USGS-NPS Vegetation Mapping Program
Theodore Roosevelt National Park, North Dakota

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March 7, 2000

U.S. Department of the Interior
Bureau of Reclamation's Remote Sensing and GIS Group
Denver Federal Center   Denver, Colorado

The Reclamation Remote Sensing and Geographic Information Group, organized in 1975 provides advice and assistance regarding the application of remote sensing and geographic information system (GIS) technologies to meet the spatial information needs of Bureau of Reclamation and other clients.

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LIST OF ABBREVIATIONS

AML	Arc Macro Language
BOR	Bureau of Reclamation (Also USBR)
BRD	Biological Resource Division (of the USGS)
CBI	Center for Biological Informatics (of the USGS/BRD)
CCC	Civilian Conservation Corps
CNAP	Colorado Natural Areas Program
CRP	Conservation Reserve Program (of the NRCS)
DEM	Digital Elevation Model
DLG	Digital Line Graph
DRG	Digital Raster Graphic
DOQQ	Digital Orthophoto Quarter Quadrangle
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System(s)
GPS	Global Positioning System
I&M	Inventory and Monitoring Program (of the NPS)
LSSAP	Leafy Spurge Scientific Advisory Panel
MMU	Minimum mapping unit
NPS	National Park Service
NAD	North American Datum (Cartography)
NBII	National Biological Information Infrastructure
NRCS	Natural Resources Conservation Service (formerly the Soil Conservation Service)
NVCS	National Vegetation Classification System
PLGR	Precision Light-weight GPS Receiver
RSGIG	Remote Sensing and Geographic Information Group (of the USBR)
THRO	Theodore Roosevelt National Park
TNC	The Nature Conservancy
USBR	United States Bureau of Reclamation (Also BOR)
USDA-SCS	United States Dept. of Agriculture – Soil Conservation Service.
USFS	United States Forest Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator (Cartography)

EXECUTIVE SUMMARY

The USGS Biological Resources Division in cooperation with the Inventory and Monitoring Program of the National Park Service has initiated a multi-year project to classify, describe, and map vegetation for 250 national parks. As a contractor under this program, the Bureau of Reclamation's Remote Sensing and Geographic Information Group with assistance from The Nature Conservancy has classified and mapped the vegetation occurring in and around Theodore Roosevelt National Park. The Park has three units with the North Unit near Watford City and the South Unit near Medora , North Dakota. The third unit lies between the North and South units and consists of the historic Elkhorn Ranch. Twenty-nine vegetation (land-cover) map classes and ten Anderson Level II land-use classes were used for interpretation of approximately 369,000 acres encompassing the Park (~ 70,200 acres) and surrounding environs (~ 298,800 acres). The interpreted data was digitally transferred into a Geographic Information Systems database.

Vegetation map classes were determined through extensive field reconnaissance, data collection, and analysis in accordance with the National Vegetation Classification System. The vegetation map was created from photographic interpretation of 1996, 1:12,000 scale color aerial photograph enlargements (0.5 hectare minimum mapping unit). All vegetation and land-use information was then transferred to the latest grayscale USGS digital orthophoto quarter-quads using a combination of on-screen digitizing and scanning techniques. Arc/Info™ (ESRI, Inc.) software was used throughout the project for digitizing, scanning, transforming, registering, and plotting the interpreted data. Overall thematic map accuracy for the entire mapping effort was assessed at 74.3 % with a Kappa Index of 71.3 %. The overall 90% confidence interval is 70.3 % to 78.3 %.

Final products are described in this report and occur on the accompanying CD-ROM disk (see Appendix P for contents description). They include the following:

- Vegetation Classification Descriptions
- Land Use Classification System
- Vegetation Key
- Representative Photos and Slides from Field Studies (slides in only 2 copies of the Report)
- Digital and Sample Hard Copy Vegetation Maps (including map-making AMLs)
- Digital Vegetation, Boundary, Field Data Points, and Roads Coverages
- Accuracy Assessment
- FGDC-compliant Spatial Database Metadata
- Final Report
- CD-ROM containing the GIS database, metadata, AML's, and this report. See Appendix P for a list of files on the CD-ROM.

Theodore Roosevelt National Park and similar national park vegetation mapping databases can be accessed at the USGS/BRD website: http://biology.usgs.gov/npsveg

1. INTRODUCTION

The National Park Service (NPS) Inventory and Monitoring (I&M) Program was created in 1991 to provide park managers with critical information on natural resources. A long-term goal of this program is to provide baseline inventories of the biological and geophysical resources for all natural resource parks. As part of the National Biological Information Infrastructure (NBII), the NPS entered a multi-year partnership with the United States Geological Survey's Biological Resources Division (USGS/BRD) to map the vegetation resources of 250 National Park units.

Goals of the USGS-NPS Vegetation Mapping Program include the following:

- Provide support for NPS Resources Management
- Promote vegetation-related research for both NPS and USGS/BRD
- Provide support for NPS Planning and Compliance
- Add to the information base for NPS Interpretation
- Assist in NPS Operations

This report details the work performed for Theodore Roosevelt National Park (THRO) under this program. The specific objectives of this study include:

- Collection and analysis of vegetation data.
- Creation of vegetation and mapping classifications based on the National Vegetation Classification System (NVCS).
- Development of a spatial database for the vegetation of THRO using remote sensing and Geographic Information System (GIS) techniques.
- Production of digital and hard copy vegetation maps, assessed to be at least 80% accurate.

Efforts to make this program successful led to various work contracts with the following government agencies and private organizations:

- The Remote Sensing and Geographic Information Group (RSGIG), USBR, Denver Federal Center, Lakewood, Colorado provided photo-interpretation and created the GIS database.
- The Nature Conservancy (TNC), Midwest Resource Offices, Minneapolis, MN was the primary subcontractor for vegetation classification, description, and characterization.

Vegetation mapping for THRO falls under the USGS-NPS Vegetation Mapping Program's general task of completing all the NPS sites within the Great Plains Ecosystem. Other sites in this region include:

> Agate Fossil Beds NM, Badlands NP, Devil's Tower NM, Fort Laramie National Historic Site, Jewel Cave NM, Mount Rushmore NM, Scott's Bluff NM, and Wind Cave NP.

Any available data pertaining to these and other USGS-NPS Vegetation Mapping projects can be accessed at the USGS/BRD's website: http://.biology.usgs.gov/npsveg

2. PROJECT AREA

THRO was first authorized by Congress on April 25, 1947 as a National Memorial Park and was designated a National Park on November 10, 1978, with 29,920 acres inside the Park designated wilderness at that time (NPS 1987). THRO consists of three units covering approximately 70,200 acres as follows: the North Unit (~24,000 acres), the South Unit (~46,000 acres), and the Elkhorn Ranch Unit (218 acres) (Figure 2-1). Significant steps to create the National Park are as follows (NPS 1987):

- 1934: Civilian Conservation Corps (CCC) personnel were sponsored by the North Dakota State Historical Society and directed by the National Park Service to begin work in Roosevelt Regional State Park. This park contained two parcels of state land inside what are now the North and South Units.
- 1936- 1941: The above two parcels were expanded by adding lands through the Federal sub-marginal land purchase program (purchase of homestead lands from those unable to derive a living) and by adding intermingled remnants of public domain and state school trust lands. This qualified the Park as a Recreation Demonstration Area, which enabled the Federal Government to aid states by developing recreation areas on lands of low agricultural value and demonstrating their worth for public parks. The last CCC camp was closed, completing work by that group and several Emergency Relief Administration and Work Project Administration personnel/projects.
- 1947: Roosevelt National Memorial Park created, which included only a portion of the South Unit and authority to acquire the Elkhorn Ranch site.
- 1948 & 1956: Two Acts of Congress added additional South Unit lands including the Petrified Forest, corrected the Elkhorn Ranch Unit land boundaries, and added a portion of the North Unit. An Act also added lands on the north side of Medora for development of Park headquarters.

The Park is best known for extensive geologic processes/exposures, scenic vistas, significant fossil resources, and mixed grass prairie and woodland ecosystems supporting abundant wildlife. Both large units contain predominately badlands erosional features, mixed-grass prairie, Little Missouri River floodplain, swales, draws, and intermittent and small perennial drainages that support trees and shrubs (Figure 2-2). The ranch unit is riparian, located entirely within the Little Missouri River floodplain. Recreational and educational activities include hiking, camping, wildlife viewing, scenic drives and vistas, and research opportunities.

2.1 Location and Regional Setting

THRO is situated in the Northern Great Plains Region of western North Dakota. The South Unit lies adjacent to Medora, ND, the North Unit lies 14 miles south of Watford City, ND, and the Elkhorn Ranch Unit lies in-between, approximately 35 miles north of Medora (Figure 2-1). All three units lie adjacent to or astride the Little Missouri River. The Park lies in Billings

(South and Elkhorn Ranch Units) and McKenzie (North Unit) Counties. North Dakota Highway 85 provides access to the North Unit directly and the

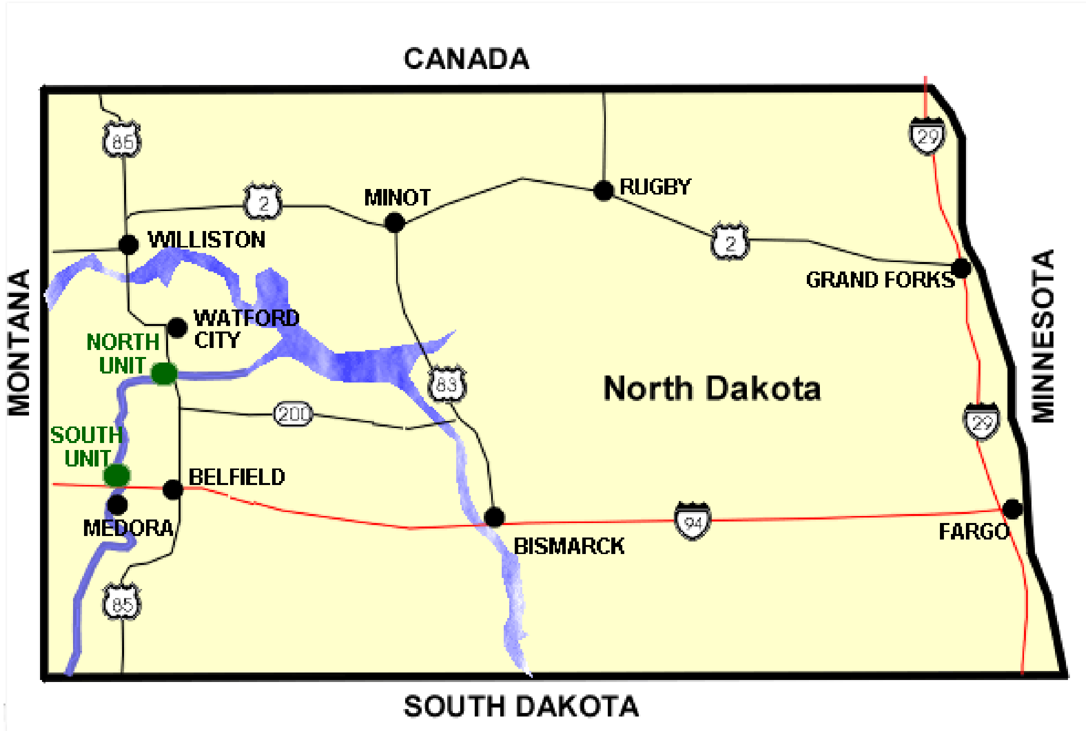


Figure 2-1a. – General Location Map

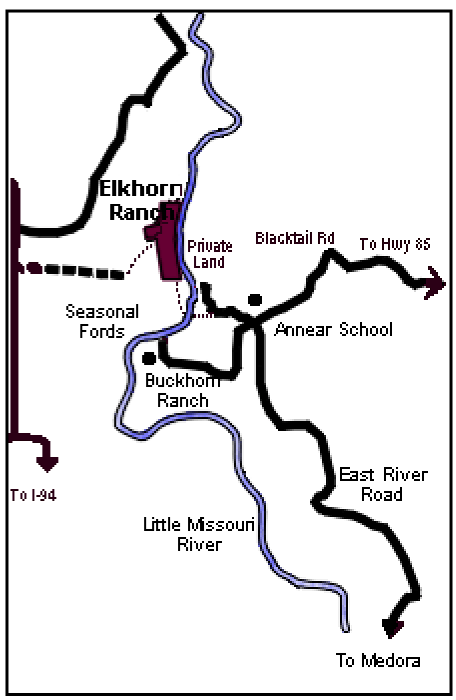


Figure 2-1b. – Elkhorn Ranch Unit Map

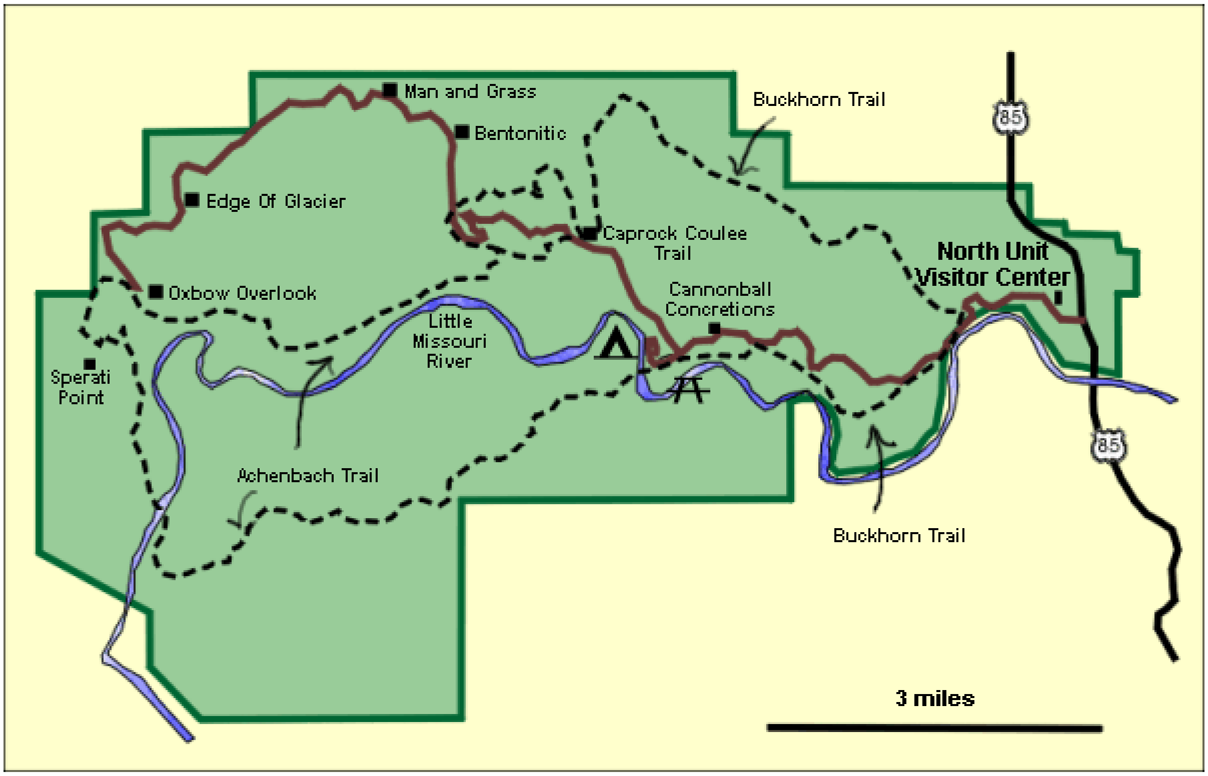


Figure 2-1c. – THRO North Unit

Figure 2-1d. – THRO South Unit.

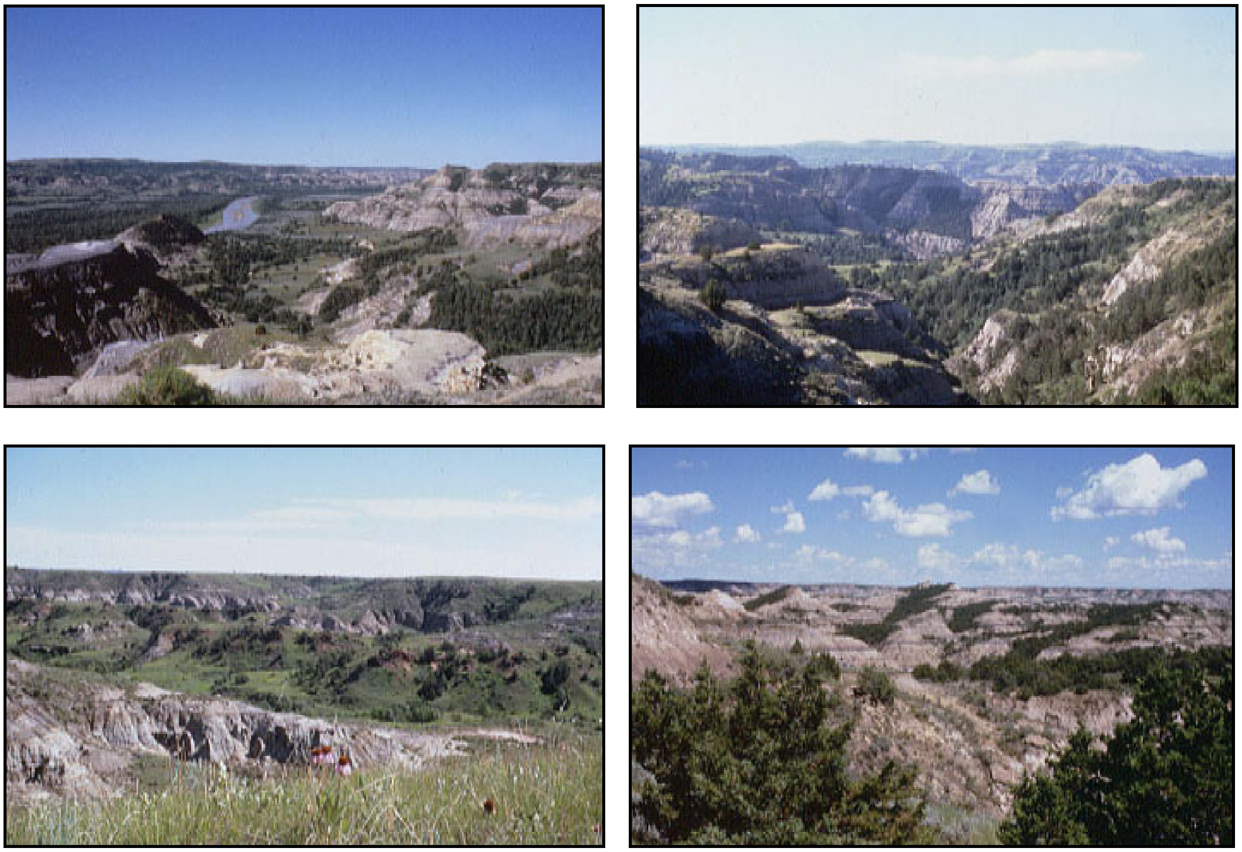


Figure 2-2. Typical Landscape of Theodore Roosevelt National Park.

Elkhorn Ranch Unit via county and private roads. Interstate Highway 94 forms much of the southern boundary for the South Unit. Additional access is provided by county roads, U. S. Forest Service (USFS) roads through the Little Missouri National Grassland, and roads developed to support oil and gas drilling operations. Both the North (14 mile-long) and South (36 mile-long) Units have scenic loop roads to provide internal visitor access.

THRO maintains the following nature and hiking trails:

Achenbach Trail -16 miles
Buckhorn Trail - 11 miles
Caprock Coulee Nature Trail - 1.6 miles
Coal Vein Trail - 0.8 miles
Jones Creek Trail - 3.7 miles
Little Mo Nature Trail - 1.1 miles
Lone Tree Spring Loop Trail - 6 miles
Petrified Forest Loop Trail - 16 miles
Paddock Creek Trail - 12.8 miles
Ridgeline Nature Trail - 0.6 miles
Talkington Trail - 9.4 miles
Upper Caprock Coulee Trail 4.1 miles
Wind Canyon Trail - 0.3 miles

In addition, there are several scenic overlooks and informational pullouts along the two scenic loop roads.

2.2 Climate

Theodore Roosevelt National Park lies within the Northern Great Plains and is typified by a semi-arid, continental climate that includes short, hot, dry summers, and long, cold, dry winters. Average temperatures recorded for Medora/Watford City range from -11.9/-11.4 degrees C in January to 21.2/21.8 degrees C in July (Hansen et al. 1984). Temperatures in the spring and fall seasons can vary dramatically and change abruptly within short time periods. Precipitation for this region is usually heaviest in late spring and early summer (75% falls between April and September), with a total annual amount of 35.4 cm recorded in Medora and 39.2 cm recorded in Watford City (Appendix A).

2.3 Geology, Hydrology, and Topography

Geologically, the area of THRO is known as "Little Missouri Badlands" (Bluemle 1977) which have also been referred to as "Mako Sica" (bad land) by the Lakota Tribe and "Mauvaises Terres a Traverser" (bad lands to cross) by French explorers (Bluemle 1977 and Schoch and Kaye 1993). The chief factors in badlands development are: 1) a climate with low rainfall that is more or less concentrated into heavy showers, 2) scarcity of deep-rooted vegetation, and 3) slightly consolidated, nearly homogenous fine-grained sediments lying at a considerable height above the main drainage channels (the occasional hard layers or beds that may be present being thin and in horizontal position) (O'Harra 1920, revised 1976 and Bluemle 1977). The badlands of the Little Missouri River began to form when a glacier diverted the river, causing it to flow eastward. The diverted river flowed over a steeper, shorter route and cut downward rapidly, carving out the badlands (Bluemle 1977). The Little Missouri River is estimated to have removed about 100 km^3 of material from the adjacent badlands area since glacial times, and erosion of badlands hill slopes has been estimated to occur at a rate of 0.28-1.04 cm per year (Bluemle 1975 and Tinker 1970)(Figure 2-3)

Western North Dakota, including THRO, contains rocks of the Williston Basin, a structural and sedimentary basin centered near Watford City, ND. The present configuration of this basin occurred during late Cretaceous time and since then, nearly 16,000 feet of sediments have been deposited over the older, Precambrian rocks underlying the basin (Bluemle 1977). Bedrock that is exposed in THRO is referred to as continental sediments, materials that were deposited by water and wind action. The continental sediments include silt, clay, sand, sandstone, lignite, petrified wood, flint, scoria, and occasional limestone.

North Dakota's landscape southwest of the Missouri River has been carved by running water over a period of several million years (Bluemle 1977). Within the Park and its environs, exposed bedrock consists principally of Paleocene Fort Union Group sedimentary rocks, e. g., Bullion Creek Formation and Sentinel Butte Formation silt, clay, and sand (Bluemle 1977, 1988). Small areas of Pleistocene glacial sediment and outwash sediment are deposited in the North Unit. These are typically unsorted mixtures of clay, silt, sand, cobbles, and some boulders. Holocene alluvium and slopewash is deposited on the floodplain of the Little Missouri River.

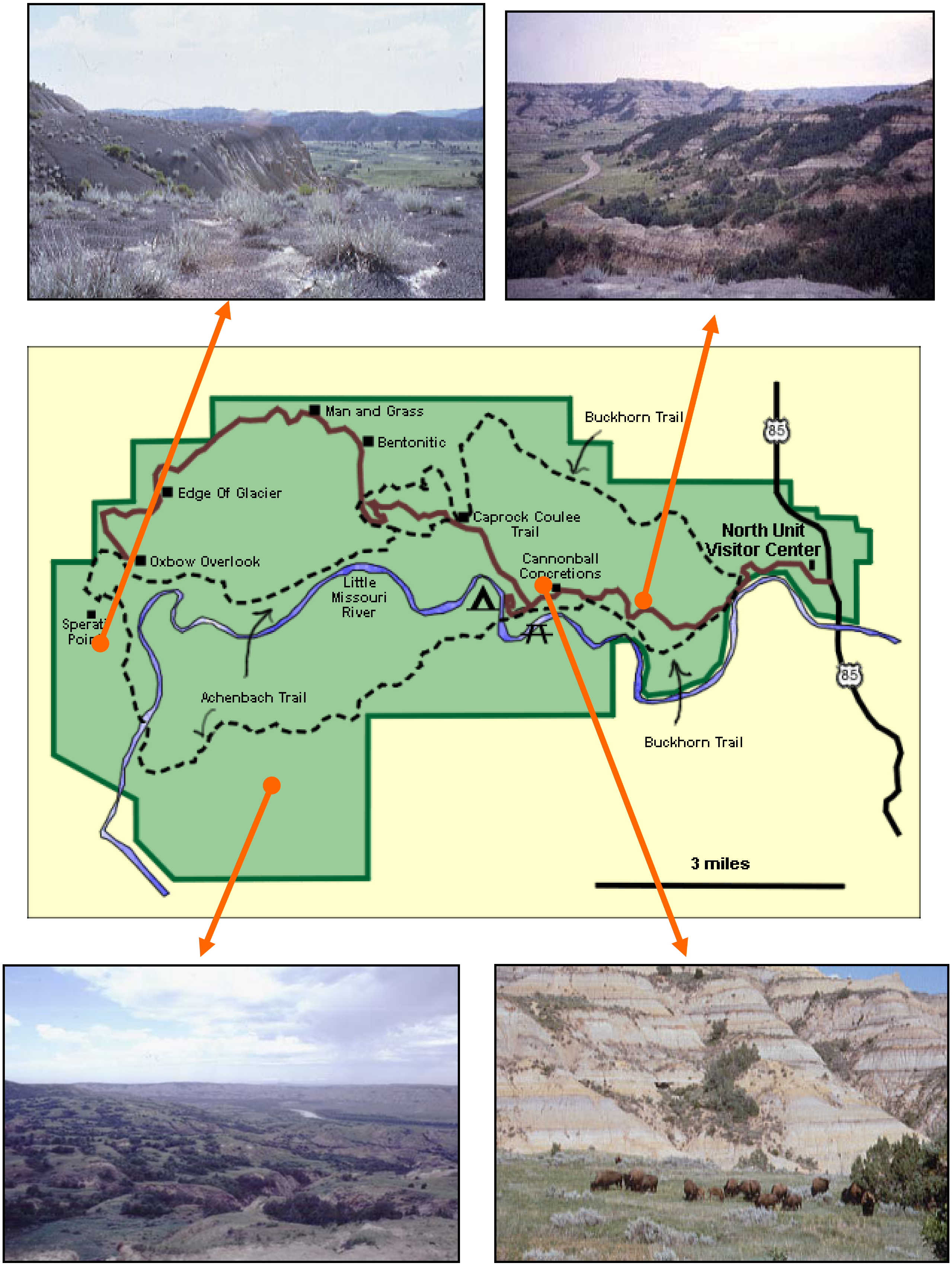


Figure 2-3a. Geologic exposures and landscape – North Unit.

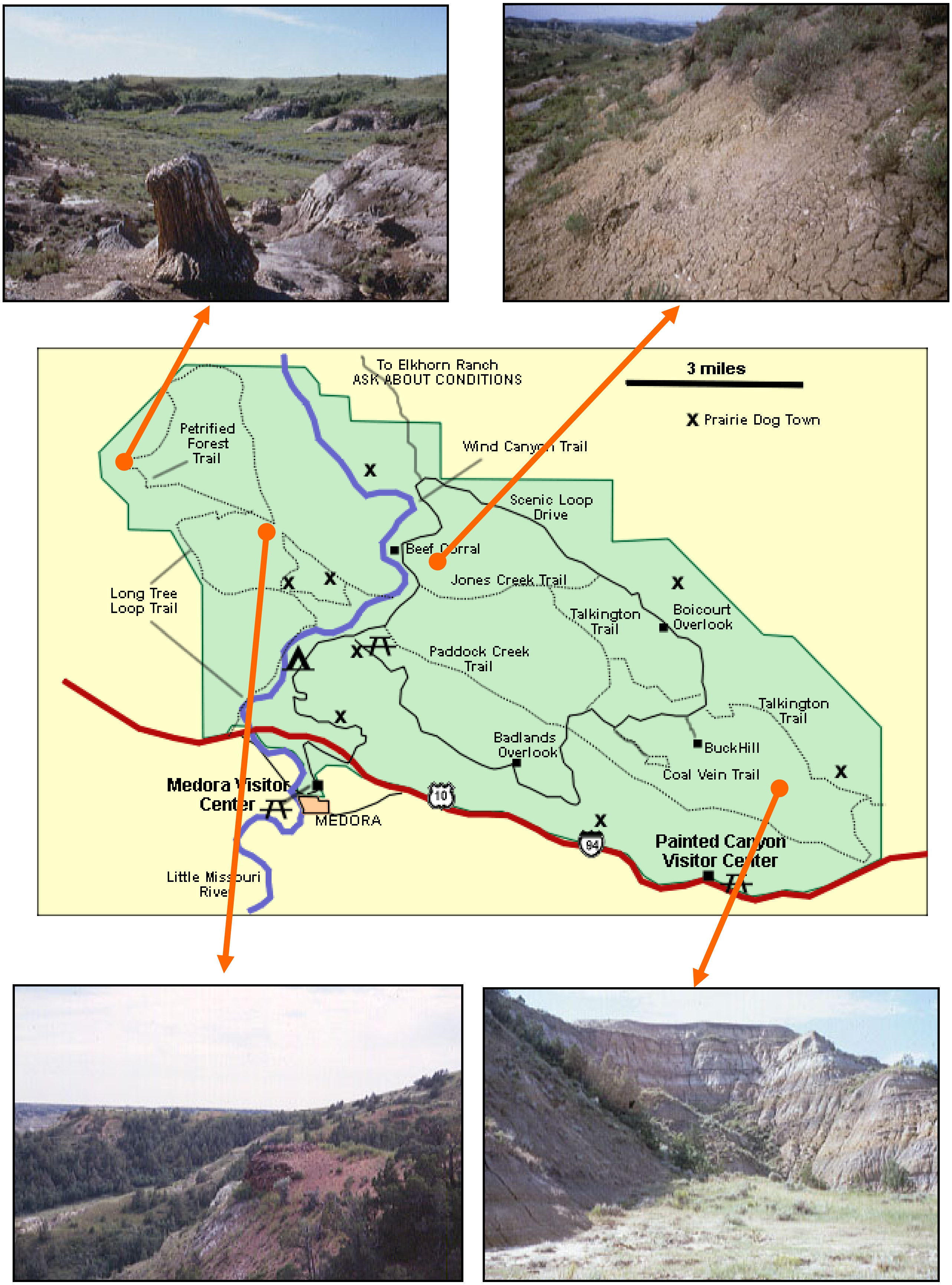


Figure 2-3b. Geologic exposures and landscape – South Unit.

Bullion Creek Formation exposures are typically yellowish in color and are located mostly in the South Unit west of the Little Missouri River and extending east along the perennial drainages east of the river (Murphy et al. 1993). The remainder of the South Unit (eastern one-half and the Petrified Forest Plateau) and most of the North Unit contain exposures of the Sentinel Butte Formation, which are dull gray in color. Both of these formations were formed from deposition of delta, lake, and river sediments.

Lignite coal, a soft coal consisting of plant fragments deposited in Paleocene swamps, is found throughout the Park. These fragments were partially decomposed by bacteria, then buried under sand (Bluemle 1977). Seams of lignite sometimes burn, producing heat that bakes the adjacent sediments into "scoria". Scoria, more properly labeled "clinker", consists of reddish to purplish layers and brick-like masses of baked and fused clay, shale, and sandstone. The intensity of the red color of scoria is determined by the grain size of the baked material and by the temperature of the burning lignite. This color is imparted by iron oxide (limonite) which forms hematite when the sediments are baked (Bluemle 1977 and Murphy et al. 1993).

Petrified wood is found throughout the region, particularly in the badlands, where stumps and intact trunks have weathered from the surrounding sediments. Many stumps are exposed on the Petrified Forest Plateau of the South Unit; these stumps are thought to be primarily species of the genus *Metasequoia* and some reach as big as 12 feet in diameter (NPS 1992, Murphy et al. 1993). A variety of other fossils are found within the geologic formations, the oldest being mollusks, fresh-water clams, turtles, and ancient alligators (Schoch and Kaye 1993).

Exposed beds/layers of bluish-gray to black bentonite clay, present mainly in the North Unit, are devoid of vegetation or support only scattered shrubs, typically long-leaved sagebrush (*Artemisia longifolia*). The largest of the bentonite beds is known locally as "Big Blue", a reference to its color (Schoch and Kaye 1993). Bentonite swells several times its volume when wet creating a cohesive mass called gumbo and drys to a crumbly, popcorn-like texture. These beds were ultimately derived from volcanic ash deposited during the Paleocene Sentinel Butte Formation and chemically altered by weathering (Schoch and Kaye 1993).

Other interesting geologic features at THRO include iron-rich limonite nodules and calcium carbonate-cemented concretions, the most notable being the "Cannonball Concretions" of the North Unit (Murphy, et al. 1993). Concretions range in shape from nearly spherical to elongate bodies called "logs" (Bluemle 1977). Layers of exposed chert within the Park are also known as pseudoquartzite or ganister. It is theorized that chert formed from silt and sand blown into ancient swamps where it eventually solidified (Bluemle 1977).

The major drainage in THRO, the Little Missouri River, flows northerly through the South and Elkhorn Ranch Units and easterly through the North Unit. Important tributary creeks flowing into the river typically trend southeast and northwest (South Unit) and west and south (North Unit); these include Knutson, Government, Jules, Jones, Paddock, and Sheep Creeks in the South Unit and Corral, Appel, and Squaw Creeks in the North Unit. There are many smaller drainages that are typically dry, flowing only during/following precipitation events. Active springs are occasional and found at scattered locations. Many small ponds and reservoirs are present in the environs surrounding the Park, in addition to wetland depressions and channels. Water is developed to support cattle grazing in the Park environs using dugouts, check dams, larger earth fill dams, pumped ground water, and natural surface water supplies.

The topography is a mixture of relatively flat plains, a moderately wide floodplain associated with the Little Missouri River, and highly dissected erosional features (Figure 2-4). It lies in the Missouri Plateau - Little Missouri Badlands region of the northern Great Plains (Bluemle 1977, Hansen et al. 1984). Elevation ranges are as follows:

North Unit: From a low of approximately 1,960' (eastern edge - Little Missouri River floodplain) to a high of 2,687' at Achenbach Hills (southwestern area).

South Unit: From a low of approximately 2,235' (northern edge - Little Missouri River floodplain) to a high of 2,885' at Buck Hill (southeast area).

2.4 Soils

Common soil associations occurring at THRO formed from 1) bedrock which was eroded and washed into old alluvial deposits on high terraces, 2) recent alluvial deposits on floodplains, in swales, and in upland depressions, and 3) sand and loess deposited by wind on uplands. The typical soils of THRO are described as regosols belonging to the Baineville Series and are developed from excessively drained, medium-textured, calcareous parent material (Omodt et al. 1968 in Hansen et al. 1984). A typical and obviously immature soil profile shows an A1 horizon overlying a C horizon with textures ranging from loams to clay loams (Hansen et al. 1984). Wali et al. (1981) state that soil parent material of this region is mainly a residuum, *i.e.*, material weathered in place.

The soils mentioned above relate to specific geologic landforms, topographic relief, climate, and the corresponding natural vegetation (Ensz 1990). On and adjacent to badlands exposures and in drainage channels, the rapidly deposited soils are nearly devoid of vegetation, supporting only a sparse, shrubby plant community. Conversely, deeper soils mantling the buttes, hills, and alluvial valleys support relatively dense and diverse plant communities, including grasslands, shrublands, and woodlands.

In some instances, plant associations are further influenced by exotic plant species invasions and wildlife or grazing livestock use. Some common examples are 1) the large areas dominated by leafy spurge (*Euphorbia esula*), almost to the exclusion of other plant species, and 2) the intense grazing in prairie dog (*Cynomys ludoviciana*) colonies, which often results in different plant associations than otherwise would be present. Prairie dogs burrow into deeper soils capable of supporting tunneling (clay loams). These soils would normally support western wheatgrass grasslands, but are often maintained as blue grama grasslands or more commonly as relatively weedy annual forblands.

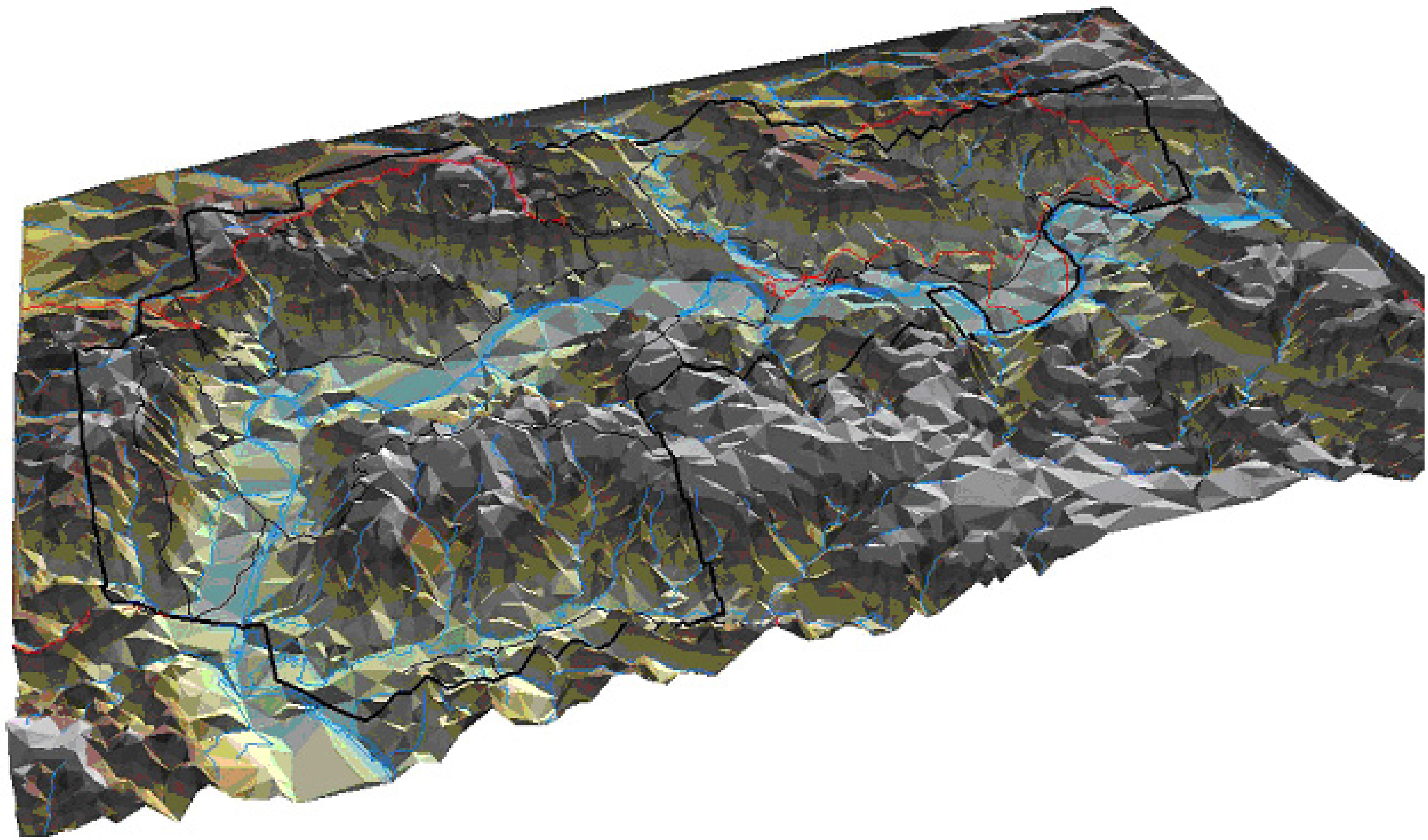


Figure 2-4a. Elevation View – North Unit
(Courtesy B. Foster at THRO)

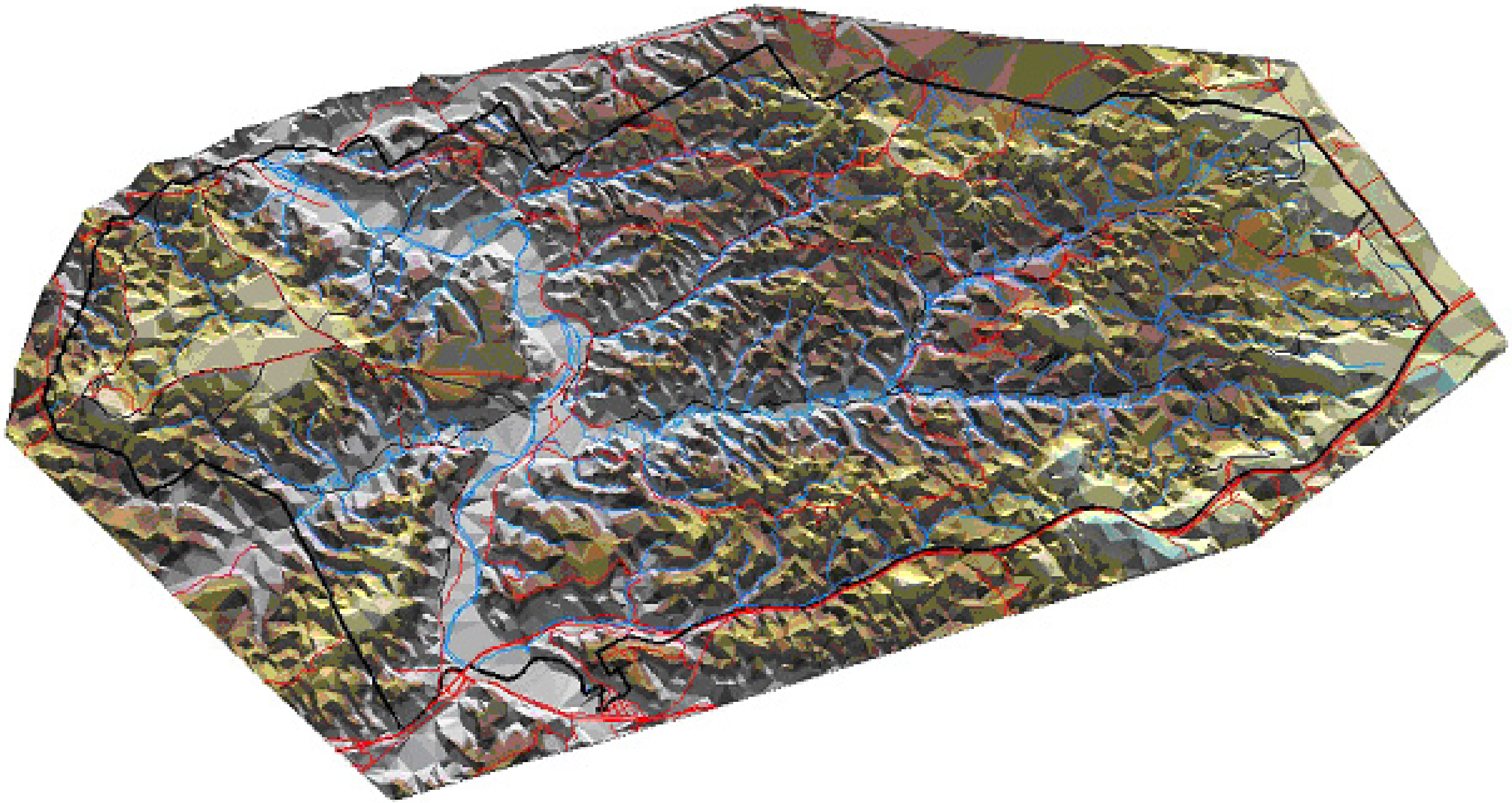


Figure 2-4b. Elevation View – South Unit
(Courtesy B. Foster at THRO)

Regional soils found in the White River Badlands of South Dakota represented four orders which may also occur in THRO: Aridisols, Entisols, Mollisols, and Vertisols (Batt 1991). Aridisols are soils of arid uplands; typically they are dry for more than 50% of the year. Entisols are newly-formed upland soils developed and deposited because of steep slope erosion, alluvial floodplain deposition, and eolian deposition. Mollisols are prairie soils found on grassy bluffs that are characterized by melanization, a darkening of the soil due to addition of organic matter. Vertisols are upland clays with very high shrink/swell potential and deep, wide cracks are often formed at the soil surface. Wali et al. (1981) state that Entisols and Mollisols are the most predominant soil orders present at THRO. Further, soil development may not occur on steeper badlands slopes because of the soft bedrock that is susceptible to erosion.

Range sites and soil associations have been generally described for the Badlands Vegetation Zone in southwestern North Dakota (USDA-SCS-ND 1975 in Marlow et al. 1984). A range site is a distinctive kind of habitat, or group of soils, that is capable of supporting similar kinds, proportions, and amounts of native vegetation. Factored into these are soil properties important to the distribution of plant associations, including moisture supply, nutrient availability, salt content, soil reaction, and seasonal high water levels (USDA-SCS 1996). Table 2-1 contains range site names and descriptions, the major soil associations identified, and the typical NVCS plant alliance or complex observed growing there (USDA-SCS-ND 1975 in Marlow et al. 1984).

2.5 Wildlife

THRO supports numerous wildlife species including many animal species native to the northern Great Plains. A total of 252 species of vertebrate wildlife have been recorded for the Park (NPS 1992). Some of the larger mammals are actively managed by Park personnel to insure the overall health of the Park's vegetation resource. These include bison (*Bison bison*), pronghorn antelope (*Antilocapra americana*), mule and white-tailed deer (*Odocoileus hemionus and O. virginianus*), Rocky Mountain elk (*Cervus elaphus*), Rocky Mountain bighorn sheep (*Ovis canadensis*), horse (*Equus caballus*), and the black-tailed prairie dog (Figure 2-5).

Rocky Mountain elk were introduced to the South Unit in 1985 and appear to be adapting well (Schoch and Kaye 1993). Another priority wildlife program currently underway is research on bighorn sheep reintroduction (effectiveness, distribution, and ecology). Bighorn sheep (Rocky Mountain subspecies) were introduced to the Park in 1956 to replace the now extinct subspecies, Audubon bighorn (*O. canadensis auduboni*)(NPS 1992). The numbers of bighorn sheep declined in the early 1980's and they are now being bred in captivity, to increase numbers for re-release.

Domesticated cattle and sheep do not currently graze within the Park, although adjacent grasslands under private ownership or managed by USFS are grazed annually. A small herd of longhorn cattle (*Bos taurus*) is maintained on the eastern portion of the North Unit for display to tourists interested in regional ranching history. Bison were reintroduced into the Park in 1956 when 29 individuals were transported from Fort Niobrara National Wildlife Refuge, NE to the South Unit (Schoch and Kaye 1993). In 1962, 20 individuals from the South Unit herd were

Table 2-1. Range Sites, Soil Associations, and Related NVCS Vegetation Types.

Range Site: Definition	Soil Association	Typical Vegetation Type
Silty: nearly level to rolling uplands and high stream terraces (0-15%).	Boxwell loam; Chama loam and silt loam; Chanta clay loam and silty clay loam; Havre loam and silt loam; Marmarth loam; Patent loam and silt loam	Western Wheatgrass - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Sandy: nearly level to rolling uplands and sloping fans and terraces (0-15%).	Chinook fine sandy loam; Rhame fine sandy loam and sandy loam; Toby fine sandy loam and sandy loam	Needle-and-Thread - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Clayey: nearly level to rolling uplands (0-15%).	Moreau clay, silty clay, and clay loam	Western Wheatgrass - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Very Shallow: gentle to very steep uplands (3-35%).	Brandenburg loam and channery loam	Western Wheatgrass - Blue Grama - Threadleaf Sedge Herbacious Vegetation; Needle- and-Thread - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Shallow Clay: undulating to steep uplands (1-35%).	Dilts clay and silty clay; Lisam clay and silty clay	Western Wheatgrass - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Shallow: nearly level to very steep uplands (3-50%).	Cabba loam; Cabbart loam, silt loam, and silty clay loam; Fleak loamy fine sand, fine sandy loam, and sandy loam; Yawdim silty clay loam	Needle-and-Thread - Blue Grama - Threadleaf Sedge Herbacious Vegetation; Little Bluestem - Sideoats Grama - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Thin Claypan: nearly level of moderately sloping uplands and terraces (0-9%).	Absher loam and clay loam; Rhoades loam, silty clay loam, and silty clay	Western Wheatgrass - Blue Grama - Threadleaf Sedge Herbacious Vegetation; Needle-and thread - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Sands: level to rolling upland and stream terraces (1-15%).	Tusler loamy fine sand	Needle-and-Thread - Blue Grama - Threadleaf Sedge Herbacious Vegetation
Wetland: level, slightly concave basins, depressions, and outwash channels.	Colvin silt loam and silty clay loam, wet; Dimmick silty clay, clay, and silty clay loam; Grano silty clay, clay, and silty clay loam	Cattail species Great Plains Herbacious Vegetation; Prairie Cordgrass - Sedge species Herbacious Vegetation

Bison

Elk

Wild Horses

Prairie Dog

Bighorn Sheep

Longhorn Bovine

Figure 2-5. Wildlife in Theodore Roosevelt National Park .
(Some photos from THRO website)

reintroduced into the North Unit. Current stocking rates for the Park include approximately 300 head in the South Unit and approximately 100 head in the North Unit. Depending on climatic conditions and numbers of other grazing mammals present (wild horses are managed at 50-90 head and elk up to 400 head in the South Unit), stocking rates between 200-500 head in the South Unit and 100-250 head in the North Unit could be considered (Marlow et al. 1984).

