchers, this includes voucher specimen collections made in the course of grassland monitoring, vegetation mapping, and opportunistic collection efforts conducted at park units. Prior to any collection effort, appropriate collection permits must be obtained for each park by the Project Manager and carried in the field by the crew leader.

Voucher Specimens

Voucher specimens are to be collected at the discretion of the field research crews. All crews have appropriate equipment to make voucher specimen collections, including a field press and newspapers for specimen collection, GPS device for location information, and sufficient data sheets. Crews will follow this procedure for collecting plants:

1. Identify the plant as best as possible in the field, taking care to note if it is potentially rare, threatened or endangered. Potential T&E plants should not be collected. These plants should be photographed (see SOP #04) and precise location should be recorded. The 10% rule should always be observed in the collection of all plants, such that no entire plant should be collected if there are fewer than 10 specimens in the immediate vicinity.
2. Care should be taken to obtain flowers, fruits, and roots as practicable.
3. Using a single fold of newspaper per plant, the specimen should be laid out and arranged to display all floral parts for ease of future identification. Arrangement should take care to have half the leaves up and half down, resemble actual plant architecture (where appropriate given size limitations) and carefully open flowers so that all floral parts are visible upon drying. Each newspaper should be labeled with the best guess of specimen identification, the date, park code, and collector initials.
4. Fill out the Voucher Specimen Documentation Form in its entirety using pencil. Record the plants identity, all appropriate location information using UTM coordinates, elevation may be

in feet or meters, and note the plant's status in the park, and whether you took a photo. Additionally, take care to fill out habitat description as clearly as possible, referring to both community type and associated species. This form remains with the specimen.

Care of Voucher Specimens post-collection

Appropriate handling of voucher specimens does not end with collection in the field. At the earliest practical opportunity, those collections that have been made using a field press need to be transferred to an appropriate herbarium press for further drying and curing of the specimen. At the time of transfer, if no firm identification of the specimen has been made, another attempt at identification should be made using appropriate floras and literature. This identification (if different than the field identification) should replace the original on the form, do not consider this an annotation, but note the determiner (if different from the collector) in the appropriate field on the data sheet. Properly secure the specimens and allow them to cure. Upon return to the office, notify the SOPN botanist of the collections that have been made for transfer to the herbarium and once the plants are dried and ready for transfer place in the herbarium cabinet in the office.

From Field Collection to Herbarium

Upon receipt of the specimens, the SOPN botanist will verify the collections and identifications prior to their transfer to the appropriate herbarium of record. The following procedures will be followed once the specimens are transferred to the herbarium:

1. Obtain the vouchering protocol from the appropriate herbarium and follow all instructions.
2. The collections are packaged appropriately and placed in the freezer to guard against insect infestation. This process takes a minimum of a week.
3. At the completion of the freezing process, the specimens are removed and placed on SOPN/NPS holding shelves. If further identification of unknowns is necessary, at this point an effort is made by SOPN botanists to clarify and identify all specimens. All those specimens deemed of insufficient quality are discarded.
4. All satisfactory specimens are then given to herbarium staff for verification of identity. All verification and annotation (if necessary) take place prior to accessioning into the appropriate herbarium collection and NPS cataloging. Once verification has taken place, all specimens will be collected by SOPN staff and sorted into park-specific batches.
5. All specimens that have received appropriate NPS catalog numbers will then be accessioned into the herbarium collection. All labeling of these specimens will utilize appropriate NPS labels which prominently bear the arrowhead logo and the NPS catalog number.
6. As per the loan agreement, specimens will remain at the herbarium for the duration of that agreement.

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) # 12

Crust Friendly Field Procedures

Version 1.0 (April 2011)

Revision History Log:

<u>Prev. Version #</u>	<u>Revision Date</u>	<u>Author</u>	<u>Changes Made</u>	<u>Reason for Change</u>	<u>New Version #</u>

This Standard Operating Procedure explains the procedures that are implemented when Biological Soil Crust (BSC) is encountered in and around monitoring plots. BSC is an important system component of the Southern Plains. BSC plays a critical role in nitrogen fixation, and in soil stability. BSC is easily destroyed through trampling, and the relatively long regeneration time of well-developed crust (maybe as long as a century) is problematic. Southern Plains monitoring efforts must exercise considerable effort to minimize 'crust busting' for several reasons. First, park values in general must not be compromised by monitoring efforts. Second, on-plot destruction of crust can impact the validity of the monitoring data – that is, monitoring information is undermined by the effects of monitoring. The latter introduces bias and provides a false representation of 'natural' system dynamics. The latter, of course, is what monitoring is intended to observe. The following procedures were adapted from those used by USGS researchers working in the Colorado Plateau. All crew members must become familiar and follow these procedures.

Walking into a monitoring plot.

Footprints last a long time in the semi-arid grassland systems of the Southern Plains. Walking the same route from a road or trail to a monitoring plot can quickly create the appearance of an 'established' trail. Park visitors tend to gravitate to such trails and over time, the plot-access route can become heavily trampled. Additionally, such trails increase the chance of monitoring-plot disturbance by visitors, which is always to be avoided.

- To avoid trail development always use a separate route to and from a monitoring plot where your footprints will create a noticeable trail.
- When traversing to and from a monitoring plot, select a route that crosses slick rock or other large rocks than can be used as stepping stones, and in washes. Tracks in the latter will be erased during the next rain storm. At all times, avoid stepping on crust, no matter the developmental stage.
- When walking on soil, only leave one set of footprints. That is, walk in single file and step in the footprints of preceding crew member(s).

Walking on a monitoring plot.

Site evaluation, site establishment, and measurement procedures require crew members to restrict their impact to specific areas on a plot.

- When walking around the plot select a pathway that optimizes stepping on rock, dead vegetation,

and washes. If these features are not available, walk at least 20-m away from the edges of the plot.

- Avoid huddling with other crew members to look at the GPS unit, to look at an unknown plant species, when taking a break from the afternoon sun, etc.
- During plot set-up and measurements, carry your water bottle and other necessities with you so a trip across the plot to reach your backpack is not necessary.
- Always leave one set of footprints by walking in existing footprints.
- Measurement procedures described in other SOPs are designed to minimize leaving the area along the transect. For example, closer inspection of species occurring at the outer-edge of a quadrat can be accomplished by leaning over the quadrat, or using stepping-stones afforded by rock or dead plant material.

Re-measuring a monitoring plot

If soil disturbance due to previous visits is extreme, note this on the site-impact form, photograph the disturbance (if possible without walking onto the plot), do not re-measure the plot, and immediately report the disturbance to the Principle Investigator. Extreme disturbance is where soil erosion originating from previous footprints is noticeable, or where deep furrows with loose soil were obviously created from previous trampling. The plot will either be rested before consideration for re-measurement, or abandoned to avoid further degradation. Detailed description and pictures will be useful to determine the proper course of action.

Vegetation Monitoring Procedure for the Southern Plains Grassland Protocol

Standard Operating Procedure (SOP) #13

Daily data management

Version 1.0 (April 2011)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This document outlines the specific daily data management tasks for all data collected in the field for this protocol. This includes tabular data, spatial data and photographs. Storage locations are suggested.

Compile data sheets

- Data sheets are compiled, organized by transect and placed into a manila folder labeled "PARK_YYYYMMDD"
- If some data is collected electronically, use the database print out function to generate paper sheets for these and store with other datasheets.
- Verify all datasheets complete and attempt to verify any unknown plants. Adjust datasheets and database as needed.
- Scan datasheets into a .pdf file for each transect, named "PARKlast 2 digits of year + Transect name" and stored on computer in Park/ PARKlast 2 digits of year_Data.
- If needed, additional hard copies of data sheets can be made and stored in a separate location.

Scan Unknown Plant samples

- At the end of every field day any unknown plant samples collected must be scanned at 600dpi resolution. Freshness of the sample scanned is paramount to future identification efforts. Refer to SOP #10 for more instruction.
- Scan each sample separately and save as a .jpeg file. Name each file "PARKlast 2 digits of year + Unk #" and stored on computer in Park/PARKlast 2 digits of year_Unks.
- Scotch tape each sample to its notation sheet and place into a manila folder labeled "PARK_YYYYMMDD_Unks".

Transfer photos

- Photos are transferred onto computer (en masse) and each labeled "PARKlast 2 digits of year_TransectName_CodeDesignation(as follows)".

Subject	Code Designation
1. From 0P toward 50P	0P–50P
2. From 50P toward 0P	50P–0P
3. From 0P toward reference feature	0P–REF
4. From reference feature toward 0P	REF–0P

For example, **SAND10_ULAND-LT02_50P-0P**. Refer to SOP #4 for more details.

- Photos are stored on computer in Park/ PARKlast 2 digits of year_PlotPhotos.

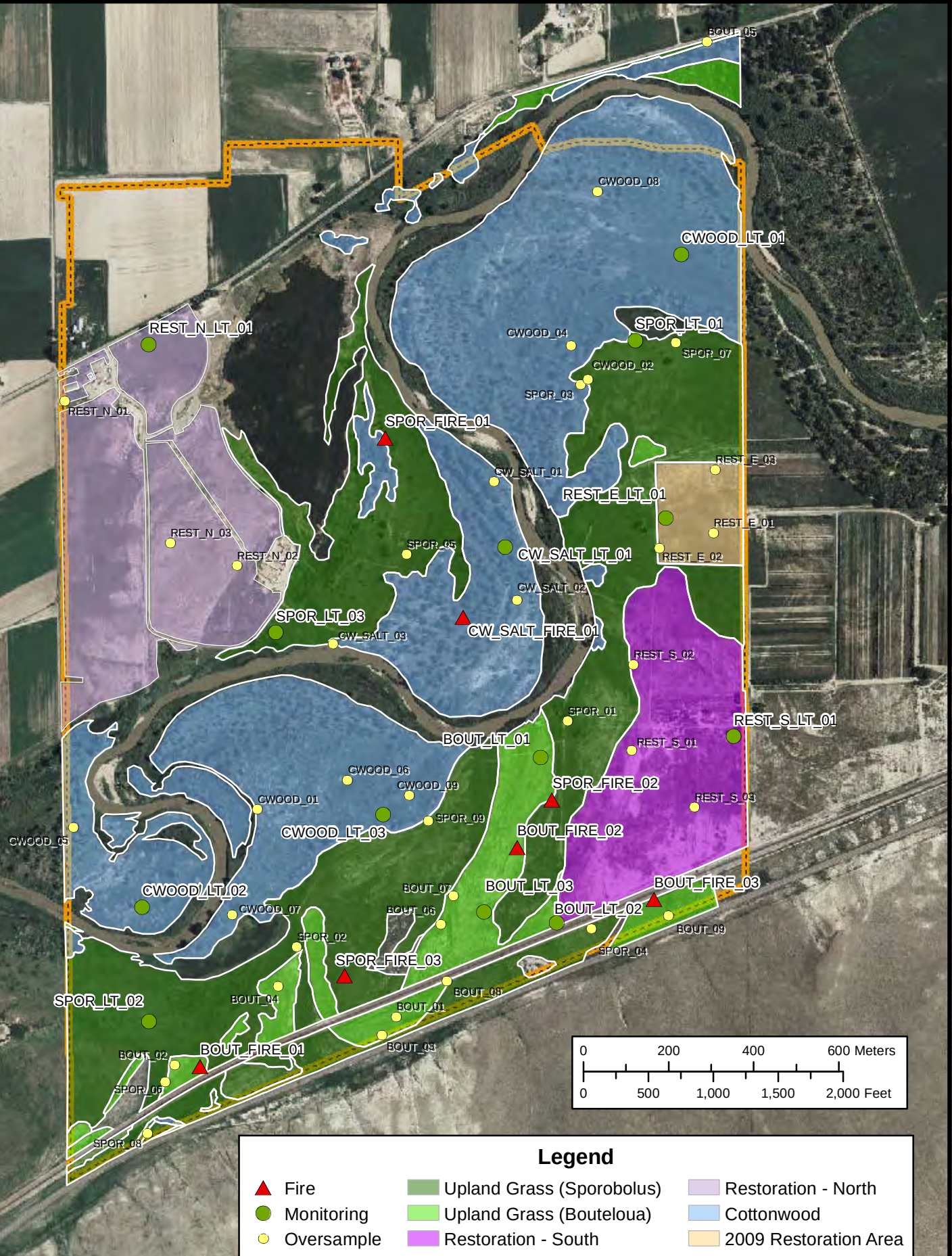
Electronic data entry - Backup MDB

- If data is collected electronically in the field using laptops or other units, place a copy of the most recent database backend or other file type (excel) used in the field (FIELD_YYYYMMDD) – with the date distinguishing beginning of current field tour, into the appropriate folder on an external hard drive or computer for back-up.
- At end of work week (once back in office) transfer all files to the network server and notify project lead or data manager of status. If using a database 'field copy', this should be appended into the current version of the parent database. All files should also be copied onto the appropriate FTP site and Project Manager(s) notified of data upload.