Livestock grazing does have an influence on the distribution of some plant species and plant associations. Figure 2-6 shows the fenceline contrast of wildlife grazing within the Park versus annual domestic livestock grazing outside the Park. Grazing effects on three-leaved sumac shrubland alliance, western wheatgrass and needle-and-thread herbaceous vegetation, and the distribution of perennial exotic plants such as leafy spurge are indicated in the photos. Within the northern fenceline of the North Unit, shrub communities such as western snowberry (buckbrush) temporarily-flooded shrubland alliance literally stop at the fenceline and are replaced by shortgrasses on annually grazed areas on the non-Park side of the fenceline. Livestock grazing outside the Park also reduces or eliminates shrub cover and sapling establishment under green ash, Rocky Mountain juniper, and quaking aspen woodland alliance. These areas are likely used by livestock for shade and forage during hot days.

Figure 2-6. Fenceline contrast for regularly grazed lands adjacent to THRO.

Marlow et al. (1984) also recognized the difference between Park and environs grasslands stating that “a majority of the Park’s annual forage production was not being utilized” (grazed). This condition had led to a build-up of litter that likely limited plant succession and would eventually lead to “lower species diversity and eventual deterioration of the existing vegetation complex”. The regular planned use of fire to help remove/reduce litter and redirect/enhance plant succession was recommended (Marlow et al. 1984 and Leafy Spurge Scientific Advisory Panel 1994).

Another interesting grazing influence relates to prairie dog colonies present within and adjacent to the Park and the plant associations that are maintained or result from prairie dog grazing and burrow construction. This is described in more detail under the vegetation section and under the project results.

2.6 Vegetation

THRO vegetation is present in several major habitat types, *i.e.*, sparse vegetation of highly eroded soils; mixed grass prairie; shrub-covered drainages, slopes, hillside slumps, and hills; wooded draws, slopes, and hills; and floodplain woodlands (Figure 2-7). Sparse vegetation associated with the badlands ridges, slopes, hills, and drainages is a mixture of low-growing shrubs, forbs, and grasses. Grasslands are distributed across deeper soils, including plains, valleys, buttes, and sand hills and ridges. Grasslands also occupy thin soils on gravelly slopes and hills that rapidly release moisture. Shrublands occupy all major drainages, heads of draws, hill slopes, and flats. Woodlands, which are typically dense, occur as both evergreen and deciduous, and are typically taller within the river floodplain than in other areas.

Shrub communities are widespread, occupying drainages with meandering rivers or streams, badlands ridges, low hills and slopes, gravelly or rocky draws, and moist swale habitats. Riparian shrublands include stands of sandbar willow in the most mesic habitats, and broad expanses of silver sagebrush (*Artemisia cana*) and buckbrush (*Symphoricarpos occidentalis*) across floodplains. These typical floodplain species and silver buffaloberry (*Shepherdia argentea*) can also be found occupying intermittent drainages, mesic swales and upland depressions, outside/above the floodplain. Sparse big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), and saltbush (*Atriplex confertifolia* and *A. canescens*) occupy badlands exposures similar to the salt desert habitat found further west. Rabbitbrush is dominant on slumps (soil that has been disturbed by slipping down steep slopes) and on cut-and-fill slopes related to road construction (noticeable on Park loop roads). Horizontal juniper (*Juniperus horizontalis*) and three-leaved sumac (*Rhus trilobata*) occupy higher hillslopes, with horizontal juniper being confined to the most mesic sites (typically north-facing hillslopes). Three-leaved sumac is widespread, but is particularly notable where outcrops of scoria, or scoria covered by a thin layer of soil, occurs. Greasewood (*Sarcobatus vermiculatus*) was only observed in two small patches near Jules Creek in the South Unit.

Woodlands occur throughout the Park and surrounding environs. The most common dominants are Rocky Mountain juniper (*Juniperus scopulorum*), green ash (*Fraxinus pennsylvanica*), and eastern cottonwood (*Populus deltoides*). Quaking aspen (*Populus tremuloides*) occupy the heads of some draws on Petrified Forest Plateau and some draws in the North Unit. Ponderosa pine (*Pinus ponderosa*), rare in the Park (one tree known, Runge personal communication 1998), occurs in a few small stands south of the interstate highway on the eastern edge of Medora, ND. These ponderosa pines are a portion of the northeastern-most stands in the western United States; this distinction was previously discussed for stands in Slope County, ND (Wali et al. 1981).

Other widely distributed vegetation types in and around THRO include emergent wetlands and prairie dog towns. Wetlands, relatively rare within Park boundaries, are found in depressions, meandering drainages, seeps, springs, and old oxbows. In many cases, ponds developed for livestock support wetland vegetation in the shallower water and in the seepage zone below the

Figure 2-7. Characteristic Vegetation Within THRO.

dam structure. Prairie dog towns are distributed on appropriate soils (those deep enough and with structure capable of supporting burrows). The townsites often are dominated by early successional forbs, many of them exotic, including fetid marigold (*Dyssodia papposa*), bigbract verbena (*Verbena bracteata*), field bindweed (*Convolvulus arvensis*), and mullein (*Verbascum thapsus*).

Several non-native/exotic plant species have been introduced to THRO, mostly prior to its designation as a Park. Trammell (1994) stated that 59 exotic plant species possibly occur within Park boundaries with 36 found during subsequent field research. They are considered a threat because they 1) replace native species, 2) reduce the land's carrying capacity for livestock and grazing wildlife, 3) may be poisonous to livestock or wildlife, 4) decrease plant species diversity and can further reduce/imperil populations of rare plant species, 5) may carry detrimental insects, diseases, or parasites, 6) can alter fire patterns and intensity, 7) can increase soil nitrogen levels to be detrimental to native species, 8) can result in increased soil erosion and runoff, and 9) can generally degrade or destroy wildlife habitat (Trammell 1994 and CNAP 1999).

The most aggressive of the exotic plant species at THRO is leafy spurge (*Euphorbia esula*), first observed in the Park in the late 1960's. Leafy spurge has invaded many areas throughout the South Unit and is becoming established along the Little Missouri River in the North Unit (Trammell 1994, LSSAP 1994, and Cogan 1999) (Figure 2-8). An all-out effort to control this species has been underway for several years by Park staff (LSSAP 1994); this effort is described in detail under the map classification section. Another exotic plant of concern is Canada thistle (*Cirsium arvense*) which is less widespread than leafy spurge, but a serious threat to native plant communities for similar reasons. Canada thistle patches tend to be smaller and more isolated than those of leafy spurge, and the plants prefer relatively mesic environments. The largest area of Canada thistle observed was along Corral Creek in the North Unit; large patches also occurred within prairie dog towns in the South Unit, near springs, and in old oxbow depressions of the river floodplain.

Figure 2-8. Leafy Spurge in Theodore Roosevelt National Park.

Historic pastures are still dominated by introduced species such as crested wheatgrass (*Agropyron cristatum*), Kentucky bluegrass (*Poa pratensis*), and smooth brome (*Bromus inermis*). Kentucky bluegrass covers extensive areas within the Park, it is particularly notable on the east side of the South Unit. Smooth brome and alfalfa (*Medicago sativa*) have been planted in disturbed road rights-of-way throughout the area. Yellow sweetclover (*Melilotus officianalis*) and white sweetclover (*Melilotus alba*) have invaded some fairly large areas of the North Unit and smaller areas in the South Unit. Both yellow and white sweetclover (biennial species from Eurasia) prefer relatively moist conditions and have been documented in the Park since at least 1960 (Nelson 1961) (Figure 2-9).

Figure 2-9. Yellow Sweetclover stand in Theodore Roosevelt NP.

3. MATERIALS AND METHODS

The organization of this project followed protocols and procedures set forth by the USGS/BRD (Appendix B) outlined in Field Methods for Vegetation Mapping, Standardized National Vegetation Classification System (TNC 1994), and Accuracy Assessment Procedures (TNC 1994). Basic steps to fulfill protocols include:

- **Planning and Scoping**
- **Preliminary Data Collection and Review of Existing Information**
- **Aerial Photography Acquisition**
- **Gradsect Design**
- **Field Survey**
- **Vegetation Classification and Characterization**
- **Vegetation Map Preparation**
- **Accuracy Assessment**

3.1 Planning and Scoping

THRO vegetation mapping incorporated the combined expertise and oversight of several organizations: 1) oversight and programmatic considerations were managed by the Center for Biological Informatics (CBI) of the USGS/BRD, 2) National Park Service and THRO personnel provided additional guidance on specific Park needs, 3) aerial photo-interpretation and technical mapping portions were contracted to the RSGIG, along with providing accuracy assessment support, 4) The Nature Conservancy was sub-contracted to provide fieldwork, data reduction, plant association local and global descriptions, and the plant association key, and 5) collection of accuracy assessment data and conduct of the accuracy assessment was contracted to Dr. Jack Butler, Central Missouri State University, with logistical assistance provided by RSGIG staff. Technical responsibilities and deliverables include the following:

RSGIG Responsibilities and Deliverables:

- Acquire existing true color aerial photography from USDA-Forest Service via USGS;
- Collect observation points to refine the preliminary classification and familiarize investigators with community characteristics and their range of variation;
- Conduct a meeting to determine mapping classes, vegetation and land use, to be used throughout the project;
- Interpret aerial photographs;
- Transfer interpreted information to a digital spatial database and produce hard copy (paper) vegetation maps;
- Conduct field verification trip to assess visual accuracy of draft vegetation maps;
- Create digital vegetation coverages including relevant attribute information;
- Produce Arc/Info export file of gradsect locations, vegetation plot, observation point, and accuracy assessment locations;

- Provide an annotated list of representative field site photographs/slides;
- Create a spreadsheet and contingency table comparing the mapped classes with the AA classes in order to determine map accuracy;
- Provide any ancillary digital files developed during the mapping process;
- Document FGDC compliant metadata files (*.html) for all created spatial data; and
- Prepare final report and CD-ROM describing procedures used in preparing all products.

TNC Responsibilities and Deliverables:

- Develop a preliminary vegetation classification for the study area from secondary sources;
- Conduct a gradsect meeting to determine intensive vegetation sampling locations;
- Design a sampling strategy;
- Collect field data to determine plant associations and vegetative variability within the Park by selecting and sampling representative stands for all community types;
- Prepare final classification, community descriptions, and key to community types;
- Field test final classification, descriptions, and key during accuracy assessment;
- Collect accuracy assessment points (Dr. Jack Butler);
- Review and comment on relevant vegetation data, participate in meetings, and review draft report; and
- Prepare local (Dr. Jack Butler) and global plant association descriptions.

Scoping Meeting:

A scoping meeting was held at the THRO Visitor's Center in Medora, ND, with all interested parties during April 1997. The purpose of this meeting was to determine the project mapping extent, aerial photography acquisition, digital orthophoto availability, and discuss field data collection logistics. A project boundary covering all or a portion of 28 topographic quadrangles (Appendix C), or approximately 394,041 acres was determined *. Following the data sampling protocols for large parks outlined in the Field Methods for Vegetation Mapping (TNC 1994), it was decided that a gradient-oriented transect or gradsect sampling approach (Austin and Heyligers 1989, Gillison & Brewer 1985) would be used at THRO.

** Budgetary constraints required that the 394,041 acre project area be reduced to approximately 369,000 acres, based on a request from RSGIG to NPS and USGS/BRD in July 1998. The reduction in mapping area occurred entirely around the 218- acre Elkhorn Ranch site.*

3.2 Preliminary Data Collection and Review of Existing Information

To minimize duplication of previous work and to aid in the overall mapping project, existing maps and reports were obtained from various sources. The staff at THRO provided digital and/or hard copy background material for boundaries, geology, soils, vegetation, exotic species, rare species, and plant species lists. Maps and vegetation information were supplied by the U. S. Forest Service, Medora Ranger Station. Range site information written by the Soil Conservation Service [now known as the Natural Resources Conservation Service (NRCS)] was obtained for the Little Missouri Badlands. The NRCS also provided information for Conservation Reserve Program registered lands which were classified as 'Seeded Mixed Grass Prairies' for this mapping effort.

Topographic maps and digital elevation models (DEM's) were obtained from the USGS. Digital orthophoto quarter-quads (DOQQ), prepared by USGS and based on the latest black-and-white photography, were used as the digital transfer base maps.

A preliminary list of community types thought to have a high likelihood of being in the mapping area was prepared by TNC and used to develop the preliminary vegetation classification. This preliminary list contained vegetation associations and alliances generated for the Park from the Midwest portion of the NVCS (Faber-Langendoen *et al*. 1996, Drake and Faber-Langendoen 1997). Modifications were made to the list through a literature review of THRO and Northern Great Plains vegetation and by contacting knowledgeable experts. Final modifications were made during a map classification meeting, in which results of field studies were also presented for consideration.

In addition to this vegetation study, two previous studies describing the overall vegetation of THRO have been completed: 1) Norland, 1984 (in association with C. B. Marlow and L. R. Irby), produced vegetation descriptions and maps for both the North and South Units of the Park. The maps are based largely on classification of vegetation using land form appearance, land form origin, and the gross structure of the associated vegetation (grassland, shrubland, wooded draw, etc.)(Marlow et al. 1984). Fourteen physiographic/vegetation classes were recognized, as were seven mapping units, and four vegetation complexes. Selected map classes from this work were entered into a GIS database for both North and South Units of the Park and were used as one basis for gradsect selection (Hager 1997); 2) Hansen and colleagues (1984), created a habitat type classification by examining potential natural vegetation types within Park boundaries. Ten (10) habitat types and one community were described in this study. It is useful to compare or cross-walk results from these classification studies and the vegetation map so that data are examined relatively equally (Appendix M).

3.3 Aerial Photography Acquisition

Aerial photography was acquired from the USFS covering the entire project area (Figure 3-1). Photographs were acquired on July 03 and 07 and August 24, 1996. True color photographs were taken at 1:24,000 (1"=2,000') scale and printed as 9"x9" contact glass positives. For interpretation purposes, these were enlarged to 18"x18" and an approximately 1:12,000 scale. To economize, every other aerial photo was enlarged. Overlap for the 9"x9" photos is approximately 50-60% (approximately 20% for every other 18"x18" photo) and sidelap between flight lines is approximately 20-30%. Additional aerial photography information is presented in Appendix D.

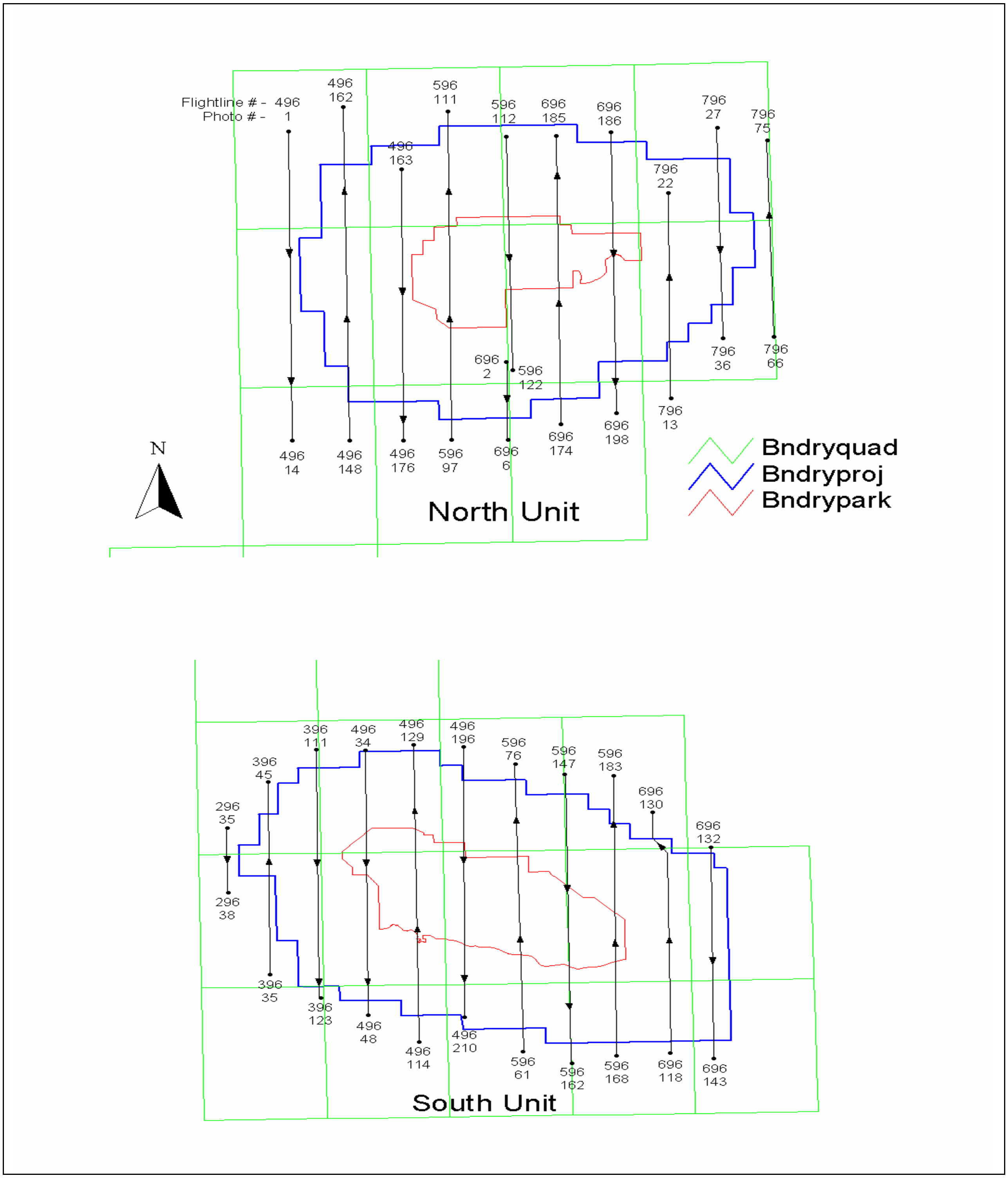


Figure 3-1. Flight Line Map -Theodore Roosevelt National Park

3.4 Gradsect Design

The THRO study area is sufficiently large to allow a gradsect approach to vegetation sampling. Gradsects were used to concentrate the sampling effort into smaller areas representing the full range of vegetation variability. This was achieved using assumptions, as follows: 1) certain site characteristics or combination of characteristics dictate the presence and growth of plant communities, 2) these characteristics tend to repeat themselves across a landscape, and 3) the concentration of sampling efforts across small heterogeneous areas provides an accurate representation of the vegetation diversity for a much larger region (Austin & Heyligers 1989).

Gradsects for THRO were designed at a meeting of Park, RSGIG, and TNC staff held in the THRO offices prior to the 1997 field season. Aerial photography was reviewed and compared with vegetation, geologic, topographic, slope and aspect, and transportation/access maps. Composite maps were also used showing the relative variability of different environmental factors. Gradsects were placed on a majority of the stratigraphic units, elevations, major soil types, and major drainages within the study area. Accessibility strongly influenced placement of the gradsects, Park personnel provided input on access to the less-visited areas of the Park. Locations and design were also slightly modified based on prior knowledge of the THRO vegetation by the principle researcher. The resulting gradsects included roughly 5.7 % of the overall study area (28 % of the Park) and were considered highly likely to include the full range of plant associations found in the area (Figure 3-2).

3.5 Field Survey

Field surveys began in the second week of July 1997. Data collection included both plot and observation points allowing investigators to record typical vegetation types and also to record variation within plant communities across larger areas.

Observation Points.

Observation points were used to become quickly familiar with plant association characteristics, plant association ranges of variation, and to field check the preliminary classification. Sampling included basic information on habitat and vegetation structure and composition. Specific information recorded included UTM X-Y coordinates (using NAD27 datum), dominant species cover data, and brief environmental characteristics (Appendix E). Data from 122 observation points were collected during the field survey. Points were recorded mainly within gradsects, and were chosen to sample the range of habitat and vegetation variability observed on aerial photography, on preliminary maps, and in the field (Figure 3-3). Limitations of observation point data included no measurement or delineation of the sampling area and cover was only estimated for the common species in each stratum.

Plot Samples

Investigators chose representative stands of plant communities to collect data for 172 of the more

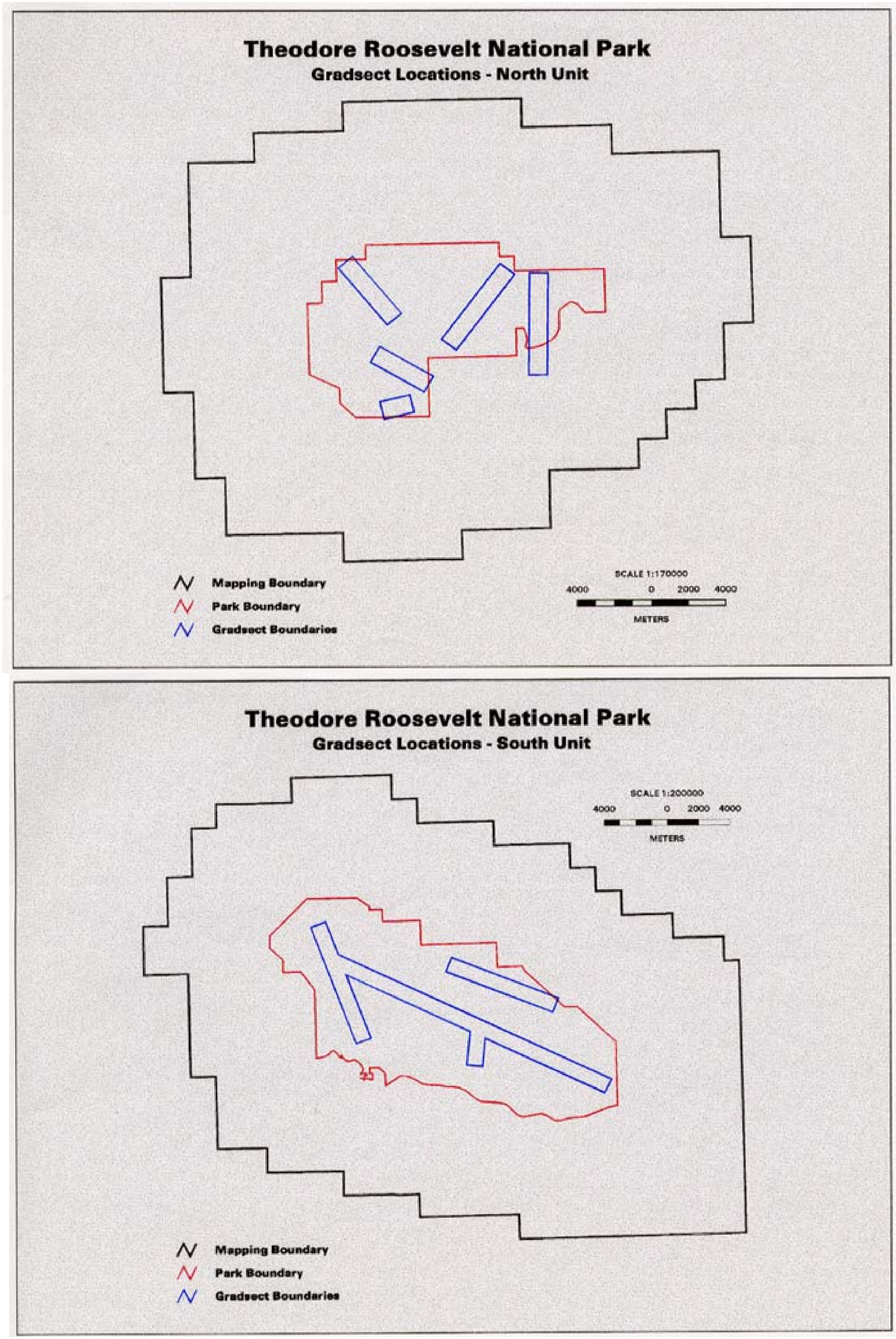


Figure 3-2. Map of Gradsect Locations for Theodore Roosevelt National Park.

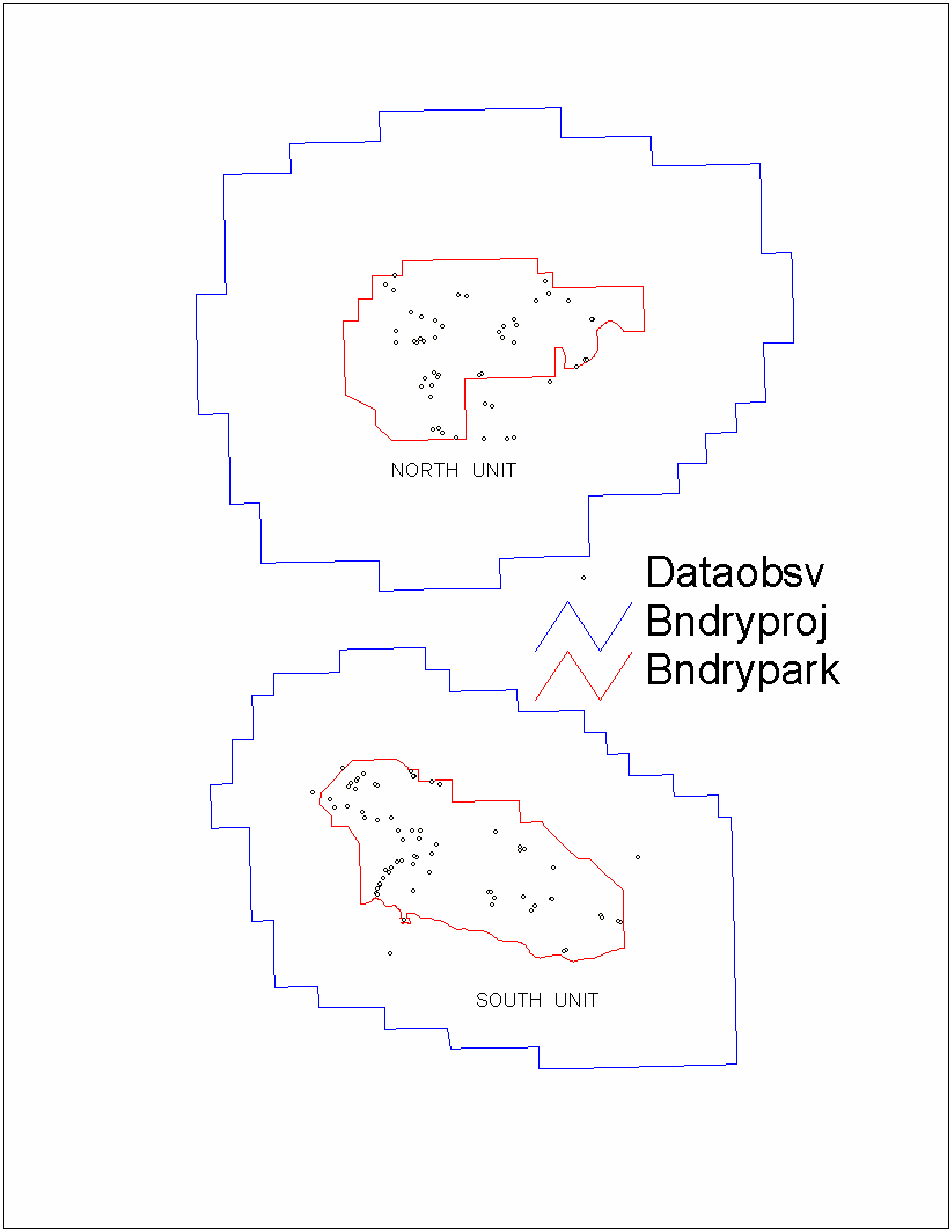


Figure 3-3. Map of Observation Points.

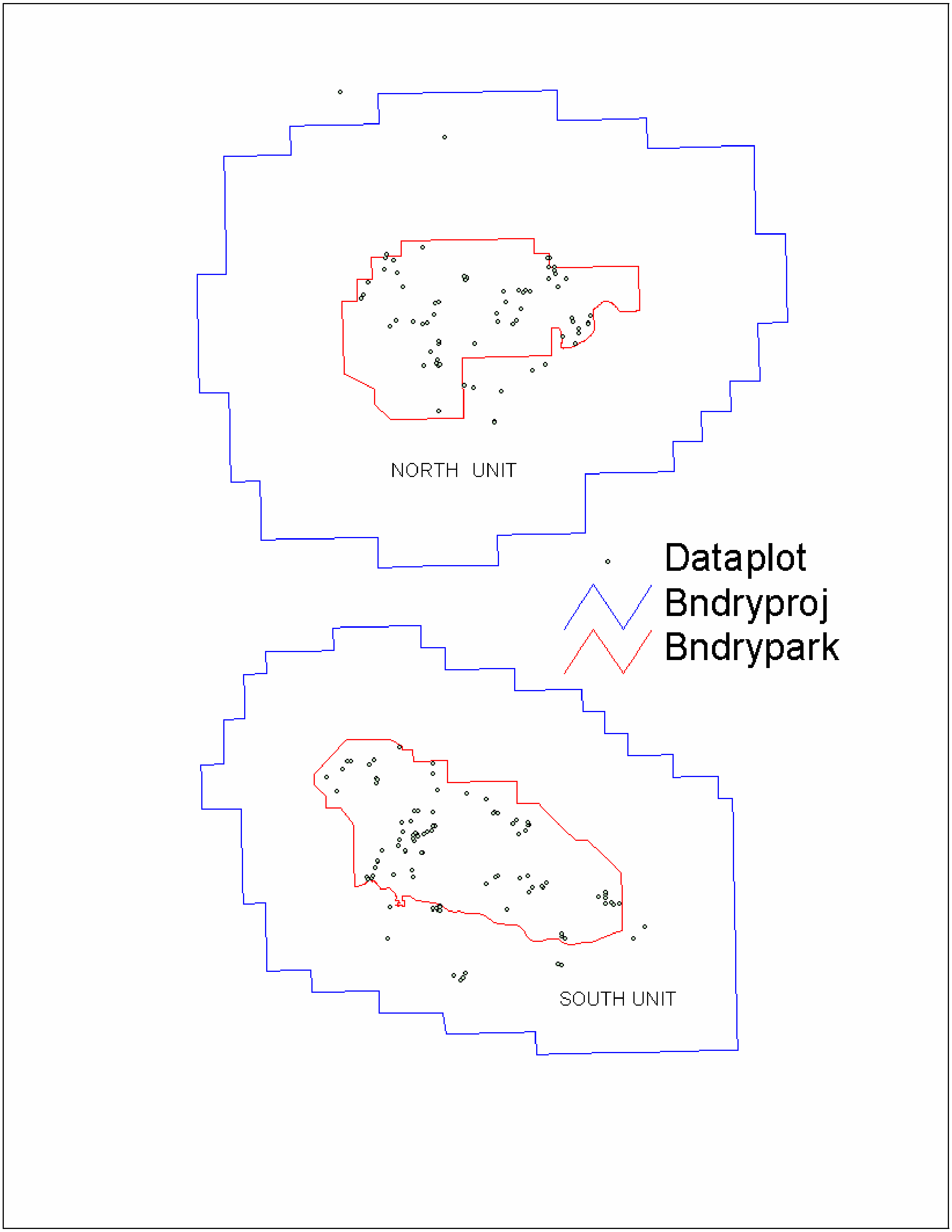


Figure 3-4. Map of Plot Locations Sampled During Summer, 1997.

intensive plot samples (Figure 3-4 above) in July 1997. Sampling sites were identified in the field within gradsects using standard methodology (Mueller-Dombois 1974). Detailed sampling plots were subjectively placed in vegetation that was representative of an area, relatively homogeneous, and covered more than 1/2 hectare (the minimum mapping unit). Thus, ecotones and small patches of vegetation were avoided. Forest and woodland communities were sampled with 20 x 20 meter plots while shrubland and herbaceous communities were sampled with 10 x 10 meter plots. Collected data included habitat characteristics (e.g. slope, aspect, elevation, and soil characteristics), vegetation composition and structure, and other site features such as wildlife or human disturbance (Appendix F). In order to collect grazed land data and data for rare associations outside the Park (such as ponderosa pine forest), investigators selected a few sample sites outside and near Park boundaries.

To characterize vegetation structure, all species found within a plot were noted and foliar cover for each species by strata was estimated using a modified Daubenmire (1959) classification. Since cover was estimated independently for both species and strata, total coverage for some of the plots was greater than 100%. In forests and woodlands, dbh (diameter at breast height) was measured for all trees greater than 10 cm dbh. Various environmental data were also collected for each plot to characterize the abiotic conditions under which the sampled vegetation occurred. The UTM coordinates and elevation of all plots where logged using a hand-held Precision Light-weight Global Positioning System (GPS) Receiver (PLGR) unit. Thirty-five (35) mm slides were taken for each plot and representatives are included in this report (Appendix G). At least three plots were sampled for each plant community found in the study area, as long as three stands were available. For a few rare plant communities (e.g., 'Greasewood Shrubland'), only one or two plots were sampled. All sampled data were entered into TNC's 'PLOTS' database.

3.6 Vegetation Classification and Characterization

The procedure for classifying vegetation followed guidelines set forth in the Vegetation Classification Standard (FGDC 1997) which was developed from the Standardized National Vegetation Classification System (NVCS) (TNC 1994, Grossman et al. 1998). This national system contains seven classification levels with the two finest (lowest) being the alliance and association (community) levels. Associations are separated from alliances through the use of total floristic composition and are named by the most dominant and/or indicator species. If two or more dominant species occur in the same stratum a dash symbol is used. If the species occur in different strata then a slash is used. Parentheses are used in instances when the diagnostic species are not consistently present in the vegetation unit.

Classification for the THRO study area involved placing all observation point data and plot data into groups based on vegetation structure and composition. From here, extensive floristic knowledge of the field team allowed most of the sampled community types to be qualitatively evaluated and subjectively assigned to an existing NVCS class. In a few instances, new NVCS classes were discerned and prepared from evaluations of the floristic data. Additional analyses were performed by TNC using the plot data combined with other similar data to provide a better regional perspective on vegetation types. These were quantitatively analyzed using ordination techniques (Detrended Correspondence Analysis "DCA" and Non-Metric Multidimensional Scales "NMS"), a clustering algorithm, Unweighted Pair-Group Method Using Arithmetic Means (UPGMA), and Two-Way Indicator Species Analysis (TWINSPAN). Since, in a number of cases, there were only a few sample plots per vegetation type, the above analyses could not be solely relied upon for classification. However, the results of the numerical analyses were compared to the subjective classification in order to detect any discrepancies between the two.

A dichotomous vegetation key for THRO was prepared following the 1997 field season (Appendix G). The key was tested during the Accuracy Assessment process in 1998 and reviewed by TNC, resulting in some modifications. A final illustrated, dichotomous key leading to association type descriptions was chosen to provide guidance to researchers in the field.

3.7 Vegetation Map Preparation

Map Units

Final THRO map units used for photo-interpretation were based on the NVCS, Anderson (1976) Level II classification system, and special requests by THRO personnel. The preliminary NVCS classification was used to determine relationships between signatures on aerial photos and vegetation associations on the ground. In most instances, one NVCS association corresponded to one map unit. However, due to various limitations in the aerial photography, certain individual NVCS had to be merged into a larger map unit (*i.e.* complex). Anderson (1976) Level II classes were used to classify land-use types including semi-natural and cultural types (*i.e.* roads, facilities, and agricultural fields). Finally, special vegetation types/habitats recognized by the Park but not part of the NVCS (e.g., prairie dog colonies, scoria outcrops, bentonite exposures, and exotic plant populations) were mapped. In these situations, the map unit had an unique photo signature and could be easily interpreted from the aerial photography.

Aerial Photograph Interpretation

All aerial photograph enlargements for THRO were covered with translucent mylar overlays. Fiducial points (corner and side marks), flight line, and photograph numbers were transferred from each photo onto its corresponding overlay. The center portion of each aerial photograph was systematically delineated to minimize the effects of edge distortion. Aerial photo enlargements and their overlays were then back-lit on a light table and visually scanned for photographic signatures using magnification. The 9"x 9" aerial photos where used in stereo pairs to investigate vegetation, land use, and topographic position as an interpretative aid for the smaller-scale (1:12,000) base photographs (enlargements).

The actual interpretation of aerial photographs involved three basic steps. First, all of the photos were initially interpreted into broad classes based solely on standard photo-interpretation signature characteristics. These included: tone, texture, color, pattern, topographic position, size, and shadow. Second, field note overlays and plot and observation point locations were used, if available, to refine the preliminary delineation into the appropriate map units. Finally, in order to ensure completeness and accuracy, digital transfer specialists reviewed all of the interpreted photos for consistency and recommended changes where necessary.

Map Validation

Before the accuracy assessment, a verification or map validation trip was taken in July 1998 to refine and assess the initial mapping effort. This trip included collecting additional observation points and ground-truthing aerial photographs using landmarks and GPS waypoints. Map classes were modified to reflect any inadequacies in the initial photointerpretation. This effort resulted in the earlier selected, Map Class 32 big sagebrush sparse shrubland, being incorporated into Map Class 2 Badlands Sparse Vegetation Complex.

Digital Transfer

An ArcInfo (copyright ESRI) GIS database was designed for THRO using the National Park GIS Database Design, Layout, and Procedures created by RSGIG (Appendix H). This was created through Arc Macro Language (AML) scripts that helped automate the transfer process and ensure that all spatial and attribute data was consistent and stored properly. Actual transfer of information from the interpreted aerial photographs to a digital, geo-referenced format involved two techniques, scanning (for the vegetation classes) and on-screen digitizing (for the land-use classes). Both techniques required the use of DOQQ's mentioned above as the project's base map.

The scanning technique used for THRO involved a multi-step process whereby mylar overlays, with interpreted line work, were scanned into digital form. The essential principle of this process is to match the scale and position of features on the photographs with the scale and position of the same features on DOQQs. This was accomplished by readjusting the scale of the photography, shifting the origin of the photo, rotating the axes, and bending/warping (rubber-sheeting) the photo between known control points (tic marks) and origin and destination points (links). The actual manipulation was conducted by computer program routines until the adjustment was considered a good fit by technicians. Any remaining land-use classes that were not already scanned were quickly transferred through on-screen digitizing. This process entered interpreted line work from aerial photos into the GIS database by manually drawing digital lines over the DOQQ (using the mouse with the DOQQ on the computer screen as a background image). Finally, the digitized line work transferred by both methods was connected, and polygon attribute information was added to produce a completed digital coverage.

Transferred information used to create vegetation polygon coverages and linear coverages in ArcInfo were based on quarter-quad borders. Attribute information including vegetation map unit, location, and aerial photo number was subsequently entered for all polygons. In addition, the spatial database has an FGDC-compliant metadata file (Appendix I).

3.8 Accuracy Assessment

The accuracy assessment (AA) for THRO vegetation mapping analyses consisted of preliminary planning and discussion, logistical planning, fieldwork, analysis of fieldwork, and computation of final results. Preliminary planning involved RSGIG and Dr. Jack Butler (Plant Ecologist hired by TNC and responsible for collecting the field AA data). Following detailed discussion, a modified accuracy assessment procedure dubbed "front-loading" (Owens 1998) was selected using protocols outlined in the Accuracy Assessment Procedures (TNC 1994) .

The following guidelines for this procedure were adopted at this time:

- Observations of vegetation classes were to be ground-based.
- Ground sampling techniques were to be similar to the Observation Points collected during initial classification.
- The number of samples per plant association/map class would vary depending on abundance of the class upon the landscape.
- Logistical planning for the AA revolved around access to work areas within the Park. The actual assessment was begun prior to completion of preliminary vegetation maps for the Park, thus the front-loading aspect of the study.
- A maximum number of points to be collected was not assigned, so that the Park could be sampled as completely as possible.

Assessment was performed within Park boundaries and data points were not limited to the previously described gradsects, but rather were located based on availability of access and to a lesser extent, time constraints. Selecting random AA sampling sites beforehand was deemed unnecessary due to familiarity of the principal researcher with vegetation types and distribution at THRO. The final points chosen for assessment were selected to be as representative as possible of the vegetation in the immediate area, well away from stand boundaries, and in a stand larger than the minimum mapping unit (exceptions were made for emergent wetland, scoria and bentonite exposures, and some exotic species classes which rarely exceeded 0.5 hectares in size). Field ecologists were supplied with a vegetation key, to be used to determine plant associations/map classes to enter on the field form. The field form used for the AA was a modified version of the observation point form (Appendix E).

AA data, including limited habitat and vegetation data, was recorded on field forms to document the classification decision made by the investigator. All AA data were collected during July 1998. The weather at this time was unusually warm and vegetation readily identifiable except where it was heavily grazed.

AA data were collected as shown in Figure 3-5 with more points collected within extensive types, e.g., AA points were collected proportional to the size of the plant association/map class within the Park. Accuracy assessment of the THRO project area was conducted in January 2000. This involved entering all accuracy data points into a coverage and overlaying these electronically on final vegetation maps (quarter-quads). AA point (identification) numbers

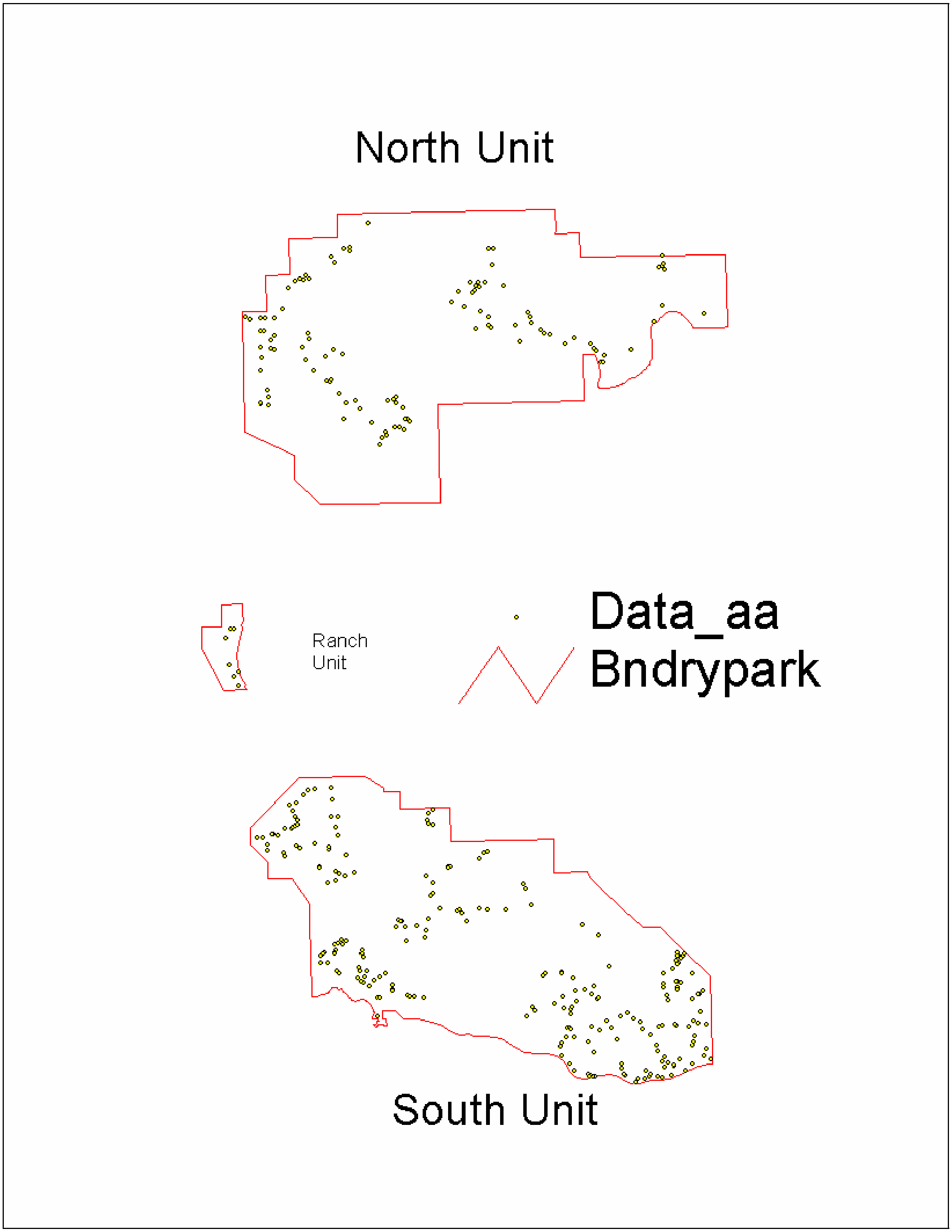


Figure 3-5. Map of Accuracy Assessment Locations Sampled During Summer/Fall 1998.

plotted alongside each point allowed for comparison with accuracy assessment data forms. A contingency table was set up to record the reference data (collected field data) versus the sample data (vegetation map) for each map unit.

Errors of commission (*i.e*. user's errors) for each class were calculated by dividing the number of correctly classified samples by the total number of samples that were classified as belonging to that map class. Errors of omission (*i.e*. producer's errors) for each class were calculated by dividing the number of samples that were classified correctly by the total number of reference samples in that class. Confidence intervals for each map class were calculated using one of the methods shown in Table 3-1. depending on the normality and size of the data.

Overall total accuracy for THRO is calculated across all sampled map classes by dividing the number of correctly classified accuracy points by the total number of accuracy points. Confidence intervals for overall total accuracy were calculated using the equation for normally distributed data (see Table 3-1). A Kappa Index (Foody 1992 in Accuracy Assessment Procedures, TNC, 1994) was used to help account for any correct classification due to chance.

Table 3-1.

Summarized Procedure and Equations Used to Calculate 90% Confidence Intervals for the THRO Accuracy Assessment.

- For large sample sizes ($n > 30$), a normal distribution was assumed when $np \geq 5$ and $n(1-p) \geq 5$, and $0.2 < p < 0.8$ where n = sample size and p = (number of correct samples / total number of samples) (Zar 1984 and Hay 1979).
- For normally distributed map classes the confidence intervals were calculated using the equation provided by Snedecor and Cochran (1967) in the Accuracy Assessment Procedures, Section 5.4 (TNC 1994).
- When the normal approximation was not valid (as determined from the above criteria), equations obtained from Zar (1984) were used to determine the lower and upper confidence intervals.
- For map classes containing small numbers of accuracy assessment points ($n \leq 30$), calculated tables of probabilities based on the underlying binomial distribution (Natrella 1963) were referenced for the upper and lower confidence limits.

4. RESULTS

4.1 Vegetation Classification and Characterization

The NVCS for the THRO study area includes 27 natural and semi-natural alliances and associations and two complexes. The natural associations are comprised of eight woodland, eight shrubland, five upland herbaceous/grassland, two wetland, and four sparse vegetation types. The semi-natural associations are comprised of three grassland types and two associations of exotic forbs. The final classification summary and detailed NVCS descriptions are presented in Appendix K. A field key with representative photographs is included in Appendix G. As expected, many of the vegetation types are representative of mixed grass prairie found throughout the Great Plains physiographic region, shrublands of floodplains and slopes, woodlands of floodplains, draws and slopes, and sparse vegetation associated with badlands exposures. Woodlands, shrublands, grasslands, and sparse plant communities are nearly equally represented in the project area. These major physiognomic groups, their distribution, and specific observations are described below in more detail.

Woodlands

Woodlands occupy floodplains, hills, ridges, draws, slopes, and slumps throughout the Park and environs. Rocky Mountain juniper (*Juniperus scopulorum*) and green ash (*Fraxinus pennsylvanica*) - American elm (*Ulmus americana*) are the most common woodlands while the rarest are ponderosa pine (*Pinus ponderosa*) woodland alliance stands that occur just outside the Park's South Unit boundary near Medora, ND. The ponderosa pine stands in this region represent its extreme northeastern distribution in the United States (Wali et al. 1980).