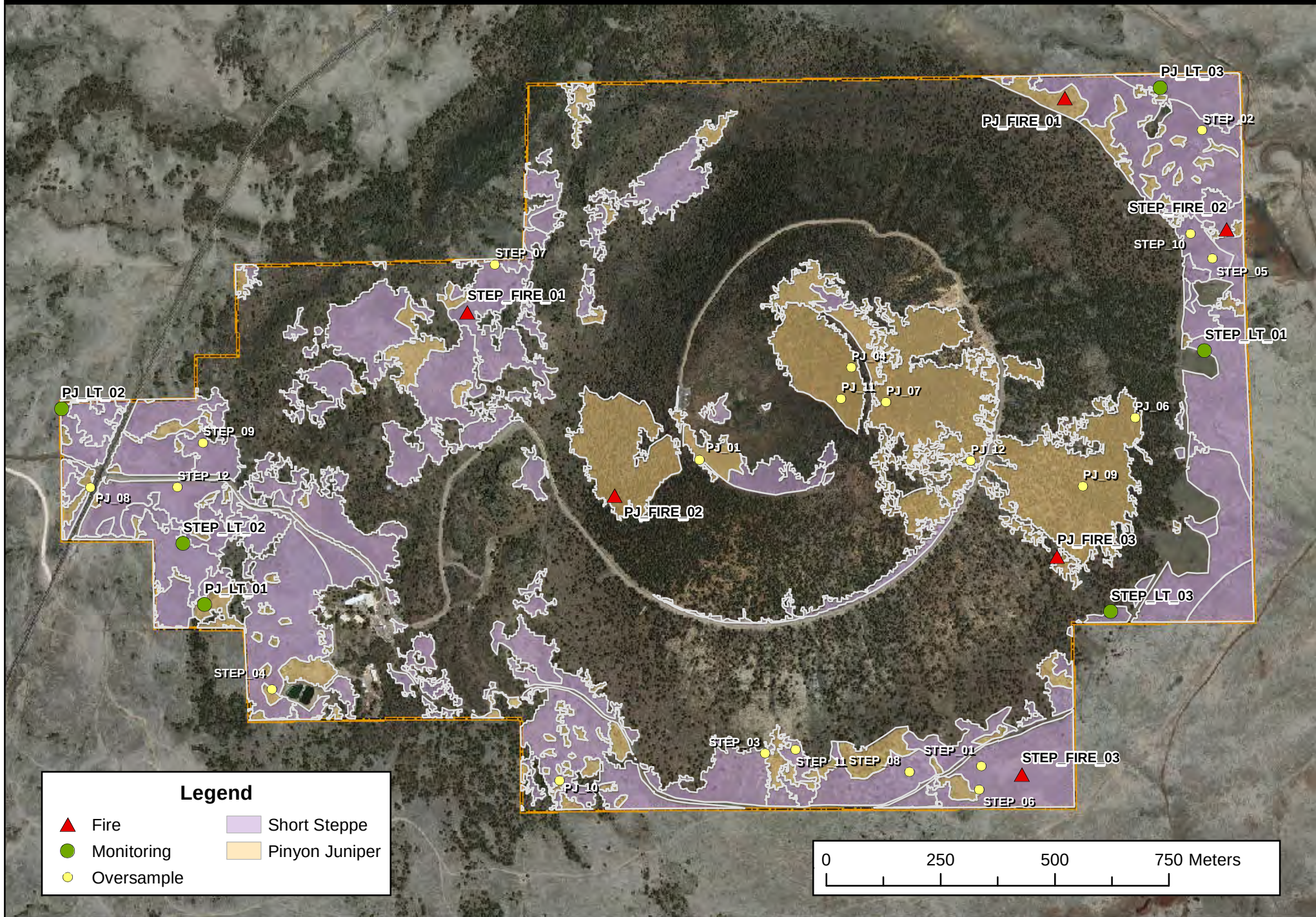
APPENDIX A

Transect Location Maps For Monitoring

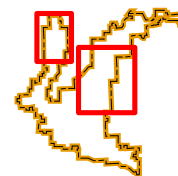
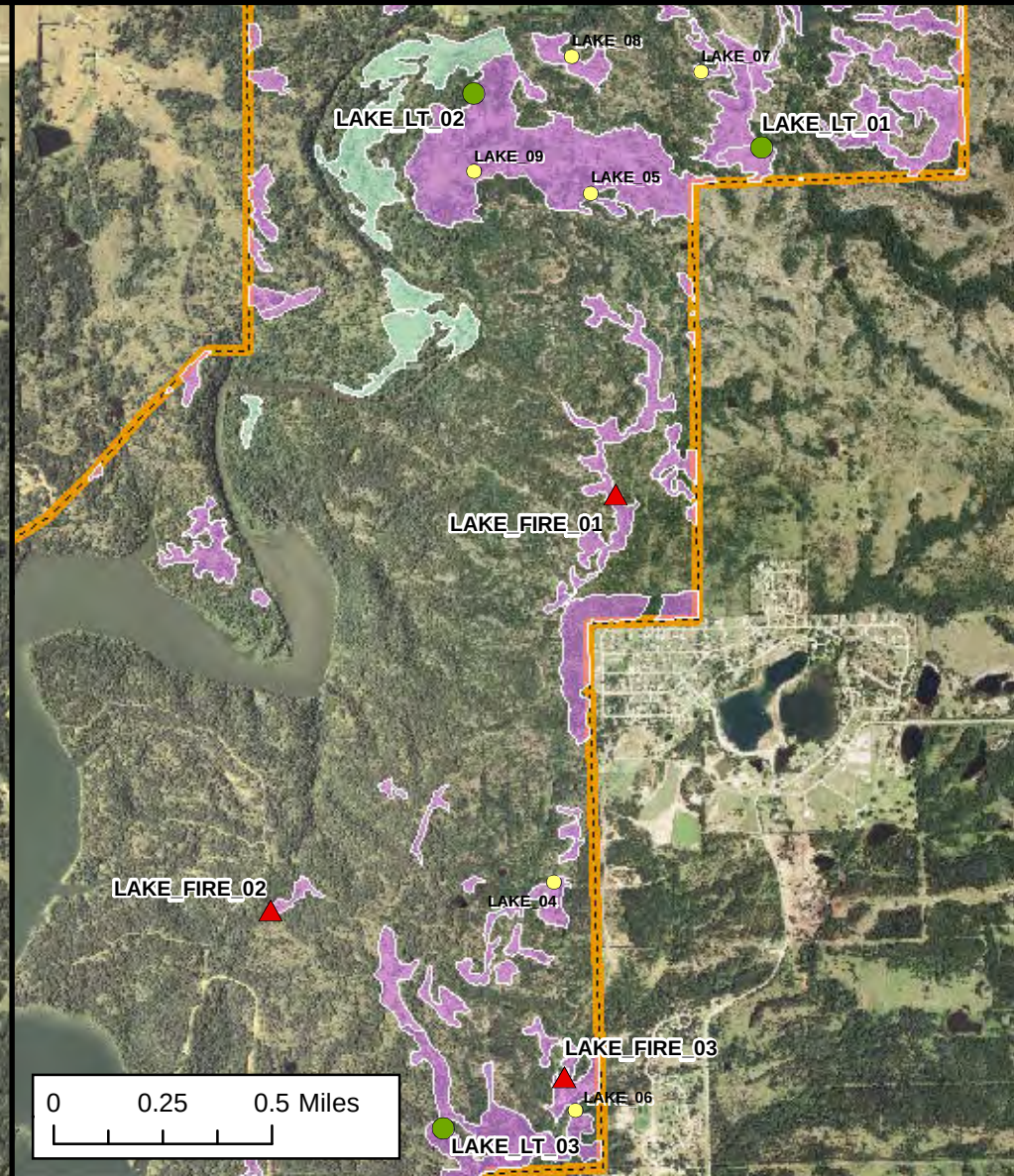
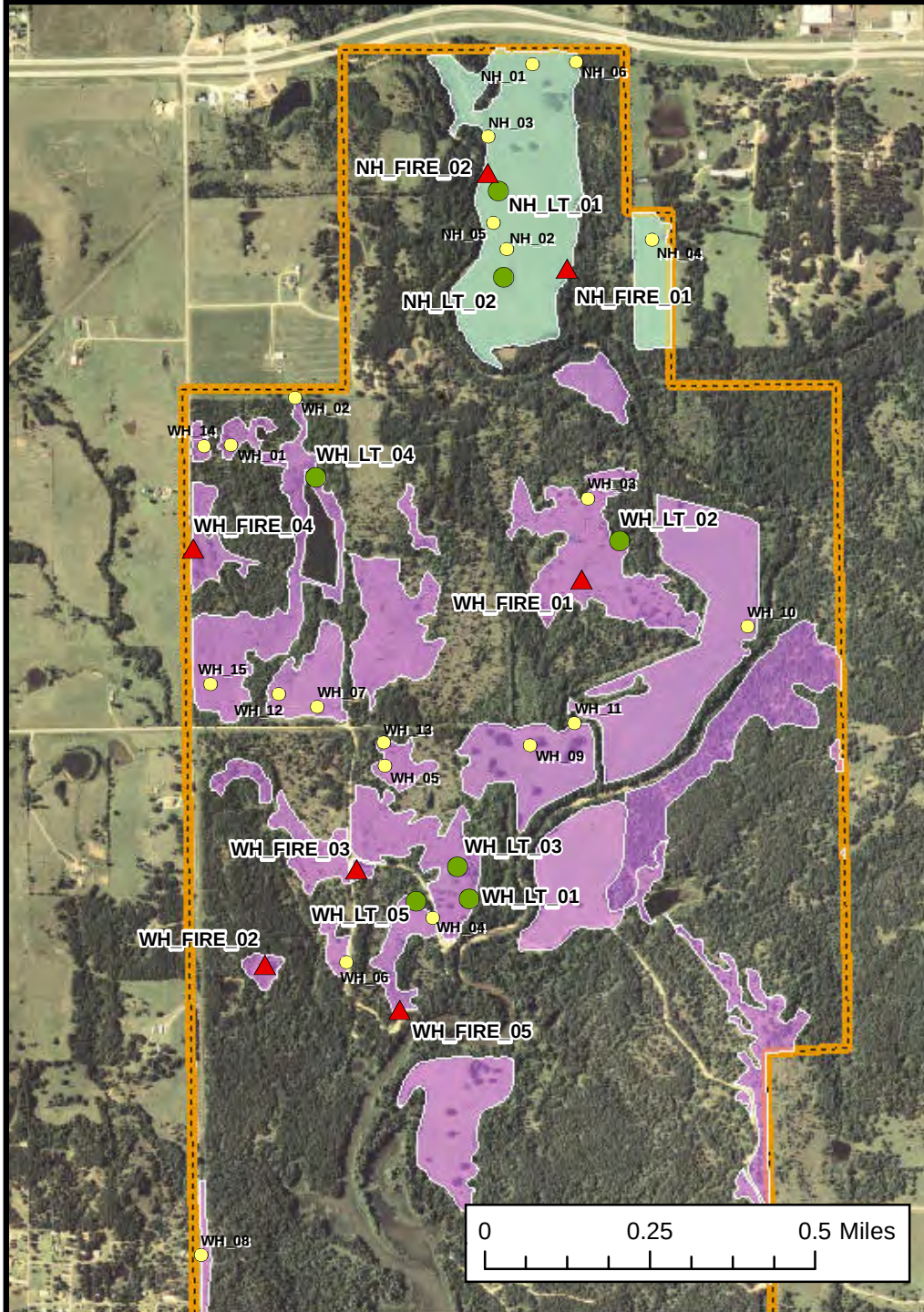
Bent's Old Fort NHS - 2011 Grassland/Fire Plots