Ponderosa pine trees are found on the north-facing slopes and crowns (all aspects) of a few low, scoria hills and in the intervening drainages, to the edge of the Interstate 94 right-of-way. In this study and another by Wali and colleagues (1980), mature canopy trees are large and much taller than Rocky Mountain juniper which co-dominate the sub-canopy along with intermediate-aged ponderosa pine and green ash. Typical understory shrubs include chokecherry (*Prunus virginiana*), three-leaved sumac (*Rhus trilobata*), buckbrush or western snowberry (*Symphoricarpos occidentalis*), and shrubby cinquefoil (*Pentaphylloides floribunda*), along with sapling ponderosa pine, Rocky Mountain juniper, and green ash. Common herbaceous species include littleseed ricegrass (*Oryzopsis micrantha*), bluebunch wheatgrass (*Pseudoroegneria spicata*), plains muhly (*Muhlenbergia cuspidata*), and yarrow (*Achillea millefolium*). A heavy ground cover of bryophytes, mostly mosses, was observed under these stands. Several exotic species are also present, the most common include Kentucky bluegrass *(Poa pratensis*), smooth brome (*Bromus inermis*), and yellow sweetclover *(Melilotus officinalis*). Some occasional burned stumps of ponderosa pine were noted, as were porcupine (*Erithizon dorsatum*) foraging activity and a number of game trails, used mostly by mule deer (*Odocoileus hemionus*) and domestic cattle (*Bos taurus*). This woodland type occurs within the Little Missouri National Grassland and is grazed annually by domestic livestock. Only one ponderosa pine tree has been observed and reported in the South Unit of THRO (Runge, personal communication, 1998).

Rocky Mountain juniper is widespread, forming many stands throughout the project area and persisting as very dense woodlands, predominantly on north, northeast, and northwest-facing slopes and in drainages/draws. These trees intermix with green ash along the drier margins of more mesic hardwood draws, and may replace the hardwoods within draws as they dry with elevation gain, or in some cases with elevation loss (an example of this is the more mesic nature of draws accepting runoff at the edges of large plateaus, becoming drier on the lower elevation midslopes and toeslopes). Rocky Mountain juniper also provides a sub-canopy under decadent eastern cottonwood (*Populus deltoides*) trees in the riparian zone of the Little Missouri River floodplain. Its presence here may represent a successional change brought on by the drying of the second and third terraces.

The data collected in Rocky Mountain juniper woodland alliance stands for this study echos that collected by the Wali et al. (1980) and Hansen et al. (1984) studies. Common shrubs are similar to those found under ponderosa pine stands and include chokecherry, three-leaved sumac, buckbrush, sapling green ash, and common juniper (*Juniperus communis*). Littleseed ricegrass is the common herbaceous species, with northern bedstraw (*Galium boreale*), false Solomon's seal (*Maianthemum stellatum*), yarrow, and harebell (*Campanula rotundifolia*) also typical. Bryophytes, mostly mosses, provide dense ground cover in shaded areas. Most of the sampled Rocky Mountain juniper stands exhibited excellent seedling reproduction. Exotic species recorded include yellow sweetclover, leafy spurge (*Euphorbia esula*), Kentucky bluegrass, Canada thistle (*Cirsium arvense*), and Japanese brome (*Bromus japonicus*). Mule deer, and in some areas elk (*Cervus elaphus*), make extensive use of the stands as evidenced by scat and many game trails. Most stands also show evidence of historic burns and cutting/logging activity, likely for the production of fenceposts and firewood, but perhaps also for limited construction materials.

Quaking aspen (*Populus tremuloides*) woodland alliance stands occupy the heads of draws on Petrified Forest Plateau in the South Unit and along the northwestern loop road in the North Unit. These sites are largely east- and south-facing. Quaking aspen trees and root sprouts are found at the interface of draws with upland grasslands and blend downslope into hardwood woodlands dominated by green ash within the space of 50m to 100m. This location insures the maximum amount of moisture received from runoff and seepage from the relatively flat plateau surface. On the Achenbach Hills in the North Unit, quaking aspen are associated with mountain (water) birch (*Betula occidentalis*) in two relatively large, north-facing stands that occur on a mesic slope. This association of quaking aspen and mountain birch is the only one recognized by Hansen et al. (1984).

When quaking aspen are located in heads of draws, chokecherry, serviceberry (*Amelanchier alnifolia*), buckbrush, buffalo currant (*Ribes odoratum*), Woods' rose (*Rosa woodsii*), sapling quaking aspen, and some boxelder (*Acer negundo*) are the common understory shrubs. The herbaceous layer includes northern bedstraw, false Solomon's seal, wild bergamot (*Monarda fistulosa*), and poison-ivy (*Toxicodendron rydbergii*). On Petrified Forest Plateau, green ash contributed to the woodland canopy cover, but the type was clearly dominated by quaking aspen. It is undetermined whether each stand is represented by a single quaking aspen clone, reproducing from root sprouts, or if there are several small clones present and intermixed. Older quaking aspen stands have many downed trunks and show signs of wildlife use by bison (rubbing) and elk (browsing).

Quaking aspen stands on the Achenbach Hills occupy a mid- to upper-slope landscape position, adjacent to and in a boulder field, perhaps taking advantage of an area of seeping groundwater or water shed from the boulders during precipitation events. These unique stands have been previously described by Hansen et al. (1984) in addition to the data collected for this study. Both the canopy and sub-canopy are dominated by mountain birch, quaking aspen, and green ash trees. Serviceberry, along with sapling quaking aspen comprise the tall shrub layer, while chokecherry and bearberry (*Arctostaphylos uva-ursi*) are present as short shrubs. The herbaceous layer consists primarily of littleseed ricegrass, poison ivy, false Solomon's seal, and northern bedstraw.

As reported by Butler (1983), the green ash - American elm woodland alliance occupies mesic draws and floodplain margins throughout the region. Wali et al. (1980) state that green ash-American elm is the most common woodland type in southwestern ND and subsequently described nine sub-types. This study treats the hardwood type growing in draws and narrow drainages as a mapping unit distinct from those growing on floodplain margins, *i.e*., adjacent to the Little Missouri River and its major tributaries, in a manner similar to that addressed by Wali et al. (1980), Butler (1983), and Hansen et al. (1980, 1984).

Green ash - American elm mesic draws and moderately steep slopes are mapped and discussed here as a single entity. Typically, the aspect is northerly for hardwood establishment, but some stands occur on obviously east- or west-oriented sites if soil moisture requirements are met. Green ash is the dominant tree on all sites, and this species often dominates the sub-canopy, as well. Other sub-canopy trees include Rocky Mountain juniper and American elm, with occasional boxelder. On drier sites, this type often intermixes with Rocky Mountain juniper woodlands and on some mesic sites it intermixes with quaking aspen. On the north-facing slopes of the Achenbach Hills (North Unit), slumps support a mosaic of intermixed or interspersed green ash and Rocky Mountain juniper stands.

The common understory shrub of the hardwood type is chokecherry (sometimes in association with saplings of dominant trees), serviceberry, currants (*Ribes* spp.), American plum (*Prunus americana*), three-leaved sumac, buckbrush, and species of rose (*Rosa* spp.). Herbaceous understory species include Virginia wild-rye (*Elymus virginicus*), Sprengel sedge (*Carex sprengelii*), northern bedstraw, and wild bergamot. Several exotic species were also noted, particularly abundant were Kentucky bluegrass, leafy spurge, burdock (*Arctium minus*), yellow sweetclover, and smooth brome.

On floodplains, the green ash - American elm temporarily-flooded woodland alliance usually occupies the outermost portion, where old meander scars and depressions are present (ground water is nearer to the soil surface), or where tributary drainages release surface and ground water into the larger drainage. Sometimes, a few decadent eastern cottonwood trees are present in the stand, as seen in the Peaceful Valley portion of the South Unit. Healthy eastern cottonwood woodlands typically occupy areas of the floodplain in closer proximity to the flowing water. Green ash is usually the dominant tree, but some stands were observed to be co-dominant with either Rocky Mountain juniper or American elm. The common understory shrubs are buckbrush and Woods' rose along with dogwood (*Cornus sericea*), silver sagebrush (*Artemisia cana*), and three-leaved sumac. Herbaceous understory species include poison ivy, Canada wild-rye (*Elymus canadensis*), and prairie sand-reed grass (*Calamovilfa longifolia*). Typical exotic species of floodplains in the Park and this woodland type include Kentucky bluegrass, leafy spurge, Canada thistle, and smooth brome.

Eastern cottonwood woodlands within and near THRO range from newly deposited point bars and islands in/along the Little Missouri River to decadent stands with a Rocky Mountain juniper and green ash sub-canopy. Wali et al. (1980) state that about 90 years of age appears to be the maximum for healthy eastern cottonwood trees, as older trees often become unhealthy. Essentially four types of eastern cottonwood woodlands were observed in the study area, they are: 1) cottonwood - Rocky Mountain juniper floodplain woodland, 2) cottonwood - peachleaf willow floodplain woodland, 3) cottonwood temporarily-flooded woodland alliance, and 4) cottonwood - sandbar willow. Mature cottonwood - peachleaf willow woodland alliance was not observed within Park boundaries, but good examples were observed and sampled on Sully's Creek and the Little Missouri River near the Chateau DeMores Interpretive Center.

Newly vegetated point bars and islands are probably more appropriately discussed as sandbar willow shrublands, even though they support many eastern cottonwood and peachleaf willow seedlings and occasional green ash and Russian-olive (*Elaeagnus angustifolia*) seedlings. The substrate is typically coarse sand and gravel, with a few cobbles present. These sites are subject to annual flooding, scouring, sediment deposition, and abrasive action from ice sheets, a situation that favors sandbar willow over tree seedlings. A considerable amount of debris, particularly tree limbs and trunks, can be deposited in this type as a result of high water events.

When enough sediment deposition has occurred to reduce the frequency of high water events or when the river/stream scours deeper into its bed, then eastern cottonwood and peachleaf willow seedlings can better complete the transition from seedlings to saplings. Typically, all shrub and seedling stems are less than 1m in height in these situations. Point bars and islands also support several other pioneering species, including prairie cordgrass (*Spartina pectinata*), common horsetail (*Equisetum arvense*), wild licorice (*Glycyrrhiza lepidota*), western ragweed (*Ambrosia psilostachya*), buffalo-bur (*Solanum rostratum*), showy milkweed (*Asclepias speciosa*), goldenrod (*Solidago gigantea*), Canada wildrye, and foxtail barley (*Hordeum jubatum*), and the exotics cocklebur (*Xanthium strumarium*), yellow sweetclover and white sweetclover (*Melilotus officianalis* and *M. alba*), leafy spurge, kochia (*Kochia scoparia*), prostrate knotweed (*Polygonum aviculare*), smooth brome, and Kentucky bluegrass. It should be noted that islands and point bars that appeared to be unvegetated on the 1996 aerial photography, may have established this vegetation type by the 1998 (late summer) accuracy assessment.

Stands of medium-aged eastern cottonwood trees (up to 60' tall) are established on first and second terraces above the Little Missouri River. These stands contain even-aged trees that grow as a monotype with a short-shrub and herbaceous understory. They are frequented by bison seeking shade, scratching/rubbing posts, and areas to wallow. Soils that have deposited on first and second river terraces are typically fine sand and silt, and occasional debris such as tree branches and trunks is present.

Shrubs are relatively sparse under the nearly closed canopy of medium-aged eastern cottonwood stands, and include buckbrush, Woods' rose, silver sagebrush, buffalo currant, and the vine, virgin's bower (*Clematis ligusticifolia*). A few seedling green ash and Rocky Mountain juniper trees are also present in the short shrub understory. Herbaceous species are somewhat shade-tolerant and often exotic, including yellow sweetclover, white sweetclover, leafy spurge, smooth brome, Kentucky bluegrass, and salsify (*Tragopogon dubius*). Native herbaceous species of the higher river terraces include prairie sandreed grass, Canada wildrye, wild licorice, showy milkweed, smooth scouring-rush (*Equisetum hyemale*), western ragweed, green sagebrush (*Artemisia dracunculus*), goldenrod, and western sagewort (*Artemisia ludoviciana*).

More mesic first and second terraces (these may be/include cut-off oxbows) along the Little Missouri River and some perennial streams support a cottonwood - peachleaf willow woodland alliance where the two species are nearly equal in aerial cover. Peachleaf willow typically reach a height of 25'-40' and some eastern cottonwood trees may exceed 60' tall. Other tree species present in this woodland type include boxelder, green ash, Russian-olive, and Rocky Mountain juniper.

The shrub stratum of the cottonwood - peachleaf willow woodland alliance includes sandbar willow further illustrating the mesic nature of the habitat. Additional shrub species common to mesic river terraces include, red-osier dogwood, buffalo currant, honeysuckle (*Lonicera* sp.), buckbrush, Woods' rose, three-leaved sumac, and the vines virgin's bower and Virginia creeper (*Parthenocissus quinquefolia*). Many exotic herbaceous species are present, particularly leafy spurge, Kentucky bluegrass, white sweetclover, yellow sweetclover, Canada thistle, and smooth brome. Native herbaceous species present in this type include Canada wildrye, western wheatgrass (*Pascopyrum smithii*), wild licorice, northern bedstraw, meadow-rue (*Thalictrum dasycarpum*), and smooth scouring-rush.

Old or decadent stands of eastern cottonwood persist on dry, second or third terraces of the Little Missouri River, well-removed horizontally and/or vertically from the river channel and associated ground water. The old trees have many dead upper branches and sometimes the entire crown is dead. Many standing dead trees are present with trunks bearing scars from past fires. Also, fallen tree trunks and branches litter the ground. Rocky Mountain juniper and some green ash trees are successfully colonizing these stands. They are able to sprout and grow to saplings under shady conditions then become mature trees as the eastern cottonwood die and the canopy opens. A green ash - American elm temporarily-flooded woodland alliance may be the climax community under these conditions. The eastern cottonwood trees are generally massive and may reach 70'-80' in height, while the Rocky Mountain juniper are more dense and reach up to 35' in height. This is an extremely valuable wildlife habitat, including many forage and nesting sites for cavity-nesting birds. Good examples of decadent eastern cottonwood stands can be observed at the Cottonwood Campground and at the Peaceful Valley Ranch concession.

Many species of shrubs have become established in the understory of decadent eastern cottonwood stands. They include three-leaved sumac, silver sagebrush, buckbrush, common juniper, buffalo currant, Woods' rose, chokecherry, poison ivy, and the vines virgin's bower and Virginia creeper. Understory herbs are quite diverse, but many of the species are exotics, such as leafy spurge, Kentucky bluegrass, smooth brome, white sweetclover, yellow sweetclover, asparagus (*Asparagus officianalis*), Japanese brome, and alfalfa (*Medicago sativa*). Native grasses and forbs present include, prairie sandreed grass, green needlegrass (*Stipa viridula*), Canada wildrye, Canada bluegrass (*Poa compressa*), American vetch (*Vicia americana*), western sagewort, false Solomon's seal, meadow-rue, northern bedstraw, smooth scouring rush, western ragweed, and goldenrod.

Shrublands

Shrublands are present on landforms throughout the study area including floodplains, flats, slopes, slumps, draws, hills, and ridges. The most extensive shrublands include silver sagebrush / western wheatgrass stands within river and creek valleys and three-leaved sumac shrubland alliance which is common on scoria hills and ridges. Silver sagebrush establishes on floodplain terraces and on some upland flats and slopes. It is usually associated with western wheatgrass and is heavily invaded by leafy spurge in the South Unit of the Park, particularly along the Little Missouri River and Knutson and Paddock Creeks. In some areas, silver sagebrush is either co-dominant with or dominated by buckbrush as observed in Beef Corral Bottoms and at the Longhorn Pullout. On one unusual site in the Little Missouri River floodplain in the North Unit, silver sagebrush, three-leaved sumac, and buckbrush were equally dominant.

The three-leaved sumac shrubland alliance occupies ridges, hills, and slopes consisting of mostly scoria outcrops and soils derived from scoria. Here, the relatively evenly-spaced dominant shrubs grow on dry exposures and are typically associated with silver sagebrush and chokecherry; plains muhly, blue grama, western wheatgrass, and bluebunch wheatgrass grow in the herbaceous stratum. On moist slopes, this shrub commonly grows with either horizontal juniper dwarf shrubland alliance or stands of little bluestem - sideoats grama herbaceous alliance. Yellow sweetclover, an invasive exotic in these stands, are easily observed (along with scoria outcrops) on south-facing ridges north of I-94 near Medora, ND.

Buckbrush (also known as wolfberry or western snowberry) temporarily-flooded shrubland alliance; 1) is widespread in the project area, growing in the same or similar habitats as silver sagebrush, 2) occupies upland depressions, mesic swales, and heads of mesic draws, 3) is an understory in all of the woodland types present at THRO, and 4), is typically very dense, usually between 75% - 90% aerial cover. The most commonly associated species observed with buckbrush at THRO is the exotic, Kentucky bluegrass.

Silver buffaloberry (*Shepherdia argentea*) shrubland alliance occurs as dense, impenetrable stands in mesic swales, outer edges of floodplains, and at the heads of mesic draws. The most easily observable stands are near the road at the Sperati Point turn-around and along the Wind Canyon Trail. It often becomes established with buckbrush in swales, horizontal juniper (*Juniperus horizontalis*) and little bluestem on moist, north-facing slopes, and along the margins and heads of hardwood draws. These stands are always below the project's MMU.

The sandbar willow temporarily-flooded shrubland alliance occupies point bars and islands of the Little Missouri River and other perennial drainages, forming dense stands. This is the first shrub to colonize newly exposed surfaces along rivers and streams, sometimes in association with cottonwood seedlings as previously described. One stand is located just west of the

Cannonball Concretions Pullout and other stands are observable from any river overlook. Commonly associated species were previously described in the discussion for eastern cottonwood floodplain woodlands.

Rabbitbrush (*Chrysothamnus nauseosus*) shrubland alliance stands, which become established on natural hillside slumps and cut-and-fill slopes disturbed by highway construction, are uncommon in the project area. The most easily observable of these habitats are the slump-slope below the Painted Canyon Overlook, the I-94 right-of-way near Medora, and the slump-slope south of the Long X Trail Pullout. Rabbitbrush is commonly associated with silver sagebrush and buckbrush on these slumps and road cuts.

Greasewood (*Sarcobatus vermiculatus*) shrub herbaceous vegetation, perhaps the rarest shrub type in the project area, is observed at only two localities in the South Unit. This type is characterized by relatively tall (0.5-1.5m) shrubs forming open stands with fringed sagewort (*Artemisia frigida*), western wheatgrass, Japanese brome, and Canada bluegrass. Individual greasewood shrubs may commingle with sagebrush and saltbush shrubs on sparsely vegetated badlands formations, where they are included with the badlands complex. In this instance, these species form a very sparse, dwarf shrubland similar to salt deserts further west and south.

Horizontal juniper dominates a dwarf shrub alliance that occupies moist areas, typically on steep north-facing slopes, sharing habitat with the little bluestem - sideoats grama herbaceous alliance, silver buffaloberry shrubland alliance, and three-leaved sumac shrubland alliance. Horizontal juniper is often dense, appearing as a low-growing “carpet” of dark green on the landscape. In the late summer this color is replaced by reddish bunches of little bluestem. Commonly associated shrubs include common juniper, shrubby cinquefoil, silver buffaloberry, three-leaved sumac, and buckbrush. Little bluestem, prairie sandreed grass, and sideoats grama are common herbaceous species on these moist exposures.

Wetlands

Wetlands (apart from woody floodplains) within THRO are rare and predominantly shrub-scrub and herbaceous. Shrub-dominated wetlands, e.g., sandbar willow, are described above with the other Park shrublands. Except for stands of the prairie cordgrass temporarily-flooded herbaceous alliance, emergent wetlands within the park are well-below the minimum mapping unit and are only mapped as observed growing on seeps and around springs. An effort was made to fill out an observation form for each small, emergent wetland encountered by researchers inside Park boundaries. More extensive wetlands occur within the project environs occupying large depressions, within and along perennial drainages, around livestock ponds, and small water storage reservoirs. Emergent wetlands typically are dominated by spikerush (*Eleocharis* spp.), Arctic rush (*Juncus arcticus*), cattails (*Typha* spp.), and foxtail barley (*Hordeum jubatum*).

Grasslands

Grasslands are also widespread throughout the project area, occupying floodplains, plateaus, buttes, hills, ridges, slopes, and flats. They intersperse with all shrublands and woodlands, becoming understory species in woody habitats. Some areas that have been disturbed historically due to facility construction and agricultural activities are dominated by exotic grass species. Exotic grasses have also invaded native grasslands where they have become the dominant species. Native dry mixed grass prairie species are most abundant, including needle-and-thread grass, blue grama, and threadleaf sedge. Stands of little bluestem represent the rarest grassland community, much of it being incorporated as understory or associated species in prairie sandreed grass, horizontal juniper dwarf shrubland and three-leaved sumac shrubland.

The prairie cordgrass temporarily-flooded herbaceous alliance is occasionally observed in the Little Missouri River floodplain, mostly in the North Unit. The stands occupy areas that are in contact with near-to-surface ground water, or are in depressions that hold water following overbank flooding events. Surrounding the stands are shrublands, typically silver sagebrush and/or buckbrush; the dead trunks of eastern cottonwood, green ash, and American elm trees are sometimes observed in or near these wet sites. Prairie cordgrass is the dominant tall-grass species and is associated with western wheatgrass, foxtail barley, Canada and Kentucky bluegrass, barnyard grass (*Echinochloa* sp.), curly-cup gumweed (*Grindelia squarrosa*), wild bergamot, and white aster (*Aster ericoides*). This vegetation type is most observable near the loop road in the North Unit, where it crosses through the longhorn cattle pasture.

Prairie sandreed grass (*Calamovilfa longifolia*) herbaceous alliance occurs as relatively small stands on knolls, hilltops, slopes, and at the heads of mesic draws in both the North and South Units. Soils of these sites are typically gravelly or sandy. This tall grass is rhizomatous and forms rounded patches on the landscape appearing light green in color. Dominance in the stand is often shared with little bluestem, needle-and-thread grass, green needlegrass, threadleaf sedge, and fringed sagewort (*Artemisia frigida*), depending on slope exposure and soil moisture availability. An uncommon association observed on the Petrified Forest Plateau and in the eastern portion of the South Unit included porcupine grass (*Stipa spartea*) as a co-dominant with prairie sandreed grass.

Little bluestem - sideoats grama herbaceous alliance is relatively rare at THRO, occurring as small, scattered patches and stands on the more moist north- and east-facing slopes. This habitat is also occupied by other vegetation types, including horizontal juniper dwarf shrub alliance, three-leaved sumac shrubland alliance, silver buffaloberry shrubland alliance, and prairie sand-reed grass herbaceous alliance. Often, little bluestem becomes an associate of or co-dominant with other recognized dominant species in this study as a result of this moist habitat preference. Later in the summer, when little bluestem has turned to its characteristic reddish-brown color, it appears much more abundant on the landscape. Common associates within little bluestem stands include big bluestem (*Andropogon gerardii*), prairie sandreed grass, porcupine grass, sideoats grama, needle-and-thread grass, threadleaf sedge, and a variety of forbs.

Western wheatgrass herbaceous alliance grasslands occur primarily in broad floodplains, as the dominant grass or as an understory species in silver sagebrush - western wheatgrass shrubland. It also occupies moist swales in drier grassland associations and slopes below some badlands formations, where additional runoff water is available. This grassland type is almost always associated with sparse silver sagebrush shrubs (sometimes intergrading into silver sagebrush shrublands) and occasionally with buckbrush. On one heavily grazed site in the environs near the North Unit, western wheatgrass was replaced in abundance by blue grama, a condition also observed at Badlands National Park (Von Loh et al 1999). Species commonly associated with western wheatgrass include green needlegrass, blue grama, needle-and-thread grass, and the exotics, Kentucky bluegrass, yellow sweetclover, and leafy spurge. Much of the area currently invaded by exotic plant species and/or occupied by prairie dog towns would most likely support western wheatgrass grasslands.

Exotic grasses make up the introduced grassland herbaceous alliance and are dominant in several areas within THRO, having spread from historic erosion control plantings along roadways, on sites seeded following disturbance due to construction, and possibly from range improvement seeding. As a result, large patches of Kentucky bluegrass, crested wheatgrass (*Agropyron cristatum*), and smooth brome are present. These species produce large amounts of litter, which in the absence of grazing and fire, shades the ground and increases soil moisture, thus excluding most native grasses and forbs.

Kentucky bluegrass dominates the eastern portion of the South Unit, from the buffalo corrals to the Painted Canyon Overlook vicinity. It occupies the more moist sites where one might expect to find western wheatgrass. Crested wheatgrass: 1) occupies a small area near the Painted Canyon Overlook, just east of the parking lot within the Park, 2) is co-dominant with smooth brome in some areas of the I-94 right-of-way, and 3), occurs as a relatively large stand on USFS-managed land near SH 85 and the Fryburg exit. Smooth brome dominates previously disturbed sites along the highways and loop roads, where it spreads laterally into moist swales and into the Little Missouri River and tributary floodplains. Particularly dense stands occur in the I-94 right-of-way, along the loop roads in both units, and at the northeastern boundary fence of the North Unit where it is co-dominant with Kentucky bluegrass.

Needle-and-thread herbaceous alliance grasslands are the most extensive herbaceous vegetation types in the Park and the surrounding environs. Particularly large expanses occur on Petrified Forest Plateau and Big Plateau in the South Unit and on the Achenbach Hills in the North Unit. This dry grassland occupies plains, flats on buttes, plateaus, mesatops, and dry hillsides. Three species, needle-and-thread grass, threadleaf sedge, and blue grama are typically dominant, their abundance is related mainly to amount and timing of grazing and soil types. Other species commonly associated with this grassland include prairie Junegrass (*Koeleria pyramidata*), western wheatgrass, purple coneflower (*Echinacea angustifolia*), prairie coneflower (*Ratibida columnifera*), little clubmoss (*Selaginella densa*), and the exotics, Japanese brome, and yellow sweetclover.

Badlands and Sparse Vegetation

Badlands formations/exposures occur throughout the study area, forming many of the ridges, outcrops, and hills. Sparse shrub, forb, and grass communities are present on the badlands but cannot be distinguished on the color photos from one another due to reflectance of light off the otherwise barren surface. Two more easily identified exceptions are the pink- to red-colored scoria outcrops (described below) and bluish-gray-colored bentonite ridges that were delineated and mapped separately as “park specials”. Another sparsely vegetated type, which is also a wildlife habitat, is the prairie dog town complex.

The badlands sparse vegetation complex includes two sparsely vegetated plant associations and barren sandstone, clay, and siltstone on ridges, cliffs, hills, mounds, slopes, erosion fans, and drainages. Drought- and salt-tolerant shrubs typical of the Great Basin, such as big sagebrush (*Artemisia tridentata*), shadscale (*Atriplex confertifolia*), four-wing saltbush (*Atriplex canescens*), snakeweed (*Gutierrezia sarothrae*), rabbitbrush, and greasewood are scattered, but common to this sparsely-vegetated type. Typical herbaceous species present on badlands exposures include western wheatgrass, blue grama, alkali sacaton (*Sporobolus airoides*), and plains prickly-pear (*Opuntia polyacantha*).

Outcrops

Scoria outcrops and exposures (scoria sparse vegetation complex) should be considered a geology/landform mapping class, since they are largely devoid of vegetation. These exposures typically occur below the MMU for the project and are often associated with other exposed bedrock, particularly the Sentinel Butte Formation. It is common to find scoria outcrops associated with needle-and-thread herbaceous alliance grasslands, three-leaved sumac shrubland alliance, and Rocky Mountain juniper woodland alliance.

Some bentonite outcrops in the North Unit support the rarest sparse shrub association identified in the Park, i.e., long-leaved sagebrush sparse vegetation alliance. However, not all bentonite outcrops support these shrubs and many are devoid of vegetation. This map class should therefore be viewed as a geology/landform class and only as a potential habitat for long-leaved sagebrush. When present, long-leaved sagebrush stands occur as a monotype, growing on flats and moderate slopes, and provide less than 5% vegetative cover. Deeper erosion rills associated with bentonite outcrops usually are colonized by sparse rabbitbrush shrubs.

Prairie dog town complex

Prairie dog towns occupy deeper soils on large flats adjacent to drainages and low- to moderately-sloping hillsides. Prairie dogs may alter grassland vegetation types over time through their cycle of burrow establishment, grazing, and burrow abandonment. Also, bison use prairie dog towns for foraging, wallowing, and staging during the breeding season, further increasing the affects to vegetation on these sites. This constant use causes the native vegetation to revert to an early successional state, i.e., a weedy, forb-dominated association. Several associations of plants may occur within a prairie dog town that have not been described by the NVCS for THRO, but rather treated as a Prairie Dog Town Complex. Plant species commonly recorded for prairie dog towns at THRO include dog fennel (*Dyssodia papposa*), dwarf horseweed (*Conyza ramosissima*), yellow sweetclover, field bindweed (*Convolvulus arvensis*), big-bract verbena (*Verbena bracteata*), rough false-pennyroyal (*Hedeoma hispida*), and Russian-thistle (*Salsola iberica*).

Exotic plant species

Exotic plant species are wide-spread in some areas of the Park, including the previously mentioned introduced grasses. The leafy spurge herbaceous alliance covers large areas of the South Unit, on floodplains, in draws, on slopes, and in upland swales. One of the largest invasions of leafy spurge occupies the east-facing slope of Petrified Forest Plateau. Only a few, small patches were observed under sandbar willow shrubs on the first terrace of the Little Missouri River floodplain in the North Unit.

Pockets of the Canada thistle herbaceous alliance are also present but most are too small to interpret and map. A number of small Canada thistle patches were identified and coordinates recorded during the observation work in 1997 and the accuracy assessment work in 1998. One particularly large patch occurs in the prairie dog town on the east side of the South Unit, and a large stand grows with silver sagebrush along Corral Creek in the southern portion of the North Unit. Many small patches of Canada thistle were observed under hardwood woodland canopies, including a patch under a green ash - American elm temporarily-flooded woodland alliance stand in the Elkhorn Ranch Unit.

Yellow sweetclover is notable, particularly in the North Unit, but is not interpreted/delineated as a separate map class (because of its height and density, it may however serve to "hide" signatures of other classes). This exotic biennial is more common in moist soils that usually support the western wheatgrass herbaceous alliance grasslands and hardwood draws. Exotic species have also invaded prairie dog towns throughout the project area, including field bindweed, yellow sweetclover, leafy spurge, and Canada thistle.

4.2 Vegetation Map Units

Map Units

Thirty-nine map classes or units were recognized and used for THRO (Appendix K). These were divided into 29 vegetation land-cover units and ten Anderson Level II (Anderson *et al.* 1976) land-use units. Map units were developed through a combination of fieldwork, preliminary photo-interpretation, and the NVCS vegetation association classification for THRO. A meeting was convened with project participants (BRD, THRO, TNC, BOR) to discuss map classes and select those to be used for the project. Deviations from the NVCS occurred when distinct photo signatures could not be discerned from aerial photography, such as for some of the shrubland and badlands types. Also, some map units did not directly correspond to the USGS-NPS vegetation mapping program but were included to aid with THRO's management needs.

Three sparse vegetation complexes were selected for the badlands erosional features based on readily identifiable coloration. Interpretation of another vegetation type, big sagebrush shrubland, was also attempted but was rejoined into the badlands complex due to lack of initial accuracy during plot verification work. Scoria outcrops and tongues of bentonite clay were often below the MMU, but were delineated and mapped where possible to improve the usefulness of the final map product for Park resource managers.

Park resource managers are often interested in the location, size, and edge identification of prairie dog towns (Plumb 1997; Appendix L). Typically, wildlife habitats would not be candidates for mapping under this program, however, prairie dogs do alter the vegetation around them to the point of creating and sustaining predictable vegetation types. Largely from similar work conducted at Wind Cave and Badlands National Parks, prairie dog towns have been designated as belonging to the Purple Threeawn-Fetid Marigold Herbaceous Vegetation Association or the Prairie Dog Town Vegetation Complex (Cogan et al. 1999 and Von Loh et al.1999). A separate attribute item was used to classify invasions of leafy spurge into habitats with dominant native overstory. This was displayed on the map as a yellow stippled pattern over the dominant classification's color pattern.

Some map classes routinely occur below the minimum mapping unit, these include scoria outcrops, bentonite tongues (Long-leaved Sagebrush Sparse Shrubland), emergent wetlands, leafy spurge and Canada thistle patches, silver buffaloberry shrubland, and greasewood shrublands. Partially based on the importance of these types for wildlife habitat and Park management needs, a decision was made to map them where possible regardless of size. This includes the use of a line coverage for thin, linear wetlands.

Aerial Photograph Interpretation

Interpretation of the true-color aerial photographs for THRO relied heavily on landscape position to help determine classes for vegetation polygons since many color, shape, and texture signatures were similar. Also, signatures were influenced by timing of photography, as aerial photographs were acquired in two different seasons; most of the Park during early July, and the eastern environs in late August. The difference in overflight dates created more photographic signatures to interpret because of moist, early summer conditions versus dry, late summer conditions and the corresponding phenology of dominant plant species. A brief description of each map class (plant association, alliance, or complex), topographic position, and photo signature characteristics is presented below (note, the number in parentheses indicates the map class number):

Prairie Dog Town Complex (1).

Location: This sparse vegetation class occupies plains, broad drainages, swales, terraces, and gentle slopes within the project region. Often, other vegetation types occur within the boundaries of individual towns.

Photo signature: Small, white stipples (burrow holes), usually somewhat interconnected by narrow trails and lying within dull white, tan, gray-green, and medium green background colors. The class is delineated to the edge of the obviously grazed zone (hazy/cloudy appearance) per Plumb (1997).

Figure: 4-1a

Badlands Sparse Vegetation Complex (2).

Location: This geologic feature and sparse vegetation class provides much of the Park's aesthetic focus and consists of barren to sparsely vegetated hills, cliffs, bluffs, pinnacles, mounds, table lands, escarpments, erosion fans, alkaline flats, overflows, and drainages.

Photo signature: For siltstone, claystone, sandstone, and sediments include a dull white to tan to yellowish color signature, sometimes with shadowing appearing as black. Pinkish-red rocks are delineated/mapped as Class 3 and layers of bentonite over the whitish sediments creates a dark gray signature that is delineated/mapped as Class 4.

Figure: 4-1b

Scoria Sparse Vegetation Complex (3).

Location: This map unit provides additional aesthetic focus and consists of barren to sparsely vegetated outcrops, hilltops, and ridgelines.

Photo Signature: Focuses on reddish- to pink-colored scoria that contrasts with dull white to tan badlands outcrops as the predominant interpretive feature.

Figure: 4-1c

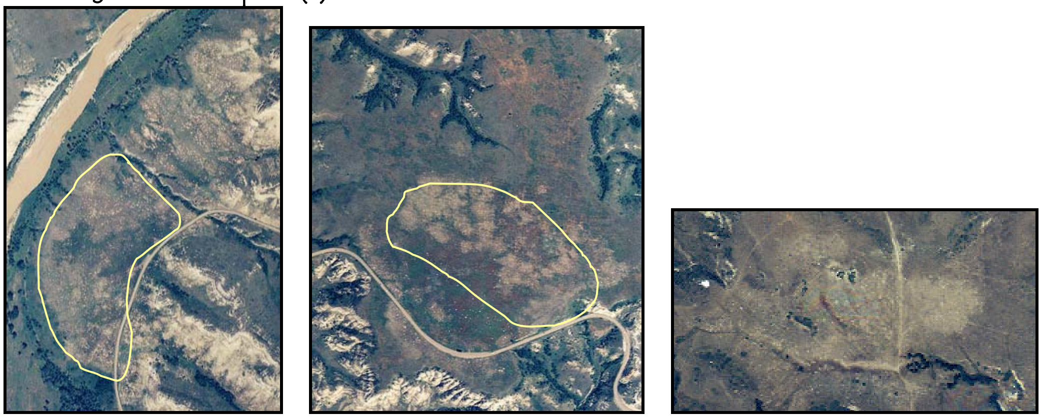
Long-leaved Sagebrush Sparse Vegetation Alliance (4).

Location: This geologic feature and sparse vegetation class provides minor aesthetic focus and consists of barren to sparsely vegetated outcrops or tongues of bentonite clay.

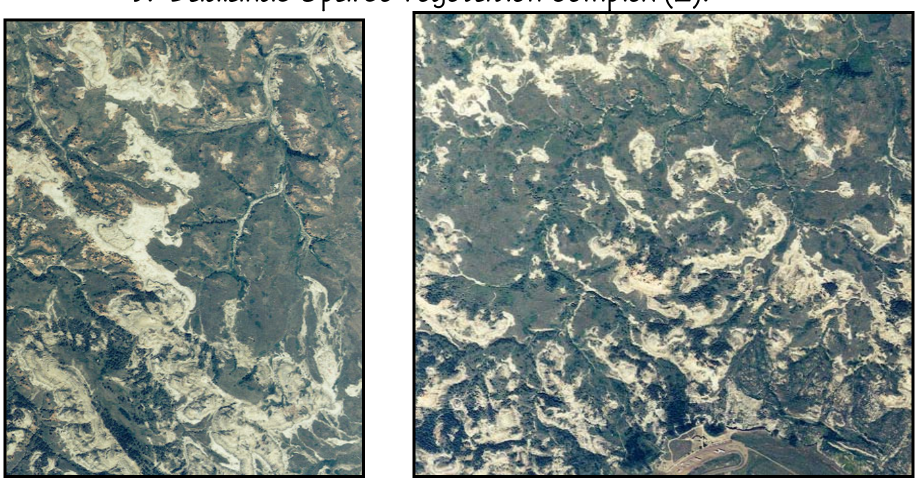
Photo Signature: Focuses on bluish-gray to creamy-colored exposures along a consistent horizontal gradient.

Figure: 4-1d

a. Prairie Dog Town Complex (1).



b. Badlands Sparse Vegetation Complex (2).



c. Scoria Sparse Vegetation Complex (3).

d. Long-leaved Sagebrush S.V.A. (4)

Figure 4-1 – Classes 1, 2, 3, & 4 Representative Photo Signatures.

Leafy Spurge Herbaceous Alliance (10).

Location: This exotic forb has invaded most habitats in the South Unit's west side and along many of the perennial waterways. It is the dominant plant in many moist drainages and floodplain sites, but exists as an understory species in shrub and tree stands.

Photo Signature: Focuses on the dull yellow to olive green color, located in South Unit and adjacent environs habitats and the texture is smooth.

Figure: 4-2a

Canada Thistle Herbaceous Alliance (11).

Location: This exotic forb occurs in small patches on moist sites and is mapped on an as-observed basis. One large patch occurs in a prairie dog town on the east side of the South Unit.

Photo Signature: A dark green to black patch of vegetation against the gray-green, stippled prairie dog town signature.

Figure: 4-2b

Prairie Sandreed Grass Herbaceous Alliance (12).

Location: Occurs in relatively pure patches along plateau rims, on hilltops, and slopes with sandy soil. Present on Petrified Forest Plateau along the rim and draw heads between flats dominated by needle-and-thread grass and draws occupied by green ash woodlands.

Photo Signature: Medium green color and circular growth pattern with smooth edges; when on scoria hills and ridges, also has the circular growth pattern but the color is dark gray.

Figure: 4-2c

Prairie Cordgrass Temporarily-Flooded Herbaceous Alliance (13).

Location: This tall wetland grass occurs in wet depressions, possibly old oxbows in the floodplain of the Little Missouri River. Best examples are in the North Unit: one stand occurs in the longhorn cattle pasture near the entry station.

Photo signature: Medium green to dark green in color, regular stand margins, and a smooth texture typically surrounded by silver sagebrush shrubs or green ash / eastern cottonwood trees.

Figure: 4-2d

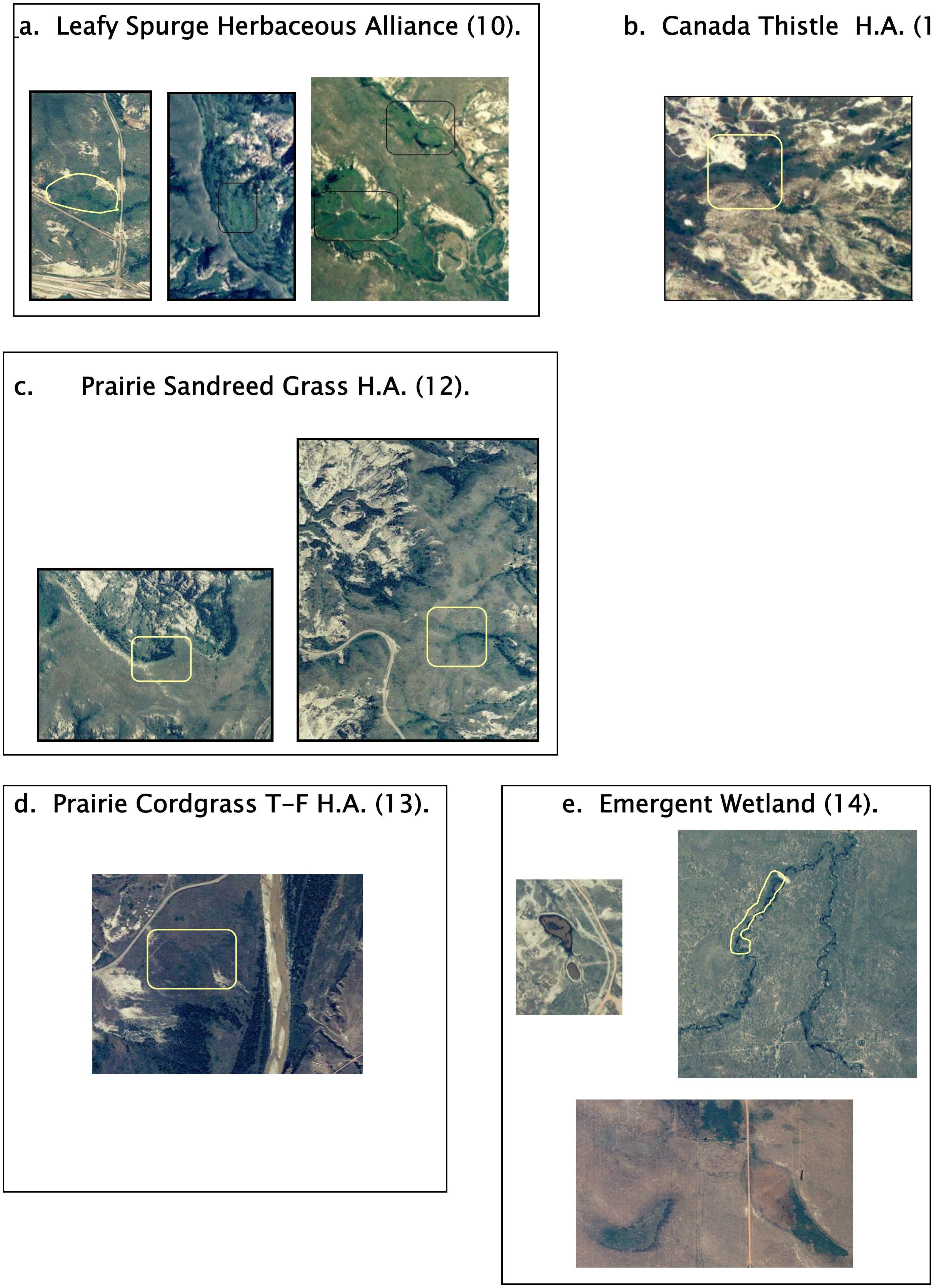


Figure 4-2 – Classes 10, 11, 12, 13, and 14 Representative Photo Signatures.

Emergent Wetland (14).

Location: Occurs on saturated and inundated soils, where water depths do not exceed one meter. Wetland vegetation is found on seeps and springs and along drainages inside the Park, and on seeps and springs, in drainages, swales, closed basins, and around dugouts, ponds, and reservoirs within the environs. All wetlands are delineated for this study, if observed, whether or not they meet the MMU. Linear wetlands of swales are delineated in a line coverage.

Photo Signature: Ranges from light green to black, smooth texture, and rounded polygon margins for clonal species like bulrush and cattail. Small pockets of open water are often present, usually brown or black in color.

Figure: 4-2e (previous page)

Little Bluestem - Sideoats Grama Herbaceous Alliance (15).

Location: This class occurs on north-facing, gravelly hillsides and ridges, often as very small patches or intermixed with shrubs of other vegetation classes.

Photo Signature: Ranges from a stippled pattern of white dots on slopes and ridges in the Achenbach Hills area to a solid, dark green to black color at other sites.

Figure: 4-3a

Western Wheatgrass Herbaceous Alliance (16).

Location: Occupies floodplains, drainages, swales, depressions, and gradual slopes. (Typical habitat: Little Missouri River floodplain and its valley slopes).

Photo Signature: Typically smooth gray-green to dark green color which may be hidden by yellow if leafy spurge or yellow sweetclover are abundant in the habitat.

Figure: 4-3b

Introduced Grassland Herbaceous Alliance (17).

Location: This class occurs along roadways, on historic agricultural fields, or in pastures where exotic species have escaped or been interseeded. Notable examples occur along the Park loop roads and the eastern flats of the South Unit, from the bison corrals to the Painted Canyon Overlook.

Photo Signatures: Smooth brome is dark gray to black and circular (“splotchy”) when undisturbed, but medium green to dark gray and smooth-textured when burned, mown, or grazed; Kentucky bluegrass is light gray to green-gray; and crested wheatgrass is yellowish green to gray-green.

Figure: 4-3c

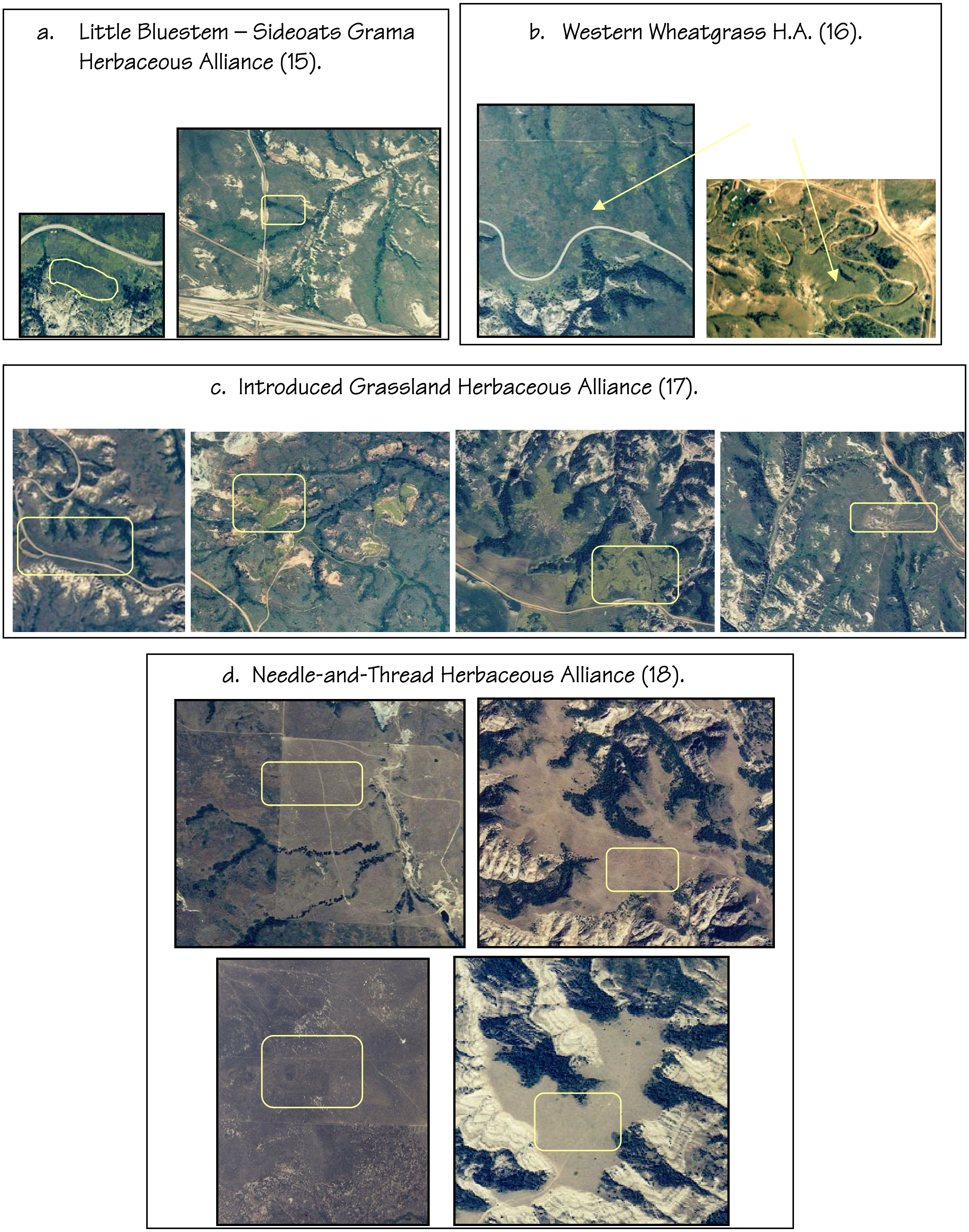


Figure 4-3 – Classes 15, 16, 17, & 18 Representative Photo Signatures.

Needle-and-Thread Herbaceous Alliance (18).