Capulin Volcano NM - 2011 Grassland/Fire Plots



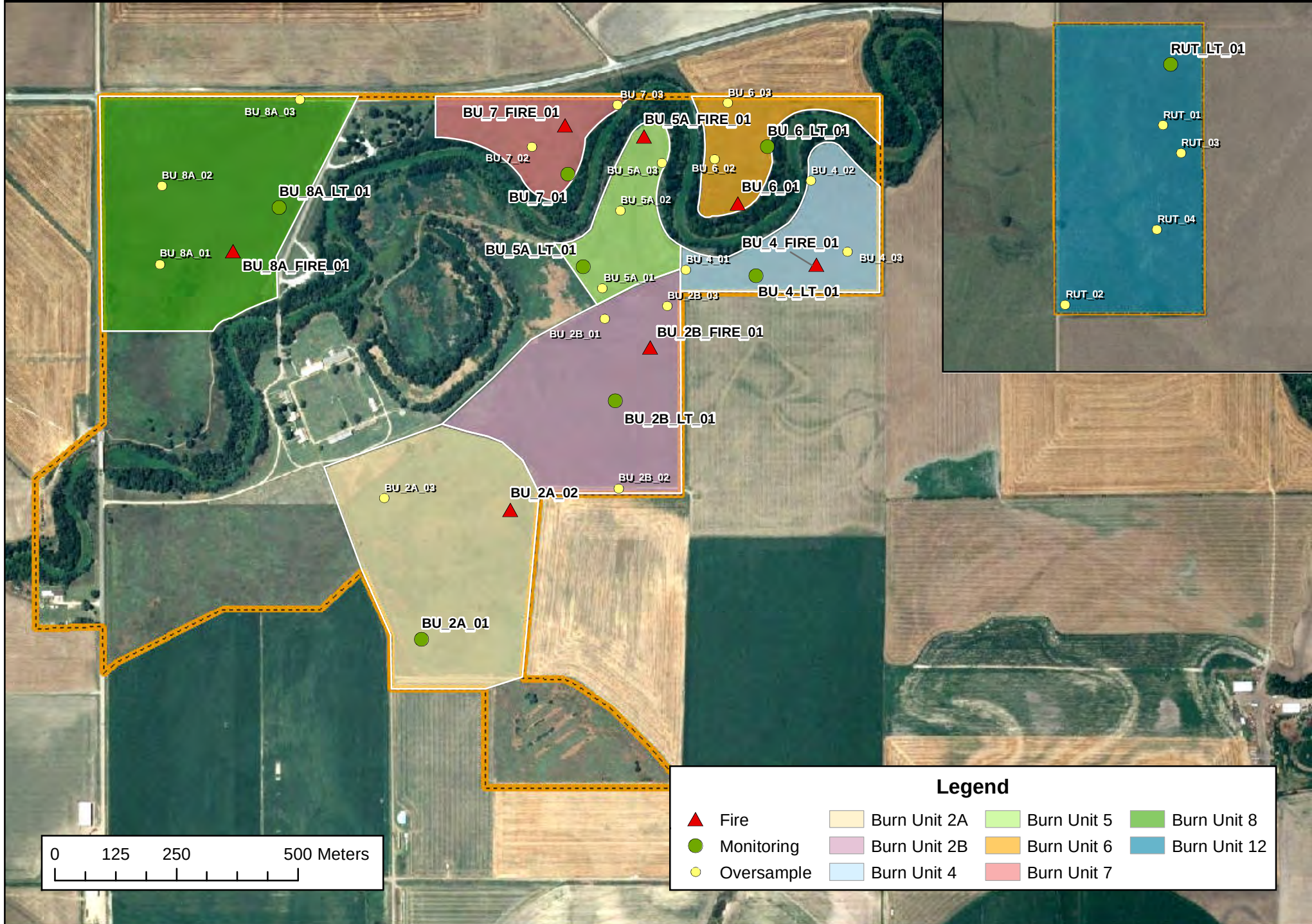
Chickasaw NRA - 2011 Grassland/Fire Plots