Location: This class is a common upland grassland throughout the region, occupying plateaus, buttes, hilltops, slopes, and ridges.

Photo Signatures: Tan, light gray-green, and greenish-gray (depending on early July or late August photography). This type always has a smooth texture, and some small, circular barren spots are occasionally present (bison wallows).

Figure: 4-3d (previous page)

Horizontal Juniper Dwarf Shrub Alliance (30).

Location: Primarily occupies steep, north-facing slopes, and occasional east- and west-facing exposures. More common in the vicinity of scoria outcrops and often intermixes with Classes 35, 36, and 15 on these mesic sites.

Photo signatures: A medium green to black, solid color on north-facing slopes to gray-green with medium green flecks on E and W exposures; the texture is smooth.

Figure: 4-4a

Silver Sagebrush / Western Wheatgrass Shrubland (31).

Location: Broad drainages, creek beds, gentle slopes, and river. Typical habitat is the oxbow bends of the Little Missouri River and meandering creeks. It often intermixes with buckbrush (Class 37), pure stands of western wheatgrass (Class 16), and is sometimes invaded by leafy spurge (Class 10) in the South Unit.

Photo signatures: Vary, ranging from gray dots against a gray-green to medium green background, to dark green or black dots against a green background on well-vegetated drainages. Leafy spurge can influence the color from a yellowish-green to an olive green and obscure the roughness of the signature. The texture may appear smooth or rough.

Figure: 4-4b

Rabbitbrush Shrubland Alliance (33).

Location: This shrub class was observed on slumping slopes and disturbed slopes. Stands occur near the North Unit access road off SH 85, the slump below Painted Canyon Overlook, and I-94 near the South Unit/Medora exit.

Photo signatures: Include a grayish, clouding effect and very small individual bumps that are gray in color.

Figure: 4-4c

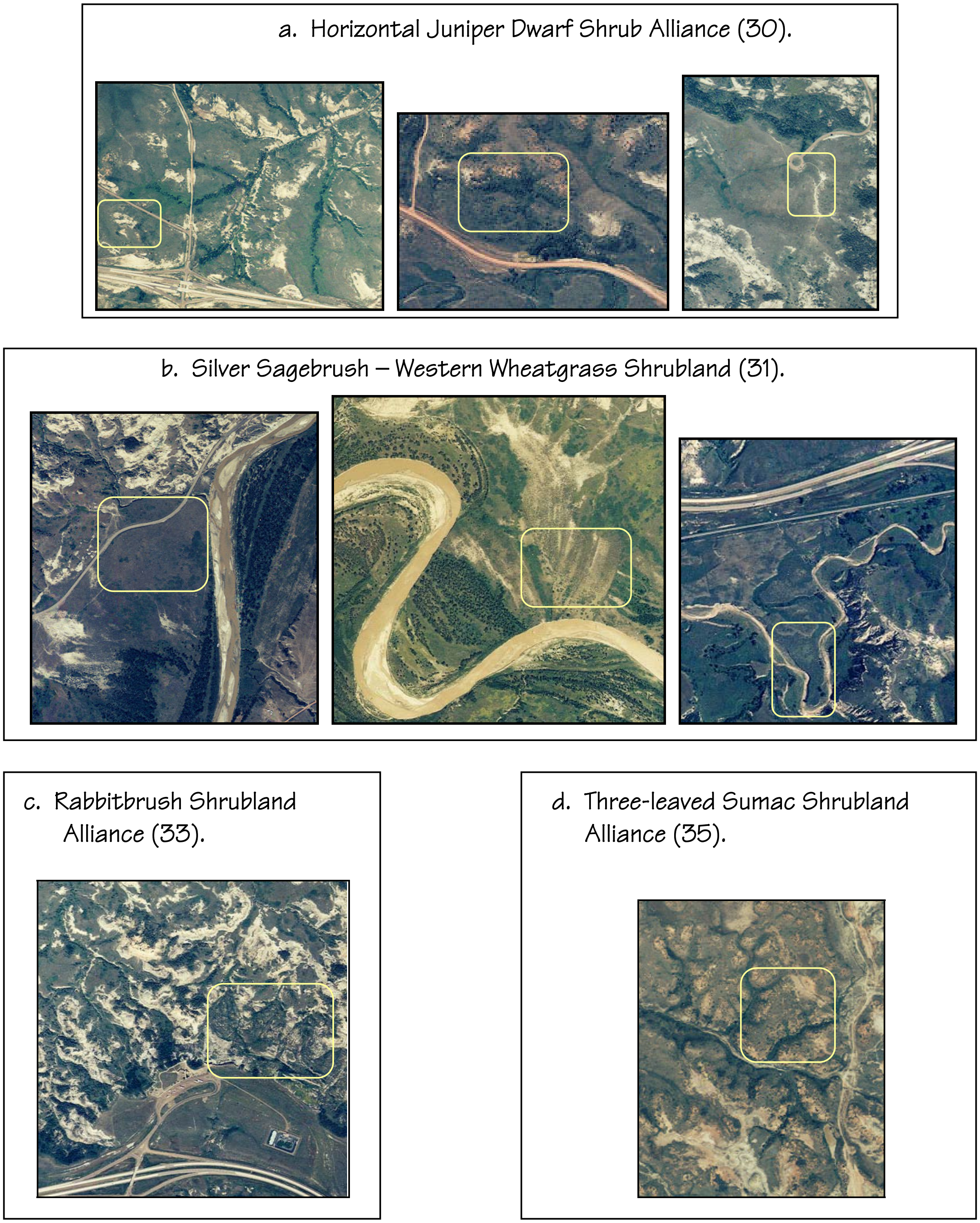


Figure 4-4 – Classes 30, 31, 33, and 35 Representative Photo Signatures.

Three-leaved Sumac Shrubland Alliance (35).

Location: Occupies the tops of low ridges and hills of scoria and more mesic zones on badlands formations. It intermingles with horizontal juniper dwarf S.A. (Class 30), little bluestem - sideoats grama H.A.(Class 15), and Rocky Mountain juniper woodland alliance (Class 47).

Photo signatures: Regular distribution of rounded shrubs that are dark green to black in color; often including small exposures of reddish scoria.

Figure: 4-4d (previous page)

Silver Buffaloberry Shrubland Alliance (36).

Location: This shrub class occurs as small patches on heads of draws, around badland formations, and along several drainages and creeks. The patches often occur below the MMU.

Photo signatures: Large, pebbly texture; a gray-green to black color, associated with a medium green to dark green background.

Figure: 4-5a

Wolfberry Temporarily-Flooded Shrubland Alliance (37).

Location: This shrub class is distributed throughout the project area in swales, depressions, drainages, and moist slopes, but occurs as larger patches in the floodplain of the Little Missouri River. It commonly intermixes with Class 31 shrubland and Class 45 woodland.

Photo signatures: Medium green to dark green or black in color; sometimes a dull gray-green was noted; the margins are rounded and individual clones are oval.

Figure: 4-5c

Sandbar Willow Temporarily-Flooded Shrubland Alliance (38).

Location: This wetland shrub class is common on Little Missouri River islands and point bars and some smaller drainages/creekbanks.

Photo signatures: Include a smooth to brushy texture and a medium green color; sometimes against the tan background of sediment deposits.

Figure: 4-5b

Greasewood Shrub Herbaceous Vegetation (39).

Location: This sparse vegetation class is rare, observed only at two locations near the South Unit Loop Road. A few small greasewood shrubs grow with other shrubs on badlands formations and are delineated as part of badlands sparse vegetation complex (Class 2).

Photo signatures: Dark green dots over a gray-green to medium green background color.

Figure: 4-5d

Cottonwood / Peachleaf Willow Floodplain Woodland (41).

Location: In mature condition, this class grows primarily along Sully's Creek and similar perennial drainages, outside Park boundaries. Within the Park, eastern cottonwood and peachleaf willow are represented by very young stands in close proximity to the Little Missouri River channel and are easily confused with sandbar willow temporarily-flooded shrubland alliance (Class 38) with which they intermix.

Photo signatures: Include large-crowned trees (pebbly texture) to brushy, thick stands of young trees, with occasional larger crowns, that are medium green to dark green, sometimes black in color.

Figure: 4-5e

Cottonwood - Rocky Mountain Juniper Floodplain Woodland (42).

Location: Found along the Little Missouri River and represents decadent stands of eastern cottonwood growing on dry floodplain sites. It intermixes with mature cottonwood temporarily-flooded woodland alliance (Class 43) and green ash - American elm temporarily-flooded woodland alliance (Class 45).

Photo signatures: Large, rounded canopies that are often evenly spaced from one another, with gray to white, dead branches apparent. Colors range from medium green to dark green or black.

Figure: 4-5f

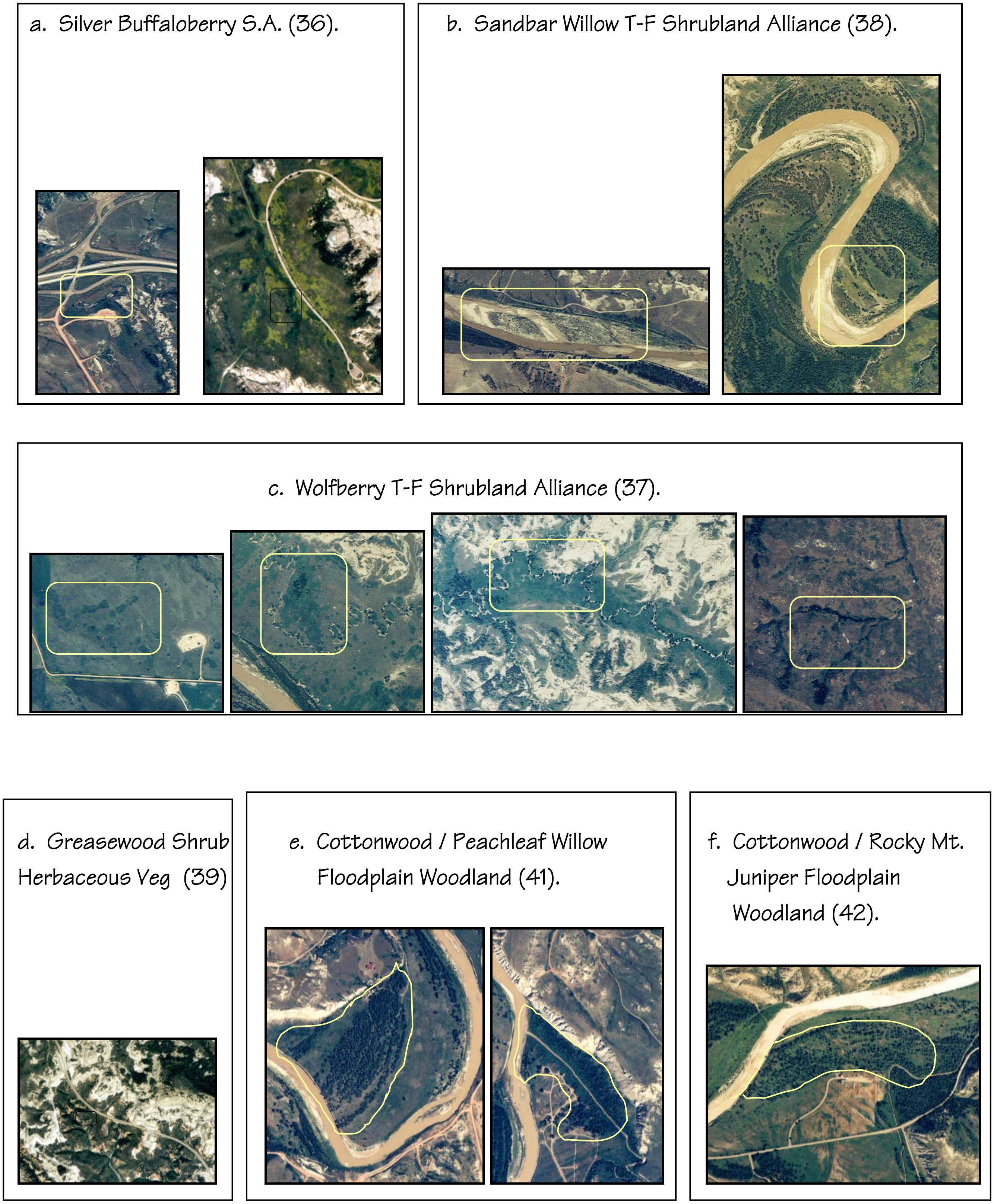


Figure 4-5 – Classes 36, 37, 38, 39, and 41 and 42 Representative Photo Signatures.

Cottonwood Temporarily-Flooded Woodland Alliance (43).

Location: This woodland class occurs in river and large creek floodplains and represents mature, medium-aged, and dense young stands of trees. It intermixes with green ash - American elm T-F woodland alliance (Class 45) and with decadent stands of cottonwood / Rcky Mt. Juniper floodplain woodland (Class 42).

Photo signatures: Large, rounded canopies ranging from medium green to dark green or black in color, creating an oblong or crescent-shaped polygon.

Figure: 4-6a

Green Ash - American Elm Woodland Alliance - Draws (44).

Location: Occupies mesic draws and drainages, sometimes spreading into moist areas of grassland at the heads of draws. It tends to intermix with Rocky Mountain juniper woodland alliance (Class 47) as draws become drier and with quaking aspen woodland alliance (Class 46) at heads of draws off some large plateaus.

Photo signatures: Dense rounded to brushy tree canopy; medium- to dark green or black in color.

Figure: 4-6b

Green Ash - American Elm Temporarily-Flooded Woodland Alliance (45).

Location: Occupies mesic oxbows, drainages, and depressions on the outer edges of river floodplains. It is shorter-statured with a more dense crown cover than eastern cottonwood mature stands, and it tends to intermix with mature and/or decadent cottonwood stands (Classes 42 & 43).

Photo signatures: Small, dense, rounded tree canopies; appear dark green to black in color.

Figure: 4-6c

Quaking Aspen Woodland Alliance (46).

Location: Occurs only on the margins of large plateaus at the heads of draws and in one area of large boulders on a slope. It quickly intergrades into Class 44 as the woodland proceeds downslope or into a drainage.

Photo signatures: Medium-green color, rounded shape, and soft, brushy texture

Figure: 4-6d

Rocky Mountain Juniper Woodland Alliance (47).

Location: Widely distributed and occupies drier draws, north-facing juniper slopes, ridge and hill tops, and slumps on side-slopes. It often intermixes with Class 44 and is the understory canopy for Classes 48 and 42.

Photo signatures: Dull, dusty-gray or gray-green to dark green or black color, and tight, pebbly- to solid-textured canopy

Figure: 4-6e

Ponderosa Pine Woodland Alliance (48).

Location: This woodland class is distributed outside but near the South Unit, just east of Medora, ND and south of I-94. It occupies ridges, draws, and hilltops adjacent to the interstate.

Photo signatures: Include extremely large canopied trees, pebbly in texture, and dark green to medium-green in color.

Figure: 4-6f

Transportation, Communications, and Utilities (51).

Description: This land-use class represents major roads and highways, disturbed powerline rights-of-way and substations, sewage lagoons, and railroad rights-of-way. These are interpreted between the right-of-way or facility fences where they are disturbed by human activities.

Photo signatures: Typically a linear, square, or rectangular dull to bright white color for unvegetated surfaces and gray-green to dark green for adjacent vegetation.

Figure: 4-7a

Mixed Urban or Built-up Land (52).

Description: This land use class represents small towns, park facilities, and other developed land.

Photo signature: Ranges from white or gray on non-vegetated surfaces to green or black for lawns and tree and shrub plantings. This class generally has a very rough texture because of the various land uses and plantings.

Figure: 4-7a

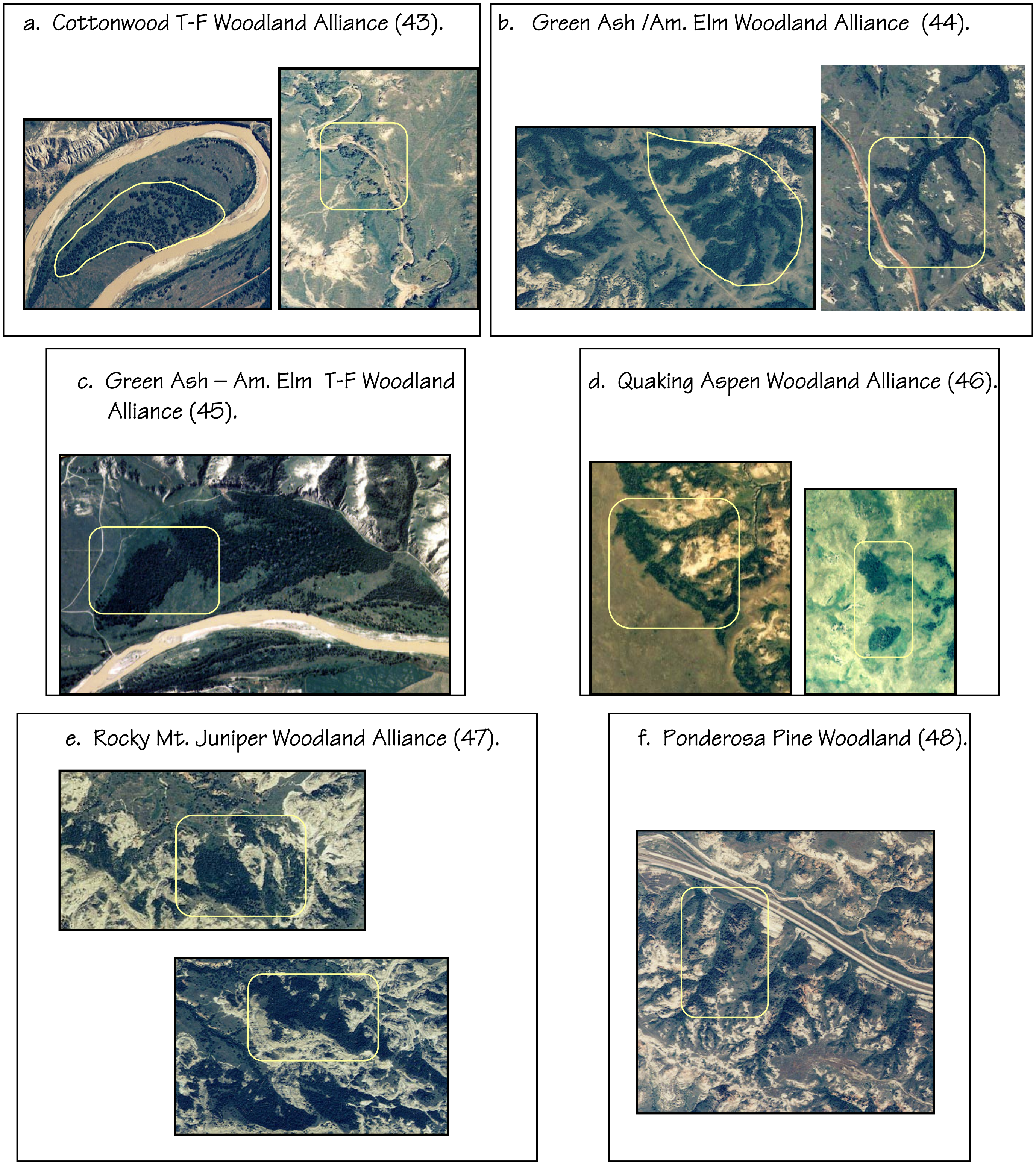


Figure 4-6 – Classes 43, 44, 45, 46, 47, and 48 Representative Photo Signatures.

Croplands and Pasture (53).

Description: This land use class includes dry-farmed and possibly a few irrigated fields, introduced pastures, and intensively used winter pastures.

Photo signatures: A striped or tilled pattern ranging from dull white to gray to gray-green, to bright cream for fallow or recently cropped land and bright green for actively growing crops. The texture for this class is smooth, often showing mowing lines, windrows of mown hay, hay bales, etc.

Figure: 4-7b

Seeded Mixed Grass Prairie (54).

Description: This land-use class represents agricultural fields placed under the CRP. To comply with program goals, restoration of these fields is typically undertaken using mid- to tall grass species and alfalfa.

Photo signature: A smooth-textured, dull, dark gray; sometimes mowing is allowed and it appears as Class 53.

Figure: 4-7c

Other Agricultural Land (55).

Description: Includes farmsteads, ranch headquarters, corrals, equipment storage areas, windbreak and shelterbelt plantings, and more remote windmill structures.

Photo signatures: Range from white for barren ground to greens and/or black depending on the vegetation present.

Figure: 4-7d

Streams and Canals (56).

Location: This class includes the Little Missouri River and small- to medium-sized drainages that flow periodically and are scattered throughout the region. These drainages meander forming large oxbow bends and support stands of scattered trees or patches of shrubs.

Photo Signature: Reflect dull white to tan, unless they are carrying water, which is typically brown or black depending on depth and clarity/turbidity.

Figure: 4-8a

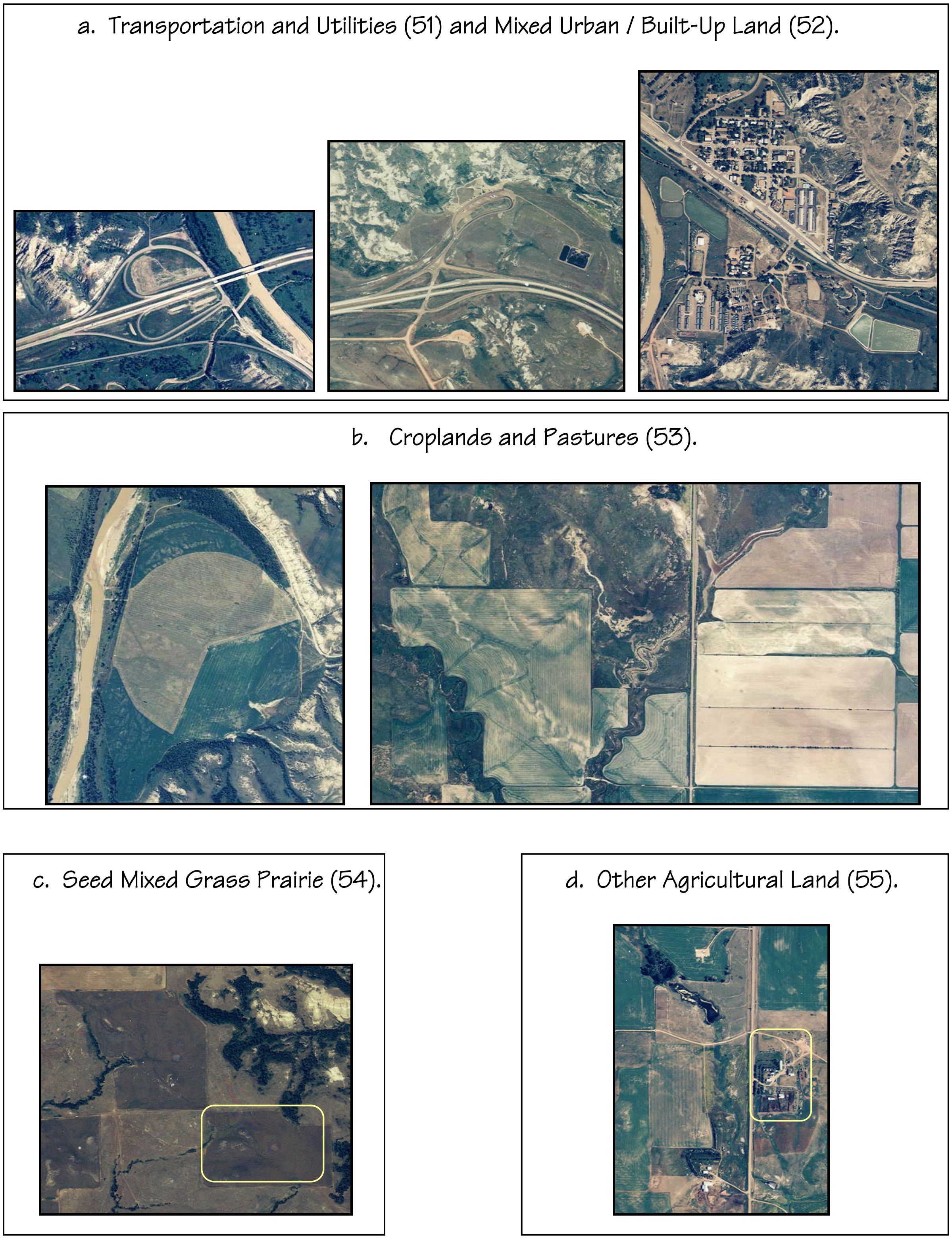


Figure 4-7 – Land-Use Classes 51, 52, 53, 54, and 55 Representative Photo Signatures.

Reservoirs and Open Water (57).

Description: This land use class ranges in size from small holes dug into the ground water table (dugouts), to large ponds and small lakes stored behind earth-fill dams. Wetlands (14) may be associated with reservoir margins and often grow into the shallower waters.

Photo signatures: Range from white when sunlight is reflected, brown for sediment-laden water, and black for deeper, clear water.

Figure: 4-8b (also 4.2d)

Beaches and Sandy Areas Other Than Beaches (58).

Description: This class represents point bars and islands along and within perennial drainage channels, mostly the Little Missouri River.

Photo Signatures: These mostly unvegetated soils reflect dull to pure white or tan on aerial photos and are interpreted using their landscape position.

Figure: 4-8c

Strip Mines, Quarries, and Gravel Pits (59).

Description: This land-use class represents soil and geologic materials removed or disturbed by heavy equipment; also includes reservoir dams.

Photo signature: Dull to bright white (sand and clay) or light to medium pink (scoria), with a corresponding haul road; piles or mounds of material are often present.

Figure: 4-8d

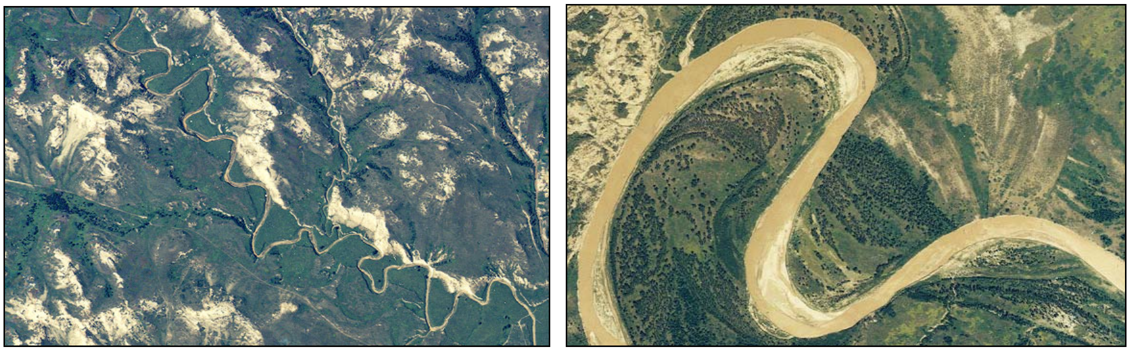
Oil and Gas Well Drill Pads and Access Roads (60).

Description: This land-use class represents disturbed surface soils usually replaced with a new surface material (scoria gravel). An area of reseeding (interpreted as class 17) is often present in a horseshoe shape around the otherwise barren site. The pads are connected by roads, ranging from trails to corridors as wide as county roads.

Photo signature: Typically a rectangular shape that is dull white to pinkish-red, with the corresponding access road of the same color.

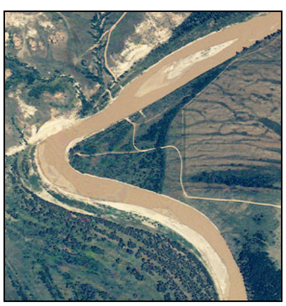
Figure: 4-8e

a. Streams and Canals (56).

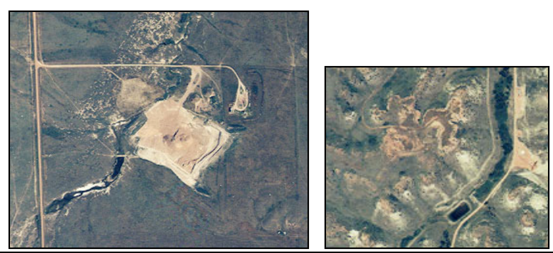


b. Reservoirs and Open Water (57).

c. Beaches and Sandy Areas (58)



d. Strip Mines, Quarries, and Gravel Pits. (59).



e. Oil and Gas Well Drill Pads and Access Roads (60).

Figure 4-8 – Classes 56, 57, 58, 59, and 60 Representative Photo Signatures.

4.3 GIS Database and Maps

GIS Database

A total of 67 vegetation coverages were created in ArcInfo™ with filenames corresponding to each USGS quadrangle in the THRO vegetation mapping project area. The file names reflect the quarter-quad area via afilename suffix numbered 1, 2, 3, or 4 with '1' representing the northwest corner and moving clockwise (ex: *medora_veg4* refers to the vegetation coverage for the sw quadrant of the Medora quadrangle). A list of USGS quadrangles and associated ArcInfo™ filenames can be found in Appendix C. Other data produced includes boundary coverages, road and railroad coverages, a linear wetland drainage coverage, and field data (plot, observation, and accuracy assessment) point coverages. The project database has an overall FGDC-compliant metadata file that describes all the coverages created for this project. (Appendix I)

Maps

Map files were created for each coverage showing the total area for each map unit segregated by location, *i.e.*, map units inside the Park or in the study area environs. Index map files were also created showing the entire project area, quadnames, map unit area totals, and display of simplified vegetation legend. Two index maps were created, one for the North Unit and one for the South Unit. Refer to Appendix Q for a sample quarter-quad vegetation map and the index maps. Note, the Elkhorn Ranch Unit was not included in the index maps and is a stand-alone vegetation coverage with filename *ranch_veg*. The area totals and number of polygons for each map unit in each Park unit and in the entire study area is summarized in Table 4-1. Hectares were calculated using the following conversion factors: 4046.9 m^2/acre and 2.471 acres/hectare. In addition, a list of the interpreted photographs that were entered into the database is presented in Appendix D.

4.4 Accuracy Assessment

A total of 346 accuracy assessment points were used to assess the THRO vegetation map by:

- using AA points collected during the summer of 1998 (front-loading method);
- entering AA point coordinates into an electronic format to overlay on the vegetation map;
- comparing map vegetation classification (transferred from photo interpretation) with field assessment of vegetation type to determine errors of omission and commission;
- resolving questions by referring to original data forms, so that Dr. Butler could make the final determination; and
- recording all information on the AA matrix (Table 4-3).

Overall, initial accuracy of the vegetation map is 74.3% for all vegetation classes and the Kappa Index is 71.3%. Results for each vegetation class are discussed here, and recommendations are made relative to creating a more accurate vegetation map, as desired.

The specific results are presented in Tables 4-2 and 4-3 below. Confidence interval calculations are presented in Appendix O. In general, the percentage of the Park that an individual map class covered is reflected in the number of AA points collected for that type. For example, needle-and-thread herbaceous alliance was interpreted for approximately 33% of the Park and is represented by 28% of the AA points, and the badlands sparse vegetation complex was interpreted for approximately 20% of the Park and is represented by 14% of the AA points. Similarly, the prairie dog town complex was interpreted for approximately 2% of the Park and is represented by 1.7% of the AA points.

However, several map classes are sampled with a larger number of AA points relative to their actual percent abundance/ground cover. For example: the silver buffaloberry shrubland alliance covers 0.1 % of the park and is represented by 2.6% of the AA points; the little bluestem - sideoats grama herbaceous alliance covers 0.3 % and is represented by 3.5% of the AA points; and the prairie sandreed herbaceous alliance covers 0.2 % and is represented by 2.3% of the AA points. Four map classes were not sampled as follows: the ponderosa pine woodland alliance does not occur within Park boundaries and is well-represented by plot and observation data; the quaking aspen woodland alliance has a plot and/or observation form for every stand known to occur in the Park and no additional stands were observed; the emergent wetland class is too small to be interpreted on aerial photos and has an observation form for every wetland observed during field research in the Park; and the Canada thistle herbaceous alliance is too small to be interpreted on aerial photos and has several observation forms reporting occurrences in the Park.

Table 4-1. - Mapping Unit Totals for THRO

NORTH UNIT MAPPING TOTALS

CODE	Park		Environs		Total		CODE	Map Code Description
	HECTARES	POLY TOT	HECTARES	POLY TOT	HECTARES	POLY TOT		
1	92.5	9	142.9	25	235.4	34	1	Prairie Dog Town Complex
2	2,163.4	917	5,554.1	4,296	7,717.5	5,213	2	Badlands Complex
3	13.3	45	225.6	670	238.9	715	3	Scoria Sparse Veg Complex
4	128.3	313	258.9	506	387.2	819	4	Lng-lf Sgaebrsh Sp. Veg. Al.
10							10	Leafy Spurge Herb. Al.
11							11	Canada Thistle Herb. Al.
12	13.0	28	99.7	182	112.7	210	12	Pr. Sand-reed Grass HA
13	11.6	16	4.2	9	15.8	25	13	Pr. Cordgrass TF Herb. Al.
14	6.1	20	639.8	842	645.9	862	14	Emergent Wetland
15	75.6	27	14.3	16	89.9	43	15	Ltl Blstm/sideoats Grn HA
16	371.1	263	1,414.2	1,438	1,785.3	1,701	16	Western Wheatgrass HA
17	145.9	50	411.6	204	557.5	254	17	Introduced Grassland HA
18	2,191.3	1,126	7,600.5	4,290	19,791.8	5,416	18	Needle&Thread HA
30	1.7	4	17.2	52	18.9	56	30	Horiz. Juniper Dwarf Shrb Al
31	577.0	157	1,710.3	506	2,287.3	663	31	Slvr SgBrush/W. Wtgrass S.
33	5.2	4	27.3	9	32.5	13	33	Rabbitbrush Shrubland Al.
35	160.9	223	804.9	1,231	965.8	1,454	35	3-leafed Sumac Shrbland Al.
36	12.7	34	135.1	443	147.8	477	36	Buffaloberry Shrubland Al.
37	733.5	1,253	886.5	2,631	1,620.0	3,884	37	Wolfberry TF Shrubland Al.
38	69.7	39	54.8	49	124.5	88	38	Sandbar Willow TF S. Al.
39	0.7	2			0.7	2	39	Greasewood TF S. Al.
41	9.3	8	58.0	37	67.3	45	41	Cttnwd/PchLf Wllw Fldp Wd
42			3.1	14	3.1	14	42	Cttnwd/RckMtJun Fldpln Wd
43	403.9	151	488.7	422	892.6	573	43	Cttnwd TF Woodland Al.
44	452.3	358	2,297.9	1,422	2,750.2	1,780	44	Grn Ash/Am Elm Wdland Al.
45	164.3	59	173.8	122	338.1	181	45	Grn Ash/Am Elm TF Wd Al.
46	5.9	7	3.8	5	9.7	12	46	Quaking Aspen Wdland Al.
47	1,648.4	934	5,764.5	2,572	7,412.9	3,506	47	Rocky Mtn Juniper Wd Al.
48							48	Ponderosa Pine Wdland Al.
51	61.0	10	533.3	39	594.3	49	51	Transp., Comm., Utilities
52	12.4	6	0.7	2	13.1	8	52	Mixed Urban/Built-up Land
53	5.3	10	10,756.4	403	10,761.7	413	53	Croplands and Pasture
54	22.9	6	1,365.8	72	1,388.7	78	54	Seeded Mixed Grass Prairie
55	0.7	1	284.6	213	285.3	214	55	Other Agricultural Land
56	114.0	17	332.2	62	446.2	79	56	Streams and Canals
57	2.6	14	84.2	283	86.8	297	57	Reservoirs & Open Water
58	50.6	83	108.5	137	159.1	220	58	Beaches, Sandy Areas
59			38.8	146	38.8	146	59	Mining and Gravel Pits
60	0.2	1	110.1	43	110.3	44	60	Energy Drill Pads & Roads
Total	9,727.3	6,195	52,406.3	23,393	62,133.6	29,588	Total	

Table 4-1, cont.

SOUTH UNIT MAPPING TOTALS

CODE	Park HECTARES	Park POLY TOT	Environs HECTARES	Environs POLY TOT	Total HECTARES	Total POLY TOT	CODE	Map Code Description
1	466.1	61	536.6	79	1,002.4	140	1	Prairie Dog Town Complex
2	3,357.9	3,303	7,529.0	8,222	10,886.9	11,525	2	Badlands Complex
3	91.6	465	456.8	1,733	548.4	2,198	3	Scoria Sparse Veg Complex
4	0.7	1	0.3	4	1.0	5	4	Lng-lf Sgaebrsh Sp. Veg. Al.
10	311.6	327	1,389.4	1,443	1,701.0	1,770	10	Leafy Spurge Herb. Al.
11	0.4	1			0.4	1	11	Canada Thistle Herb. Al.
12	44.2	68	397.4	488	441.6	556	12	Pr. Sand-reed Grass HA
13			3.0	5	3.0	5	13	Pr. Cordgrass TF Herb. Al.
14	5.1	31	500.5	1,022	505.6	1,053	14	Emergent Wetland
15	9.6	22	48.4	65	58.0	87	15	Ltl Blstm/sideoats Grn HA
16	837.0	825	2,982.8	2,899	3,819.8	3,724	16	Western Wheatgrass HA
17	191.9	65	604.1	360	796.0	425	17	Introduced Grassland HA
18	7,098.1	2,052	27,730.7	5,654	34,828.8	7,706	18	Needle&Thread HA
30	82.1	220	242.5	654	324.6	874	30	Horiz. Juniper Dwarf Shrb Al
31	586.3	388	2,097.8	1,572	2,684.1	1,960	31	Slvr SgBrush/W. Wtgrass S.
33	34.1	25	16.8	21	50.9	46	33	Rabbitbrush Shrubland Al.
35	812.9	1,146	1,876.6	2,583	2,689.5	3,729	35	3-leafed Sumac Shrbland Al.
36	13.9	65	493.5	1,825	507.4	1,890	36	Buffaloberry Shrubland Al.
37	843.0	2,359	1,511.9	5,023	2,354.9	7,382	37	Wolfberry TF Shrubland Al.
38	16.8	23	75.5	102	92.3	125	38	Sandbar Willow TF S. Al.
39	0.3	2			0.3	2	39	Greasewood TF S. Al.
41	28.6	33	40.8	66	69.4	99	41	Cttnwd/PchLf Wllw Fldp Wd
42	70.3	31	15.0	32	85.3	63	42	Cttnwd/RckMtJun Fldpln Wd
43	91.2	202	372.4	730	463.6	932	43	Cttnwd TF Woodland Al.
44	765.6	944	1,521.7	2,889	2,287.3	3,833	44	Grn Ash/Am Elm Wdland Al.
45	54.8	72	224.4	309	279.2	381	45	Grn Ash/Am Elm TF Wd Al.
46	17.4	12	1.2	4	18.6	16	46	Quaking Aspen Wdland Al.
47	2,191.0	1,762	2,117.7	2,131	4,308.7	3,893	47	Rocky Mtn Juniper Wd Al.
48			45.1	14	45.1	14	48	Ponderosa Pine Wdland Al.
51	140.1	21	894.4	48	1,034.5	69	51	Transp., Comm., Utilities
52	9.3	13	120.1	56	129.4	69	52	Mixed Urban/Built-up Land
53	4.7	4	6,782.6	300	6,787.3	304	53	Croplands and Pasture
54			545.6	21	545.6	21	54	Seeded Mixed Grass Prairie
55	1.5	1	285.2	153	286.7	154	55	Other Agricultural Land
56	145.5	48	384.5	148	530.0	196	56	Streams and Canals
57	1.3	17	70.6	323	71.9	340	57	Reservoirs & Open Water
58	29.4	51	49.5	97	78.9	148	58	Beaches, Sandy Areas
59	0.2	1	64.8	282	65.0	283	59	Mining and Gravel Pits
60			657.0	150	657.0	150	60	Energy Drill Pads & Roads
Total	18,354.5	14,661	62,685.9	41,507	81,040.4	56,168	Total	

Table 4-1, cont.

ELKHORN RANCH UNIT MAPPING TOTALS

CODE	Park HECTARES	Park POLY TOT	Environs HECTARES	Environs POLY TOT	Total HECTARES	Total POLY TOT	CODE	Map Code Description
1							1	Prairie Dog Town Complex
2	4.5	4	312.2	236	316.7	240	2	Badlands Complex
3			0.2	2	0.2	2	3	Scoria Sparse Veg Complex
4							4	Lng-lf Sgaebrsh Sp. Veg. Al.
10			0.9	3	0.9	3	10	Leafy Spurge Herb. Al.
11							11	Canada Thistle Herb. Al.
12							12	Pr. Sand-reed Grass HA
13							13	Pr. Cordgrass TF Herb. Al.
14			2.3	9	2.3	9	14	Emergent Wetland
15							15	Ltl Blstm/sideoats Grn HA
16	0.7	2	107.7	94	108.4	96	16	Western Wheatgrass HA
17			21.3	24	21.3	24	17	Introduced Grassland HA
18	3.2	3	379.7	215	382.9	218	18	Needle&Thread HA
30	0.5	1	3.0	7	3.5	8	30	Horiz. Juniper Dwarf Shrb Al
31	8.3	7	187.6	44	195.9	51	31	Slvr SgBrush/W. Wtgrass S.
33			8.5	3	8.5	3	33	Rabbitbrush Shrubland Al.
35	1.3	3	78.7	125	80	128	35	3-leafed Sumac Shrbland Al.
36			0.6	3	0.6	3	36	Buffaloberry Shrubland Al.
37	11.3	9	33.9	117	45.2	126	37	Wolfberry TF Shrubland Al.
38	0.1	1	8.8	12	8.9	13	38	Sandbar Willow TF S. Al.
39							39	Greasewood TF S. Al.
41	2.9	2	11.2	11	14.1	13	41	Cttnwd/PchLf Wllw Fldp Wd
42	17.2	1	36.7	7	53.9	8	42	Cttnwd/RckMtJun Fldpln Wd
43	8.0	8	41.8	41	49.8	49	43	Cttnwd TF Woodland Al.
44	3.2	4	96.8	68	100	72	44	Grn Ash/Am Elm Wdland Al.
45	21.2	2	37.0	19	58.2	21	45	Grn Ash/Am Elm TF Wd Al.
46	4.5	7			4.5	7	46	Quaking Aspen Wdland Al.
47			299.2	189	299.2	189	47	Rocky Mtn Juniper Wd Al.
48							48	Ponderosa Pine Wdland Al.
51			6.8	5	6.8	5	51	Transp., Comm., Utilities
52							52	Mixed Urban/Built-up Land
53			189.0	17	189	17	53	Croplands and Pasture
54							54	Seeded Mixed Grass Prairie
55			9.4	7	9.4	7	55	Other Agricultural Land
56	0.2	3	31.3	1	31.5	4	56	Streams and Canals
57			0.5	2	0.5	2	57	Reservoirs & Open Water
58			17.9	27	17.9	27	58	Beaches, Sandy Areas
59			0.2	2	0.2	2	59	Mining and Gravel Pits
60			8.5	9	8.5	9	60	Energy Drill Pads & Roads
Total	87.1	57	1,931.7	1,299	2,018.8	1,356	Total	

Table 4-1, cont.

THEODORE ROOSEVELT NP VEGETATION MAPPING TOTALS

CODE	Park		Environs		Total		CODE	Map Code Description
	HECTARES	POLY TOT	HECTARES	POLY TOT	HECTARES	POLY TOT		
1	558.2	70	679.2	104	1,237.8	174	1	Prairie Dog Town Complex
2	5,525.8	4,224	3,395.3	12,754	18,921.1	16,978	2	Badlands Complex
3	104.9	510	682.6	2,405	787.5	2,915	3	Scoria Sparse Veg Complex
4	129.0	314	259.2	510	388.2	824	4	Lng-lf Sgaebrsh Sp. Veg. Al.
10	311.6	327	1,390.3	1,446	1,701.9	1,773	10	Leafy Spurge Herb. Al.
11	0.4	1	0.0	0	0.4	1	11	Canada Thistle Herb. Al.
12	57.2	96	497.1	670	554.3	766	12	Pr. Sand-reed Grass HA
13	11.6	16	7.2	14	18.8	30	13	Pr. Cordgrass TF Herb. Al.
14	11.2	51	1,142.6	1,873	1,153.8	1,924	14	Emergent Wetland
15	85.2	49	62.7	81	147.9	130	15	Ltl Blstm/sideoats Grn HA
16	1,208.8	1,090	4,504.7	4,431	5,713.5	5,521	16	Western Wheatgrass HA
17	337.8	115	1,037.0	588	1,374.8	703	17	Introduced Grassland HA
18	9,292.8	3,181	45,710.9	10,159	55,003.5	13,340	18	Needle&Thread HA
30	84.3	225	262.7	713	347.0	938	30	Horiz. Juniper Dwarf Shrb Al
31	1,171.6	552	3,995.7	2,122	5,167.3	2,674	31	Slvr SgBrush/W. Wtgrass S.
33	39.3	29	52.6	33	91.9	62	33	Rabbitbrush Shrubland Al.
35	975.1	1,372	2,760.2	3,939	3,735.3	5,311	35	3-leafed Sumac Shrbland Al.
36	26.6	99	629.2	2,271	655.8	2,370	36	Buffaloberry Shrubland Al.
37	1,587.8	3,621	2,432.3	7,771	4,020.1	11,392	37	Wolfberry TF Shrubland Al.
38	86.6	63	139.1	163	225.7	226	38	Sandbar Willow TF S. Al.
39	1.0	4	0.0	0	1.0	4	39	Greasewood TF S. Al.
41	40.8	43	110.0	114	150.8	157	41	Cttnwd/PchLf Wllw Fldp Wd
42	87.5	32	54.8	53	142.3	85	42	Cttnwd/RckMtJun Fldpln Wd
43	503.1	361	902.9	1,193	1,406.0	1,554	43	Cttnwd TF Woodland Al.
44	1,221.1	1,306	3,916.4	4,379	5,137.5	5,685	44	Grn Ash/Am Elm Wdland Al.
45	240.3	133	435.2	450	675.5	583	45	Grn Ash/Am Elm TF Wd Al.
46	27.8	26	5.0	9	32.8	35	46	Quaking Aspen Wdland Al.
47	3,839.4	2,696	8,181.4	4,892	12,020.8	7,588	47	Rocky Mtn Juniper Wd Al.
48	0.0	0	45.1	14	45.1	14	48	Ponderosa Pine Wdland Al.
51	201.1	31	1,434.5	92	1,635.6	123	51	Transp., Comm., Utilities
52	21.7	19	120.8	58	142.5	77	52	Mixed Urban/Built-up Land
53	10.0	14	17,728.0	720	17,738.0	734	53	Croplands and Pasture
54	22.9	6	1,911.4	93	1,934.3	99	54	Seeded Mixed Grass Prairie
55	2.2	2	579.2	373	581.4	375	55	Other Agricultural Land
56	259.7	68	748.0	211	1,007.7	279	56	Streams and Canals
57	3.9	31	155.3	608	159.2	639	57	Reservoirs & Open Water
58	80.0	134	175.9	261	255.9	395	58	Beaches, Sandy Areas
59	0.2	1	103.8	430	104.0	431	59	Mining and Gravel Pits
60	0.2	1	775.6	202	775.8	203	60	Energy Drill Pads & Roads
Total	28,168.9	20,913	117,023.9	66,199	145,192.8	87,112	Total	

Table 4-2. Summary of AA Results for Theodore Roosevelt National Park, by Map Class.

Map Class	Discussion
1-Prairie Dog Town Complex	This map class assessed at 100%/100% (omission/comission) accurate and is considered adequate as mapped.
2-Badlands Sparse Vegetation Complex	This map class assessed at 90%/88% accurate and is considered adequate as mapped.
3-Scoria Sparse Vegetation Complex	This map class assessed at 20%/100%, but is only considered adequate for larger outcrops. Many small outcrops become included in badlands formations, shrubland polygons, and woodland polygons.
4-Long-leaved Sagebrush Sparse Vegetation Alliance	This map class assessed at 100%/100% and is considered adequate as mapped.
10-Leafy Spurge Herbaceous Alliance	This map class assessed at 44%/80%, with much of the error associated with dense shrub overstory canopies of map classes 31 and 37 confusing the signature.
11-Canada Thistle Herbaceous Alliance	This map class was not assessed because it cannot be interpreted from the aerial photos. Observation point data were taken on several occurrences within the Park.
12-Prairie Sandreed Grass Herbaceous Alliance	This map class assessed at 17%/33%, with the error scattered across several grassland and shrubland classes.
13-Prairie Cordgrass Temporarily-Flooded Herbaceous Alliance	This map class assessed at 0%/no sample and was confused with two other floodplain map classes 16 and 31.
14-Emergent Wetland	This map class was not assessed because it cannot be interpreted on the aerial photos (except larger occurrences in the environs). Observation point data were taken on each wetland location within the Park.