Legend

- ▲ Fire
- Monitoring
- Oversample
- Upland Grass
- Old Field
- CHIC Boundary

Fort Larned NHS - 2011 Grassland/Fire Plots



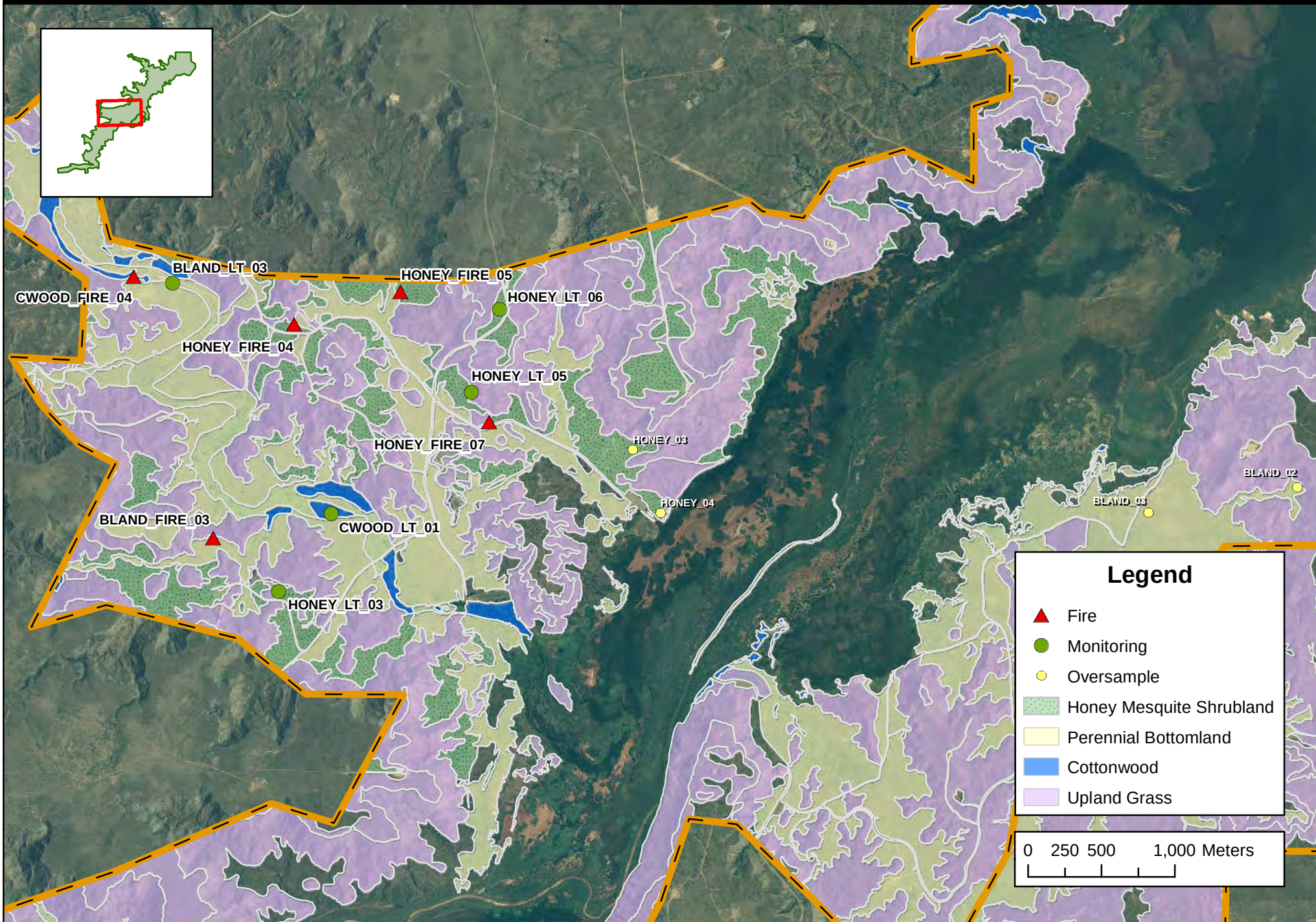
Fort Union NM - 2011 Grassland/Fire Plots

Legend

- Monitoring
- Oversample
- Shortgrass
- FOUN Boundary

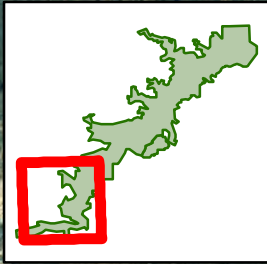


Lake Meredith NRA - 2011 Grassland/Fire Plots Center Region



Lake Meredith NRA - 2011 Grassland/Fire Plots

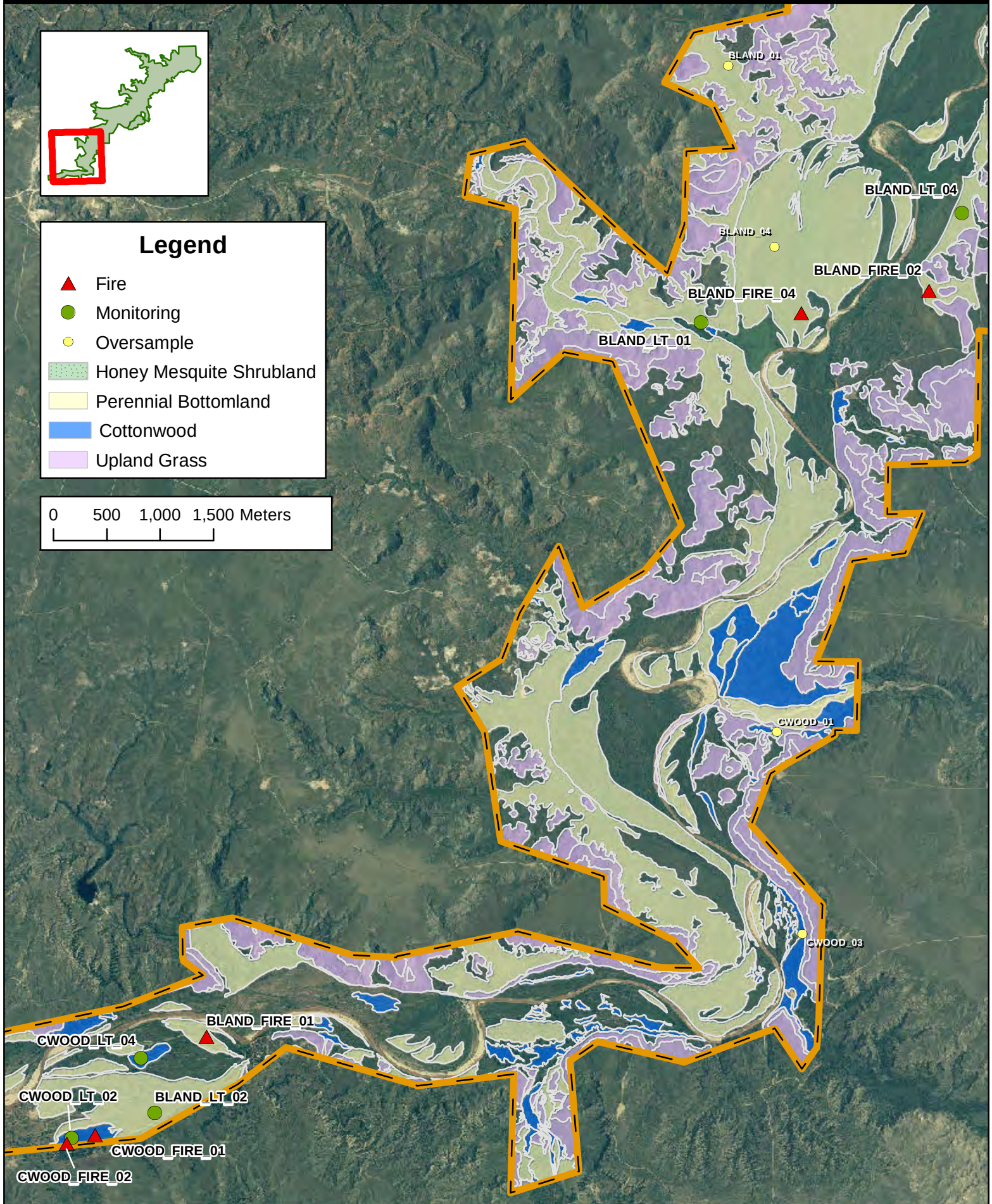
Lower Region



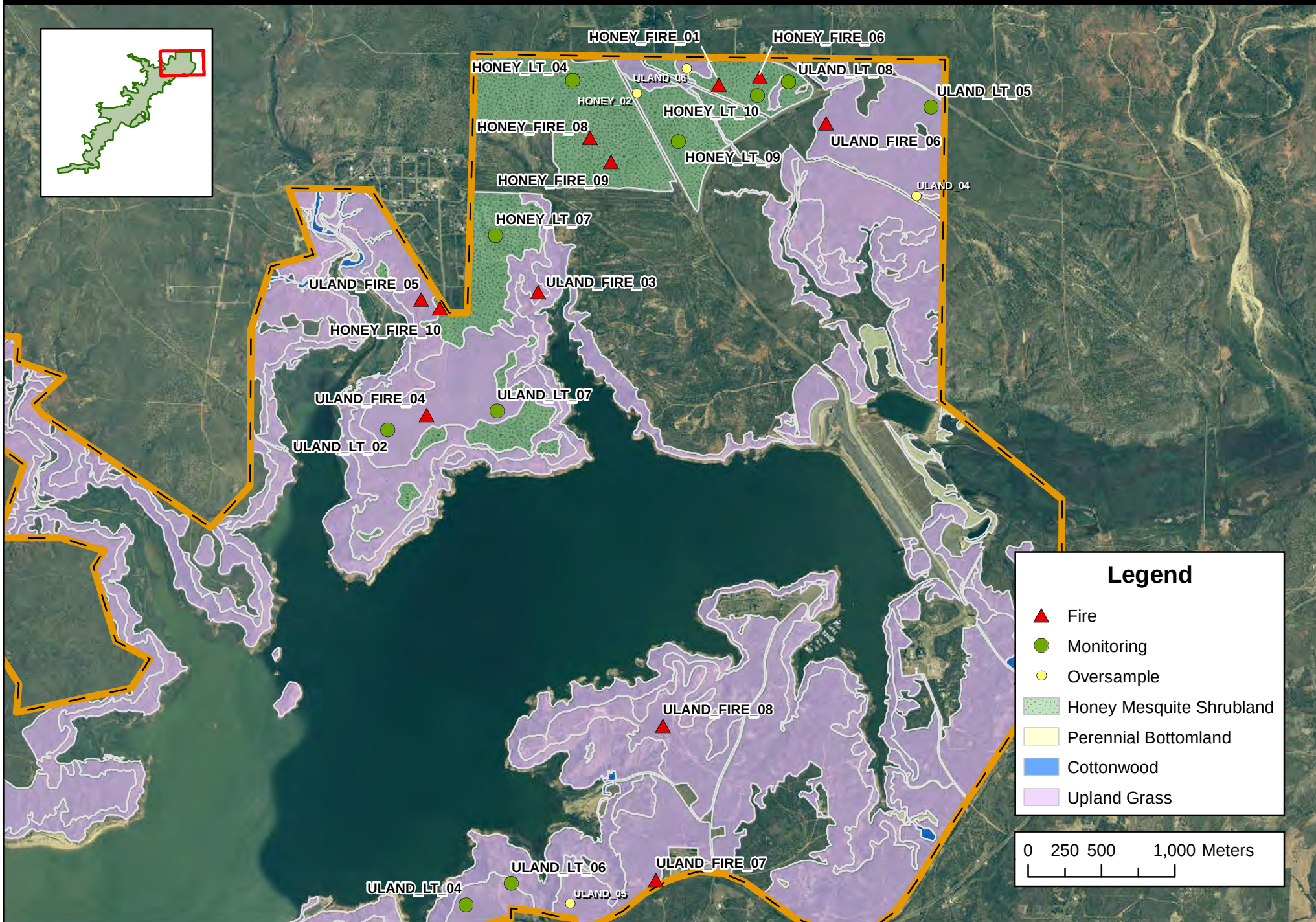
Legend

- ▲ Fire
- Monitoring
- Oversample
- Honey Mesquite Shrubland
- Perennial Bottomland
- Cottonwood
- Upland Grass