15-Little Bluestem - Sideoats Grama Herbaceous Alliance	This map class assessed at 17%/100% with most error falling under map class 18.
16-Western Wheatgrass Herbaceous Alliance	This map class assessed at 29%/56% with most error falling under map class 18.
17-Introduced Grassland Herbaceous Alliance	This map class assessed at 95%/86% and is considered adequate as mapped.
18-Needle-and-thread Herbaceous Alliance	This map class assessed at 96%/64% with most error associated with map classes 15 and 16. This map class is considered adequate as mapped.
30-Horizontal Juniper Dwarf Shrub Alliance	This map class assessed at 20%/50% with most error associated with map class 18.
31-Silver Sagebrush / Western Wheatgrass Shrubland	This map class assessed at 52%/67% with most error associated with map classes 37 and 18/16.
33-Rabbitbrush Shrubland Alliance	This map class assessed at 67%/67% and is considered adequate as mapped. All error was associated with map class 2.
35-Three-leaved Sumac Shrubland Alliance	This map class assessed at 92%/79% and is considered adequate as mapped.
36-Silver Buffaloberry Shrubland Alliance	This map class assessed at no sample/0%. Most error was associated with map classes 18 and 44
37-Wolfberry (Buckbrush) Temporarily-Flooded Shrubland Alliance	This map class assessed at 87%/57% and is considered adequate as mapped. Most error is associated with map class 31 and confusion with heavy infestations of map class 10.
38-Sandbar Willow Temporarily-Flooded Shrubland Alliance	This map class assessed at 75%/50% with all error associated with other floodplain shrubland map classes.
39-Greasewood Shrub Herbaceous Vegetation	This map class assessed at 100%/100% and is considered adequate as mapped.

41-Cottonwood - Peachleaf Willow Floodplain Woodland	This map class assessed at 0%/no sample, the one sample taken being confused with map class 43.
42-Cottonwood-Rocky Mountain Juniper Floodplain Woodland	This map class assessed at 50%/75% with all error associated with other floodplain map classes.
43-Cottonwood Temporarily-Flooded Woodland Alliance	This map class assessed at 88%/70% and is considered adequate as mapped.
44-Green Ash - American Elm Woodland Alliance (Draws)	This map class assessed at 93%/81% and is considered adequate as mapped. Most error is associated with map classes 36 and 47.
45-Green Ash - American Elm Temporarily-Flooded Woodland Alliance	This map class assessed at 60%/50% with most error associated with cottonwood woodlands (map classes 42 and 43).
46-Quaking Aspen Woodland Alliance	This map class was not sampled for AA points because every stand is represented by plot and/or observation data.
47-Rocky Mountain Woodland Alliance	This map class assessed at 90%/90% and is considered adequate as mapped.
48-Ponderosa Pine Woodland Alliance	This map class was not sampled for AA points because it does not occur within Park boundaries and it is well-represented by plot and/or observation data.

Table 4-3. Contingency table (error matrix) for THRO vegetation mapping accuracy assessment.

		Reference Data (Accuracy Assessment Class)																									Total N
	Map Code	1	2	3	4	10	12	13	15	16	17	18	30	31	33	35	36	37	38	39	41	42	43	44	45	47	
S	1	6																									6
a	2		43	2					1		1				1											1	49
m	3			1																							1
p	4				4																						4
l	10					4																1					5
e	12						1					1						1									3
	13							0																			0
D	15								2																		2
a	16						1	1		5				2													9
t	17								1		19	2															22
a	18		2				2		7	12		63	3	3		1	4									1	98
	30						1						1														2
	31					2		1						12				1	1				1				18
	33		1												2												3
	35		1	1									1			11											14
	36																0										0
	37					3	1							4			1	13	1								23
	38													1					3								4
	39																			1							1
	41																				0						0
	42																					3			1		4
	43																				1	1	7		1		10
	44		1						1								3							26		1	32
	45													1					1			1			3		6
	47			1																				2		27	30
Total N:		6	48	5	4	9	6	2	12	17	20	66	5	23	3	12	8	15	6	1	1	6	8	28	5	30	

OVERALL TOTAL ACCURACY = 74.3 %

OVERALL KAPPA INDEX = 71.3% [Pchance = 0.10406]

Total Correct:	257
Total Samples:	346

OVERALL TOTAL ACCURACY 90% UPPER AND LOWER CONFIDENCE INTERVAL = + 78.3 % - 70.3 %

the total sample size (N) and is used to calculate Overall Total Accuracy.

(Omission and Commision errors were calculated using total accuracy)

Table 4-3 Contingency Table, continued

Total Correct	Sample Data		Comission Error	90% Confidence Interval (%)		Referenc Data		Omission Error	90% Confidence Interval (%)	
r	N	Map Code	% Correct	-	+	N	Map Code	% Correct	-	+
6	6	1	100.0%	65.5%	100.0%	6	1	100.0%	66.5%	100.0%
43	49	2	87.8%	77.3%	94.5%	48	2	89.6%	79.3%	95.8%
1	1	3	100.0%	10.0%	100.0%	5	3	20.0%	2.1%	62.1%
4	4	4	100.0%	50.0%	100.0%	4	4	100.0%	50.0%	100.0%
4	5	10	80.0%	37.9%	97.9%	9	10	44.4%	21.0%	76.8%
1	3	12	33.3%	3.5%	80.4%	6	12	16.7%	1.7%	54.2%
0	0	13	n/a	n/a	n/a	2	13	0.0%	0.0%	68.4%
2	2	15	100.0%	31.6%	100.0%	12	15	16.7%	4.5%	39.8%
5	9	16	55.6%	23.2%	79.0%	17	16	29.4%	14.0%	50.0%
19	22	17	86.4%	71.1%	94.9%	20	17	95.0%	79.7%	99.5%
63	98	18	64.3%	55.8%	72.8%	66	18	95.5%	88.7%	98.7%
1	2	30	50.0%	5.1%	94.9%	5	30	20.0%	2.1%	62.1%
12	18	31	66.7%	46.4%	83.7%	23	31	52.2%	32.8%	72.6%
2	3	33	66.7%	19.6%	96.5%	3	33	66.7%	19.6%	96.5%
11	14	35	78.6%	57.8%	91.9%	12	35	91.7%	70.6%	99.1%
0	0	36	n/a	n/a	n/a	8	36	0.0%	0.0%	25.5%
13	23	37	56.5%	38.1%	72.7%	15	37	86.7%	67.4%	96.4%
3	4	38	75.0%	32.0%	97.4%	6	38	50.0%	20.1%	79.9%
1	1	39	100.0%	10.0%	100.0%	1	39	100.0%	10.0%	100.0%
0	0	41	n/a	n/a	n/a	1	41	0.0%	0.0%	90.0%
3	4	42	75.0%	32.0%	97.4%	6	42	50.0%	20.1%	79.9%
7	10	43	70.0%	35.2%	88.4%	8	43	87.5%	58.2%	98.7%
26	32	44	81.3%	66.3%	91.5%	28	44	92.9%	79.9%	98.1%
3	6	45	50.0%	20.1%	79.9%	5	45	60.0%	24.7%	88.8%
27	30	47	90.0%	78.1%	96.3%	30	47	90.0%	78.1%	96.3%

5. DISCUSSION

Theodore Roosevelt National Park lies within the Northern Great Plains grasslands and includes many badlands erosional features that have formed within the Little Missouri River drainage. The Park also occupies relatively level plains on the eastern and western portions of the South Unit and on the northern portion of the North Unit. Relatively level plains grassland also occupies the tops of plateaus and buttes within the Park. The geology and topography of this region creates a complex landscape mosaic of plant associations, made more interesting because of the introduction or invasion of exotic plant species, particularly perennial forbs and grasses. These factors combine to produce challenging vegetation classification, photographic interpretation, and digital transfer needs that were met and addressed in the USGS-NPS National Park vegetation mapping effort. Final accuracy for the vegetation map reflects the time and effort required and given by researchers to understand and appreciate the complex nature of THRO vegetation.

5.1 Vegetation Classification and Characterization

Most of the vegetation present in the THRO study area was classified using existing community types for the Northern Great Plains, some of which have been recently described in previous National Park Vegetation Mapping Program projects. One recent example includes the work with prairie dog town complex vegetation that was introduced at Badlands and Wind Cave National Parks, SD. As a result, the Purple three-awn / Fetid marigold Disturbed Vegetation type was created for Wind Cave, the Prairie Dog Town Complex was created for Badlands, and either title could now be used to describe this similar vegetation at THRO. In a few cases, new types were described and created that also occur outside the study area but were not identified and/or described prior to this project. Scoria sparse vegetation complex associations would fall under this category.

Using true-color aerial photographs (1:24,000 with 1:12,000 enlargements) to delineate this diverse and complex flora was challenging, as many color signatures are similar and vegetation types rapidly repeat across the intricately dissected landscape. High interpretive values were therefore placed on vegetation pattern, height, and landscape position, as well as color. Some of the photos along the eastern project edge were acquired almost two months after the rest (late August versus early July) resulting in different photo signatures during a drier time of the year and with more advanced plant phenology. Moreover, interpreted data were transferred to grayscale DOQQ's rather than color DOQQ's.

It would be appropriate to test and compare the effectiveness of color-infrared aerial photography flown in June-July (at 1:12,000 scale) versus the 1996 true color photography (1:24,000 scale), with regards to providing more readily interpretable photo signatures, particularly in ecotones. Color-infrared photos may also improve the ability to accurately identify exotic plant species distribution such as leafy spurge and Canada thistle, especially when they are present as small patches or have become an understory species with shrubs and trees, rather than the stand dominant. In addition, DOQQ's of the same year and scale or ortho-rectified aerial photos would greatly improve and economize transfer of interpreted data.

Woodlands

The most common woodland types in the study region are those dominated by Rocky Mountain juniper and green ash-American elm woodland alliances. It is often difficult to determine the boundary (essentially a moisture gradient based on slope and aspect) between adjacent stands of these types using the true-color aerial photography; therefore, this decision was usually made based on topographic position. Similarly, the boundaries between stands of quaking aspen and green ash-American elm woodland alliances were not sharply defined on the aerial photos and field observation greatly aided interpretation. Stands of ponderosa pine woodland alliance represent the rarest woodland formation in the area and occupy habitat that would probably revert to Rocky Mountain juniper woodland alliance domination under more adverse conditions.

Eastern cottonwood floodplain woodland classification depended largely on stand maturity (i.e., tree densities, crown diameters, and position within the floodplain). The most mature/decadent stands (those most heavily invaded by Rocky Mountain juniper) were interpreted by scattered, large trees with dead material evident in the crowns, and they typically occupied outer floodplain positions and/or elevated positions within floodplains. Floodplain woodlands dominated by green ash also occupied the outer floodplain areas and usually contained some decadent eastern cottonwood trees. For this reason, the natural succession of floodplain woodlands, in the absence of frequent flooding, may be from eastern cottonwood to Rocky Mountain juniper to green ash-dominated stands. At least one prescribed burn was observed in the North Unit that appeared to be focused on an old eastern cottonwood stand with relatively young Rocky Mountain juniper in the understory.

Map accuracy for this project could be improved slightly (by 4 AA points or 1.2%) by combining all eastern cottonwood types into one map class. Of course, some detail relative to age of stands and resulting management implications would be forfeited.

Shrublands

The purest (monotypic) stands and most common shrubland alliances at THRO include silver sagebrush, buckbrush (western snowberry), three-leaved sumac, and sandbar willow. All of these types may intermingle in floodplains, while three-leaved sumac is the typical dominant of upland hills and ridges. Silver sagebrush/western wheatgrass shrubland stands often include patches of buckbrush and western wheatgrass, and all of their photo signatures may be affected by invasion of leafy spurge in the South Unit and yellow sweetclover in both units. Sandbar willow temporarily-flooded shrubland alliance stands almost always support a few peach-leaf willow and eastern cottonwood trees that may have sufficiently large canopies to confuse the signature with that of eastern cottonwood floodplain woodlands.

Other shrub types occur and are recognizable during on-ground surveys. They often occur in mixtures of several dominant shrub and herbaceous species. For example, the horizontal juniper dwarf shrub alliance usually contains the following dominants from other types: Rocky Mountain juniper, silver buffaloberry, three-leaved sumac, prairie sandreed grass, and little bluestem. In order to map these types from one another, interpretation below the MMU requirement of 0.5 hectares is required. An early attempt was made to interpret a big sagebrush type from the badlands complex. This attempt was not successful due to the photo-reflectance of badlands features and inability to consistently locate the type signature on badlands formations and in adjoining stands of shrubs; it is therefore considered part of the badlands sparse vegetation complex. Invasion by leafy spurge greatly influences signatures within shrub communities, particularly the silver sagebrush/western wheatgrass and buckbrush shrubland types. A future advantage may be gained in separating this type by using color infrared photos to interpret the signature. Shrublands dominated by the greasewood and rabbitbrush shrubland alliances only rarely occur in the Park.

Map accuracy for this project could be improved slightly (by nine AA points or 2.6%), by eliminating silver buffaloberry shrubland alliance as a map class (36) because of: 1) its small stand size, 2) its scattered distribution (often on the fringe of woodland types), and 3) the inability to interpret the class accurately. However, it could be made a “Park Special” to be mapped where known from plot and observation points. Park resource specialists, seasonals, and volunteers could then collect additional coordinates where silver buffaloberry shrubland alliance stands occur eventually creating an accurate point coverage for the type.

Grasslands

Common grasslands within THRO may be relatively simple to interpret, such as the needle-and-thread herbaceous alliance occupying the higher elevations on dry soils, or they can be extremely confusing. Western wheatgrass herbaceous alliance proved difficult to separate from the drier needle-and-thread herbaceous alliance because its typical habitat of swales, depressions, and slopes did not consistently support stands of this more mesic species. On some slopes where one would normally expect western wheatgrass, prairie sandreed grass was the site dominant. Other confusing grassland types occurred where exotic grass species replaced or intermixed with native grassland species, as on the eastern and southern edges of the South Unit and the northeastern boundary of the North Unit. At these sites, the soils and topography suggest that western wheatgrass herbaceous alliance would be the dominant with needle-and-thread herbaceous alliance occupying drier knolls. Little bluestem - sideoats grama herbaceous alliance often occurs in very small patches or is associated with other, more dominant shrubs and grasses, particularly horizontal juniper, three-leaved sumac, and prairie sandreed grass.

Map accuracy could be improved by combining certain grassland map classes. A combination of little bluestem - sideoats grama (map class 15) and needle-and-thread (map class 18) herbaceous alliances would improve map accuracy by seven AA points (2.1%). Also, a combination of western wheatgrass (map class 16) and needle-and-thread (map class 18) herbaceous alliances would improve map accuracy by 12 AA points (3.5%).

Exotics

Small patches of the Canada thistle herbaceous alliance could not be discerned on the true-color aerial photographs. Locations consist of observation points and two sets of coordinates recorded during the accuracy assessment work. Leafy spurge herbaceous alliance photo signatures were obvious in some areas (western portion of the South Unit environs), but became less so where it became co-dominant with or understory to shrub species. Five leafy spurge herbaceous alliance AA points had mistakenly been interpreted as silver sagebrush/western wheatgrass or buckbrush (wolfberry temporarily-flooded) shrub communities. To allow more accurate vegetation maps to be prepared, a yellow dot pattern was overlain on woodland and shrubland communities where leafy spurge was the known understory dominant. This pattern attribute allows more correct calculation of leafy spurge acreage in the project area. In the North Unit, flowering yellow sweetclover plants created a yellowish canopy over the dominant grassland signature. Since the moisture requirements for yellow sweetclover are similar to those for the western wheatgrass herbaceous alliance, these areas were interpreted under Map Class 16.

Sparse Vegetation

The long-leaved sagebrush sparse vegetation alliance is actually a potential habitat or a geology unit. It may be more appropriate to identify it as "bentonite clay exposure" with the class described as "occasionally supporting stands of sparse long-leaved sagebrush." With the exception of one location observed in the southwestern corner of the South Unit, all bentonite clay exposures occur in the North Unit with about 20% of the areas occupied by sparse long-leaved sagebrush.

Exposures of scoria (map class 3) within the Park are typically small and lie atop larger badlands erosional features or within shrub communities dominated by three-leaved sumac or sparse Rocky Mountain juniper stands. The interpretive error (four AA points) reflects this condition exactly.

Land Use

Several historic oil and/or gas well pad sites and their associated access roads had been restored by reseeding prior to this study and could be easily recognized on the aerial photographs. Since it was not possible to visit many of these sites in the mapping environs, they were all placed in map class 17 (introduced grassland herbaceous alliance). At least one of these sites was observed to be covered by native western wheatgrass and another by blue grama, but a separate study would be needed to accurately describe the vegetation of restored well-pad sites and the age of the restoration work.

5.2 Vegetation Map Production

Photo Interpretation

The USGS-NPS vegetation mapping projects are designed to produce both a vegetation classification and a set of map units. Typically the systems are very similar, but sometimes there is not a strict one-to-one correspondence between the two. Photographic interpretation centers around the ability to accurately and consistently delineate map classes based on complex signatures. Vegetation characteristics that can be seen on aerial photography are not necessarily the same as those apparent on the ground and vice versa. Effective field work and map verification work aided enormously in developing the map units and discerning the inherent variability of each photographic signature.

The final mapping scheme for THRO contains 5 basic elements:

- NVCS associations represented by an unique photo-signature and topographic position, *e.g.,* Rocky Mountain Juniper Woodland Alliance;
- multiple NVCS associations that together are represented by an unique signature, *e.g.,* needle-and-thread herbaceous alliance;
- stands of vegetation that were not addressed by the NVCS but are seen as management concerns for THRO and could be recognized on the aerial photography, *e.g* introduced grassland herbaceous alliance and leafy spurge herbaceous alliance;
- wildlife habitat units that were also identified as management concerns, *e.g.,* prairie dog town complex; and
- geologic formations/exposures and land-use classes that were not addressed by the NVCS.

The number and variability of vegetation signatures sometimes made them difficult to distinguish and consistently interpret. Environmental factors such as annual grazing in the environs, moisture gradients, slope exposure, presence and density of exotic grasses and forbs, and soil diversity result in several photographic signatures for each grassland and some shrub and woodland classes. Also, on true color photos, these signatures may only be various shades of greens and grays, causing a larger reliance on topographic position to determine the map class.

Seasonal changes from the time of aerial photography acquisition (early July 1996 inside Park boundaries) to the collection of accuracy assessment data (August 1998) also results in a change in dominance (with respect to foliar cover) from cool season to warm season grasses. For example, both little bluestem and prairie sandreed grass are warm season grasses that are somewhat innocuous in the spring but gradually change to very prominent clumps of reddish-brown stems (little bluestem) or tall, light-green patches (prairie sandreed grass) in late summer. The aerial photography records late spring (except for the late-summer photos on the eastern side of the project area) phenology where species like western wheatgrass, needle-and-thread grass, and Kentucky bluegrass are the dominant actively growing plants, which would also be readily observable on the ground. Floristic composition changes in the fall, as areas with little bluestem and prairie sandreed grass become more pronounced. The distinctness of warm season grass species at this time may cause an observer to classify them out of proportion to their actual dominance.

One challenging and somewhat puzzling grassland type (in terms of distribution and establishment) was the western wheatgrass herbaceous alliance (map class 16). This class proved difficult to interpret consistently since field verification of early photo-interpretation attempts discovered an over-interpretation of this type, particularly on slopes and in shallow swales, drainages, and depressions. However, overall project interpretation, when examined under the map accuracy assessment, indicates an under-interpretation of the western wheatgrass herbaceous alliance in favor of the drier needle-and-thread herbaceous alliance. It is very likely that a better separation of these types (slightly mesic versus arid grasslands) could be made using color infrared photography, as was the case at Badlands National Park (Von Loh et al. 1999). Soils maps of THRO were not available for this study and may have been useful to more accurately interpret the distribution of western wheatgrass herbaceous vegetation alliance grasslands, in particular, and to a lesser extent those areas dominated by little bluestem and prairie sandreed grass.

Digital Transfer

Digital transfer and registration of information from aerial photographs to a spatial database also proved to be a challenging task for THRO. This was largely due to: 1) the complex and intricate line work needed to delineate all vegetation types, 2) the physical challenge of using 20x20-inch photo enlargements, 3) transferring data using DOQQ's that were grayscale and were derived from older photographs, and 4), the highly dissected landscape and exotic species invasions. To insure transfer of all the line work, scanning and multiple transformation processes using landmarks as controls were used for each aerial photograph overlay. Other transfer processes, particularly on-screen digitizing, received discussion and/or experimentation. However, these were either considered too time consuming or insufficient for the needs of this project. Therefore, scanning and multiple geographic transformations produced digital polygons across the entire project area. Further editing and quality checking of the digital polygons created borders that tightly bounded corresponding features on the DOQQ base map. Automation of the scanning and transfer process (via in-house AMLS) using a 'shell' system greatly aided speed and consistency. However, the file sizes on this project were large (up to and exceeding 2000 polygons/cover) and therefore very 'slow' with which to work.

Accuracy Assessment

Comparison of the AA points collected for THRO and the areas covered by individual map classes reveal that Park vegetation is nearly evenly distributed among sparse, grassland, shrubland, and woodland types. The actual area covered by individual map classes reveals that only eight of them (map classes 2, 17, 18, 31, 35, 37, 44, and 47) comprise the vast majority of the vegetated surface within the Park. Several vegetation types (map classes 1, 2, 4, 17, 18, 31, 35, 37, 39, 43, 44, and 47) are considered accurate near or above the desired 80% minimum accuracy level for the program. Four vegetation types were not sampled with AA points for a number of reasons, e.g., 1) ponderosa pine woodland alliance (map class 48) does not occur in the Park and the stand is well-represented by plot and observation data, 2) quaking aspen woodland alliance (map class 46) stands in the Park are all represented by either plot or observation data, 3) emergent wetlands (map class 14) cannot be interpreted from the aerial photography because they are very small and many are under an overstory canopy; all observed emergent wetlands are represented by observation data, and 4) Canada thistle herbaceous alliance (map class 11) patches are also too small to interpret and several have also established under an overstory canopy.

The remaining thirteen vegetation map classes could be combined or eliminated to improve map accuracy as follows:

- Map classes 15, 16, and 18 could be combined into a single Mixed Grassland type which would improve accuracy by 19 additional correct assessment points.

- Map classes 11 and 36 could be eliminated from consideration because of their small size and non-distinguishing features on true color aerial photography, potentially increasing accuracy by 9 additional correct assessment points for map class 36.

- Map class 3 and 2 could be combined but maintain each classes' identity with a different color or pattern. This would increase accuracy by two additional correct assessment points for map class 2 and two additional correct assessment points for vegetation (one each for map classes 35 and 47).

One change has been incorporated for the vegetation map during the AA process. That is to consider map class 11 (Canada thistle herbaceous alliance) as a park special, where the location coordinates are given to Park resource managers for future actions.

5.3 Recommendations for Future Projects

Several recommendations for future mapping projects have come out of the experience gained at THRO. First, having aerial photographs and ortho-rectified photo basemaps (such as DOQQ's) at the same scale (nominally 1:12,000) or, having the aerial photographs ortho-rectified (for use as the base maps), would improve transfer accuracy and allow photo-interpretation to be performed more easily. For the latter case, check maps could be overlain on top of the ortho-rectified photo for quality checking not only for attribute accuracy but also for polygon shape and location. They would decrease the time it takes for transfer, eliminating the time-consuming process of locating control points. It could also allow photo-interpretation to be performed on-screen instead of on mylar overlays. Second, it is probable that color-infrared photography would help to sort out the complex mosaic of polygons inherent to a highly dissected and topographically diverse landscape. Third, determining the size of the project environs in relation to the Park size, layout, and management needs must be examined closely for each vegetation mapping project. In the case of THRO, nearly 60% of the interpretive and data transfer efforts were focused outside Park boundaries. And last, the GPS data points should be collected using the same datum at the base maps. For this project, that would be in NAD83.

It is strongly recommended that future mapping projects begin field work with a reconnaissance step involving observation point data collection from a large number of sites. This type of sampling is conducted relatively fast, and allows investigators to become familiar with plant communities and their variability in the study area. Following this step, representative stands within gradsects can be selected and sampled using more detailed vegetation plots. Data collected for observation points also supplements vegetation plot data in preparing association descriptions and provides an interim assessment of accuracy useful for photo-interpretation. In the case of THRO, several previous vegetation studies and the on-site experience of the principal investigator, aided research teams in efficiently collecting adequate plot data for each vegetation type in the Park.

Developing two compatible classification systems (plant associations and map units) has proven to be challenging, not just at Theodore Roosevelt, but at other mapping projects in the Great Plains as well. It is important for users of the vegetation map that the two classifications be as similar as possible. At the beginning of this project, emphasis was placed on developing a protocol for communication between photo-interpreters and field ecologists. A preliminary vegetation classification and an initial photo-signature classification with delineated polygons for a portion of the study area was available early so that compatibility problems could be addressed using field verification of preliminary map products.

The accuracy assessment approach must be thoroughly planned. A front-loading method was used here that allowed a thorough assessment of all types. However, using this method tends to under-sample major map classes (in total land area) and over-samples minor map classes. As a result, the relatively minor map classes/vegetation types can exert a greater, potentially negative outcome on the overall results. A random selection of polygons to assess will alleviate the potential problem of minor map classes unduly influencing the total accuracy assessment outcome. Where time and/or budget are not an issue, a random selection of polygons is preferred over the front-loading process.

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APPENDIX A.

Average Monthly Precipitation Values
For
Medora, ND (South Unit) and Watford City, ND (North Unit).

(referenced on page 2-5)

(Summarized from National Weather Service (NWS) and monthly precipitation data.)
(URL: http://www.ncdc.noaa.gov/ol/climate/online/coop-precip.html)

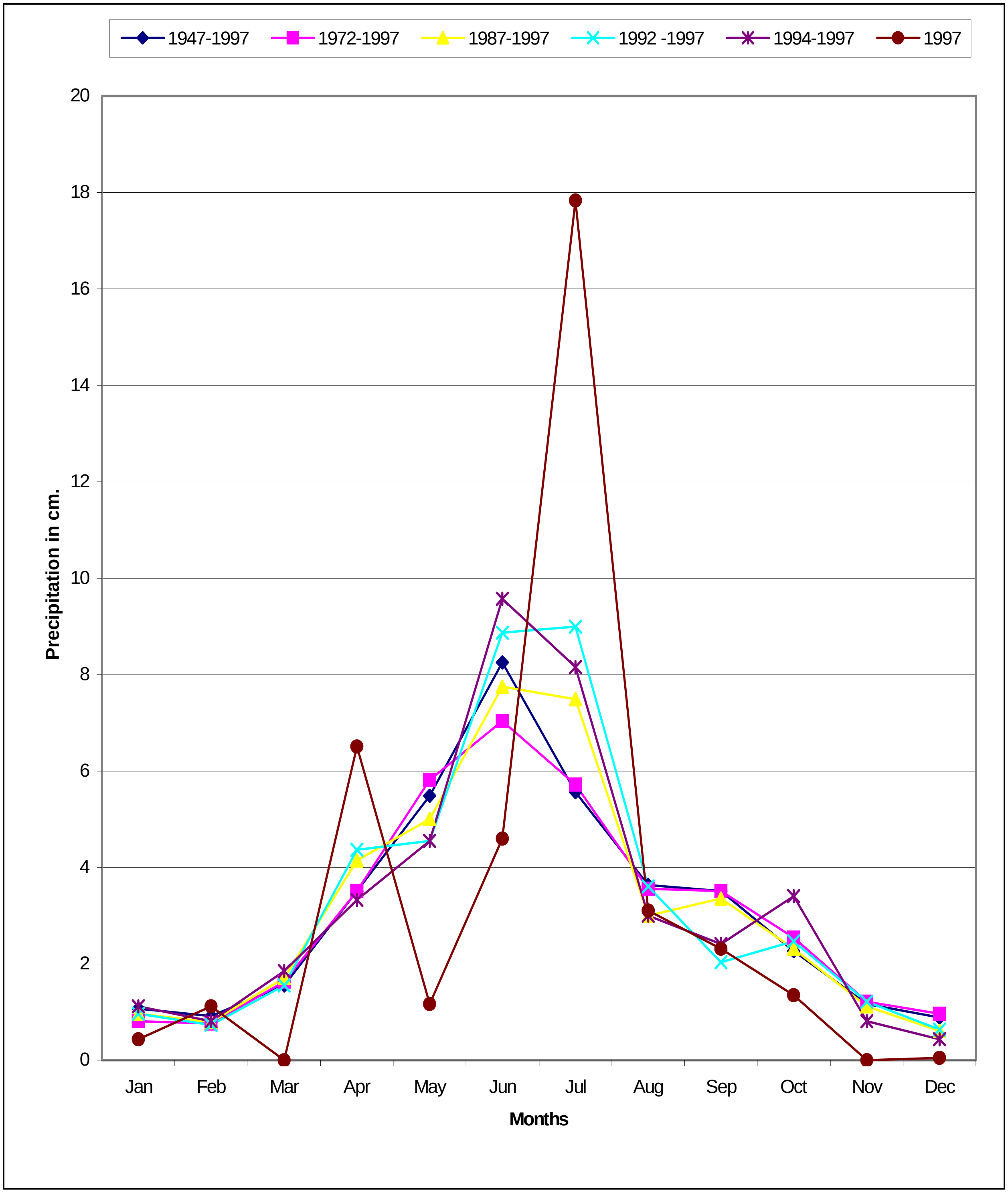


Figure A1. *Comparisons of mean 1997 monthly precipitation values with 3, 5, 10, 25 and 50-* year averages as recorded at **Medora**, North Dakota.

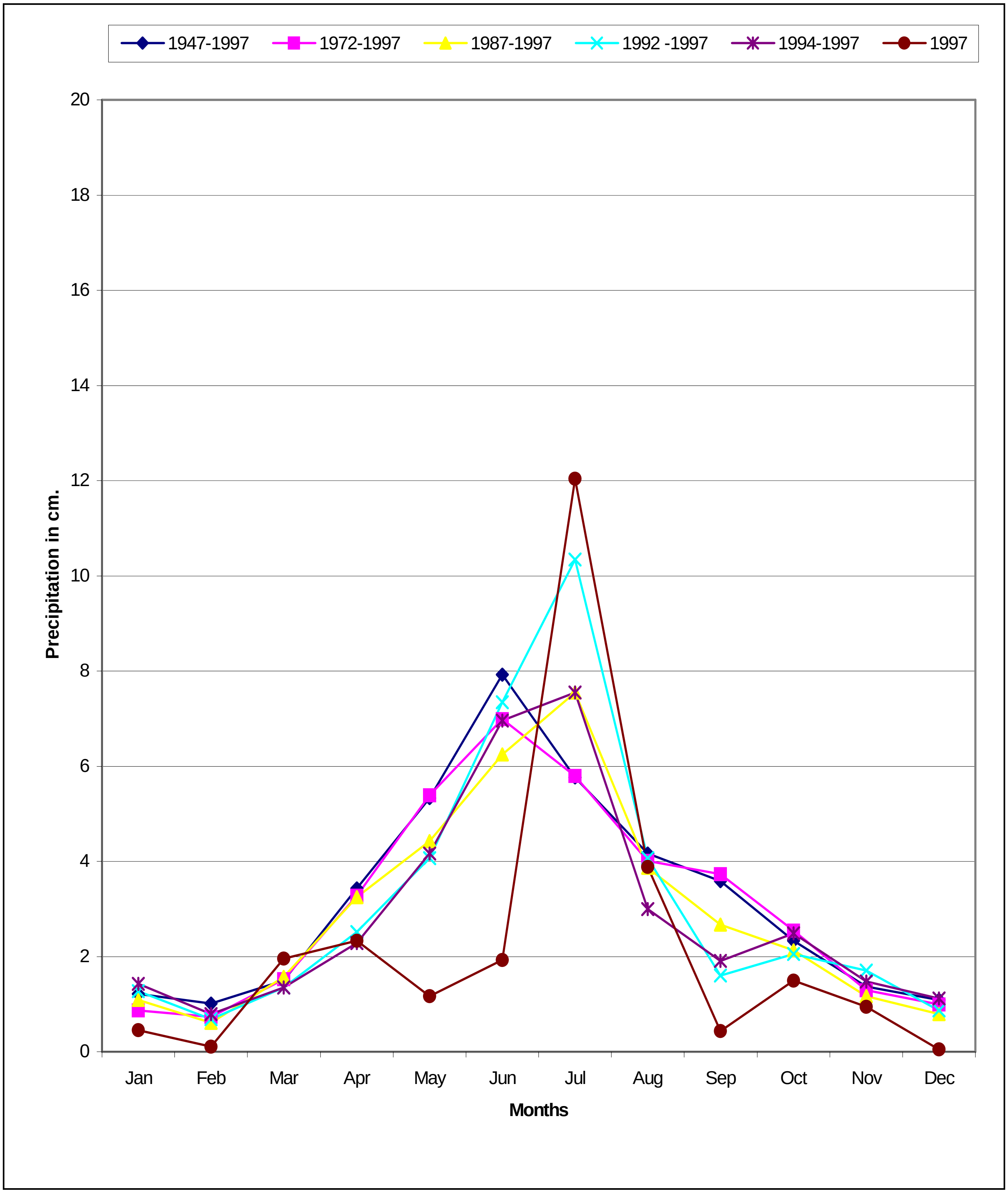


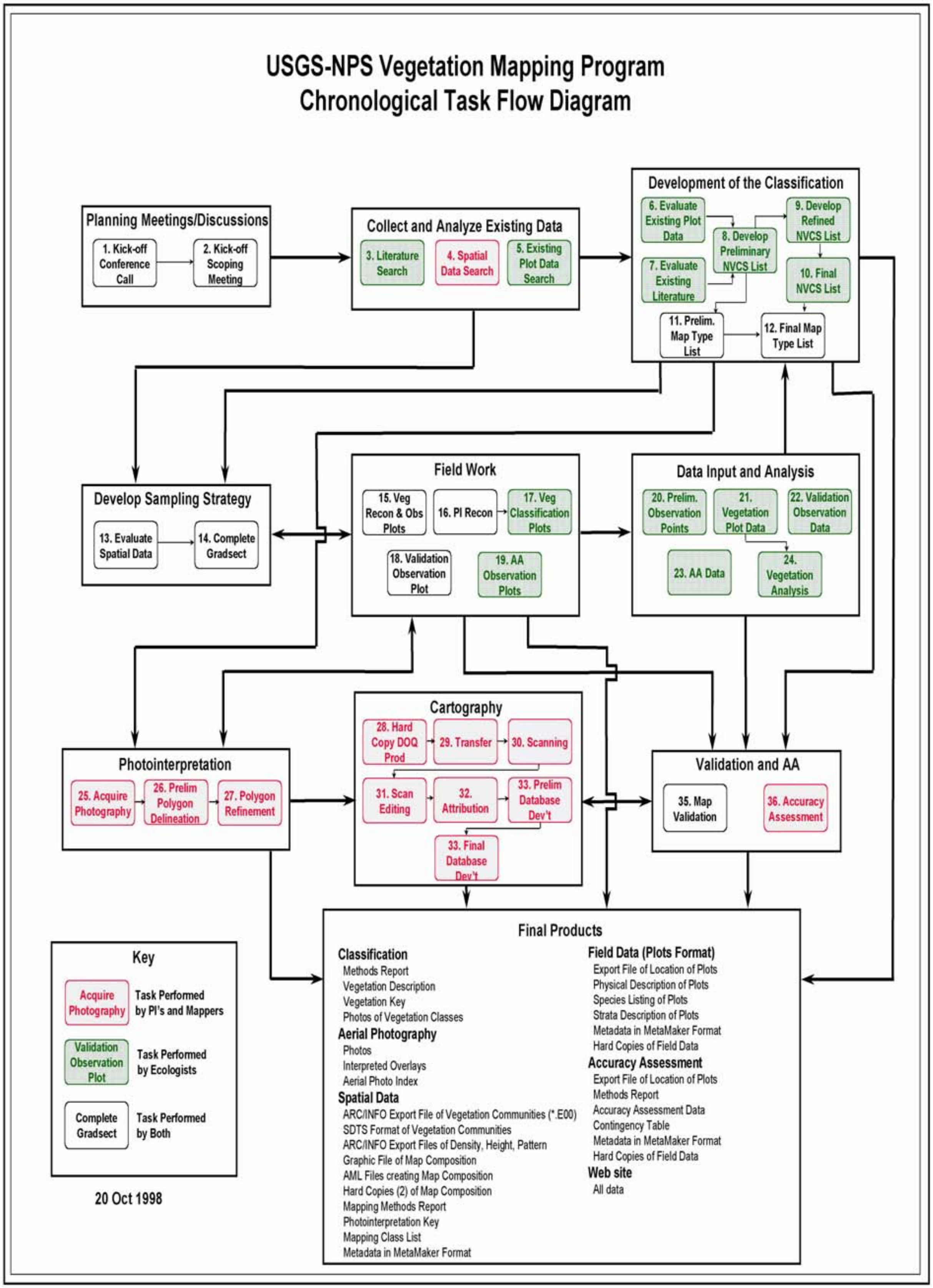
Figure A2. Comparisons of mean 1997 monthly precipitation values with 3, 5, 10, 25 and 50-year averages as recorded at **Watford City**, North Dakota.

APPENDIX B.

Flowchart
of
USGS-NPS National Parks Vegetation Mapping Program

(Created by Tom Owens, USGS/BRD)

(referenced on page 3-1)


USGS-NPS Vegetation Mapping Program
Chronological Task Flow Diagram
Planning Meetings/Discussions
1. Kick-off Conference Call
2. Kick-off Scoping Meeting
Collect and Analyze Existing Data
3. Literature Search
4. Spatial Data Search
5. Existing Plot Data Search
Development of the Classification
6. Evaluate Existing Plot Data
7. Evaluate Existing Literature
8. Develop Preliminary NVCS List
9. Develop Refined NVCS List
10. Final NVCS List
11. Prelim. Map Type List
12. Final Map Type List
Develop Sampling Strategy
13. Evaluate Spatial Data
14. Complete Gradsect
Field Work
15. Veg Recon & Obs Plots
16. PI Recon
17. Veg Classification Plots
18. Validation Observation Plot
19. AA Observation Plots
Data Input and Analysis
20. Prelim. Observation Points
21. Vegetation Plot Data
22. Validation Observation Data
23. AA Data
24. Vegetation Analysis
Cartography
28. Hard Copy DOQ Prod
29. Transfer
30. Scanning
31. Scan Editing
32. Attribution
33. Prelim Database Dev't
33. Final Database Dev't
Photointerpretation
25. Acquire Photography
26. Prelim Polygon Delineation
27. Polygon Refinement
Validation and AA
35. Map Validation
36. Accuracy Assessment
Final Products
Classification
Methods Report
Vegetation Description
Vegetation Key
Photos of Vegetation Classes
Aerial Photography
Photos
Interpreted Overlays
Aerial Photo Index
Spatial Data
ARC/INFO Export File of Vegetation Communities (*.E00)
SDTS Format of Vegetation Communities
ARC/INFO Export Files of Density, Height, Pattern
Graphic File of Map Composition
AML Files creating Map Composition
Hard Copies (2) of Map Composition
Mapping Methods Report
Photointerpretation Key
Mapping Class List
Metadata in MetaMaker Format
Field Data (Plots Format)
Export File of Location of Plots
Physical Description of Plots
Species Listing of Plots
Strata Description of Plots
Metadata in MetaMaker Format
Hard Copies of Field Data
Accuracy Assessment
Export File of Location of Plots
Methods Report
Accuracy Assessment Data
Contingency Table
Metadata in MetaMaker Format
Hard Copies of Field Data
Web site
All data
Key
Acquire Photography
Task Performed by PI's and Mappers
Validation Observation Plot
Task Performed by Ecologists
Complete Gradsect
Task Performed by Both
20 Oct 1998

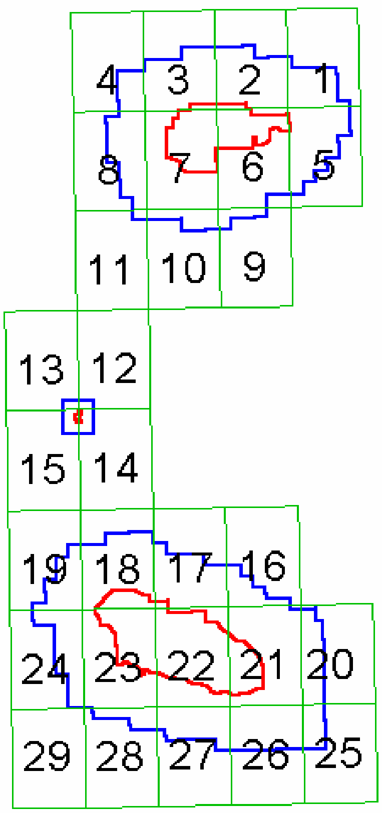
APPENDIX C

Quad Index and Project Area Map

(Created by Doug Crawford, USBR)

(referenced on pp. 3-2 and 4-31)

Theodore Roosevelt NP GIS Project Area



Index to USGS 1:24k Quadrangle Maps:

North Unit:

1. Lone Butte NW (ln_bt_nw)
2. Tepee Buttes (tepe_bts)
3. Stocke Butte (stck_bt)
4. Bear Butte (bear_bt)
5. Lone Butte (lone_bt)
6. Long X Divide (longx_dv)
7. Sperati Point (sprti_pt)
8. Red Wing Creek (rdwng_cr)
9. Buckskin Butte (bkskn_bt)
10. Wolf Coulee (wolf_cle)
11. Ice Box Canyon (icebx_cn)

Elk Horn Ranch Unit:

12. Hanks Gully
13. Eagle Draw
14. Roosevelt Creek East
15. Roosevelt Creek West

South Unit:

16. Gorham SE (gorhm_se)
17. Gorham SW (gorhm_sw)
18. Wannagan Creek East (wna_cr_e)
19. Wannagan Creek West (wna_cr_w)
20. Belfield (belfield)
21. Fryburg NE (frybr_ne)
22. Fryburg NW (frybr_nw)
23. Medora (medora)
24. Buffalo Gap Campground (bufgp_cp)
25. Belfield SW (blfld_sw)
26. Fryburg (fryburg)
27. Tracy Mountain (tracy_mt)
28. Chimney Buttes (chmny_bt)

Note: Name in ( ) indicates the associated GIS database directory and vegetation coverage name. Elk Horn Ranch Unit vegetation coverage not associated with quadrangle names due to small size.

APPENDIX D.

Interpreted Photograph Index.

Sorted by USGS quadrangle.

(Created by Doug Crawford, USBR)

(referenced on pp. 3-3 and 4-31)

USGS -NPS Vegetation Mapping Program - Theodore Roosevelt National Park

Table of Interpreted Photgraphs - Sorted by Quad Name							
Quad Name	**QQ**	**Photo Numbers**					
		296-	**396-**	**496-**	**596-**	**696-**	**796-**
Bear Butte	se			158, 160, 165			
Belfield	nw					133, 135	
Belfield	sw					135, 137, 139	
Belfield SW	nw					139, 141	
Buckskin Butte	nw					4, 173, 175	
Buckskin Butte	ne					173, 175	
Buffalo Gap Campgnd	nw	36, 37, 40, 42					
Buffalo Gap Campgnd	ne		38, 40, 42, 116-120				
Buffalo Gap Campgnd	se		38, 120, & 122				
Chimney Buttes	nw		122	47			
Chimney Buttes	ne			47, 116			
Elk Horn Ranch Unit	--		103, 105				
Fryburg	nw				158, 160, 169, 170, 172		
Fryburg	ne				169, 170, & 172	119, 121, 139, 141	
Fryburg NE	nw				150, 152, 154, 176, 178		
Fryburg NE	ne				176, 178, & 210 125, 127,	125, 127, 133, 135	
Fryburg NE	se				172, 174 &176 123, 125,	123, 125, 135, 137, 139	
Fryburg NE	sw				154, 156, 158, 172, 174		
Fryburg NW	nw			202, 204	67, 69, & 71		
Fryburg NW	ne				69, 71, 150, 152, 154		
Fryburg NW	se				65, 67, 154, 158		
Fryburg NW	sw			204, 206 & 208	65, 67		
Gorham SE	se				180, 210		
Gorham SE	sw				148, 150, & 180		
Gorham SW	nw			126, 128, & 198	75		
Gorham SW	ne				75		
Gorham SW	se				71, 73, 75, 148, & 150		
Gorham SW	sw			126, 198, 200, & 202	71, 73, & 75		
Ice Box Canyon	ne			150			
Lone Butte	nw						18, 20, 22, 30, 32, 34
Lone Butte	ne						30, 32, 34, 70, 72
Lone Butte	sw						16, 18, & 34
Lone Butte NW	se						29, 30, & 72
Lone Butte NW	sw					186 & 187	22, 29, & 30

USGS -NPS Vegetation Mapping Program - Theodore Roosevelt National Park

Table of Interpreted Photgraphs - Sorted by Quad Name							
Quad Name	**QQ**	**Photo Numbers**					
		296-	**396-**	**496-**	**596-**	**696-**	**796-**
Long X Divide	nw				116, 118, & 120	177, 179, & 181	
Long X Divide	ne					177, 179, 181, 190, 192	18, 20
Long X Divide	se					175, 177, 192, 194, 195	16, 18
Long X Divide	sw				120, 122	4, 175, & 177	
Medora	nw		116, 118, & 120	40, 42, & 44			
Medora	ne			40, 42, 44, 120-3, 202			
Medora	se			44, 46, 47, 116-120			
Medora	sw		120, 122	44, 46, & 47			
Red Wing Creek	ne			5,7,8, 154,6,8, 165,7			
Red Wing Creek	se			8, 150, 152, 154, 173			
Sperati Point	nw			165, 167, & 169	103, 104, 105, & 106		
Sperati Point	ne				103-106, 118, 120		
Sperati Point	se				99, 101, 103, 120, 122	4	
Sperati Point	sw			169, 171, & 173	99, 101, & 103		
Stocke Butte	ne				111 & 112		
Stocke Butte	se				106 - 116		
Stocke Butte	sw			160, 163, & 165	107, 109, & 111		
Tepee Buttes	nw				112	185	
Tepee Buttes	ne					185 & 186	
Tepee Buttes	se					181-190	22
Tepee Buttes	sw				112-116, 181-185		
Tracy Mountain	nw			116, 208, & 210	63, 65		
Tracy Mountain	ne				63, 65, 158, & 160		
Wanngan Creek East	nw		112	34, 36			
Wanngan Creek East	ne			34, 36, 126, 128, 198			
Wanngan Creek East	se			36-40, 123-6, 200-2			
Wanngan Creek East	sw		38, 112, 114, & 116	36, 38, & 40			
Wanngan Creek West	ne		44, 45, & 112				
Wanngan Creek West	se		42, 44, 45, 112, 114, 116				
Wanngan Creek West	sw	36	42				
Wolf Coulee	nw			173	99		
Wolf Coulee	ne				99	4	

APPENDIX E.

Observation Point Form
for the
National Park Vegetation Mapping Program

(Also used for the Accuracy Assessment)

(from The Nature Conservancy)

(referenced on page 3-5 & 3-12)

NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM

IDENTIFIERS/LOCATORS

Plot Code________________________ Polygon Code________________________

Provisional Community Name____

State ___ Park Name ________________________ Park Site Name ________________

Quad Name________________________________ Quad Code________________

GPS file name____________ Field UTM X___ ___ ___ ___ ___ ___ m E Field UTM Y___ ___ ___ ___ ___ ___ ___ m N

please do not complete the following information when in the field
Corrected UTM X___ ___ ___ ___ ___ ___ m E Corrected UTM Y___ ___ ___ ___ ___ ___ ___ m N UTM Zone__________

Survey Date____________ Surveyors________________________________

ENVIRONMENTAL DESCRIPTION

Elevation ________________ Slope ________________ Aspect________________

Topographic Position

Landform

Cowardian System	Hydrologic Regime		Salinity/Halinity Modifiers
___Upland ___Riverine ___Palustrine ___Lacustrine	Non-Tidal ___Permanently Flooded ___Semipermanetly Flooded ___Seasonally Flooded	___Saturated ___Temporarily Flooded/Saturated ___Intermittently Flooded	___Saltwater ___Brackish ___Freshwater

Environmental Comments:	Unvegetated Surface: *(please use the cover scale below)*
	___ Bedrock ___ Litter, duff ___ Wood (> 1 cm) ___ Large rocks (cobbles, boulders > 10 cm) ___ Small rocks (gravel, 0.2-10 cm) ___ Sand (0.1-2 mm) ___ Bare soil ___ Other:________________________

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Cover Scale for Strata & Unvegetated Surface	Height Scale for Strata
Trees and Shrubs ___Evergreen ___Cold-deciduous ___Drought-deciduous ___Mixed evergreen - cold-deciduous ___Mixed evergreen - drought-deciduous Herbs ___Annual ___Perennial	___Broad-leaved ___Needle-leaved ___Mixed broad-leaved/Needle leaved ___Microphyllous ___Graminoid ___Forb ___Pteridophyte	___Forest ___Woodland ___Shrubland ___Dwarf Shrubland ___Herbaceous ___Nonvascular ___Sparsely Vegetated	01 5% 02 10% 03 20% 04 30% 05 40% 06 50% 07 60% 08 70% 09 80% 10 90% 11 100%	01 <0.5 m 02 0.5-1m 03 1-2 m 04 2-5 m 05 5-10 m 06 10-15 m 07 15-20 m 08 20-35 m 09 35 - 50 m 10 >50 m

Strata	Height	Cover Class	Dominant species (mark any known diagnostic species with a *)	Cover Class
T1 Emergent	_____	_____		
T2 Canopy	_____	_____		
T3 Sub-canopy	_____	_____		
S1 Tall shrub	_____	_____		
S2 Short Shrub	_____	_____		
S3 Dwarf-shrub				
H Herbaceous	_____	_____		
N Non-vascular	_____	_____		
V Vine/liana	_____	_____		
E Epiphyte	_____	_____		

please see the table on the previous page for height and cover scales for strata

Other Comments

Cover Scale for Species
01 <1%
02 1-5%
03 5-25%
04 25-50%
05 50-75%
06 75-100%

APPENDIX F.