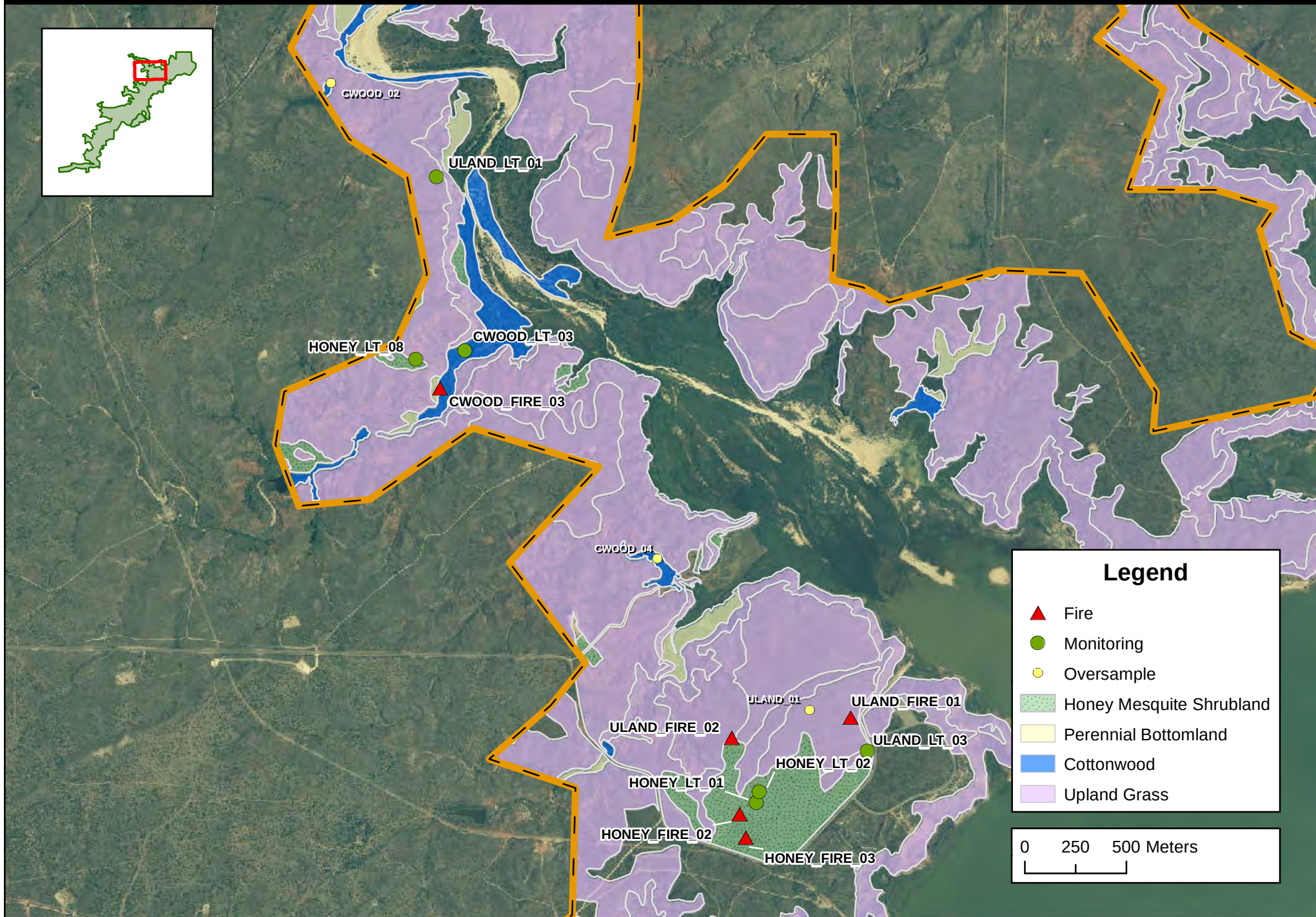
0 500 1,000 1,500 Meters



Lake Meredith NRA - 2011 Grassland/Fire Plots North Region



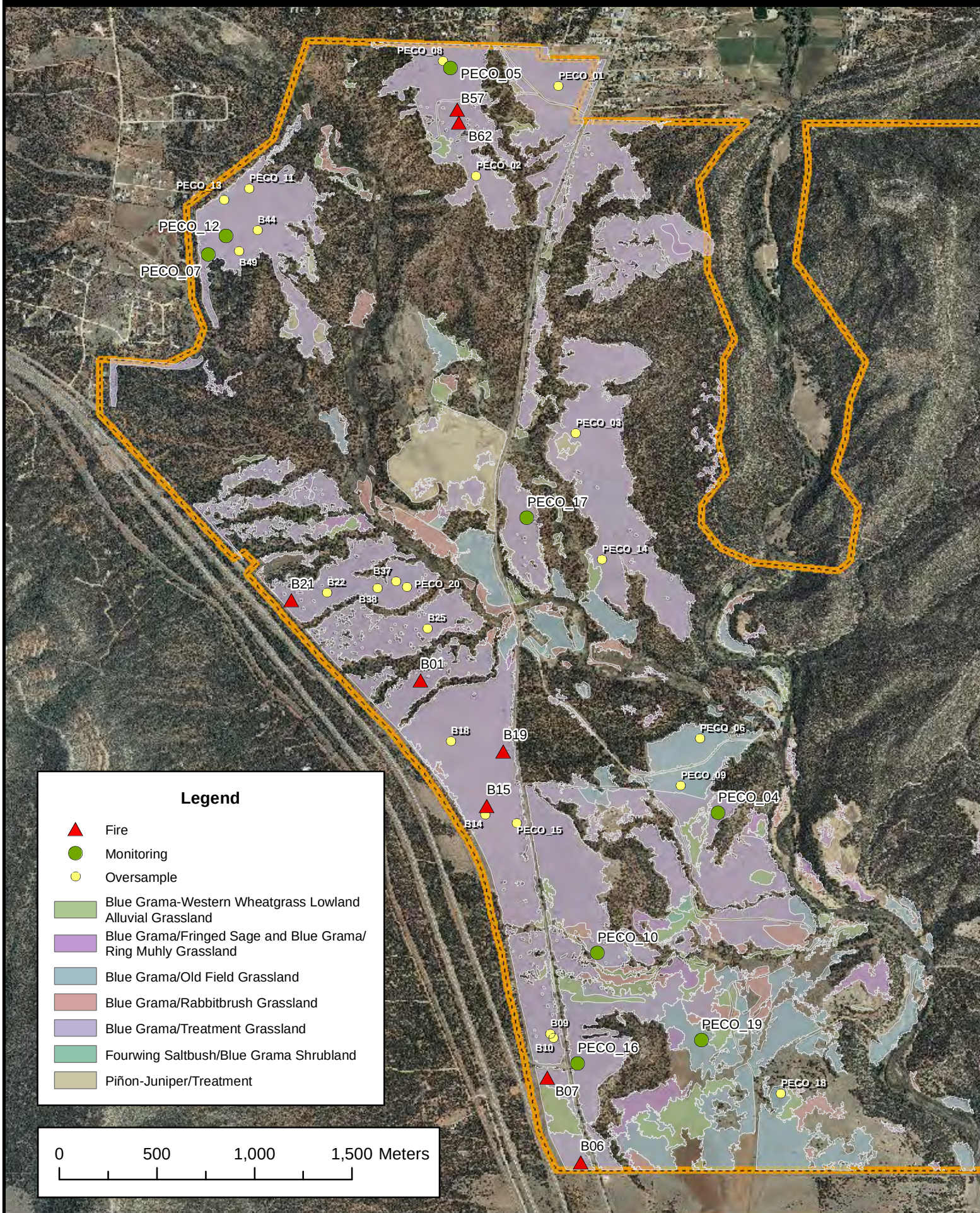
Lake Meredith NRA - 2011 Grassland/Fire Plots Northeast Region



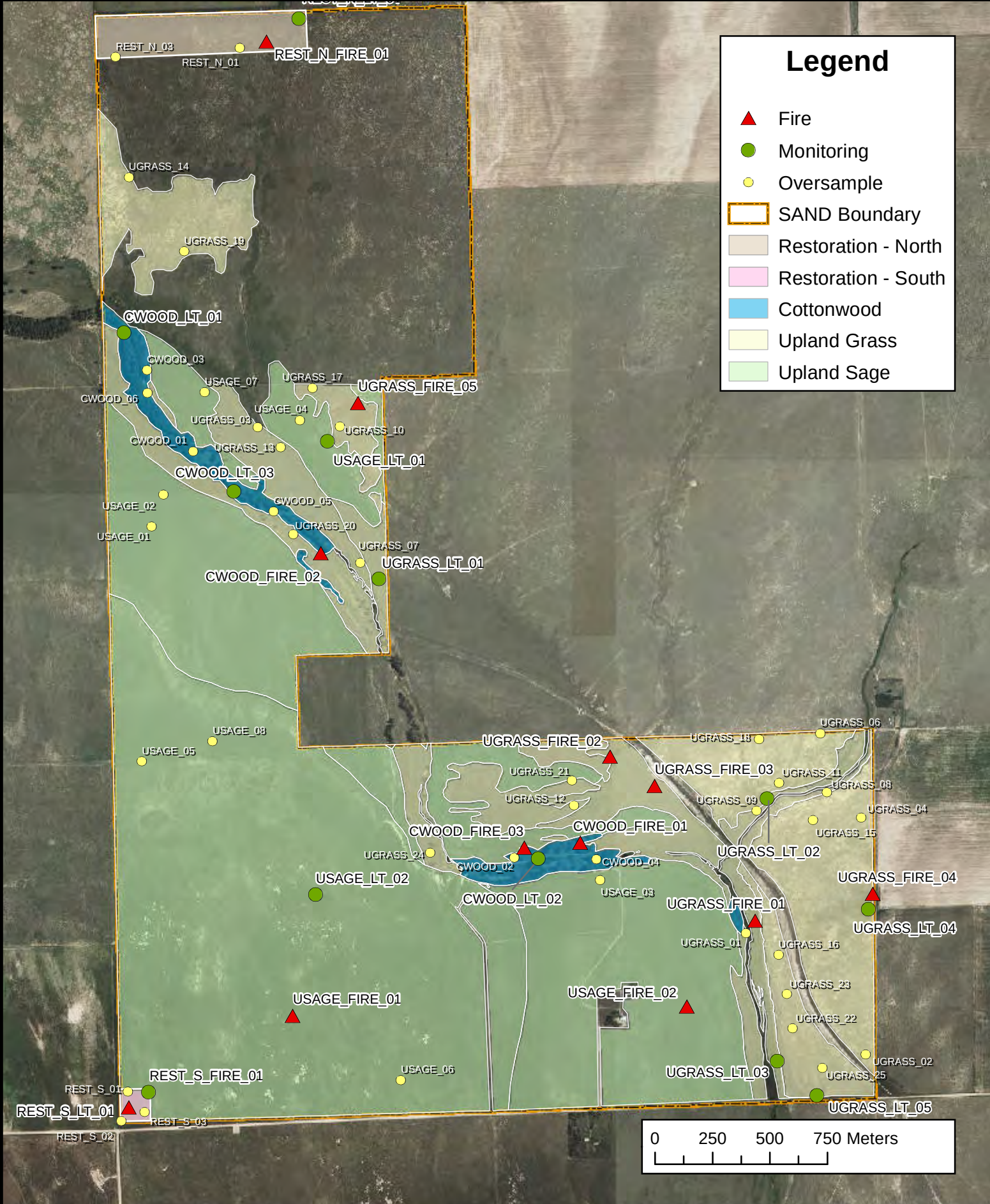
Lyndon B. Johnson NHP - 2011 Grassland/Fire Plots



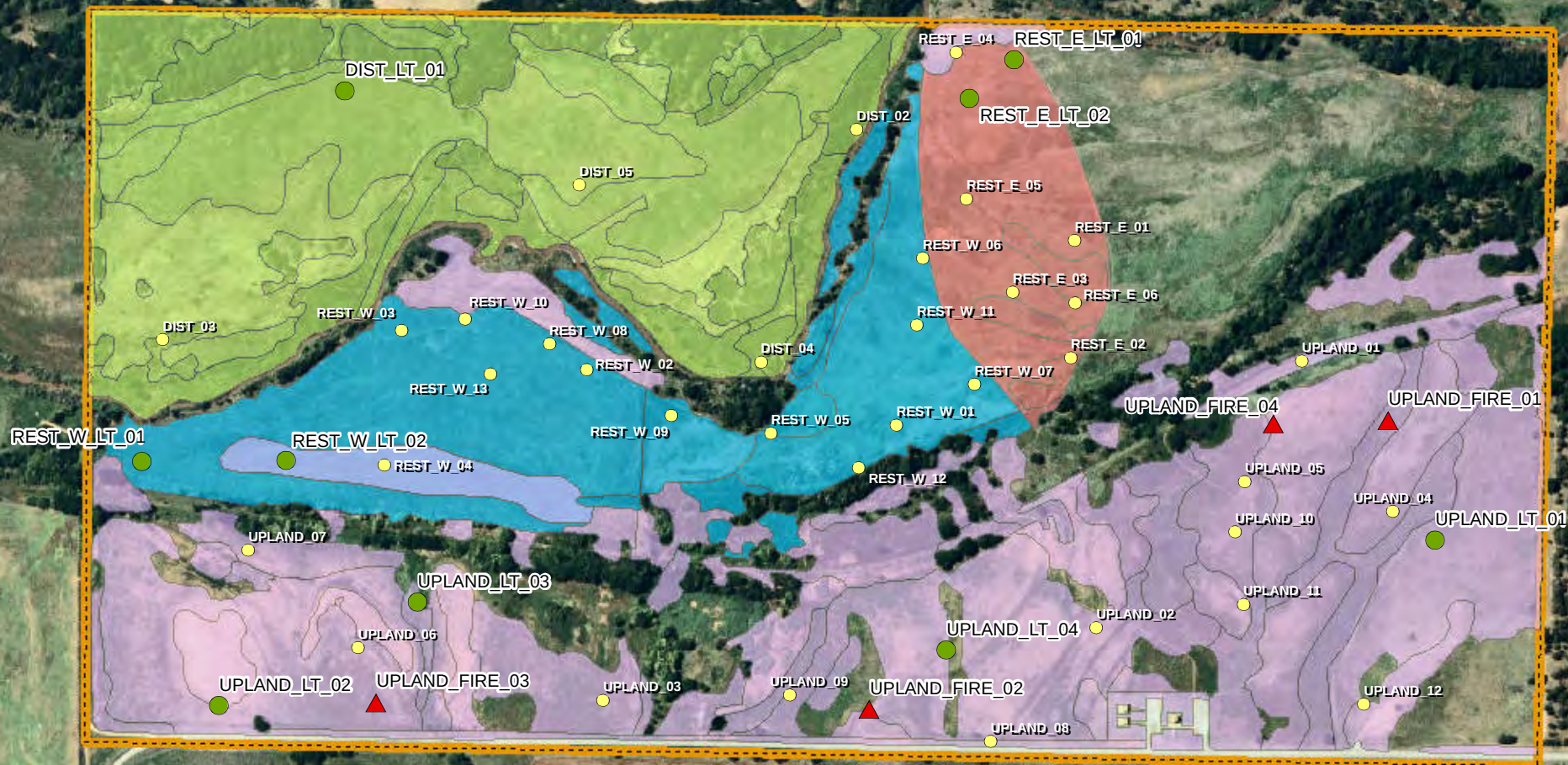
Pecos NHP - 2011 Grassland/Fire Plots



Sand Creek Massacre NHS - 2011 Grassland/Fire Plots



Washita Battlefield NHS - 2011 Grassland/Fire Plots



Legend

- | | |
|--------------|--------------------|
| ▲ Fire | Upland Grass |
| ● Monitoring | Restoration - West |
| ● Oversample | Restoration - East |