Plot Survey Form
for the
National Park Vegetation Mapping Program

(from The Nature Conservancy)

(referenced on page 3-5)

NATIONAL PARK VEGETATION MAPPING PROGRAM: PLOT SURVEY FORM

IDENTIFIERS/LOCATORS

Plot Code____ Polygon Code________________________________

Provisional Community Name____

State ___ Park Name__ ______________________ Park Site Name___________________________

Quad Name____ Quad Code_____________________________

GPS file name________________ Field UTM X___ ___ ___ ___ ___ ___ m E Field UTM Y___ ___ ___ ___ ___ ___ ___ m N

please do not complete the following information when in the field
Corrected UTM X___ ___ ___ ___ ___ ___ m E Corrected UTM Y___ ___ ___ ___ ___ ___ ___ m N UTM Zone___________

Survey Date_____________ Surveyors____

Directions to Plot

Plot length______ Plot width______ Plot Photos (y/n) ___ Roll Number _____ Frame Number _____ Plot Permanent (y/n) ____

Plot representativeness

ENVIRONMENTAL DESCRIPTION

Elevation ______________________ Slope _____________________ Aspect_________________________

Topographic Position

Landform

Surficial Geology

Cowardian System
___Upland
___Riverine
___Palustrine
___Lacustrine

Non-Tidal
___Permanently Flooded
___Semipermanetly Flooded
___Seasonally/Temporarily Flooded
___Saturated
___Seasonally Flooded/Saturated
___Intermittently Flooded

Environmental Comments:

Soil Taxon/Description

Unvegetated Surface: *(please use the cover scale on next page)*
___ Bedrock ___ Litter, duff ___ Wood (> 1 cm)
___ Large rocks (cobbles, boulders > 10 cm)
___ Small rocks (gravel, 0.2-10 cm)
___ Sand (0.1-2 mm) ___ Bare soil
___ Other:____

Soil Texture
___ sand___ loamy sand ___ sandy loam ___ loam
___ silt loam ____ silt ___ clay loam ___ silty clay
_ _ clay ___ peat ___ muck

Soil Drainage
___ Rapidly drained ___ Well drained
___ Moderately well drained ___ Somewhat poorly drained
___ Poorly drained ___ Very poorly drained

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Cover Scale for Strata & Unvegetated Surface	Height Scale for Strata
Trees and Shrubs ___Evergreen ___Cold-deciduous ___Drought-deciduous ___Mixed evergreen - cold-deciduous ___Mixed evergreen - drought-deciduous Herbs ___Annual ___Perennial	___Broad-leaved ___Needle-leaved ___Microphyllous ___Graminoid ___Forb ___Pteridophyte	___Forest ___Woodland ___Shrubland ___Dwarf Shrubland ___Herbaceous ___Nonvascular ___Sparsely Vegetated	01 5% 02 10% 03 20% 04 30% 05 40% 06 50% 07 60% 08 70% 09 80% 10 90% 11 100%	01 <0.5 m 02 0.5-1m 03 1-2 m 04 2-5 m 05 5-10 m 06 10-15 m 07 15-20 m 08 20-35 m 09 35 - 50 m 10 >50 m

Strata	Height Class	Cover Class	Diagnostic species (if known)
T1 Emergent	________	________	________
T2 Canopy	________	________	________
T3 Sub-canopy	________	________	________
S1 Tall shrub	________	________	________
S2 Short Shrub	________	________	________
H Herbaceous	________	________	________
N Non-vascular	________	________	________
V Vine/liana	________	________	________
E Epiphyte	________	________	________

please see above table for height and cover scales

Animal Use Evidence

Natural and Anthropogenic Disturbance Comments

Other Comments

Plot Code____

Species/percent cover: Starting with the uppermost stratum, list all species with % cover for each species in the stratum. For forests and woodlands, on a separate line below each tree species, list the DBH of all trees above 10 cm diameter. Separate measurements with a comma. Put an asterisk next to any species that are known diagnostics for a particular community in the classification. Also list species outside the plot at the end of the table or designate with a 0 in in Cover Class column.

Species Name	Cover	Species Name	Cover	Species Name	Cover

Cover Scale for Species

01	< 1%
02	1-5%
03	5-25%
04	25-50%
05	50-75%
06	75-100%

APPENDIX G.

Field Key to the NVCS Vegetation Associations at THRO

(Created by Jack Butler, slides by USBR)

(referenced on pp. 3-9 and 4-1)

PLANT ASSOCIATION/ALLIANCE KEY - THEODORE ROOSEVELT NATIONAL PARK

How to Use the Key--- On the following pages, associations/alliances are arranged in 24 dichotomous couplets with corresponding field descriptions. Starting with the number "1", read through the statements and choose the one that is most appropriate. If necessary, follow the numbers within the parentheses until a "best match" is found. Read the description to verify the match. It may be necessary to compare descriptions for similar associations by backtracking. The map code for each association is given in parenthesis after each association name. Note that not all associations were mapped directly (1:1) on the THRO map, so some may appear within alliances or complexes on the map.

There will be some stands that do not match any of the descriptions exactly. Many plant associations are variable in composition, and, while the descriptions attempt to address variability, there will be exceptions. Stands can represent transition zones between two types. There can be small inclusions of one type in larger stands of another. It is important to survey sufficiently large stands (~0.5 ha or at least 50 m diameter area around a point, or at least 100 m length in riparian areas) when classifying, and to base decisions on representative areas within stands.

1. Site unvegetated to < 25% vegetated; comprised of eroding cliffs, mounds, haystacks, fans, drainages, and flats formed from mudstone, claystone, siltstone, scoria, and some sandstone.
Badlands Sparse Vegetation Complex. (Map Unit 2)



Five associations occur within this complex, and each is supported by a description:
***Artemisia longifolia* Badlands Sparse Vegetation** (Map Unit 4);


***Artemisia tridentata* ssp. *wyomingensis / Pascopyrum smithii* Shrubland;**
***Artemisia tridentata - Atriplex confertifolia* Shrubland;**
Eroding Great Plains Badlands Sparse Vegetation; and
Scoria Sparse Vegetation Complex (Map Unit 3) (Photo on next page).

1. Site vegetated > 25% cover **(2)**.

2. Site supports > 10% tree and/or shrub aerial cover **(3)**.
2. Site mostly herbaceous; grasses and forbs, shrubs and/or trees, if present, providing < 10% aerial cover **(16)**.

(Map Unit 3 Photo)

3. Site mostly vegetated by trees > 4 m tall (tree cover > 10%, and typically > 25%) **(4)**.
3. Site mostly vegetated by shrubs < 4 m tall (shrub cover > 10%, and typically > 25%) **(9)**.

4. Trees mostly evergreen, *i.e.* Rocky Mountain juniper and ponderosa pine **(5)**.
4. Trees mostly deciduous, *i.e.* cottonwood, peachleaf willow, green ash, American elm, quakinging aspen **(6)**.

5. Ponderosa pine present, > 25% aerial cover, associated with Rocky Mountain juniper.
***Pinus ponderosa / Juniperus scopulorum* Woodland.** (Map Unit 48)

(no photo avialable)

5. Rocky Mountain juniper present, >25% aerial cover, associated with littleseed ricegrass, and green ash and ponderosa pine <25% cover; occupies steep north-facing slopes and drier (usually upper) reaches of upland draws and drainages.
***Juniperus scopulorum / Oryzopsis micrantha* Woodland.** (Map Unit 47)

6. Site within floodplain, or immediately above first terrace, of the Little Missouri River **(7)**.

6. Moderate to steep slopes, upland draws, and depressions; trees mostly green ash or quaking aspen.

***Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana* Woodland.** (Map Unit 44)



***Populus tremuloides / Prunus virginiana* Woodland.** (Map Unit 46)

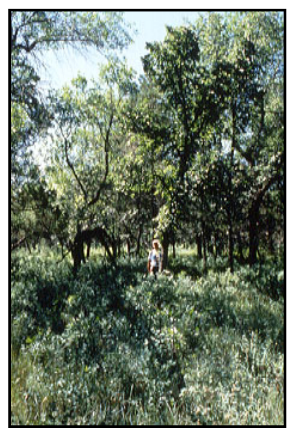


7. Cottonwood trees dominate and clearly form an emergent layer **(8)**.

7. Green ash dominant with Siberian elm as a secondary species.

***Fraxinus pennsylvanica (Ulmus americana)* Temporarily Flooded Woodland.** (Map Unit 45).

***Fraxinus pennsylvanica - (Ulmus americana) / Symphoricarpos occidentalis* Forest.** (Map Unit 45)



8. Cottonwood trees generally large and mature, lacking secondary tree species, understory primarily herbaceous; buckbrush common to infrequent.

***Populus deltoides* Temporarily Flooded Woodland.** (Map Unit 43)



8. Cottonwood dominant with Rocky Mountain juniper or peachleaf willow subdominant.
***Populus deltoides / Juniperus scopulorum* Woodland.** (Map Unit 42)

***Populus deltoides - (Salix amygdaloides) / Salix exigua* Woodland.** (Map Unit 41)

9. Dwarf shrublands (<30 cm tall) dominated by horizontal juniper.
***Juniperus horizontalis / Schizachyrium scoparium* Dwarf Shrubland.** (Map Unit 30).

9. Shrubs of various heights to 3 m tall, predominantly silver sagebrush, big sagebrush, three- leaved sumac, buckbrush (wolfberry), sandbar willow, greasewood, and/or rabbitbrush **(10)**.

10. Shrubs tall, > 2 m, predominantly silver buffaloberry and sandbar willow **(11).**
10. Short shrubs, < 1.5 m, predominantly silver sagebrush, three-leaved sumac, buckbrush (wolfberry), greasewood, and/or rabbitbrush **(12)**

11. Shrub thickets, predominantly silver buffaloberry, silvery green color, dense, spiny, impenetrable.
***Shepherdia argentea* Shrubland.** (Map Unit 36)


11. Shrub thickets along river and creek banks, wet and moist drainages, predominantly sandbar willow, gray-green color, dense, penetrable.
***Salix exigua* Temporarily Flooded Shrubland.** (Map Unit 38)



12. Shrubs 1-1.5 m tall, occupying saline clay hardpans, predominantly greasewood, yellow green with white stems, brittle, spiny, cover often between 10 and 25%.
***Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub H.V.** (Map Unit 39)

12. Shrubs not spiny, typically shorter than 1 m tall, occupying a variety of habitats. **(13)**

13. Shrubs of draws, drainages, within river and creek floodplains, gentle slopes, and depressions **(14).**
13. Shrubs of steep scoria slopes, slumps, and fill slopes adjacent to roadways **(15).**

14. Short-statured silver sagebrush shrubs, < 1.5 m tall, occupying shrub savannas (10-25%) within river and creek floodplains, draws, gentle slopes, sagebrush flats, and depressions in relatively open stands. Shrub cover variable.

***Artemisia cana / Pascopyrum smithii* Shrubland.** (Map Unit 31)


14. Short-statured buckbrush shrubs < 0.5 m tall, forming rounded colonies in oxbows, moist drainages, swales, and depressions, and long narrow colonies in upland draws.

***Symphoricarpos occidentlis* Shrubland.** (Map Unit 37)


15. Site supporting predominantly three-leaved sumac shrubs, on steep scoria slopes or scoria ridgelines. Shrub cover is often between 10 and 25%.

***Rhus trilobata / Carex filifolia* Shrub Herbaceous Vegetation.** (Map Unit 35)



15. Site supporting predominantly rabbitbrush, on disturbed substrate, usually cut and fill slopes adjacent to roadways and slumps (rabbitbrush is also a minor component of the Badlands Sparse Vegetation Complex).
***Chrysothamnus nauseousus / Pseudoroegneria spicata* Shrubland**. (Map Unit 33)

16. Site a prairie dog town, replete with burrow mounds and barking critters (except in recently abandoned sites); predominantly weedy native forbs and introduced grasses or western wheatgrass or blue grama.
Blacktailed Prairie Dog Town Grassland Complex. (Map Unit 1)

16. Site not a prairie dog town (no burrow mounds and/or no barking critters), although burrowing activity by other fossorial mammals (pocket gophers, and ground squirrels) and bison wallows may be evident, predominantly upland grasses or grass-like wetland species **(17).**

17. Site predominantly (>70%) introduced/exotic species, especially *Bromus inermis, Poa pratensis, Agropyron cristatum, Cirsium arvense, and Euphorbia esula* **(18)**.
17. Site predominanty native, perennial grass or grass-like species **(19).**

18. Site predominantly (>70%) exotic forbs, especially *Euphorbia esula* and *Cirsium arvense*. Can occupy a wide variety of habitats but more common along the floodplain of the Little Missouri River (especially *Euphorbia esula*) and upland draws and drainages.

***Euphorbia esula* Herbaceous Vegetation.** (Map Unit 10) (Photos on next page)
***Cirsium arvense* - Weedy Forb Great Plains Herbaceous Vegetation.** (Map Unit 11) (Photos on next page)


(Map Unit 10 Photos)


(Map Unit 11 Photos)

18. Site predominantly (>70%) exotic/introduced perennial grasses, along roadways and in abandoned fields, especially *Bromus inermis, Poa pratensis*, and *Agropyron cristatum.*

Introduced Grassland. (Map Unit 17)


Three semi-natural or introduced grassland associations may occur (all in Map Unit 17):
***Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation;**
***Poa pratensis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation;**
***Agropyron cristatum - (Pascopyrum smithii, Stipa comata)* Semi-natural Herbaceous Vegetation.**

19. Sites with saturated to moist soils dominated by cattails, bulrushes or prairie cordgrass and sedges **(20).**
19. Grassland species of upland soils ranging from clayey to sandy range sites and occupying various topol positions **(21).**

20. Sites with saturated to moist soils dominated by cattails and bulrushes.

***Typha* spp. *Great Plains* Herbaceous Vegetation.** (Map Unit 14) (Photo on next page)

(Map Unit 14 photo)

20. Sites with saturated to moist soils dominated by prairie cordgrass and sedges.
***Spartina pectinata* - *Carex* spp Herbaceous Vegetation.** (Map Unit 13).

21. Site on clayey and silty range sites, occupying drainages, valleys, and hillsides; supporting predominantly rhizomatous grasses and some bunchgrasses. **(22).**

21. Site on sandy or very shallow range sites, occupying tables, plains, hilltops, hillsides, depressions, breaks, and slope shoulders; supporting stoloniferous grasses and bunchgrasses, short to tall in height **(23).**

22. Site dominated by western wheatgrass, usually in association with needle-and-thread grass, threadleaf sedge, blue grama, and/or little bluestem.
***Pascopyrum smithii* - *Bouteloua gracilis* - *Carex filifolia* Herbaceous Vegetation.** (Map Unit16)

22. Site dominated by western wheatgrass in association with green needlegrass.
***Pascopyrum smithii* - *Nassela viridula* Herbaceous Vegetation.** (Map Unit16)

23. Site on coarse textured level to nearly level range sites, typically dominated by short to medium tall grasses, such as needle-and-thread, blue grama, threadleaf sedge, and prairie Junegrass.

***Stipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation.** (Map Unit 18)



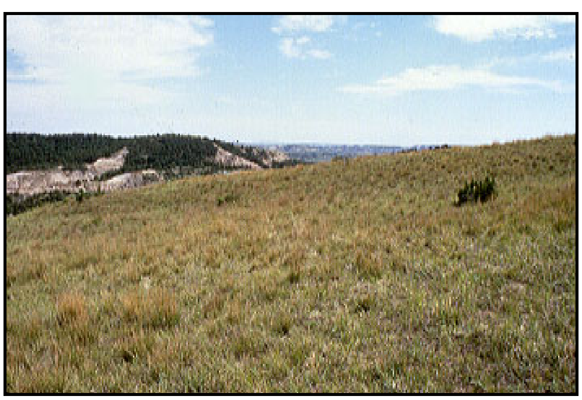
23. Site on sandy range sites along ridge lines associated with upland draws and drainages, hillsopes and broad drainages, dominated by the medium tall grasses prairie sandreed, little bluestem, and sideoats grama. **(24).**

24. Site dominated by prairie sandreed.

***Calamovilfa longifolia / Carex inops ssp. heliophila* Herbaceous Vegetation.** (Map Unit 12)

24. Site dominated by little bluestem.

***Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia* Herbaceous Vegetation**. (Map Unit 15)




APPENDIX H.

Bureau of Reclamation's RSGIG National Parks GIS Database Design, Layout, and Procedures

(Doug Crawford, Jay Carlson; RSGIG, D-8260, USBR; Revised 12-14-99)

(referenced on page 3-11)

Design, Layout, and Procedures for Parks GIS Database Creation
as performed by the Remote Sensing and GIS Group, USBR

I. Background - The mapping projects involve two main stages of work. They are (1) vegetation classification and interpretation and (2), GIS database creation. This document details the GIS database creation process. The first stage involves creation of vegetation classes and then interpreting them from color or color infra-red (CIR) photo positive prints. Mylar overlays are placed on the prints and photo interpretation line work is delineated on the mylars. The line work on the mylars are then transferred into the GIS database as detailed herein.

II. Design and Layout - Each GIS park project directory is set up as follows:

1. Each park project has its own directory. Naming convention for the directory is either the first four letters of its name or the first two letters of the first two words of the park name if the name consists of two or more words.

Example:	Badlands directory name is:	'badl'
	Jewel Cave directory name is:	'jeca'

2. The main project directory consists primarily of directories / workspaces with very few individual files and no coverages/grids. All coverages/grids are located in workspaces below the main project directory.

3. All final coverages for a park are in datum NAD83 and the same UTM zone. If a coverage in NAD27 is needed, the suffix '_d27' is added to the coverage name. For a project which encompasses more than one UTM zone, the final, main coverages will be in one particular zone and if a working coverage in another zone is needed, it is indicated by putting suffix '_z14' (for zone 14) on the coverage name. If there is a need to designate different datum and zone, suffix 'z14d27' is used (for zone 14). This limits the coverage name to 7 characters before the addition of the suffix.

4. Each park project directory may have the following sub-directories and workspaces. Naming convention for coverages should include either the four-letter park name (same as the directory name; ie; for Badlands it is 'badl') or the workspace name (ie: for bndry workspace, covers named 'bndrypark')

amls: This directory contains amls particular to its project. All aml=s associated with the shell menu are not located here - see item 7. below.

aspect: Workspace containing any aspect coverages.
Naming convention: <park>_asp

biology: Workspace containing all coverages related to biological features. This workspace has sub-workspaces named according to associated USGS quads.

In the quad workspaces are the vegetation coverages which are broken down into quarter-quad areas.

Naming convention: biology/<quadname>/<quadname>_veg#
where # indicates the quarterquad area (1,2,3, or 4)

A >base= coverage may exist (biology_base) which is used in creating all the individual quarter-quad ‘veg’ coverages.

If aerial photos will have mylars scanned, each quad biology workspace needs to have a blank coverage named cirtics with is used for transforming arcs into the correct geo-space.

bndry: Workspace containing all boundary coverages.
Naming convention:

bndrypark	(Park boundary coverage)
bndryproj	(GIS project area boundary coverage)
bndryquad	(Boundaries of all the 7.5m quads)
bndrygrds	(Grad- sect boundaries)

data: Workspace containing all data point coverages.
Naming convention:

dataobsv	(Coverage of observation data points)
dataplot	(Coverage of plot data points)
data_aa	(Coverage of accuracy assessment pnts)

doqq: Directory of all the doqq files.
Naming convention: <quadname>#.bil & .hdr
Note: ‘quadname’ needs to be the same as the attribute of the label point in
The bndryquad coverage.

The ‘# ‘> refers to the quarterquad area as follows:
\# = 1 for the nw quadrant
2 for the ne quadrant
3 for the se quadrant
4 for the sw quadrant

hydro: Workspace containing all hydrological coverages.
Naming convention: <park>_strm (Streams coverage)

manmade: Workspace containing all coverages of non-natural features.
Naming convention: <park>_road
<park>_rail
<park>_bldg

menus: Directory of arc/info aml menus particular to its project. All menus associated with the shell menu are not located here - see item 7. below.

misc: Directory / Workspace containing miscellaneous files and special coverages.

plot: Directory / Workspace containing plot files, grids, etc. and other files needed to make the paper maps.

slope: Workspace for slope coverage.
Naming convention: <park>_slp

soils: Workspace for soils coverages:
Naming convention: soil_park
soil_proj
soil_state

5. Each coverage should be setup for attributing as follows:

<quadname>_veg: Polygon coverage with labels in each polygon with item **'veg_code'** (3 3 I) attributed with the proper vegetation *classification number*; item **'location'** (10 10 c) attributed with either *park* or *buffer*; item **'photo'** (4 4 I) attributed with the *photo number* from which the polygons were derived; and park special items such as prairie dog ['pdog' (2 2 I)] and leafy spurge ['lspr (2 2 I)] identifying attributed with 0 (none) or 1 (yes). Also, the .aat file (for the arcs) should have the **'veg_code'** item and another item that indicates the type of arc called **'digtype'** (2 2 I) with attributes of :

1 = indicates arc derived from heads-up, on screen digitizing.
2 = indicates arc derived from scanning the mylar overlay.
3 = border arc representing edge of GIS study area.
4 = border arc of the quarter-quad.
5 = border arc representing park boundary.

bndrypark: line coverage - no special attributing needed. Exception: THRO has three units (north, middle, south) therefor it is built as a polygon cover with labels in each unit with item **'unit'** (6 6 c) attributed with 'north', 'middle' or 'south'.

bndryproj: line coverage - no special attributing needed. Exception: same as bndrypark for THRO.

bndryquad: polygon coverage with labels in each quad with the following items:
quadname (8 8 c) - abbreviated name for each quad
fullname (20 20 c) - full quadname with 1st letter in caps
Exception: each quad label is also attributed with **'unit'** for THRO (same as bndrypark for THRO).

dataobsv &: dataplot — point coverages of label points with items as follows:
plot_code (3 3 n) with plot number from plot data sheets
veg_code (14 14 c) with veg class text.
type (10 10 c) with broad veg type (eg: woodland)
x-coord and y-coord added with addxy command

6. Special considerations:

6.1 ARC/Info's max. filename length is 13 characters, therefore, base cover names should not exceed 8 characters so '_veg#', '_z##' or '_d##'= (see 6.2, 6.3 below) can be added.

6.2 For Badlands project, the GIS project area encompasses more than one UTM zone, therefore, preliminary coverages may have a suffix on its covername, either '_z13' for zone 13 or '_z14' for zone 14. All final coverages should be in zone 13 and the '_z13' would be dropped from the covername.

6.3 For the Data point coverages, the data points usually were collected using GPS units set to datum NAD27, therefore preliminary coverages may have suffix '_d27' added to distinguish from (final) coverage in datum nad83. CAUTION: If you need coverages in nad27, do not re-project bndryquad into nad27 - the tics will be wrong - need to create identifying a new bndryquad cover from scratch and name it bndryquad_d27.

7. Shell AMLs and MENUs. - At the main login directory, there is a directory called 'shell'. It contains three sub-directories called 'amls', 'menus' , and 'misc'. The 'misc' directory contains miscellaneous files used by the shell amls and menus. The 'amls' and 'menus' directories contain files used by 'shell.aml'. You can use this shell to do most all of your arc/info work. To use it, change directory to the desired project (ie, badl) and type &r shell from the arc prompt. Also, you must have 'shell.aml' in your project directory.

Note, the database setup and naming conventions must be maintained for 'shell.aml' to function properly.

III. Digital Orthophoto Quarter Quads. - The parks projects will be using DOQQ's as the basemap for transfer of information from the aerial photos to the GIS database. The images are stored on CD-ROM's. As mentioned above, the naming convention for the doqq's should be <quadname>#.bil. In addition to the image, there needs to be a world header file and its filename should be <quadname>#.hdr.

The filenames on the CD-ROM's (from USGS) do not match this format and will need to be renamed. The cd-rom's also do not contain the needed .hdr files. The **shell menu** has an AAux Program@ named **'doqqhdr'** that renames the file and creates the .hdr file.

The header file for each bil (.hdr) is a simple text file that is set up (by the above mentioned AML) as follows for display in Arc/Info:

nrows <value> (Number of rows or lines in the image)
ncols <value> (Number of columns or samples in the image)
skipbytes <value> (Old header format = 4 x ncols; new format = ncols)
ulxmap <value> (X-Coordinate of upper left pixel)
ulymap <value> (Y-Coordinate of upper left pixel)
xdim 1 (Size of pixel in x direction in meters)
ydim 1 (Size of pixel in y direction in meters)
nbands 1 (These BIL=s only have one band)

All data for this file can be read from the image file. For the old file format, use program header.exe on DOS machine (note - all ':' must be deleted after the .hdr file is generated). For the new format, USGS has not made an executable file yet to read the header info directly into a text file so you have to read from the image file using the 'more' command at unix prompt.

IV. Registration and Editing Procedures. -

A. Introduction. - Data interpreted from aerial photography must often be joined together in one large file. In most cases these data must be geo-referenced, so that a point in the data can be explicitly associated with a point on the earth=s surface, so that:

1. The point can be located on a map or with a Global Positioning System receiver, for field checking.

2. Area can be measured in hectares, acres, etc. more accurately (since each photo scale varies).

3. Data interpreted on one photograph don't overlap or have gaps with the adjacent photograph, due to distortion in the photograph introduced by aircraft pitch, roll, and yaw as well as elevation change of the aircraft relative to the ground.

There are various ways to enter air photo classification linework onto a geographically registered map base. Three main methods exist: (1) heads-up digitizing, (2) use of a projector such as a Map-o-Graph or Saltzman, and (3) scanning the air photo mylar overlay.

Briefly, heads-up digitizing is a procedure whereby the operator digitizes by hand and eye on a computer terminal screen showing a digital image of an ortho-rectified photo. By looking at similar features on both the aerial photograph from which the classification was made and on the orthophoto, the line drawn on the aerial photo overlay is transferred to the digital image, which is registered to coordinates on the earth. This technique should produce good results except where there is little feature contrast on the ortho, in which case the operator must estimate the shape and location of the linework. Using this technique, a curve on the photo may appear to be a series of short, differently-angled straight line segments, since it is easier to make a curve with a pencil or pen than it is with digitized discrete points. Depending on the density of digitized points, this may or may not be a problem. The analyst may set the digitizing software to calculate a pseudo-curve of many points by inputting as few as three points to define a curve.

The Saltzman or Map-o-Graph is a device which projects the image of an air photo onto a map base (orthophoto, topo quad map, etc.). By adjusting the scale of projection, the operator can match features from one image to the other. The classification lines, projected with the photo, can be traced on the orthophoto hard copy map base. This technique should produce good results if the scale of projection is accurate and the focus is crisp. In some places, the orthophoto can be dark and consequently the projected line to be traced is difficult to see. It can be difficult to get the scale precise enough to do all but a small area, and then either the photo or the map must be shifted to the next small area. The tracing of one line with another introduces an additional (small, the analyst hopes) source of error.

The third technique of scanning involves digital manipulation of the scanned mylar by first converting the scanned image into a line coverage and then geo-referencing the coverage (scale, shift, rotate, and rubber-sheet). It still relies on the human eye, just like the other two, but only for fine-tuning the transfer accuracy, not for the transfer itself. The essential idea is that the air photo overlay has a certain number of scanner inches for a particular distance on the ground; so does the orthophoto. If the scale of the overlay can be adjusted to the scale of the orthophoto, then the lines should match features of the orthophoto without any digitizing or tracing. The shift accounts for the different origin on each photo: approximately 0,0 on the air photo and probably some high number on the orthophoto (whose coordinates are determined by a map projection and grid system). The rotation occurs due to the unlikelihood of perfect alignment of axes between the air photo and the orthophotomap. Finally, the rubber sheeting occurs due to minor error in the scale, shift, and rotate procedures. Even if these things were perfect, there would be distortion in the air photo that has been removed from the orthophotomap, necessitating rubber-sheeting the air photo. Rubber sheeting involves the recording of origin and destination points (i.e., links) and the higher-order mathematical adjustment of locations to best fit the origin points to the new. If many adjustment links are used and are evenly distributed throughout the data, and locations linked actually represent the same place on the earth, the adjustment should be good.

Transfer work for the parks projects will consist of two methods, either heads-up digitizing or scanning. Heads-up digitizing will be used whenever the aerial photo (1) does not include many complicated grassland polygons as these are the most difficult to transfer using heads-up digitizing, and (2) does not differ in time of photography from the doqq by more than a couple of years. This will usually mean photos that have polygon boundaries that are easy to see on the digital ortho image will be transferred using the heads-up method. All others will be scanned as describe below.

IV.B. Scanning Procedures and Techniques.

B.1 Manual Method. -

B.1.1 Mark photocontrol points (i.e., road junctions, farmhouses, boulders, other identifiable small points that don’t move or disappear) on each Mylar. Six control points should be located for best results though a minimum of 4 are required for a projective transform and 3 for an affine transform plus one additional tic if you want an RMS error generated. Mark each control point with sequential ID numbers (Important if using the AML as described below). The control points are found by displaying the DOQQ in an ArcEdit session.

If you use the AML, choose coverage *bndrycirtics* as the editcoverage for displaying the DOQQ. When a control point is found, place (Add) a tic at the location with tic id same as the ID marked on the Mylar. Save *bndrycirtics* with the new tics you just added. Make sure the Tic ID you choose does not already exist in the coverage.

B.1.2 Scan Mylar (into scanner inches). - Both options below are for the Scansmith Scan software either on the color or B&W scanner:

a) Gray scale scan. - Scan as Gray scale, around 300dpi, tif image. This will produce a file about 5Meg in size. Using the Scansmith software, can crop and rotate the image as needed.

b) Line art scan. - Scan as linear, around 400 dpi, tif image, packbits option with the following additional settings:

Threshold:	For graphite line work - 125 to 150
	For green lead - 100
	For red lead - 75
Hysteresis:	7
Dynamic:	4

B.1.3 Use ***imagegrid*** (arc command) to convert scanned image (probably .tif format) into Arc Grid format.

B.1.4 Use ***gridline*** (arc command) to convert grid into arc/info line coverage format. Use the photo number (4 digits) in the arc cover name. Could also use Provec software to convert into line coverage.

B.1.5 In ArcEdit:

a) Edit line coverage fixing badly converted lines, dangles, and extraneous arcs such as those associated with the class numbers that are marked on the Mylars.

b) Add, or move, if necessary, tics until you have five or more tics located at the perimeter of the linework area. Must have at least five tics to do a projective transform.

c) Put labels where photocontrol marks exist on line coverage (with image or grid as backdrop to show marks, if necessary). Idea is to have labels at places that can be seen both on orthophoto and on air photo (the control points mentioned in step 1).

d) Instead of c), you can add tics to the line coverage at the photocontrol points AND a blank coverage in the exact real-world locations as shown on the ortho. Then bypass items B.1.6 and 7 below.

Alternative: Instead of turning the image into a line coverage, use the image as backdrop and digitize over the lines to make a line coverage, thereby avoiding possibly excessive editing of poorly scanable mylars.

B.1.6 Create an empty coverage containing only tics that are located in the real-world location of the photo as follows:

a) Determine scale factor between aerial photo and real-world units. Measure distance between two points on photo and same two points on digital. These points should be chosen such that the line connecting them goes through the center area of the photo, and ideally should not be very close together, nor close to photo edge, nor be greatly different in elevation. These measurements will allow calculation of a rescaling factor, i.e., how many inches on the scan correspond to how many orthophotoquad units on the ground (typically in meters). The approximate number will be 12000/39.37 (air photo nominal scale 1:12,000 divided by 39.37 inches/meter). The actual number will usually be slightly above or below this number.

b) Rescale the line coverage using the scaling factor just calculated. Copy the line coverage AND delete all arcs in the copy coverage. Go into tables or info (in arc), select the .tic file for the copy coverage. Subtract the lowest xtic and ytic values from the xtic and ytic items so that the lower left corner has value 0,0. Then multiply the xtic and ytic items by the rescaling factor. Example:

input tics 1,1; 1,6; 6,1; 6,6
Shift to: 0,0 0,5 5,0 5,5 Multiply by 12,000/39.37: 0,0; 0,1524; 1524,0; 1524,1524

c) Add appropriate x + y offsets to the output copy coverage tics in info, so that you will end up in the approximate neighborhood of your ortho. That is, if the coordinates of the area of interest on your ortho are approximately x=100000 and y=500000, then in info or tables, calculate your x tics to be your x tics + 100000 and your y tics to be your y tics + 50000, in effect shifting the tics.

d) Now you have a copy coverage that is approximately the right size and position. You may want to make a backup copy before transforming. Transform (arc command) the scanned image line coverage to the empty (tics only) copy coverage. Try with the affine (default) option and with the projective (specifically for air photo) option and see which appears better.

B.1.7 Now, in ArcEdit, you may have to rotate or move the coverage for it to line up approximately with the (backdrop) orthophotoquad features. You can use the *multipleselect* command in ArcEdit to select both the labels and the arcs simultaneously for movement/rotation. Don't forget to make your snap distance small so that lines don't snap together inappropriately.

B.1.8 Once things line up approximately (i.e., the best you can get from shift, rotate, & scale), add links from the label locations to the same feature locations on the (backdrop) orthophoto. The more links, the better. Link any additional features you can make out (that are unlikely to have changed) between coverage and orthophotoquad, e.g., sharp points, small ponds, stream junctions, etc. Try to distribute the links throughout the coverage instead of clustering them in one portion. If a point on the cover is already exactly where it's supposed to be and you don't want it to move, put a link of zero displacement (appears square) there. If you have trouble making one, copy it from the outside of the coverage, where outermost zero displacement links were automatically created when the "editfeature link" and "add" commands were selected. Read the arc info documentation on links and rubber sheeting. Make a backup copy of the coverage in case the rubber sheeting doesn't produce accurate results

B.1.9 Use the adjust command in ArcEdit to rubber sheet. Make sure snap distance is very small. If the results are bad, you can issue the oops command and go back (unless you issue a save command first).

B.1.10 Place the completed, converted coverage in the biology directory for final attribution and rubbersheeting to other linework. Naming convention for this coverage should be: p####_arcs where #### is the photo number.

B.2 Automated Method using AML. - Run **LINK** program from the **shell menu**. This AML has been developed to automate the transfer process. The AML incorporates 3 steps as follows:

Step 1 - Establish Control Tics. - Step one starts an arcedit session where you will be adding at least 6 tics that are common 'control' points between the Cir photo and the doqq to a coverage named *cirtics*. Mark these control points on the mylar overlaying the cir photo and 'add' tics in coverage *cirtics* in exact same location as the photo control points marked on the mylar. Make sure tic id matches id on the mylar **AND** that the tic id number does not already exist in the coverage.

Quit and save at this point.

CAUTION: Do Not Build the *CIRTICS* coverage!

Step 2 - Scan the mylar and ftp it to your workspace. The scanned image file (.tif) needs to be in the same workspace as your biology "A_veg" coverage.

Step 3 - Convert Scanned Image. - This session :

a. Converts the scanned image (.tif) into an arc coverage. The program names the coverage ***p####_1_scan***. (the #### refers to the aerial photo number)

b. Starts an arcedit session so you can clean-up the arc coverage (which is not geo-referenced yet, ie, it is in digitizer inches) and add tics (and label points*). First, delete the 'generic' tics that where created when the image was converted into an arc coverage. Second, add tics at the locations that were marked on the mylar. *Third, at the location of each tic you have added, you need to add a label point. Set snapfeature to lab tic (sf lab tic), set the snapping tolerance to a circle surrounding the tic (snapping button on the menu under 'TOLERANCES'), and add labels with the 'add' command. The labels should snap right to the tics. Last, edit line work as needed to clean up dangles and unclosed polygons that may not have come thru during the conversion.

c. Once the arc coverage has tics/labels added and arcs cleaned up, Quit (and save) and you will be asked to transform the coverage. Once the transform completes, the program will ask you to proceed, ie, is the RMS error acceptable. If the RMS is not ok, will need to stop and assess the situation ... otherwise, answer 'yes'. This step creates an intermediate coverage that will be named ***p####_2_xfrm***. (note, xfrm is abbreviation for transform)

d. The next session starts another arcedit session where you will be adding 'links' from the label points to the tics. After the transform, the tics have moved relative to the arcs/labels so this step adds links that will be used to 'adjust' or 'rubber-sheet' the line work according to the new (transformed) tic locations.

The editcover is ***p####_2_xfrm*** and the back cover is ***p####_3_ltic***. NOTE: the program copies the *cirtics* coverage to *p####_3_ltic* at this point. Also, the program sets snapping so that links snap to the tic in *p####_3_ltic*. However, the user needs to set the snapping distance tolerance with the 'snapping' button on the menu. Once you have added links from all the labels to tics, Quit (and save) and you will be asked to 'Adjust' the coverage. If you answer yes, you will be done converting and a coverage named ***p####_4_link*** is created.

e. After the adjust, your arcedit session will display the adjusted coverage. At this point you should bring up the cover's associated DOQQ and veg cover (as a back cover). At this point, you need to examine the coverage for accuracy, ie, how well does the line work match features on the doqq. If everything looks ok and only minor changes are needed to the line work, type '&return' and the program with ask you if the *_4_link* coverage is acceptable. If you answer 'yes', the program will clean _4_link and a new and final coverage name ***p####_final*** is created. If you answer 'no', the program will terminate without creating the *_final* coverage and you will need to start the program again and edit either the *_1_scan* or *_2_xfrm* coverage in order to improve the result achieved in the *_4_link* coverage.

f. After the _final cover is made, the program will pop-up a menu and ask you to kill covers and grids and ask you if you want to edit the _final coverage. If you choose all the defaults, all miscellaneous covers and grids will be deleted and you will be put into and arcedit session for the next step, editing (B.3 below).

<u>B.3 Editing</u>. - The final arc coverage line work should be compared to the doqq and existing "_veg" coverage. The first stage of edge matching should be done here. Bring up the _veg cover as back cover and edit line work as much as possible to match up with the _veg cover. Since some lines in this cover may be 'better' than in the _veg cover, you will need a second stage of edge matching, ie, once you are done editing the _final cover, edit the _veg cover with the _final cover as back cover and match up the rest of the line work. Suggested procedure is as follows:

B.3.1. If you are not using the LINK AML, start an arcedit session and choose the **"_final"** coverage as the edit coverage. (LINK will start this session for you.)

B.3.2. Display the "_veg#" coverage(s) associated with the _final coverage as a back cover. This may involve displaying more that one "_veg#" coverage if the "_final" coverage overlaps into another quarter-quad area.

B.3.3. Edit arcs as needed to match to arcs in the back cover (_veg#). Best edit commands to use are **'snap'**, **'split'**, **'vmove'**, and **'extend'**. You can also display doqq=s to aid in the edge matching (you may need to fill in gaps via 'heads-up digitizing'). This step may show that arcs in the "_final" coverage are better than arcs in the "_veg#' coverage. If so, **save** the current edit coverage and then reverse coverages so that the "_veg#" coverage is the editcover and "_final" is the backcover and edit arcs in "_veg#" to match those in "_final". In addition to edge matching, you may need to move some line work to better match up with the DOQQ since the registration process is not perfect.

B.3.4. At this point, it might be good to move or 'put' any arcs that should be attributed with code 14 (linear wetland feature) into the 'drainage' coverage. You will want to do this before labels are created to avoid having to delete labels that would no longer represent a polygon once these arcs were deleted. Note, code 14 arcs should be deleted once 'put' EXCEPT for those portions that define a unique polygon. Refer to section IV.D below for further information.

B.3.5. If you want to attribute polygons now, make sure **"_final"** is the edit coverage and go to keyboard prompt and type **build**. If the build is successful, it will add labels to each polygon. If the build fails, you will need to quit and save and you will then be prompted to build, clean, or exit. Choose clean. When the clean is done, you will be asked to create labels - hit 'yes'. Return to arcedit and begin attributing the polygon labels (see Section IV.D. below for attributing procedures).

B.3.6. Once all revisions, edge matching, and attributing is done, you will need to merge the _final coverage into the _veg# coverage. Start an arcedit session and select the **"_veg#"** coverage associated with the "_final" coverage as the edit cover. If you need to finish edge matching, do it at this point.

B.3.7. To merge, on the AE menu, there is a button titled **"MENUS"**. Click on it and there will be a list of programs you can run. Choose **'GetFeatures'**. Select the appropriate "_final" coverage from the pop-up list. The program will merge arcs (and labels) from "_final" into the current edit coverage. You will need to do some arc editing at this point to clean up dangles and to connect arcs as needed. Note, if major snapping errors occur after the merge, check the PRECISION on your coverage as you may need to switch to double precision, but this is not likely with these coverages.

B.3.8. After all line work has been edited, you are ready to add labels and attribute. Note that even if you added and attributed labels in the "_final" coverage, there will be 'new' polygons created in the "_veg#" coverage (due to the merge) that will need to have labels added and attributed. To add labels, either (1) go to keyboard prompt and type **build**; or (2), quit and save, build, and create labels from arc, i.e., using the List button on the main menu, go to the appropriate workspace, highlight the coverage you want, and hit the 'Create labels' button on the List menu.

IV.C. On-Screen Digitizing Techniques. - This method, commonly referred to as 'heads-up' digitizing, is used when the operator has determined that scanning is not needed either due to simplicity of the line work or the terrain does not warrant scanning (to much vertical topology or trouble finding control points). This is the preferred method because it typically takes less time than scanning. This process is 'learn as you go' and some areas of discussion are as follows:

C.1 Zoom Factor. - The operator needs to determine a proper zoom factor that they feel most comfortable working at. A rule of thumb is to not be zoomed too far in such that you are being too detailed or zoomed so far out that your polygons (on the map product) look blocky. What you see on the screen vs what you see in front of you on the CIR print (either with or without a magnifier) should be about 1.5:1

C.2 DOQQ Compatibility. - Most of the DOQQ's used are only a couple of years older than the aerail photos. However, some are as much as 5 or 6 years older and heads-up digitizing may be difficult and will require the operator to make line work decisions. This is generally ok but if there is a significant difference between the CIR and DOQQ, get help from the photo-interpreter. Also, there may be drastic changes such as a new road or hydrological differences. The database is to be accurate to the aerial photo, not the DOQQ. Therefore, the print should always be followed. For example; if a pond looks smaller on the photo than on the DOQQ, the photo should be followed.

C.3 Patterns and Shapes. - Once you gain experience with this process, you will be able to digitize not only on stark shade differences between vegetation types, but also on subtle shade differences in the grayscale of the DOQQ that correspond to the polygon/line your are transferring. Sometimes the shading is different for the same class of polygon or something light colored on the CIR is dark on the DOQQ and vis versa. Also, regarding shapes, especially for small polygons, emphasis should be placed on digitizing the general shape. Small details in the line work such as dips and small tight curves will not be visible on the final map (scale 1:12,000).

C.4 Coverage Borders. - The DOQQ that you have displayed should NOT be used to digitize line work outside of the coverage borders. If you are in a location where the CIR photo covers an area outside of your _veg# cover, either stop editing at the border or bring up the DOQQ image associated with that area and continue editing. Note, the arcs outside of your _veg# coverage border can be 'put' to the correct coverage later.

IV.D. Digitizing, Editing, and Attributing.

D.1 Hydrological Features.

D.1.1. - Any drainage that is linear in nature and appears wet and is 10 meters or less in width usually is interpreted on the mylars as a line. These arcs should be attributed with veg_code = 14 and should be 'put' into a coverage named 'drainage'. This coverage is located in the biology workspace. The arcs can be 'put' using the MENUS button on the main AE menu. Select the PutFeatures item and select 'drainage' from the pop-up list. If all the selected arcs can be deleted, select 'delete' from the following pop-up list. The _veg# coverage should not have any arcs attributed with veg_code = 14 EXCEPT if the arc is need to delineate a polygon and therefore can not be deleted. If a drainage is dry and less than 10 meters in width, it is not interpreted/digitized.

D.1.2. - Rivers and drainages wider than 10 meters are interpreted/digitized as polygons. Units that are wet are classified different from those that are not. Therefore, if you have a dry drainage flowing into a wet river, it should be a separate polygon.

D.2 Infrastructure. - Infrastructure that is linear in nature and is 10 meters or less in width are not interpreted as polygons. Instead, they are digitized as arcs and 'put' into special coverages named 'sec_roads', 'railroads', and for Badlands, 'spirit_w'. Use the MENUS button, select PutFeatures, and select the appropriate name from the pop-up list.

D.3 Polygons. - All polygons should have labels. The labels should be attributed with *veg_code, photo, location,* and *pdog* as follows:

'veg_code':	refers to the vegetation or land use classification.
'location' :	refers to polygons that are in the 'park' or outside the park (buffer).
'photo':	refers to the CIR photo number which the polygon was interpreted from.
'pdog', 'lspr':	Some projects need two classifications for veg-code. If a polygon is for example a grassland type and it has prairie dog colony which has not resulted in complete mowing down of the grass, the polygon

would be attributed for its grassland type (veg_code) and '1' for the pdog item which would mean it includes pdog's. Answering 'yes' to the pdog menu item calc's the pdog item to '1'. There is also a leafy spurge (lspr) attribute used in a similar manner if there is lspr associated with a more dominate veg code.

D.4 Arcs. - All arcs should be digitized with *digtype* as follows:

1 = arcs derived from heads-up digitizing.
2 = arcs derived from scanning (Note: the Link program automatically calc's arcs in the "_final' coverage to digtype 2).
3 = arcs representing GIS project area boundary.
4 = arcs for the veg cover border (same as quarter-quad boundary).
5 = arcs representing a park boundary

Note, digtype's 3, 4, and 5 should already be attributed in the _veg# coverage. However, in adding and editing arcs, sometimes the border arcs are over-written when arcs are merged from another coverage or via snapping processes. Therefore, you may need to re-attribute some border arcs.

D.5 Edge Matching. - When working at the border of your _veg# coverage, you will need to make sure that arcs from adjoining coverages are edge matched. The best way to do this is to bring up the adjacent _veg# coverage as a back cover and when adding your line work, make sure it matches to any existing line work in the adjacent coverage. Your arcs should snap to the coverage border and not overextend into the next quarter-quad area. Edge matching for polygon labeling will be done at a later time so you don't have to be concerned about that at this point.

D.6 Attributing. - All of these items can be attributed via the button titled **'ATTR'** on the AE menu. Note: the word 'cal' on the ATTR list means *calculate* which is the ArcEdit command to attribute a label or arc.

D.6.1. There are several ways that one can attribute the labels. What follows is the suggested technique: After new labels have been created, go to the SELECT button on the AE menu and choose 'Sel Photo No' (note, must do a save before this button will recognize the new labels). Select '0' and all the new labels will be highlighted in red. May need to do a 'reselect' if there are other un-attributed labels in the coverage that are not associated with the photo you are working on. Once all the desired labels are selected, can attribute for 'photo no', 'location', and color ($symbol) all at once. Change the color of the labels so they stand out better. The colored labels also indicate that they have been attributed for 'photo_no' and 'location'. Next, select labels randomly for veg_code. Notice that after you calc the veg_code via the menu button, the color of the label point changes to green. This will help you see which labels have been attributed for veg_code and which ones have not.

D.6.2 When digitizing arcs (heads-up method usually), it is beneficial to change the display color of the arcs for two reasons: The color indicates that they are 'done' and they are also easier to see. Sometimes the white lines cannot be seen on top of the DOQQ. The color can be changed using the **$symbol** choice under the **ATTR** button.

<u>D.7. Put Features</u>. - In certain instances you may have arcs (and labels) that fall outside of the "_veg#" cover's boundary when an aerial photo coveres an area that overlapps into another doqq. You will need to 'put' those features into the neighboring "_veg#" coverage as follows:

D.7.1. Select the arcs that need to be moved.

D.7.2. From the **MENUS** button on the AE menu, chose **'PutFeatures'**. You will be asked where you want to put the features via pop-up menus. Select 'other' from the first pop-up list and you will be asked to select a coverage in the present workspace or a different workspace. The program will put the selected features into the selected coverage and then it will ask you if you want to delete the selected features in the current editcover. If the 'put' was successful, answer 'yes'. Do a **save** immediately after putting so as to save the features in the put-to coverage.

D.7.3. If there are any labels that need 'putting', select them and repeat step #2 above.

<u>IV.E. On-Screen QA/QC</u>.

E.1. When attributing for a particular photo or the entire veg coverage is done, there are several quick checks to make sure that all labels have been attributed.

E.1.1. The **'Sel Photo No.'** item under the SELECT button on the AE menu. -. This will display all the photo numbers that have been attributed and will list a '0' if there are any labels that have not been attributed for this item. It also will list all the photo numbers, so if you typed the photo number wrong , that 'wrong' number will show up on the pop-up list so check the entire to list to make sure there are no typo's.

E.1.2. The **'Sel VegCode'** item under the SELECT button on the AE menu. - This will display all the veg codes that have been attributed and will list a '0' if there are any labels that have not been attributed for veg_code. It also will list all the veg_code numbers so if you typed the veg_code number wrong, that 'wrong' number will show up on the pop-up list so check the entire to list to make sure there are no typo's. Note: this button is set for editfeature label so you can not use it check arcs that have been attributed for veg_code.

E.1.3. The **'Sel Location'** item under the SELECT button on the AE menu. - This will display all the location attributes and will list a >blank= for a label that has not been attributed for 'location'. You can also use this button to highlight all the labels that you attributed for in the 'park' or in the 'buffer' to see if you made any mistakes.

E.1.4. Check for node dangles and arcs that have same veg_code for adjacent polygons as follows:

a. With *ef* set to arc, type *sel dangle* and delete or close them off.

b. With *ef* set to arc, type sel lpoly# = rpoly#, highlight the selected arcs (if any), and determine if they should be deleted and polygons combined (don't forget to delete labels of polygons that have been combined with other polygons).

E.2. Once the veg cover is complete, there are two qaqc programs you should run on the entire coverage as follows:

E.2.1. The **'PhotoChk'** item under the MENUS button on the AE menu. - This program checks to see if you attributed all the polygons correctly related to the photo flight-line number. Follow the prompts given by the program. When the program completes, your screen will have the labels highlighted based on flight-line - if there is a 'color' out of place or a label that is still white, it means that label has the wrong photo number or is not attributed at all.

E.2.2. The **'LblError'** item under the MENUS button on the AE menu. - This program checks for label errors, ie, it will check to see that all polygons have a label and/or check to see if there is a polygon that has more than one label - every polygon should have ONE label. NOTE: This program may not run if the coverage needs building - if it fails, quit and save and build the cover (do not do the build in arcedit) and then run the 'LblError' program again. You may notice a lot of polygons that have duplicate labels. This usually arises when you have done some editing where you have deleted or changed a polygon that had a label in it. So whenever you delete an arc (and a polygon), make sure to move or delete the label point associated with any polygon that is altered by the deletion.

V. Maps.

All maps can be generated using the Shell system which utilizes ArcPlot to make the maps. There are two types of maps which are required as a 'final' deliverables to the client. They are the vegetation maps and an index map. Other maps are used for in-house purposes.

A. Vegetation Maps. - There are two phases of map products for the vegetation maps. They are QA/QC and FINAL versions. Both can be produced by selecting the 'Map Plotting' button on the main shell menu. To produce a vegetation map, select 'veg_doqq' from the pop-up list. Next, select either 'qaqc' or 'final' and the program will prompt you for coverage selection.

A.1 QA/QC Map. - This map is used to check the accuracy of the transfer work. The photo-interpreter will review the map and then return it to the technician for any changes. The map will also be used to edge match (to check polygon coding) between different _veg# coverages so do not destroy the map until edge matching has been completed. Note, it probably would be a good idea to keep the marked-up map until the AA is done since some of the review changes may be changes in interpretation.

A.2 Final Map. - This is the map that has the official information presented such as project name, cartographic information, and area (hectare) totals. This map version can be produced to send drafts to the client, otherwise, it only needs to be produced at the end of the project. The Shell program will ask the user if they want to produce a frequency (frq) table. This is used to calculate area totals.

B. Index Map. - This map shows the entire project area and can be used before the project in complete in order to show status of the transfer work. Otherwise, it only needs to be produced at the end of the project.

APPENDIX I.

Metadata
for the
Theodore Roosevelt NP Vegetation Mapping Project
GIS Database

(Created by Doug Crawford, USBR)

(referenced on pp. 3-11 and 4-31)

Theodore Roosevelt National Park, Spatial Vegetation Data Metadata

Identification_Information:
Citation:
Citation_Information:
Originator:
Remote Sensing and GIS Group, Technical Service Center, US Bureau of Reclamation, MC-D8260, POB 25007, Denver CO 80225
Publication_Date: 2000
Title: Theodore Roosevelt NP Vegetation Database
Geospatial_Data_Presentation_Form: map
Series_Information:
Series_Name: USGS-NPS Vegetation Mapping Program
Issue_Identification: Theodore Roosevelt NP
Publication_Information:
Publication_Place: Denver, CO
Publisher: USGS/BRD
Other_Citation_Details: Database created under contract to the USGS/BRD
Online_Linkage: http://biology.usgs.gov/npsveg/index.html
Online_Linkage: http://www.usbr.gov/pmts/rsgis/
Online_Linkage: http://biology.usgs.gov/npsveg/thro/index.html#geospatial_veg_info
Description:
Abstract:
This metadata is for all coverages associated with the vegetation land cover and land use geo-spatial database for Theodore Roosevelt National Park and surrounding areas. The project is authorized as part of the USGS/NPS Vegetation Mapping Program. The program is being administered by the Biological Resources Division (BRD) of the United States Geological Survey (USGS). The USGS/BRD is responsible for overall management and oversight of all ongoing mapping efforts. This mapping effort was performed by the US Bureau of Reclamation's (USBR) Remote Sensing and GIS Group, Technical Service Center, Denver, CO. The vegetation mapping program is part of a larger Inventory and Monitoring (I&M) program started by the National Park Service (NPS) Their website is : http://science.nature.nps.gov/im/
Purpose:
The purposes of the mapping effort are varied and include the following: Provides support for NPS Resources Management; Promotes vegetation-related research for both NPS and USGS/BRD; Provides support for NPS Planning and Compliance; Adds to the information base for NPS Interpretation; and Assists in NPS Operations. The NPS I&M goals are, among others, to map the vegetation of all national parks and monuments and provide a baseline inventory of vegetation.
Supplemental_Information:
The following vegetation and land use classes were mapped for this project: LAND USE: 51 Transportation, Communications, and Utilities; 52 Mixed Urban or Built-up Land; 53 Croplands and Pasture; 54 Seeded Mixed Grass Prairie; 55 Other Agricultural Land; 56 Streams - Rivers; 57 Reservoirs; 58 Beaches and Sandy Areas; 59 Strip Mines, Quarries, and Gravel Pits; and 60 Oil/Gas Well Drill Pads and Roads. VEGETATION: 1 Prairie Dog Town Disturbed Community; 2 Badlands Sparse Vegetation Complex; 3 Scoria Sparse Vegetation Complex; 4 Long-leaved Sagebrush Sparse Vegetation Alliance; 10 Leafy Spurge Herbaceous Alliance; 11 Canada Thistle Herbaceous Alliance; 12 Prairie Sand-reed Grass Herbaceous Alliance; 13 Priarie Cordgrass Temporarily Flooded Herbaceous Alliance; 14 Cattail - Bulrush Semi-permanently Flooded Herbaceous Alliance; 15 Little Bluestem - Sideoats Grama Herbaceous Alliance; 16 Western Wheatgrass Herbaceous Alliance; 17 Introduced Grassland Herbaceous Alliance; 18 Blue Grama Herbaceous Alliance; 30 Horizontal Juniper Dwarf Shrub Alliance; 31 Silver Sagebrush/Western Wheatgrass Shrubland; 33 Rabbitbrush Shrubland Alliance; 35 Three-leaved Sumac Shrubland Alliance; 36 Buffaloberry Shrubland Alliance; 37 Wolfberry Temporarily Flooded Shrubland Alliance; 38 Sandbar Willow Semi-permanently Flooded Shrubland Alliance; 39 Greasewood Temporarily Flooded Shrubland Alliance; 41 Cottonwood - Peachleaf Willow Floodplain Woodland; 42 Cottonwood - Rocky Mtn Juniper Floodplain Woodland; 43 Cottonwood Temporarily Flooded Woodland Alliance; 44 Green Ash - American Elm Woodland Alliance (Draws); 45 Green Ash - American Elm Temporarily Flooded Woodland Alliance; 46 Quaking Aspen Woodland Alliance; 47 Rocky Mountain Juniper Woodland Alliance; and 48 Ponderosa Pine Woodland Alliance.

Time_Period_of_Content:
  Time_Period_Information:
    Multiple_Dates/Times:
      Single_Date/Time:
        Calendar_Date: 199607
      Single_Date/Time:
        Calendar_Date: 199608
  Currentness_Reference: Dates of aerial photography
Status:
  Progress: Complete
  Maintenance_and_Update_Frequency: Unknown
Spatial_Domain:
  Description_of_Geographic_Extent: Theodore Roosevelt NP and surrounding environs
  Bounding_Coordinates:
    West_Bounding_Coordinate: -103.75
    East_Bounding_Coordinate: -103.125
    North_Bounding_Coordinate: 47.75
    South_Bounding_Coordinate: 46.75
Keywords:
  Theme:
    Theme_Keyword_Thesaurus: None
    Theme_Keyword: Land cover
    Theme_Keyword: Land use
    Theme_Keyword: Vegetation
    Theme_Keyword: National Park Service
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: North Dakota
    Place_Keyword: Theodore Roosevelt National Park
    Place_Keyword: Little Missouri River
    Place_Keyword: Little Missouri National Grasslands
    Place_Keyword: Elkhorn Ranch
    Place_Keyword: Medora
Taxonomy:
  Keywords/Taxon:
    Taxonomic_Keyword_Thesaurus: none
    Taxonomic_Keywords: vegetation
    Taxonomic_Keywords: plants
    Taxonomic_Keywords: National Vegetation Classification System
  Taxonomic_System:
    Classification_System/Authority:
      Classification_System_Citation:
        Citation_Information:
          Originator: Anderson, et al
          Publication_Date: 1976
          Title: A Land Use and Land Cover Classification System for Use with Remote Sensor Data
          Geospatial_Data_Presentation_Form: document
          Series_Information:
            Series_Name: Geological Survey Professional Paper
            Issue_Identification: No. 964
          Publication_Information:
            Publication_Place: Washington, DC
            Publisher: US GPO
          Other_Citation_Details: This project used the Level II Land Use Classes
          Online_Linkage: http://biology.usgs.gov/npsveg/classification/index.html
    Taxonomic_Procedures: Sequence of field test data plots, observation plots, and photo-signature observations.
  General_Taxonomic_Coverage:
    Refer to complete listing of mapped plant alliances/associations under Supplemental Information above.
    Taxanomic_Classification:
  Taxonomic_Classification:
    Taxon_Rank_Name: Kingdom
    Taxon_Rank_Value: Plantae
Access_Constraints: None
Use_Constraints:
  Acknowledgment of the USGS/BRD and the USBR/RSGIS Group would be appreciated in products derived

from these data. Any person using the information presented here should fully understand the data collection and compilation procedures, as described in the metadata, before beginning analysis. The burden for determining fitness for use lies entirely with the user.
Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Person: USGS-NPS Vegetation Mapping Program Coordinator
Contact_Organization:
USGS Biological Resources Division, Center for Biological Informatics
Contact_Address:
Address_Type: Physical Address
Address: USGS
Address: Biological Resources Division, CBI
Address: Building 810, Room 8000
City: Denver
State_or_Province: Colorado
Postal_Code: 80225-0046
Country: USA
Contact_Address:
Address_Type: Mailing Address
Address: USGS
Address: Biological Resources Division, CBI
Address: PO BOX 25046, DFC, MS302
City: Denver
State_or_Province: Colorado
Postal_Code: 80225-0046
Country: USA
Contact_Voice_Telephone: (303) 202-4220
Contact_Facsimile_Telephone: 303-202-4229
Contact_Facsimile_Telephone: 303-202-4219 (org)
Contact_Electronic_Mail_Address: gs-b-npsveg@usgs.gov
Browse_Graphic:
Browse_Graphic_File_Name: http://biology.usgs.gov/npsveg/thro/images/throveg.pdf
Browse_Graphic_File_Description: 386 Kbyte
Browse_Graphic_File_Type: PDF
Data_Set_Credit:
Dan Cogan, Doug Crawford, Jean Pennell, Trudy Meyer, Jim Von Loh
Native_Data_Set_Environment: UNIX-ARC/INFO

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
These data have an overall accuracy of 74.3% (71.3% Kappa index) within a 90% confidence interval of 70.3 to 78.3%.
Logical_Consistency_Report:
All polygon features are checked for topology and existence of label points using the ARC/INFO software. Each polygon begins and ends at the same point with the node feature. All nodes are checked for error so that there are no unintentional dangling features. There are no duplicate lines or polygons. All nodes will snap together and close polygons based on a specified tolerance. If the node is not with the tolerance it is adjusted manually. The tests for logical consistency are performed in ARC/INFO using certain commands.
Completeness_Report:
All data that can be photo-interpreted are digitized in accordance with the minimum mapping unit (MMU) of 1/2 hectare. This includes selected features that fall into the NVCS vegetation classification and the Anderson Level II land use classification. Some classes below the MMU are included such as wetlands and grasslands in badlands areas and polygons cut off by other features and borders. Roads (out to visible disturbed ground right-of-way or fence line) and streams/drainages wider than approx 10 meters were digitized as polygons and attributed accordingly. Roads visible on the orthophotos but thinner than 10 meters were digitized as lines. Wet drainages thinner than 10 meters were digitized as lines and attributed with code #14. Dry drainages thinner than 10 meters were not digitized.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
USGS DOQQ's were used as the basemap for this project. The attribute accuracy stated above may

also reflect horizontal positional accuracy.
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report:
This database contains no vertical or elevation data.
Lineage:
Methodology:
Methodology_Type: Field
Methodology_Identifier:
Methodology_Keyword_Thesaurus: None
Methodology_Keyword: Ground Truth
Methodology_Keyword: GPS
Methodology_Keyword: Field Plot
Methodology_Keyword: National Vegetation Classification System
Methodology_Keyword: Anderson Level II
Methodology_Description:
Refer to the steps outlined in Process Description below.
Methodology_Citation:
Citation_Information:
Originator:
Remote Sensing and GIS Group, Technical Service Center, US Bureau of Reclamation, MC-D8260, POB 25007, Denver CO 80225
Publication_Date: 2000
Title: Theodore Roosevelt NP Vegetation Database
Geospatial_Data_Presentation_Form: map
Series_Information:
Series_Name: USGS-NPS Vegetation Mapping Program
Issue_Identification: Theodore Roosevelt NP
Publication_Information:
Publication_Place: Denver, CO
Publisher: USGS/BRD
Other_Citation_Details: Database created under contract to the USGS/BRD
Online_Linkage: http://biology.usgs.gov/npsveg/index.html
Online_Linkage: http://www.usbr.gov/pmts/rsgis/
Source_Information:
Source_Citation:
Citation_Information:
Originator: USGS
Publication_Date: Unknown
Title:
Digital Orthophoto Quarter Quadrangles. See other information below for list.
Geospatial_Data_Presentation_Form: remote-sensing image
Other_Citation_Details:
List of DOQQs used as basemaps for this project (text in parenthesis indicates Arc/Info coverage filename): Bear Butte (bear_bt), Belfield (belfield), Belfield SW (blfld_sw), Buckskin Butte (bkskn_bt), Buffalo Gap Campground (bufgp_cp), Chimney Buttes (chmny_bt), Eagle Draw, Gorham SE & SW (gorhm_se, gorhm_sw), Fryburg, (fryburg), Fryburg NE & NW (frybr_ne, frybr_nw), Ice Box Canyon (icebx_cn), Hanks Gully, Lone Butte (lone_bt), Lone Butte NW (ln_bt_nw), Long X Divide (longx_dv), Medora, Red Wing Creek (rdwng_cr), Roosevelt Creek East & West, Sperati Point (sprti_pt), Stocke Butte (stck_bt), Tepee Buttes (tepe_bts), Tracy Mountain (tracy_mt), Wannagan Creek East & West (wna_cr_e, wna_cr_w), Wolf Coulee (wolf_cle)
Online_Linkage: http://edcsns17.cr.usgs.gov/EarthExplorer/
Source_Scale_Denominator: 12000
Type_of_Source_Media: CD-ROM
Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1991
Ending_Date: 1995
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: None
Source_Contribution: None
Source_Information:
Source_Citation:
Citation_Information:
Originator: USDA-FSA, Aerial Photography Field Office

Publication_Date: 199608
Title: 1:24k Color Aerial Photographs
Geospatial_Data_Presentation_Form: remote-sensing image
Series_Information:
Series_Name: Little Missouri National Grasslands
Issue_Identification: 611089
Publication_Information:
Publication_Place: P.O. Box 30010, SLC, Utah 84130
Publisher: USDA, Farm Service Agency
Other_Citation_Details: See database for photographs used.
Online_Linkage: http://www.apfo.usda.gov/
Source_Scale_Denominator: 24000
Type_of_Source_Media: photographs
Source_Time_Period_of_Content:
Time_Period_Information:
Multiple_Dates/Times:
Single_Date/Time:
Calendar_Date: 199607
Single_Date/Time:
Calendar_Date: 199608
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: None
Source_Contribution: None
Process_Step:
Process_Description:
PHOTO INTERPRETATION: All map classes were interpreted from 1:24,000 scale, color photography flown in July & August 1996. The photographs were acquired from the USDA and were enlarged to 1:12000. Photo-interpretation used the standard identification features such as tone, texture, color, pattern, topographic position, and shadow. In addition, field sample locations and their vegetation descriptions aided in assigning map class to each polygon. Photographs were examined using a stereoscope as needed. Linework was created on mylars placed over the photos. GIS PROCEDURES: The linework on the mylar overlays were transfered into the GIS database by one of two methods, either heads-up digitizing or scanning. METHOD I: Heads-up digitizing will be used whenever the photo does not include many complicated grassland polygons as these are the most difficult to transfer using heads-up digitizing. This will usually mean photos with mostly badlands topography or agricultural lands (i.e., have boundaries that are easy to see on the digital orthophoto image) will be transferred using the heads-up method. Briefly, heads-up digitizing is a procedure whereby the operator digitizes by hand and eye on a computer terminal screen showing a digital image of an ortho-rectified photo. By looking at similar features on both the aerial photograph from which the classification was made and on the orthophoto, the line drawn on the aerial photo overlay is transferred to the digital image, which is registered to coordinates on the earth. This technique should produce good results except where there is little feature contrast on the ortho, in which case the operator must estimate the shape and location of the line work. Using this technique, a curve on the photo may appear to be a series of short, differently-angled straight line segments, since it is easier to make a curve with a pencil or pen than it is with digitized discrete points. Depending on the density of digitized points, this may or may not be a problem. The analyst may set the digitizing software to calculate a pseudo-curve of many points by inputting as few as three points to define a curve. METHOD II: Photos that are too difficult to accurately transfer via heads-up will be scanned, ie, the mylars overlays will be scanned, not the actual photos. Before the mylar is scanned, it will be marked with control points that correspond to visible points on the DOQQ. The GIS software was used to convert the scanned mylar into a geo-referenced coverage which was then attributed and combined with the larger vegetation coverage associated with the quarter quad area. The entire transfer and editing sequence was automated via in-house Arc/INFO AML programs. The final vegetation coverages consist of (1) Quarter-quad, Park, and GIS project area boundary arcs, if applicable, and (2) vegetation polygons. Linear wetland features were put in a separate coverage called 'drainage'. Another step involved heads-up digitizing of roads and railroads visible on the DOQQ in accordance with the criteria discussed above. OTHER DATA: Coverages for the plot and observation data points were created from the plot and observation data sheets. The coordinates on the data sheets were in datum NAD27. Once the coverages were finalized they were reprojected into datum NAD83. The Drainage coverage was created by taking arcs attributed with veg_code = 14 out of the vegetation coverage and 'put' into the drainage coverage.
Process_Date: 1999
Process_Contact:
Contact_Information:

Contact_Organization_Primary:
Contact_Organization:
Remote Sensing and Geographic Information Group, USBR
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 25007
City: Denver
State_or_Province: Colorado
Postal_Code: 80225
Country: USA
Contact_Voice_Telephone: 303-445-2267
Contact_Facsimile_Telephone: 303-445-6337
Contact_Electronic_Mail_Address: mpucherelli@do.usbr.gov
Hours_of_Service:
7:00 a.m. to 3:00 p.m. Monday Through Friday, Mountain Time

Spatial_Data_Organization_Information:
Indirect_Spatial_Reference:
Theodore Roosevelt National Park, USGS 7.5 minute quadrangle names
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Label point

Spatial_Reference_Information:
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False_Northing: 0
Scale_Factor_at_Central_Meridian: .9996
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Coordinate_Representation:
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Ordinate_Resolution: 1
Planar_Distance_Units: meters
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Semi-major_Axis: 6378137
Denominator_of_Flattening_Ratio: 298.257

Entity_and_Attribute_Information:
Overview_Description:
Entity_and_Attribute_Overview:
VEGETATION COVERAGES: Due to the large size of the database, vegetation coverages were named according to associated USGS 7.5m quads. Exception; the Elkhorn Ranch Unit coverage is named ranch_veg. Naming convention: <quadname>_veg# with # referring to the quarter quadrant as follows: 1 - Northwest quadrant; 2 - Northeast quadrant; 3 - Southeast quadrant; 4 - Southwest quadrant. Coding Information: Polygon coverage with labels in each polygon with the following custom items: (veg_code - 3 3 I)* coded with vegetation classification number. See Supplemental Info under Id Info above for complete listing of attribute codes and their descriptions; (photo - 6 6 I) coded with associated photo number; (location - 10 10 I) coded according to whether the polygon is in the park or environs (buffer) area; (pdog - 2 2 I) for prairie dog colonies coded with 0 (no pdog holes) or 1 (polygon has pdog holes); and (lspr - 2 2 I) for leafy spurge coded with 0 for none and 1 for polygon has leafy spurge. These last two itens were used to show areas that were not classified as prairie dog colonies or leafy spurge but had substantial pdog use or leafy spurge; Also, each arc was coded as follows: (digtype - 2 2 I)) coded

to identify how the arc was transferred into the database or type of arc as follows: 1 = heads-up, on screen digitizing; 2 = scanned mylar; 3 = arc associated with GIS project border; 4 = arc associated with quarterquad border; 5 = arc associated with park border. (veg_code - 3 3 I) linear wetland features coded with vegetation classification number. Arcs attributed class 14 were extracted and put into a separate (line) coverage named drainage. Some of the class 14 arcs remained in the _veg coverage if it also delineated a unique polygon. BOUNDARY COVERAGES: bndrypark - Park boundary coverage. This coverage was obtained from Theodore Roosevelt National Park Headquarters. bndryproj - GIS mapping project area. bndryquad - Boundaries of all the 7.5m quads. bndrygrds - Grad-sect boundaries. Coding Information: bndrypark - line coverage - no custom attributing. bndryproj - line coverage - no custom attributing. bndryquad - polygon coverage with labels in each quad polygon with the following items: (quadname - 8 8 c) - abbreviated name for each quad; (fullname - 20 20 c) - full quadname. DATA COVERAGES: dataobsv - Point coverage of observation data points. dataplot - Point coverage of plot data points. Coding Information: Label points with items as follows: (plot_code - 3 3 n) coded with plot number from plot data sheets; (veg_code - 14 14 c) coded with veg class text; (type - 10 10 c) coded with broad vegetation class (eg: woodland). Note1: x-coord and y-coord added with ARC/INFO "addxy" command. Note2: Field data points were collected with GPS units set to datum NAD27. All coverages were re-projected into Datum NAD83 so the x- y-coordinates will not match those shown on the data sheets. OTHER COVERAGES: sec_roads - Line coverage of secondary roads digitized from USGS DOQQ. railroads - Line coverage of railroads digitized from USGS DOQQ. The parks projects will be using DOQQ's as the basemap for transfer of information from the photos to the GIS database. The DOQQ's are standard USGS product and are in datum of NAD83. (*) Item definition in the arc/info database.

Entity_and_Attribute_Detail_Citation:
Theodore Roosevelt National Park, USGS/NPS Vegetation Mapping Program, Techincial Memorandum No. 8260-00-04, USBR

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: USGS-NPS Vegetation Mapping Program Coordinator
Contact_Organization: Center For Biological Informatics, USGS/BRD
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 24046, MS-302
City: Denver
State_or_Province: Colorado
Postal_Code: 80225
Country: USA
Contact_Voice_Telephone: 303-202-4259
Contact_Facsimile_Telephone: 303-202-4229
Contact_Facsimile_Telephone: 303-202-4219 (org)
Contact_Electronic_Mail_Address: gs-b-npsveg@usgs.gov
Hours_of_Service: 7:30am to 4:00 pm Mon-Fri, Mountain Time
Resource_Description: Theodore Roosevelt National Park Vegetation Maps
Distribution_Liability:

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Standard_Order_Process:
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        Recording_Format: ISO 9660
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    Digital_Transfer_Information:
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      Online_Option:
        Computer_Contact_Information:
          Network_Address:
            Network_Resource_Name: http://biology.usgs.gov/npsveg/thro/index.html#geospatial_veg_info
  Fees: None

Metadata_Reference_Information:
Metadata_Date: 200001
Metadata_Review_Date: 20071108
Metadata_Contact:
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    Contact_Address:
      Address_Type: mailing and physical address
      Address:
        U.S. Geological Survey, Center for Biological Informatics, MS 302,
        Room 8000, Building 810, Denver Federal Center
      City: Denver
      State_or_Province: Colorado
      Postal_Code: 80225
      Country: USA
    Contact_Voice_Telephone: (303) 202-4220
    Contact_Facsimile_Telephone: (303) 202-4219
    Contact_Electronic_Mail_Address: gs-b-npsveg@usgs.gov
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Metadata_Extensions:
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APPENDIX K.

Mapping Units & NVCS Summaries & Descriptions for THRO

(NVCS Descriptions Created by Jack Butler & Jim Drake
with tables and listings by USBR)

(referenced on pages 4-1, 4-11)

Table of Map Unit Codes, Descriptions, and associated NVCS Names

All map units that end with 'Woodland', 'Shrubland', or 'Grassland' are at the Association level; Other units (ex; 'Complex', 'Alliance', etc) are grouping of associations for more amenable map units.

Map Code	Map Unit Description	NVCS Association or Complex
1	Prairie Dog Town Complex	- Blacktailed Prairie Dog Town Grassland Complex.
2	Badlands Sparse Vegetation Complex	- Badlands Sparse Vegetation Complex; - Eroding Great Plains Badlands; - Artemisia tridentata – Atriplex confertifolia Shrubland; - Artemisia tridentata spp. Wyomingenis / Pascopyrum smithii Shrubland.
3	Scoria Sparse Vegetation Complex	
4	Long-leaved Sagebrush Sparse Vegetation Alliance	- Artemisia longifolia Badlands Sparse Vegetation.
10	Leafy Spurge Herbaceous Alliance	- Euphorbia esula Herbaceous Vegetation.
11	Canada Thistle Herbaceous Alliance	- Cirsium arvense - Weedy Forb Great Plains Herbaceous Vegetation.
12	Prairie Sandreed Grass Herbaceous Alliance	- Calamovilfa longifolia - Carex inops ssp. heliophila Herbaceous Vegetation.
13	Prairie Cordgrass Temporarily Flooded Herbaceous Alliance	- Spartina pectinata - Carex spp. Herbaceous Vegetation.
14	ent Wetland	- Typha spp. Great Plains Herbaceous Vegetation.
15	Little Bluestem - Sideoats Grama Herbaceous Alliance	- Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation.
16	Western Wheatgrass Herbaceous Alliance	- Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation; - Pascopyrum smithii - Nassella viridula Herbaceous Vegetation.
17	Introduced Grassland Herbaceous Alliance	- Agropyron cristatum - (Pascopyrum smithii, Stipa comata) Semi-natural Herbaceous Vegetation; - Poa pratensis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation; - Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation.
18	Needle-and-Thread Herbaceous Alliance	- Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation.
30	Horizontal Juniper Dwarf Shrub Alliance	- Juniperus horizontalis / Schizachyrium scoparium Dwarf-shrubland.
31	Silver Sagebrush / Western Wheatgrass Shrubland	- Artemisia cana / Pascopyrum smithii Shrubland.
33	Rabbitbrush Shrubland Alliance	- Chrysothamnus nauseosus / Pseudoroegneria spicata Shrubland.
35	Three-leaved Sumac Shrubland Alliance	- Rhus trilobata / Carex filifolia Shrub Herbaceous Vegetation.
36	Silver Buffaloberry Shrubland Alliance	- Shepherdia argentea Shrubland.
37	Wolfberry Temporarily-Flooded Shrubland Alliance	- Symphoricarpos occidentalis Shrubland.
38	Sandbar Willow Temporarily-Flooded Shrubland Alliance	- Salix exigua Temporarily Flooded Shrubland.
39	Greasewood Shrub Herbaceous Vegetation	- Sarcobatus vermiculatus / Pascopyrum smithii -

Map Code	Map Unit Description	NVCS Association or Complex
		(Elymus lanceolatus) Shrub Herbaceous Vegetation.
41	Cottonwood - Peachleaf Willow Floodplain Woodland	- Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland.
42	Cottonwood – Rocky Mtn Juniper Floodplain Woodland	- Populus deltoides / Juniperus scopulorum Woodland.
43	Cottonwood Temporarily-Flooded Woodland Alliance	- Populus deltoides Temporarily Flooded Woodland.
44	Green Ash - American Elm Woodland Alliance (Draws)	- Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana Woodland.
45	Green Ash - American Elm Temporarily Flooded Woodland Alliance	- Fraxinus pennsylvanica (Ulmus americana) Woodland Alliance (Floodplain); - Fraxinus pennsylvanica - (Ulmus americana) / Symphoricarpos occidentalis Forest.
46	Quaking Aspen Woodland Alliance	- Populus tremuloides / Prunus virginiana Woodland.
47	Rocky Mountain Juniper Woodland Alliance	- Juniperus scopulorum / Oryzopsis micrantha Woodland.
48	Ponderosa Pine Woodland Alliance	- Pinus ponderosa / Juniperus scopulorum Woodland.
51	Transportation, Communications, and Utilities	- none
52	Mixed Urban or Built-up Land	- none
53	Croplands and Pastures	- none
54	Seeded Mixed Grass Prairie (CRP Lands)	- none
55	Other Agricultural Land	- none
56	Streams and Canals	- none
57	Reservoirs - Open Water	- none
58	Beaches and Sandy Areas Other than Beaches.	- Riverine Sand Flats - Bars Sparse Vegetation.
59	Strip Mines, Quarries, and Gravel Pits	- none
60	Oil/Gas Well Drill Pads and Roads	- none

Hierarchical Summary of NVCS for THRO

NVCS Association and Complex	**Common Name/Synonym**
FOREST & WOODLANDS:	
Fraxinus pennsylvanica - (Ulmus americana) / Symphoricarpos occidentalis Forest	Green Ash - (American Elm) / Western Snowberry Forest
Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana Woodland	Green Ash – American Elm / Choke Cherry Woodland
Fraxinus pennsylvanica (Ulmus americana) Woodland Alliance (Floodplain)	Green Ash - American Elm Woodland Floodplain
Juniperus scopulorum/Oryzopsis micrantha Woodland	Rocky Mountain Juniper / Little-seed Ricegrass Woodland
Pinus ponderosa / Juniperus scopulorum Woodland	Ponderosa Pine / Rocky Mountain Juniper Woodland
Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland	Cottonwood - Peach-Leaf Willow Floodplain Woodland
Populus deltoides / Juniperus scopulorum Woodland	Cottonwood / Rocky Mountain Juniper Woodland
Populus deltoides Temporarily Flooded Woodland	Eastern Cottonwood Woodland
Populus tremuloides / Prunus virginiana Woodland	Trembling Aspen / Choke Cherry Woodland
SHRUBLANDS:	
Artemisia cana / Pascopyrum smithii Shrubland	Silver Sagebrush / Western Wheatgrass Shrub Prairie
Artemisia tridentata - Atriplex confertifolia Shrubland	Wyoming Big Sagebrush - Spiny Saltbush Shrubland
Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrubland	Wyoming Big Sagebrush / Western Wheatgrass Shrubland
Chrysothamnus nauseosus / Pseudoroegneria spicata Shrubland	Common Rabbitbrush/Bluebunch Wheatgrass Shrub Prairie
Juniperus horizontalis / Schizachyrium scoparium Dwarf-shrubland	Creeping Juniper / Little Bluestem Dwarf-shrubland
Salix exigua Temporarily Flooded Shrubland	Narrowleaf Willow Temporarily Flooded Shrubland
Shepherdia argentea Shrubland [Provisional]	Silver Buffalo-berry Shrubland
Symphoricarpos occidentalis Shrubland (Provisional)	Western Snowberry Shrubland
HERBACEOUS VEGETATION:	
Blacktailed Prairie Dog Town Grassland Complex	Blacktailed Prairie Dog Town Grassland Complex
Agropyron cristatum - (Pascopyrum smithii, Stipa comata) Semi-natural Herbaceous Vegetation	Crested Wheatgrass - (Western Wheatgrass, Needle-and-Thread Grass) Semi-natural Herbaceous Vegetation
Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation	Smooth Brome - (Western Wheatgrass) Semi-natural Herbaceous Vegetation
Calamovilfa longifolia - Carex inops ssp. heliophila Herbaceous Vegetation	Prairie Sandreed - Long-stolon Sedge Herbaceous Vegetation
Cirsium arvense - Weedy Forb Great Plains Herbaceous Vegetation [Provisional]	Canada Thistle - Weedy Forb Great Plains Herbaceous Vegetation
Euphorbia esula Herbaceous Vegetation	Leafy Spurge Herbaceous Vegetation
Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation	Western Wheatgrass - Blue Grama - Threadleaf Sedge Prairie
Pascopyrum smithii - Nassella viridula Herbaceous Vegetation	Western Wheatgrass - Green Needlegrass Mixedgrass Prairie
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NVCS Association and Complex	**Common Name/Synonym**
HERBACEOUS VEGETATION, continued:	
Poa pratensis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation	Kentucky Bluegrass - (Western Wheatgrass) Semi-natural Herbaceous Vegetation
Rhus trilobata / Carex filifolia Shrub Herbaceous Vegetation	Ill-scented Sumac / Thread-leaved Sedge Shrub Prairie
Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation	Greasewood / Western Wheatgrass Shrub Prairie
Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation	Little Bluestem - (Sideoats Grama, Blue Grama) - Threadleaf Sedge Herbaceous Vegetation
Spartina pectinata - Carex spp. Herbaceous Vegetation	Prairie Cordgrass - Sedge species Herbaceous Vegetation
Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation	Needle-and-Thread - Blue Grama Mixedgrass Prairie
Typha spp. Great Plains Herbaceous Vegetation	Cattail species Great Plains Herbaceous Vegetation
SPARSE VEGETATION:	
Artemisia longifolia Badlands Sparse Vegetation	Longleaf Sage Badlands Sparse Vegetation
Badlands Sparse Vegetation Complex	Badlands Sparse Vegetation Complex
Eroding Great Plains Badlands Sparse Vegetation	Eroding Great Plains Badlands Sparse Vegetation
Riverine Sand Flats - Bars Sparse Vegetation	Riverine Sand Flats - Bars Sparse Vegetation

Index to Detailed NVCS Descriptions:

(Note: Number in parentheses indicates map unit code for THRO)

Juniperus scopulorum/Oryzopsis micrantha Woodland

COMMON NAME	Rocky Mountain Juniper / Little-seed Mountain Ricegrass Woodland
SYNONYM	Rocky Mountain Juniper / Little-seed Ricegrass Woodland
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen Woodland (II.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.A.4.N)
FORMATION	Round-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	JUNIPERUS SCOPULORUM WOODLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM Terrestrial

RANGE

Theodore Roosevelt National Park

Rocky Mountain juniper / little-seed ricegrass woodlands are predominantly found on slopes in both the North and South Units. Such sites occur throughout the scoria hills and in the transition zones of the upland grassland and old river terrace regions. This association is also sometimes found at the upper reaches of north facing hardwood draws in close association with *Fraxinus pennsylvanica.*

Globally

This community is found in southeastern Montana, southwestern North Dakota, western South Dakota, eastern Wyoming, and western and central Nebraska.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Slope and aspect appear to play major roles in the extent and development of these woodlands. The soils on such steep slopes tend to be poorly developed clay, clay loams, and scoria slopes (Girard 1985). This alliance is frequently used by native ungulates (bison, elk, and deer) for lounging. Well-worn trails are common on many sites. Stumps from historic logging were also quite common in many of these woodlands.

Globally

This community typically occurs on moderate to steep (16-70%) north-facing slopes, but can occur on a variety of aspects (Johnston 1987, Von Loh *et al*. 1999). The soils are poorly developed, shallow, loamy sands, sandy loams, and clay loams, sometimes with high gravel content. These woodlands are frequently associated with outcrops of sandstone (DeVelice *et al*. 1995) or scoria and clay slopes (Girard *et al*. 1989).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Juniperus scopulorum, Fraxinus pennsylvanica*
Short Shrub	*Prunus virginiana, Symphoricarpos occidentalis, Rhus trilobata, J. scopulorum*
Herbaceous	*Oryzopsis micrantha, Maianthemum stellatum, Elymus virginicus*

Globally

Stratum	Species
Tree canopy	*Juniperus scopulorum, Juniperus virginiana*
Short shrub	*Rhus trilobata, Symphoricarpos occidentalis*
Forb	*Campanula rotundifolia, Galium boreale, Maianthemum stellatum*
Graminoid	*Oryzopsis micrantha*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Juniperus scopulorum, Oryzopsis micrantha

Globally

Juniperus scopulorum, Juniperus virginiana, Oryzopsis micrantha

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

This community is densely wooded with interlocking canopies of *Juniperus scopulorum*. Mean foliar cover of *J. scopulorum* is about 41%. *Fraxinus pennsylvanica* is a common , but low density associate, especially on the upper reaches of upland draws. *Prunus virginiana* is a frequent understory shrub, often occurring in dense patches. *Oryzopsis micrantha* (= *Piptatherum micranthum*) is the major characteristic herbaceous species. *Smilacina stellata* (= *Maianthemum stellatum*) and a moss (probably *Thuidium abietinum*, Girard 1985) are frequent herbaceous associates.

Globally

This woodland community is dominated by small *Juniperus scopulorum* trees through most of its range, and is replaced by *J. virginiana* and introgressant hybrids in the eastern portion of its range in Nebraska (Kaul *et al*. 1983). Some stands contain *Fraxinus pennsylvanica*. Most of these trees are 10-20 cm dbh and 4-6 meters tall (Nelson 1961, Hansen *et al*. 1984). Some trees can be up to 30-40 cm dbh. The basal area has been reported at 22-29 m^2/ha in North Dakota (Hansen *et al.* 1984) and up to 22-41 m^2/ha in southeastern Montana and northwestern South Dakota (Hansen and Hoffman 1988). Tree canopy is moderate to dense. In North Dakota, Girard *et al*. (1989) measured densities of 975 trees/ha. Where the canopy is dense the shrub and herbaceous strata are poorly developed. Where the canopy is less full, shrubs and herbaceous species are more abundant. On 7 stands in southwest North Dakota mosses and lichens covered 72% of the ground surface, shrubs covered 17.4%; graminoids - 69.1%; forbs - 9.4% (Hansen *et al*. 1984). Three stands in southeastern Montana had less coverage in each strata (Hansen and Hoffman 1988). Among the shrubs that may be found in this community are *Juniperus communis*, *J. horizontalis*, small *J. scopulorum or J. virginiana*, *Mahonia repens*, *Pentaphylloides floribunda*, *Prunus virginiana, Rhus trilobata, Ribes aureum, R. cereum, Rosa woodsii*, *Symphoricarpos albus, and S. occidentalis*. Typical herbaceous species include *Anemone patens, Antennaria microphylla, Campanula rotundifolia*, *Carex inops* ssp. *heliophila*, *Chenopodium fremontii*, *Elymus lanceolatus, E. trachycaulus, Galium boreale*, *Geum triflorum, Koeleria macrantha*, *Oryzopsis micrantha*, *Maianthemum stellatum, Parietaria pensylvanica*, and *Taraxacum officinale*. *Acer negundo* and *Fraxinus pennsylvanica* saplings are sometimes found in depressions where soil and moisture accumulate.

OTHER NOTEWORTHY SPECIES

CONSERVATION RANK G3. A number of sites have been impacted by cutting for fenceposts or railroad ties. Fire suppression may increase the extent of the community within its range.

DATABASE CODE CEGL000747

SIMILAR ASSOCIATIONS

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Pinus ponderosa / Juniperus scopulorum Woodland

COMMON NAME	Ponderosa Pine / Rocky Mountain Juniper Woodland
SYNONYM	Ponderosa Pine / Rocky Mountain Juniper Woodland
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen Woodland (II.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.A.4.N)
FORMATION	Round-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	PINUS PONDEROSA WOODLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM Terrestrial

RANGE
Theodore Roosevelt National Park
This woodland is found in the project area on only one site near Theodore Roosevelt NP.

Globally
The range of this community includes southeastern Montana, eastern Wyoming, southwestern North Dakota, western South Dakota, western Nebraska, and possibly northeastern Colorado. A community of this name has been reported in New Mexico but its present status and similarity to this community is uncertain. In southwestern North Dakota this type is restricted to near the Little Missouri River and its tributaries (Girard *et al*. 1989).

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Pinus ponderosa is the single dominant overstory species on somewhat steep (26-49%) north and northeast facing slopes. This alliance occurred in close association with *Fraxinus pennsylvanica* and *Juniperus scopulorum*.

Globally
This community has been found primarily on slopes between 16-45 percent with a variety of aspects. In the central and southern portions of its range, it is predominantly on dry-mesic north- or east-facing slopes. In more mesic local climates or with heavier soils this community can exist on south-facing slopes. In North Dakota, Girard *et al*. (1989) found *Pinus ponderosa* stands on level to gently sloping (0-15 percent) mostly south-facing slopes. Throughout its range, the type can be found on bedrock of sandstone, limestone, or shale. Soils are usually well-drained, shallow, very stony, clay loams, silt loams, and sandy loams.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Pinus ponderosa, Juniperus scopulorum, Fraxinus pennsylvanica*
Short Shrub	*Prunus virginiana, Pentaphylloides floribunda, Rhus trilobata*
Herbaceous	*Oryzopsis micrantha, Smilacina stellata (=Maianthemum stellatum)*

Globally

Stratum	Species
Tree Canopy	*Pinus ponderosa*
Tree sub-canopy	*Juniperus scopulorum*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Pinus ponderosa, Juniperus scopulorum, Pentaphylloides floribunda, Oryzopsis micrantha

Globally
Juniperus scopulorum, Pinus ponderosa, Schizachyrium scoparium

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Pinus ponderosa is the dominant tree species and is found locally in only one area within the project area on the south side of Interstate 90 at the end of the Medora eastbound exit. The woodland is generally found on mesic, north-facing slopes that support fairly high species richness. *Juniperus scopulorum* is a common associate of the overstory. Almost every shrub species found in the area was recorded in the sampled plots, with *Potentilla fruiticosa* (= *Pentaphylloides floribunda*), *Prunus virginiana*, and *Rhus trilobata* as the principle species.

Globally
This community has a dense to moderately open canopy of *Pinus ponderosa* that is typically 10-20 m high. Most of the trees in the canopy are 20-40 cm dbh (Hoffman and Alexander 1987). *Juniperus scopulorum* forms a subcanopy that is 2-4 m high and is also moderately dense to open. There is usually a shrub layer that contains *Cercocarpus montanus, Rhus trilobata, Symphoricarpos occidentalis*, and *Yucca glauca*. The herbaceous layer is sparse or absent, especially under areas of dense canopy or on very steep, eroding slopes. Total vegetation cover averaged 33 percent in seven stands in southeastern Montana (Brown 1971). Litter can accumulate to a depth of 10 cm or more where conifers are dense (Thilenius *et al*. 1995). Where the herbaceous stratum is present it is dominated by prairie graminoids. These include *Bouteloua curtipendula, B. gracilis, Carex filifolia, Pseudoroegneria spicata*, and *Schizachyrium scoparium*.

CONSERVATION RANK G4. Type is fairly widespread across 4 states, though it is not known to be very extensive in any of its range. Protection status across the range of this type is not known.

DATABASE CODE CEGL000861

SIMILAR ASSOCIATIONS
Juniperus scopulorum / Oryzopsis micrantha Woodland (Stands dominated by both *Pinus ponderosa* and *Juniperus scopulorum*, but with less than 25% *Pinus ponderosa*, are placed in this type.)

Juniperus scopulorum Woodland (is very similar, but the density of *Juniperus scopulorum* is high.)

COMMENTS

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Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana Woodland

COMMON NAME	Green Ash – American Elm / Choke Cherry Woodland
SYNONYM	Green Ash - Elm Woody Draw
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous Woodland (II.B)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.B.2.N)
FORMATION	Cold-deciduous woodland (II.B.2.N.a)
ALLIANCE	FRAXINUS PENNSYLVANICA - (ULMUS AMERICANA) WOODLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM Terrestrial

RANGE

Theodore Roosevelt National Park

This woodland is common throughout Theodore Roosevelt NP where it is usually associated with upland draws and drainages, and moderately steep north and northeast facing slopes.

Globally

This community is reported from Montana, North Dakota, and South Dakota; it is found in four sections of two ecoregion provinces.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Green ash - American elm woodlands are common along upland drainages where they are often found in long, narrow draws. These woodlands can also be found on moderately steep north and northeast facing slopes in close association with *Juniperus scopulorum.* Soils in the draws are generally well developed in the toeslopes and north-facing backslopes (Butler 1983). Soils on south-facing backslopes tend to be dry, shallow, and much less vegetated. These woodlands provide important habitat for a wide variety of wildlife species.

Globally

In western South Dakota and North Dakota, this community occurs in upland ravines and broad valleys or on moderately steep slopes. It also occurs along small permanent or ephemeral streams. In central North Dakota, this community is also found along the north slopes of end moraines or kames and along lakeshores (Williams 1979 and Godfread 1976). On these sites, soil and topography permit greater than normal moisture conditions. In south-central South Dakota this community occurs on steep, north-facing escarpments and around boulder outcrops. In the western Dakotas soils are clay loams, sandy clay loam, silty clay, and sandy loam. Soil pH ranges from 6.3 to 7.5 in South Dakota, while soils in North Dakota have pH of 6.0-8.1. Slopes range from 0 to 40 percent. In south-central South Dakota soils are dry to moist, and moderately drained (Hansen and Hoffman 1988, Girard *et al*. 1989).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Fraxinus pennsylvanica, Ulmus americana, Acer negundo*
Short Shrub	*Prunus virginiana, Symphoricarpos occidentalis, Rosa woodsii*
Herbaceous	*Poa pratensis, Carex sprengelii, Galium boreale*

Globally

Stratum	Species
Tree canopy	*Fraxinus pennsylvanica*
Tall shrub	*Prunus virginiana*
Graminoid	*Carex sprengelii*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Fraxinus pennsylvanica, Ulmus americana, Acer negundo, Prunus virginiana, Symphoricarpos occidentalis, Rosa woodsii, Poa pratensis, Carex sprengelii, Galium boreale

Globally

Fraxinus pennsylvanica, Prunus virginiana

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Fraxinus pennsylvanica is the dominant tree species (30% mean foliar cover) with *Ulmus americana* (12% mean foliar cover) and *Acer negundo* (3% mean foliar cover) as secondary species. *Prunus virginiana* is the most common shrub along the shrubby border between the woodland and the associated grassland on the footslope, which is usually in the *Pascopyrum smithii* Herbaceous Alliance. *Shepherdia argentea* sometimes forms a border between woodland and grassland communities along the upper slopes and shoulders on north and east facing draws. Further, the *Calamovilfa longifolia* Herbaceous Alliance and *Schizachyrium scoparium – Bouteloua curtipendula* Herbaceous alliances, usually found on the shoulders of the slopes, often form the boundary between this alliance and the upland grasslands such as the *Stipa comata – Bouteloua gracilis* Herbaceous Alliance. Other common shrubs associated with green ash draws include *Rosa woodsii*, *Rhus trilobata*, and *Amelanchier alnifolia*. Mean foliar cover for the herbaceous layer is about 45% with *Poa pratensis*, *Carex sprengelii*, and *Galium boreale* as the most common species.

Globally

This community is an open to closed canopy woodland dominated by *Fraxinus pennsylvanica. Ulmus americana* sometimes achieves codominance. The largest trees are 50 to 60 cm dbh, but most trees are 20 to 30 cm dbh. In sharply cut, V-shaped upland ravines, the largest trees are near the center or bottom of the ravine where there is greater soil moisture. The average tree age is 70 to 80 years. In undisturbed stands, the understory is composed of two layers. The taller and more conspicuous layer is a shrub layer 2 to 3 m tall. This layer is dominated by *Prunus virginiana* with smaller amounts of *Symphoricarpos occidentalis*. The lower layer is dominated by grasses and sedges such as *Elymus virginicus* and *Carex sprengelii*. Common herbaceous species include *Galium boreale, G. aparine*, and *Maianthemum stellatum*. In central South Dakota this community is a woodland with an open canopy of ash trees and an extremely dense shrubby understory. The average tree height is 6.7 m and the shrub understory is 1.6 m high. There are few herbaceous species (U.S. Army Corp of Engineers 1979). The continuation of the status of *Ulmus americana* as a prominent part of this community is uncertain due to the effects of Dutch Elm disease (Hansen *et al*. 1984, Hansen and Hoffman 1988, Girard *et al*. 1989, Hansen *et al*. 1990).

CONSERVATION RANK G2G3. There are probably fewer than 100 occurrences of this community rangewide. It is reported from Montana (where it is ranked S1Q), North Dakota (SU), and South Dakota (SU). Currently 41 occurrences are documented from North Dakota. Historical acreage and trends are unknown.

DATABASE CODE CEGL000643

SIMILAR ASSOCIATIONS

Acer negundo / Prunus virginiana Forest (may represent a disturbed variant of this type)

Fraxinus pennsylvanica - Ulmus americana / Symphoricarpos occidentalis Forest (may resemble stands which are overgrazed (Girard et al. 1989).)

Fraxinus pennsylvanica / Prunus virginiana Forest

COMMENTS

In Theodore Roosevelt National Park, cattle grazing was common in these stands, as is true elsewhere in the range of this type. In Theodore Roosevelt National Park, bison utilize this habitat for grazing, watering, and summer-time shade (Hansen *et al*. 1984). Past heavy grazing by cattle is reflected in the dominance of some weedy species, such as *Melilotus officinalis, Melilotus alba,* and *Poa pratensis* (Hansen *et al*. 1984).

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Populus tremuloides / Prunus virginiana Woodland

COMMON NAME	Trembling Aspen / Choke Cherry Woodland
SYNONYM	Aspen / Chokecherry Woodland
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous Woodland (II.B)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.B.2.N)
FORMATION	Cold-deciduous woodland (II.B.2.N.a)
ALLIANCE	POPULUS TREMULOIDES WOODLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This aspen woodland is relatively rare in the project area. It is found on only one site in the south unit of Theodore Roosevelt NP.

Globally
This community is found in western North Dakota, southern Manitoba, and possibly in southern Saskatchewan.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Populus tremuloides is the major overstory species on the top of somewhat steep (26-49%) north facing slopes. The occurrence of this alliance is usually associated with sites that receive additional moisture because of enhanced snow catchment. Further, delayed snow melt in the spring tends to produce cold, wet soils that favor development of these stands. *Fraxinus pennsylvanica* is a common lower slope associate.

Globally
In southwestern North Dakota, this community is largely limited to gentle (0-20 percent) slopes on the fringes of other woodlands. The soils are deep (>40 cm) loam, with a pH of 7.2 to 8.0 (Girard et al. 1989). At the eastern edge of its range, this community can be found on dry-mesic to wet-mesic sites and on flat to rolling topography.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Populus tremuloides, Fraxinus pennsylvanica*
Short Shrub	*Prunus virginiana, Symphoricarpos occidentalis*
Herbaceous	*Poa pratensis, Galium boreale*

Globally

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Populus tremuloides, Fraxinus pennsylvanica, Prunus, virginiana

Globally

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
This woodland occurs infrequently in the study area at the top of a few north facing slopes. It is usually contiguous with the *Fraxinus pennsylvanica* – (*Ulmus americana*) Woodland Alliance or the *Juniperus scopulorum* Woodland Alliance, both of which can occur along the lower portions of the same slope. Mean foliar cover for the canopy is about 43%. Most of the *Populus tremuloides* appear to be older individuals with few, if any, new suckers in the understory. The shrub layers are usually fairly diverse with the usual woodland dominants found in the project area (*Prunus virginiana, Symphoricarpos occidentalis*, *Rhus trilobata*, and *Amelanchier alnifolia*). Shrub cover is fairly high (101% mean foliar cover). The herbaceous layer is equally species rich with no clear dominants.

Globally
Across its range, the dominant canopy species in this community is *Populus tremuloides*, often associated with *Fraxinus pennsylvanica. Betula papyrifera* is sometimes present or even codominant (Girard et al. 1989). In the eastern portion of its range, *Quercus macrocarpa* and *Populus grandidentata* are also typical canopy associates. *Populus tremuloides* spreads by root suckering and this can result in high stem density, especially in younger stands. Girard et al. (1989) found 722 stems/ha in southwestern North Dakota. There is a significant shrub layer that is dominated by *Prunus virginiana*. Other common shrub species include *Ribes aureum var. villosum, Amelanchier alnifolia, Symphoricarpos occidentalis, Corylus spp*., and *Rosa spp*. The herbaceous layer is not as well-developed as the shrub layer but is still significant. *Maianthemum stellatum, Galium boreale*, and *Aralia nudicaulis* are typically found in the herbaceous layer.

OTHER NOTEWORTHY SPECIES

CONSERVATION RANK G4G5.

DATABASE CODE CEGL002130

SIMILAR ASSOCIATIONS
COMMENTS
Stands containing Betula occidentalis (22% cover) in the understory at Theodore Roosevelt National Park (Hansen et al. 1984) appear to be a variant of this type;, those stands also contain Prunus virginiana (31% cover). A wet-mesic stand containing Be Fire is necessary to maintain this community, especially in the more mesic eastern portion of its range (MN NHP 1993). The occurrence of these stands on the top of north-facing slopes may result in increased snow catch as the winds blow across the tops of other buttes, while the downslope portions are more sheltered. In the spring, the soils on these tops sometimes remain frozen after the frost has gone out downslope. The cold, wet conditions, which are unfavorable for seed germination, may favor *Populus tremuloides*, which can reproduce by sprouting. Similarly, in the wetter slope positions, the soil may be so saturated as to be unstable for some species. *Populus tremuloides* may act to stabilize these positions, and thereby be succeeded by *Fraxinus pennsylvanica* stands.

REFERENCES

Populus deltoides Temporarily Flooded Woodland

COMMON NAME	Eastern Cottonwood Woodland
SYNONYM	
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous Woodland (II.B)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.B.2.N)
FORMATION	Temporarily flooded cold deciduous woodland
ALLIANCE	POPULUS DELTOIDES TEMPORARILY FLOODED WOODLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL

USFWS WETLAND SYSTEM   Terrestrial

RANGE
Theodore Roosevelt National Park
This woodland is common along the floodplain of the Little Missouri River throughout Theodore Roosevelt NP.

Globally

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Populus deltoides is the single dominant emergent species of the first and second terrace of the Little Missouri River floodplain. The soils are formed in alluvium on the floodplain and low terraces of the River.

Globally

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

<u>Stratum</u>	<u>Species</u>
Tree Canopy	*Populus deltoides, Juniperus scopulorum, Fraxinus pennsylvanica*
Short Shrub	*Symphoricarpos occidentalis, Prunus virginiana,*
Herbaceous	*Poa pratensis, Bromus inermis*

Globally

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Populus deltoides

Globally

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Large and mature *Populus deltoides* trees that form a distinctive emergent canopy characterize this woodland. Density of smaller *P. deltoides* trees and secondary tree species such as *Fraxinus pennsylvanica* and *Juniperus scopulorum* in the tree and tall shrub layer is low and sometimes even absent. The short shrub component is usually quite diverse with *Symphoricarpos occidentalis* common to infrequent. *Melilotus officinalis* and *Euphorbia esula* (in the South Unit) are common understory species. This alliance is closely associated with the *Artemisia cana* Temporarily Flood Shrubland Alliance, *Populus deltoides / Juniperus scopulorum* Woodland, and the *Populus deltoides – Salix amygdaloides / Salix exigua* Woodland.

Globally

OTHER NOTEWORTHY SPECIES

Populus deltoides / Juniperus scopulorum Woodland

COMMON NAME	Eastern Cottonwood – Rocky Mountain Juniper Floodplain Woodland
SYNONYM	Cottonwood / Rocky Mountain Juniper Woodland
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous Woodland (II.B)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.B.2.N)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b)
ALLIANCE	POPULUS DELTOIDES TEMPORARILY FLOODED WOODLAND ALLLIANCE

CLASSFICATION CONFIDENCE LEVEL

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This woodland community is found along the floodplain of the Little Missouri River throughout Theodore Roosevelt NP.

Globally
This community has been identified only in southwestern North Dakota. It is reported from one ecoregion section.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This alliance is found near the Little Missouri River on more recent alluvium. Soils are poorly developed are typically dominated by sand.

Globally
This woodland community is found on soils with an upper profile of silt loam (0-60 cm) and a lower profile of sandy loam (61-90 cm). These soils developed from alluvial deposits. The pH is circumneutral and there is a high water holding capacity. This community occurs on broad, flat floodplains (Girard et al. 1989).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Populus deltoides, Juniperus scopulorum*
Short Shrub	*Symphoricarpos occidentalis, Prunus virginiana,*
Herbaceous	*Poa pratensis, Bromus inermis*

Globally

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Populus deltoides, Juniperus scopulorum

Globally

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Mean foliar cover for trees found in this woodland is about 46%. *Juniperus scopulorum* is subdominant to *Populus deltoides*. *Juniperus scopulorum*, along with *Fraxinus pennsylvanica*, dominate the tree, tall shrub, and short shrub layers. On some sites, *Fraxinus pennsylvanica* assumes an almost equal status with *Juniperus scopulorum*. The understory is fairly sparse (19% mean foliar cover) and similar to the *Populus deltoides* Temporarily Flooded Woodland Alliance.

Globally
The dominant species in this community is mature *Populus deltoides*. It has three times the cover of the *Juniperus scopulorum*. Small amounts of *Fraxinus pennsylvanica* are often present as small trees and, more commonly, saplings. *Juniperus scopulorum* also occurs as saplings and seedlings but *Populus deltoides* reproduction is very limited. This community is a seral stage that develop into a *Fraxinus pennsylvanica*-dominated system. Hansen et al. (1984) attributed the abundance of *Juniperus scopulorum* to adequate light available to the understory layers of the community as a result of wide spacing of the old *Populus*. ^The prevalence of *Juniperus scopulorum* decreases in the lower layers of this community, while *Fraxinus pennsylvanica* increases. The shrub layer of this

community is composed chiefly of *Rosa woodsii, Symphoricarpos occidentalis*, and small *Juniperus scopulorum*. The herbaceous stratum typically contains *Toxicodendron rydbergii, Elymus canadensis, Melilotus officinalis*, and *Thalictrum dasycarpum*.

CONSERVATION RANK G1G2. There are probably fewer than 20 occurrences of this community rangewide. No occurrences are currently documented. This community is ranked S1S2? in North Dakota, and it is only known from southwestern North Dakota, in one ecoregion section. Many stands have been subject to extensive grazing, and weedy species may predominate.

DATABASE CODE CEGL002152

SIMILAR ASSOCIATIONS

COMMENTS
This type is found closest to the river on young, unstabilized floodplains, where it colonizes the freshly deposited alluvial substrates on the meanders of the streams and rivers. Proceeding away from the river, other later succcessional stages include, in the Little Missouri River drainage, a *Populus deltoides/Fraxinus pennsylvanica* community type (CEGL000658), and a *Fraxinus pennsylvanica - (Ulmus americana) / Symphoricarpos occidentalis* Forest (CEGL002088). As the stream continues to move away from the more recent deposits, the stand may eventually succeed to the Fraxinus pennsylvanica type, a process that could take 100 years (Girard *et a*l. 1989).

REFERENCES

Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland

COMMON NAME	Eastern Cottonwood - (Peachleaf Willow) / Sandbar Willow Woodland
SYNONYM	Cottonwood - Peach-Leaf Willow Floodplain Woodland
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous Woodland (II.B)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.B.2.N)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b)
ALLIANCE	POPULUS DELTOIDES TEMPORARILY FLOODED WOODLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM Terrestrial

RANGE

Theodore Roosevelt National Park

Cottonwood - willow woodlands are typically found on the terrace immediately above the Little Missouri River and sometimes on well stabilized point bars, usually adjacent to the *Salix exigua* Temporarily Flooded Shrubland Alliance and the *Populus deltoides / Juniperus scopulorum* Woodland. This community is probably successional between these two communities.

Globally

This community is found in southern Manitoba, North Dakota, South Dakota, central and western Nebraska, western Kansas, eastern Colorado, and Oklahoma. It may occur in Texas and New Mexico.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

These woodlands occupy the margins of the Little Missouri River in recent alluvium. Poorly developed, sandy soils dominate these sites.

Globally

This community is found along the banks of streams and rivers, usually within 100 feet of the stream channel. It develops on newly deposited alluvium. The soils are predominantly sand, although silt, clay, or loam may be present. Soils are poorly developed. The water table fluctuates with the level of the river or stream and flooding is common, especially in the spring. In Wyoming, height above the stream channel varies from 1.5 to 10 feet (Jones and Walford 1995).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Populus deltoides, Salix amygdaloides*
Short Shrub	*Salix exigua, Symphoricarpos occidentalis*
Herbaceous	*Glycyrrhiza lepidota, Melilotus alba, M. officinalis*

Globally

Stratum	Species
Tree canopy	*Populus deltoides, Salix amygdaloides*
Short shrub	*Salix exigua, Symphoricarpos occidentalis*
Forb	*Ambrosia psilostachya, Glycyrrhiza lepidota, Helianthus petiolaris*
Fern	*Equisetum arvense*
Graminoid	*Carex emoryi, Carex lanuginosa, Pascopyrum smithii, Poa pratensis, Spartina pectinata, Sporobolus cryptandrus*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Populus deltoides, Salix amygdaloides, Salix exigua

Globally

Populus deltoides, Salix amygdaloides, Salix exigua

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Salix amygdaloides is subdominant to *Populus deltoides.* Contribution of short shrubs to the alliance is minimal. The herbaceous layer is fairly species rich with no clear dominants. However, *Glycyrrhiza lepidota, Melilotus alba,* and *M. officinalis* usually appear as the most obvious herbaceous species. This community is probably successional between the *Salix exigua* Temporarily Flooded Shrubland Alliance and the *Populus deltoides / Juniperus scopulorum* Woodland.

Globally
This community has an open canopy 6-12 m tall and typically dominated by *Populus deltoides* and *Salix amygdaloides*, though *Salix amygdaloides* can be absent in some examples of this community. *Fraxinus pennsylvanica* may be present, especially on the upland side of this community, and *Elaeagnus angustifolia* or *Juniperus* spp. may invade some sites. This woodland community has closely spaced shrubs and small trees. *Salix exigua* is usually more abundant along the streamside margins of this community and where the canopy of taller trees is most open, which may occur following a scouring (heavy flood) event. This shrub grows to 2-5 m tall. Other shorter shrubs that can be found are *Symphoricarpos occidentalis* and *Toxicodendron rydbergii*. Graminoids adapted to mesic sites dominate the understory of most sites, the most common species including *Carex emoryi, C. pellita, Elymus canadensis, Hordeum jubatum, Muhlenbergia racemosa, Pascopyrum smithii, Poa pratensis*, and *Spartina pectinata*. Forbs that are frequently abundant in relatively undisturbed sites include *Equisetum arvense* and *Glycyrrhiza lepidota*. Flooding often creates open patches in the herbaceous layer that are available for colonization by nearby species. The floristic composition of these patches is greatly affected by the species that are near and can invade the disturbed areas. Because of the high permeability of the sandy floodplain soils, species typical of upland prairie may invade in addition to annual forbs typical of disturbed sites. Widely distributed species that are adapted to these sites include *Ambrosia psilostachya, Artemisia campestris ssp. caudata, A. ludoviciana, Calamovilfa longifolia, Cenchrus longispinus, Euphorbia serpyllifolia, E. esula, Grindelia squarrosa, Helianthus petiolaris, Heterotheca villosa, Lippia lanceolata, Opuntia macrorhiza, Poa pratensis*, and *Sporobolus cryptandrus*. These sites are prone to invasion by exotic grasses and forbs, the most widely established being *Agrostis stolonifera, Bromus tectorum, Cirsium arvense, Kochia scoparia, Melilotus* spp., *Taraxacum officinale*, and *Tragopogon dubius*.

CONSERVATION RANK G3G4. In the absence of regular flooding, many sites will undergo succession to later seral stages. Many sites are overgrazed and invaded by exotic woody and herbaceous species.

DATABASE CODE CEGL000659

SIMILAR ASSOCIATIONS
Populus deltoides / Panicum virgatum - Schizachyrium scoparium Woodland (may be a subtype of this community whose character is maintained by winter grazing.)

COMMENTS
Populus deltoides/ Panicum virgatum - Schizachyrium scoparium Woodland (CEGL001454) may be a subtype of this community whose character is maintained by winter grazing. Flooding and scouring by sand and ice are common in most examples of this community. During floods, erosion and deposition of material may occur. Drought stress affects shallow-rooted plants when the water table drops. This community is a seral community This type is subject to, and maintained by, periodic flooding. Thirty years post-flood, this type will likely transition into a grassland type, as the cottonwood and willow species do not regenerate (Bellah and Hulbert 1974).

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Fraxinus pennsylvanica - (Ulmus americana) / Symphoricarpos occidentalis Forest

COMMON NAME	Green Ash - American Elm Woodland Floodplain
SYNONYM	
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous Woodland (II.B)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (II.B.2.N)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b)
ALLIANCE	

CLASSFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This woodland occurs sporadically in mesic oxbows, drainages, and depressions along the floodplain of the Little Missouri River, primarily in the North Unit of Theodore Roosevelt NP.

Globally
This type is found primarily in the northwestern Great Plains.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This community is found within the floodplain of the Little Missouri River immediately adjacent to, and often intermixed with, the *Artemisia cana* Temporarily Flooded Shrubland and the *Populus deltoides* Woodland. It appears that flooding of these communities is relatively common, especially in the spring.

Globally
Stands are found on nearly level floodplains and lower terraces of rivers and streams, generally away from the river on older, stabilized sites. The water table may be relatively deep on higher terraces, allowing drier species to establish (Girard et al. 1989). Soils are typically clays or silty clays.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Fraxinus pennsylvanica, Ulmus pumila*
Short Shrub	*Symphoricarpos occidentalis, Artemisia cana*
Herbaceous	*Poa pratensis, Bromus inermis*

Globally

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Fraxinus pennsylvanica, Ulmus pumila

Globally

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Fraxinus pennsylvanica dominates the canopy with *Ulmus pumila* as a secondary species. Ash and elm trees are generally short statured. Typically, a few, large *Populus deltoides* trees may be present as emergents; however, they are generally absent from the lower canopy and shrub layers. *Juniperus scopulorum* is also present, but much less abundant than *Fraxinus pennsylvanica*. *Symphoricarpos occidentalis* is the most common short shrub species while *Poa pratensis* is the most abundant herbaceous species.

Globally
The tree layer is variable in structure, ranging from open (25-50%) to closed (50% or more) canopy. *Fraxinus pennsylvanica* is the leading dominant. In some parts of the range *Juniperus scopulorum* is present in the subcanopy, particularly where the canopy is still open. *Populus deltoides* may be present as an emergent. Emergent *Populus deltoides* may also occur under a canopy of *Fraxinus pennsylvanica*, reflecting a successional shift in some stands (Girard et al. 1989). *Fraxinus pennsylvanica* is common in the

subcanopy and sapling layer, and, in some stands, *Ulmus americana* may be an associate. *Acer negundo* may only be occasionally present in some parts of the range. The dominant shrub is *Symphoricarpos occidentalis*. Other shrub species may be present, including *Cornus sericea, Rosa woodsii*, and *Rhus aromatica*. A variety of herbs may be present, none at high cover values, including *Elymus canadensis, Maianthemum stellatum, Melilotus officinalis, Muhlenbergia racemosa, Parthenocissus vitacea, Poa pratensis, Thalictrum dasycarpum*, and *Toxicodendron rydbergii* (Hansen et al. 1984, Girard et al. 1989).

CONSERVATION RANK G?.

DATABASE CODE CEGL002088

SIMILAR ASSOCIATIONS

COMMENTS

This type is usually found away from the river on older, stabilized floodplains. Proceeding towards the river, other more pioneer successional forest stages may occur, including, in the Little Missouri River drainage, a *Populus deltoides/Fraxinus pennsylvanica* community type (CEGL000658), and a *Populus deltoides/Juniperus scopulorum* woodland community type (CEGL002152). The latter community colonizes the freshly deposited alluvial substrates on the meanders of the streams and rivers. As the stream continues to move away from these deposits, the stand may eventually succeed to the *Fraxinus pennsylvanica* type, a process that could take 100 years (Girard et al. 1989).

REFERENCES

Artemisia cana / Pascopyrum smithii Shrubland

COMMON NAME	Coaltown Sagebrush / Western Wheatgrass Shrubland
SYNONYM	Silver Sagebrush / Western Wheatgrass Shrub Prairie
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen Shrubland (III.A)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.A.4.N)
FORMATION	Temporarily flooded microphyllous shrubland (III.A.4.N.c)
ALLIANCE	ARTEMISIA CANA TEMPORARILY FLOODED SHRUBLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM Terrestrial

RANGE
Theodore Roosevelt National Park
This community is common along the floodplain and slightly elevated terraces of the Little Missouri River and its major tributaries.

Globally
This community is found in western North and South Dakota, eastern Montana, and is rare in Nebraska.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Silver sagebrush / western wheatgrass shrublands form the prominent and relatively large “sagebrush flats” that occur on nearly flat and gently sloping floodplains, and the slightly elevated terraces along the Little Missouri River and its major tributaries.

Globally
This community occurs on flat alluvial deposits on floodplains, terraces or benches, or alluvial fans. The soils are moderately deep to deep (USFS 1992) and either silt loam, clay loam, or sandy loam (Johnston 1987, Hansen and Hoffman 1988). The soils may have moderate salt content (Hanson and Whitman 1938). Flooding occurs periodically and this tends to retard soil profile development (Hirsch 1985).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Fraxinus pennsylvanica,*
Short Shrub	*Artemisia cana, Symphoricarpos occidentalis, Prunus virginiana,*
Herbaceous	*Pascopyrum smithii, Bromus inermis, Euphorbia esula*

Globally

Stratum	Species
Short Shrub	*Artemisia cana*
Graminoid	*Bouteloua gracilis, Nassella viridula, Pascopyrum smithii*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Artemisia cana, Pascopyrum smithii

Globally
Artemisia cana, Nassella viridula, Pascopyrum smithii

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Artemisia cana is the dominant shrub species with *Pascopyrum smithii* as the major species found in the herbaceous layer. *Symphoricarpos occidentalis* often occurs as dense clones, above and below the minimum mapping size, within this alliance. Cover of *P. smithii* usually decreases in the more dense *Symphoricarpos* patches. *Bouteloua gracilis* tends to increase on portions that appear to be heavily utilized by bison. *Euphorbia esula* and *Bromus inermis* are frequent components. This shrubland is most often bordered by the *Populus deltoides* / *Juniperus scopulorum* Woodland and the *Bromus inermis* Grassland Alliance, the latter usually associated with the park roads.

Globally

This community is dominated by a combination of shrubs and graminoids. The total vegetation cover is typically moderate, but depends on frequency of flooding. The USFS (1992) found that on 14 stands in western North Dakota, shrubs averaged 28 percent canopy cover, graminoids 59 percent, and forbs 2 percent. The tallest and most conspicuous stratum is a shrub layer that is usually 0.6-1.2 m, but it may be as short as 0.4 m or as tall as 1.5 m (Hansen and Hoffman 1988). The variation in soils within and between stands of this community results in variable species composition. *Artemisia cana* and *Pascopyrum smithii* are the dominant shrub and graminoid species, respectively. *Symphoricarpos occidentalis* is frequently present. There are also shorter shrubs such as *Artemisia frigida, Krascheninnikovia lanata, Rosa woodsii*, and *Gutierrezia sarothrae*. The most abundant graminoid is *Pascopyrum smithii*. This species is typically 0.5-1.0 m tall. It is often accompanied by *Nassella viridula* and sometimes *Koeleria macrantha, Poa pratensis*, and *Stipa comata. Bouteloua gracilis* is the most abundant short graminoid. Typical forb constituents of this community are *Achillea millefolium, Gaura coccinea, Sphaeralcea coccinea*, and *Lactuca tatarica* var. *pulchella*.

CONSERVATION RANK G4.

DATABASE CODE CEGL001072

SIMILAR ASSOCIATIONS

COMMENTS

Periodic flooding occurs in many stands of this community.

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Salix exigua Temporarily Flooded Shrubland

COMMON NAME	Narrowleaf Willow Temporarily Flooded Shrubland
SYNONYM	Sandbar Willow Shrubland
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.B.2.N)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d)
ALLIANCE	SALIX EXIGUA TEMPORARILY FLOODED SHRUBLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM Terrestrial

RANGE

Theodore Roosevelt National Park

This shrubland occurs immediately adjacent to the Little Missouri River on the more stabilized point bars. The stands are typically quite small, often occurring below the minimum mapping unit.

Globally

This community is found along rivers and streams in Oregon, Washington, Idaho, Montana, southern Manitoba, Wyoming, Colorado, Oklahoma, Nebraska, South Dakota, and Iowa. It probably extends into North Dakota.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Sandbar willow shrublands occur along stabilized point bars where moist, sandy sediments collect. The sites are level and subirrigated from the Little Missouri River.

Globally

This community is found on recently deposited or disturbed alluvial material. The parent material is alluvial sand, although silt, clay, or gravel may be present. Soil development is poor to absent.

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Populus deltoides*
Short Shrub	*Salix exigua*
Herbaceous	*Melilotus alba, Xanthium strumarium, Spartina pectinata*

Globally

Stratum	Species
Shrub	*Salix exigua*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Salix exigua, Spartina pectinata

Globally

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Salix exigua is the dominant species, usually forming dense cover (>75%) in the tall shrub layer. Several to many young *Populus deltoides* are also found, usually as tall shrubs. *Melilotus alba* and *M. officinalis*, *Xanthium strumarium*, and *Spartina pectinata* are the most common herbaceous species.

Globally

This community is dominated by shrubs, generally between 2 and 4 meters tall. The most common of these is *Salix exigua. Salix irrorata* and saplings of *Populus deltoides* or *Salix amygdaloides* are also frequently found in the shrub layer. This stratum can have moderate to high stem density in the community as a whole. The species in the shrub layer do not form a closed canopy, allowing significant light to reach the ground layer. There are often patches where the shrub layer is absent. The herbaceous cover is sparse to moderate. Older stands and places with less competition from the shrubs have greater herbaceous cover. The composition of the herbaceous layer can vary greatly. Species that are often found in this community are *Cenchrus longispinus, Polygonatum lapathifolium, Scirpus americanus, Triglochin maritimum*, and *Xanthium strumarium*.

CONSERVATION RANK G5. This type is widespread and common throughout its range.

DATABASE CODE CEGL001197

SIMILAR ASSOCIATIONS
Salix exigua / Mesic Graminoids Shrubland (These two types may be essentially the same.)

COMMENTS
In Nebraska, Steinauer and Rolfsmeier (1997) report that *Amorpha fruticosa, Cornus sericea*, and *Salix lutea* are also present in the shrub layer. In the herbaceous layer they report the following species: *Ambrosia artemisiifolia* and *Aster lanceolatus*.

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Symphoricarpos occidentalis Shrubland (Provisional)

COMMON NAME	Western Snowberry Shrubland
SYNONYM	Western Snowberry Shrubland
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.B.2.N)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d)
ALLIANCE	SYMPHORICARPOS OCCIDENTALIS TEMPORARILY FLOODED SHRUBLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM Terrestrial

RANGE

Theodore Roosevelt National Park

Western snowberry, wolfberry, or buckbrush, shrublands are found throughout the project area on a wide variety of topographic situations. The vast majority of the stands are relatively small, often occurring below the minimum mapping unit.

Globally

This community is widespread in western Montana and North Dakota. It is also present in South Dakota, Nebraska, Wyoming, and Saskatchewan.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

These shrublands are common throughout the area in swales, draws, and small depressions. These sites generally receive supplemental moisture in the form of runoff. Western snowberry stands occur in close association, and often intermixed with, a wide variety of vegetation types.

Globally

This community is found in mesic swales, depressions, ravines and floodplains. Some examples of this community experience intermittent and brief flooding. The soils are fertile and well drained to imperfectly drained silts and loams. The upper soil horizon is usually deep, although a thin layer of sand may be present if the site has been recently flooded (Jones 1995).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Fraxinus pennsylvanica*
Short Shrub	*Symphoricarpos occidentalis Prunus virginiana*
Herbaceous	*Pascopyrum smithii, Poa pratensis, Nassella viridula*

Globally

Stratum	Species
Short Shrub	*Symphoricarpos occidentalis*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Symphoricarpos occidentalis, Pascopyrum smithii, Nassella viridula

Globally

Symphoricarpos occidentalis

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Symphoricarpos occidentalis is the dominant species usually forming dense patches that are frequently intermixed with other vegetation types such as the *Artemisia cana – Pascopyrum smithii* within the sagebrush flats area and the *Fraxinus pennsylvanica (Ulmus americana*). Woodland Alliance that occur in upland draws. The *Symphoricarpos occidentalis* alliance also occurs, at or below minimum mapping unit size, in shallow depressions within the *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation. Although a wide variety of species can be found associated within this alliance, *S. occidentalis* usually occurs in such dense patches that abundance of most species is quite low. The most common associates include *Poa pratensis, Pascopyrum smithii*, and *Nassela viridula*.

Throughout its range this community is dominated by shrubs approximately 1 m tall. Shrub cover is typically greater than 50%, and in places it can approach 100%. These shrubs form dense clumps that exclude most other species. *Symphoricarpos occidentalis* is the most common shrub, but *Rhus aromatica* (or *Rhus trilobata*) and *Prunus virginiana* can be locally abundant and can grow to 2-3 meters in places. Herbaceous species and smaller shrubs are most abundant at the edge of this community and in gaps between the clumps of taller shrubs where the shading is less complete. *Rosa woodsii* is a typical smaller shrub. Common graminoids include *Pascopyrum smithii* and *Poa pratensis*. *Achillea millefolium, Artemisia ludoviciana, Galium boreale*, and *Solidago* spp. are common forbs of this community. Woody vines sometimes occur, incl. *Parthenocissus itacea*.

CONSERVATION RANK G4G5. This type is common througout the northen Great Plains. Historically, it may never have been very extensive. It has been observed to grow out from forest or woodland edges and shade out the grasses. It is tolerant of both grazing and fire (Hansen and Hoffman 1988), and is under no threat from human activities. In some cases, heavily grazed pastures may favor this types. Many examples are somewhat weedy; thus the type is not demonstrably secure.

DATABASE CODE CEGL001131

SIMILAR ASSOCIATIONS
Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana Woodland (Related in terms of habitat; floristically distinct.)

COMMENTS
The *Symphoricarpos occidentalis* shrubland type occurs as thickets thoughout its range. These thickets are surrounded by grasslands or occasionally by tall shrublands (e.g., *Prunus virginana*). *Symphoricarpos occidentalis* Shrublands often have a significant component of exotic species, especially where grazing has been heavy. *Bromus inermis, Cirsium arvense*, and *Poa pratensis* are among the most abundant of these exotics. *Symphoricarpos occidentalis* seems to thrive in disturbed areas (Hansen and Hoffman 1988), especially those subject to disturbance by fire and cattle grazing.

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Juniperus horizontalis / Schizachyrium scoparium Dwarf-shrubland

COMMON NAME	Creeping Juniper / Little Bluestem Dwarf-shrubland
SYNONYM	Creeping Juniper / Little Bluestem Dwarf-shrubland
PHYSIOGNOMIC CLASS	Dwarf-shrubland (IV)
PHYSIOGNOMIC SUBCLASS	Evergreen dwarf-shrubland (IV.A)
PHYSIOGNOMIC GROUP	Needle-leaved or microphyllous evergreen dwarf-shrubland (IV.A.1)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (IV.A.1.N)
FORMATION	Creeping or matted needle-leaved or microphyllous dwarf shrubland (IV.A.1.N.b)
ALLIANCE	JUNIPERUS HORIZONTALIS DWARF-SHRUBLAND ALLIANCE

CLASSFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM Terrestrial

RANGE

Theodore Roosevelt National Park

This dwarf-shrubland is found on somewhat steep (26-49%) north facing scoria slopes. This alliance typically occurs as relatively small patches, usually barely making the minimum-mapping unit. In most cases, the alliance extends across the slopes and shoulders of several adjacent ridges.

Globally

This community is found in South Dakota, North Dakota, southeast, central, and northeastern Montana, and southern Manitoba. Further details of its distribution within these states and province are not available.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Slope, aspect, and soil appear to play a major role influencing the distribution of this shrubland. The community is best developed on steep, north facing slopes with considerable amounts of gravel and scoria near the surface. The slopes appear to be fairly well stabilized because of the relatively continuous mat of cover provided by horizontal juniper.

Globally

Stands occur on moderate to steep slopes, usually on upper slopes (Hansen et al. 1984, USFS 1992). Typically, in the northern plains, stands occur on north and, rarely, west-facing slopes (Johnston 1987), but in Manitoba it is thought to occur on dry south-facing slopes (Greenall 1995). Parent materials are sandstone, siltstone, claystone, and sandy glacial till (USFS 1992). Soil textures include shallow silty loam, sandy loam, or clay loam soil. Hirsch (1985) reported significant amounts of gravel and scoria near the surface.

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree Canopy	*Juniperus scopulorum, Fraxinus pennsylvanica*
Short Shrub	*Prunus virginiana, Pentaphylloides floribunda, Rhus trilobata*
Dwarf Shrub	*Juniperus horizontalis*
Herbaceous	*Schizachyrium scoparium, Calamovilfa longifolia*

Globally

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Juniperus horizontalis, Schizachyrium scoparium

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

These are dwarf shrublands (plants < 30 cm in height) dominated by *Juniperus horizontalis*, which typically forms a continuous mat of vegetation. A wide variety of shrubs are common constituents. The sites may also contain a few, short (< 3 m) *Fraxinus pennsylvanica and Juniperus scopulorum trees. Schizachyrium scoparium* and *Calamovilfa longifolia* is typically found in very close association with *Juniperus horizontalis* on these sites. This alliance is often characterized by exceptionally high species richness, probably the highest in the project area.

Globally

This community is dominated by short shrubs and graminoids. Vegetation cover is moderate to high. The USFS (1992) found that in 11 stands in western North Dakota the average cover of shrubs was 44 percent, graminoids covered 32 percent, and forbs 2 percent. The dominant species is usually *Juniperus horizontalis*, a mat-forming shrub. Other low shrubs include *Artemisia frigida, Pentaphylloides floribunda, Symphoricarpos occidentalis*, and *Rosa arkansana. Rhus trilobata* and *Prunus virginiana* are taller shrubs that may be present. The most abundant graminoid is *Schizachyrium scoparium*. Other common graminoids include *Calamovilfa longifolia, Carex filifolia, Carex inops ssp. heliophila, Carex duriuscula (=Carex eleocharis), Koeleria macrantha*, and *Muhlenbergia cuspidata*. Some of the forbs that are associated with this community are *Anenome patens, Campanula rotundifolia, Comandra umbellata, Echinacea angustifolia, Dalea purpurea, Galium boreale, Senecio plattensis*, and *Linum perenne*. Bare ground may occupy 25-45 percent of the surface (Hirsch 1985).

CONSERVATION RANK G4.

DATABASE CODE CEGL001394

SIMILAR ASSOCIATIONS

COMMENTS

REFERENCES

Blacktailed Prairie Dog Town Grassland Complex

COMMON NAME	Blacktailed Prairie Dog Town Grassland Complex
SYNONYM	Blacktailed Prairie Dog Town Grassland Complex
PHYSIOGNOMIC CLASS	()
PHYSIOGNOMIC SUBCLASS	()
PHYSIOGNOMIC GROUP	()
PHYSIOGNOMIC SUBGROUP	()
FORMATION	()
ALLIANCE	

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

Black-tailed prairie dog (*Cynomys ludovicianus*) towns occur throughout Theodore Roosevelt National Park. They are especially prominent along roadsides in the South Unit. Towns may range in size from about a hectare to several hundred hectares.

Globally

This complex occurs widely throughout the Great Plains of the central United States. The blacktailed prairie dogs (*Cynomys ludovicianus ludovicianus*) occur on the Great Plains and the whitetailed prairie dogs (*Cynomus leucurus*) occur in the Great Basin (Knight 1994). Prairie dog towns historically covered millions of hectares in the Great Plains; currently their towns range in size from tens to hundreds of hectares, with an average density of 10 to 55 animals/ha (Whicker and Detling 1988).

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Prairie dog towns are located on clay, clay loam, silty loam, and sandy loam soils deposited following erosion from adjacent uplands, including badlands formation. The soils are deep and not easily eroded. Towns are found on level sites in the sage brush flats areas, along drainages, in broad valleys, on gentle to moderately sloping hillslopes, and on tables and buttes.

Globally

Prairie dog towns are located on a wide variety of soils, including clay, clay loam, silty loam and some sandy loam soils deposited following erosion from adjacent uplands, including badlands formations. Soils are deep, structured and not easily eroded. This type is found on level sites along drainages, in broad valleys, on gentle to moderately sloping hillslopes, and flats on tables and buttes (Von Loh et al. 1999). Prairie dogs create extensive burrows in their towns. Large volumes of soil are moved, improving filtration, hastening the incorporation of organic matter, facilitating nutrient cycling, and increasing the spatial heterogeneity of vegetation, soils, and other ecosystem components (Knight 1994).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Verbena bracteata, Hedeoma hispida, Dyssodia papposa, Aristida purpurea, Buchloe dactyloides, Pascopyron smithii*

Globally

Stratum	Species
Short Shrub	*Artemisia frigida*
Forb	*Dyssodia papposa*
Graminoid	*Aristida purpurea, Bouteloua gracilis, Buchloe dactyloides, Pascopyrum smithii*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Verbena bracteata, Hedeoma hispida, Dyssodia papposa, Aristida purpurea, Buchloe dactyloides, Pascopyron smithii

Globally

Aristida purpurea, Artemisia frigida, Bouteloua gracilis, Conyza ramosissima, Dyssodia papposa, Hedeoma hispida, Pascopyrum smithii, Verbena bracteata

OTHER SPECIES (GLOBAL)

Stratum	Species

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Although several plant species are consistently found in the prairie dog towns, overall vegetation characteristics are highly variable depending upon size and age of the town and its position on the landscape. The more common patches of vegetation within towns include purple three-awn (*Aristida purpurea*), fetid dogweed (*Dyssodia papposa*), field bindweed (*Convolvulus arvensis*), and large-bract verbena (*Verbena bracteata*). The vegetation in all towns usually tends toward a prostrate growth form because of intensive grazing by prairie dogs and bison. The overall pattern of vegetation appears in relatively concentric zones relating to the outward expansion of town boundaries over time. Foliar cover varies from <25% to almost 100%. Towns located adjacent to roadsides and on the sage brush flats associated with the Little Missouri River often contain more exotic plant species, especially smooth brome (*Bromis inermis*), compared to the more isolated towns. Bison often heavily use towns located near the Little Missouri River.

Globally

Blacktailed prairie dog towns are located in open mixedgrass or shortgrass prairie habitat, and their activity has both direct and indirect effects on the vegetation. The blacktailed prairie dogs keep the surrounding vegetation clipped close to the ground, presumably to improve their ability to detect stalking predators. This clipping gives the impression of a mowed lawn, or overgrazed rangeland. Cover averages between 30 and 80%, but some patches may be 100%. Prairie dogs repeatedly clip and graze plants, rarely allowing shoots to reach full size. Thus, canopy height within the colony is about 5-10 cm, compared to 20-50 cm in nearby, uncolonized grassland (Whicker and Detling 1988). Changes in plant species composition may begin as early as 2 or more years after colonization. Shortgrass species, such as *Bouteloua gracilis* and *Buchloe dactyloides*, and annual forbs, such as become abundant and replace mid-height or tall grasses, such as *Pascopyrum smithii*. Continued heavy grazing may eventually result in complete dominance by a few species of forbs or dwarf shrubs, such as *Artemisia frigida, Dyssodia papposa*, and *Aristida purpurea* (Whicker and Detling 1988). Grazing may even cause genetic shifts within species. The shorter, more prostrate, growth forms of *Pascopyrum smithii* on prairie dog towns have been shown to be more abundant than those away from towns, suggesting that some genotypes within the species may tolerate grazing better than others (Jaramillo and Detling 1988, Whicker and Detling 1988). ^Bison may be attracted to the prairie dog towns, and a series of studies found that bison preferentially graze them (Coppock et al. 1983, Coppock and Detling 1986, Day and Detling 1990). The forage on the colonies is more nutritious than off, with higher nitrogen content and younger shoots, apparently because the animal waste products are deposited there. In turn, the presence of bison waste products further increases the soil fertility and forage quality (Knight 1994). Pronghorns may also prefer the prairie dog towns (Knight 1994). Plant species diversity is increased by the small-scale disturbances caused by the digging of prairie dogs, and animal species diversity may also increase because of the habitat provided for the badger, rattlesnake, burrowing owl, black-footed ferret, and cottontail, in addition to the bison and pronghorn (Knight 1994). ^Prairie dog towns also move over time, expanding and contracting, and, as larger towns can cover thousands of hectares at a time, the effect on the prairie landscape is substantial. ^The plant community types on a prairie dog colony are roughly indicative of the extent of herbivore disturbance and reflect the cumulative impact of grazing intensity, grazing duration, activities of other animals, soil characteristics, and weather (Whicker and Detling 1988). Early stages of the town may have a typical mixed grass or shortgrass prairie type. With continued grazing and age of the town, the composition may shift to a mix of annual species and dwarf-shrubs. These latter stages have not been classified, but are treated here as a complex. Species richness appears to be highest under moderate levels of disturbance, because grass species have not yet begun to disappear, but forb species have begun to increase.

ENVIRONMENTAL CONDITION

Prairie dog towns are located on a wide variety of soils, including clay, clay loam, silty loam and some sandy loam soils deposited following erosion from adjacent uplands, including badlands formations. Soils are deep, structured and not easily eroded. This type is found on level sites along drainages, in broad valleys, on gentle to moderately sloping hillslopes, and flats on tables and buttes (Von Loh et al. 1999). Prairie dogs create extensive burrows in their towns. Large volumes of soil are moved, improving filtration, hastening the incorporation of organic matter, facilitating nutrient cycling, and increasing the spatial heterogeneity of vegetation, soils, and other ecosystem components (Knight 1994).

CONSERVATION RANK G4. This rank has been assigned based on the G4 rank that is currently assigned to the Blacktailed prairie dog itself. However, more careful review of the rank from a community perspective is needed.

DATABASE CODE CECX002003

SIMILAR ASSOCIATIONS

Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation

Pascopyrum smithii - Nassella viridula Herbaceous Vegetation

COMMENTS

REFERENCES

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Badlands Sparse Vegetation Complex

COMMON NAME	Badlands Sparse Vegetation Complex
SYNONYM	Badlands Complex
PHYSIOGNOMIC CLASS	()
PHYSIOGNOMIC SUBCLASS	()
PHYSIOGNOMIC GROUP	()
PHYSIOGNOMIC SUBGROUP	()
FORMATION	()
ALLIANCE	

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

The Badlands Sparse Vegetation Complex occurs throughout Theodore Roosevelt National Park. The formations occur as exposed cliffs, ridges, slopes, narrow gorges, buttes, mounds, fans, and drainages.

Globally

This complex is found in the badlands formations of the western Great Plains of the United States and Canada.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

The area is part of the unglaciated region of Missouri River Plateau. Stratified beds of soft shales, clays, silts, lignite, and sandstone of the Tertiary Tongue River Formation of the Fort Union Group characterize the soils. These soft and highly erodible substrates have been severely dissected by the Little Missouri River and its associated tributaries. The result is a badlands type topography characterized by an intricate maze of gullies and ravines separated by relatively large upland plateaus and small erosional-proof buttes capped by scoria. Topographic relief varies considerably from 30 m at the southern edge of the region to more than 150 m at the northern end. The badlands formations extend for about 180 km along both sides of the River and vary in width from 11 km in the south to 56 km in the north.

Globally

Badlands are produced by a combination of factors, including elevation, type of rainfall, carving action of streams, and a particular material. Badlands are basically a type of mature dissection with a finely-textured drainage pattern and steep slopes. Badlands can only form where the land lies well above its local base level. The land must also be easily erodable, or vegetation cover will stabilize the surface. An arid climate will also discourage vegetation growth and will tend to have infrequent, but torrential, rains with great eroding action. In the Great Plains, the geologic formations forming the badlands complex include Cretaceous shales, Oligocene siltstones, sandstones, and clayey mudstones (Von Loh et al. 1999). The soils in the Great Plains badlands complex are generally poorly consolidated clays with bands of sandstone or isolated conglomerates (Froiland 1990).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Shrub	*Gutierrezia sarothrae, Artemisia tridentata, Atriplex confertifolia, Krascheinnikovia lanata*
Herbaceous	*Sueda depressa, Distichlis spicata*

Globally

Stratum	Species
Short Shrub	*Eriogonum pauciflorum, Gutierrezia sarothrae, Opuntia polyacantha*
Forb	*Atriplex argentea, Cryptantha thyrsiflora, Grindelia squarrosa*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Gutierrezia sarothrae, Artemisia tridentata, Atriplex confertifolia, Krascheinnikovia lanata,
Sueda depressa, Distichlis spicata

Globally
Atriplex argentea, Atriplex canescens, Cryptantha thyrsiflora, Eriogonum pauciflorum, Grindelia squarrosa, *Gutierrezia sarothrae, Opuntia polyacantha*

OTHER SPECIES (GLOBAL)

Stratum	Species
Forb	*Astragalus barrii, Eriogonum visheri, Oenothera cespitosa*

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Foliar cover on the Badlands Sparse Vegetation Complex is usually low, about 5% and rarely exceeds 10%. Plant density and height is quite low on these sites. The least amount of vegetation occurs on the steep, south facing slopes. On these sites, the transition to vegetation types on the lower slopes is fairly abrupt. On other sites, the vegetation may grow in patches and in rows associated with the sedimentary material. Species composition is generally quite consistent across the sites.

Globally
This badlands community complex varies from stands with virtually no vegetation (eroding slopes and badland walls) to stands that may exceed 10% vegetative cover, but more often are less than 5%. On level terrain, the vegetation is relatively evenly distributed, but on steeper slopes and cliffs the vegetation may grow in patches and in rows or seams. Plant species that are nearly always present include the dwarf-shrubs *Eriogonum pauciflorum, Gutierrezia sarothrae, Opuntia polyacantha, Atriplex argentea*, *Cryptantha thyrsifolia*, and the forb *Grindelia squarrosa*. *Atriplex canescens* dwarf-shrubs were observed throughout the type, but were typically short-statured and scattered in distribution (Von Loh *et al.* 1999). *Eriogonum visheri*, a spring annual, is a rare plant found primarily in badlands in the Dakotas (Froiland 1990). *Astragalus barrii* is another uncommon Great Plains species that is associated with these badlands habitats (Froiland 1990).

CONSERVATION RANK G5. This badlands complex is somewhat restricted in distribution, occurring in selected localities where geologic conditions are right for its formation, but it is a rugged, persistent type, with extensive areas protected.

DATABASE CODE CECX002004

COMMENTS
Four associations are currently included in the complex, based on work in South Dakota: CEGL002050, CEGL002195, CEGL002294, CEGL00005270. Other associations may be added with further range-wide review: e.g. CEGL000993.

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Artemisia tridentata - Atriplex confertifolia Shrubland

COMMON NAME	Wyoming Big Sagebrush - Spiny Saltbush Shrubland
SYNONYM	Big Sagebrush - Shadscale
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.A.4.N)
FORMATION	Microphyllous evergreen shrubland (III.A.4.N.a)
ALLIANCE	ARTEMISIA TRIDENTATA SSP. WYOMINGENSIS SHRUBLAND ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

The Wyoming Big Sagebrush - Spiny Saltbush Shrubland is widespread throughout Theodore Roosevelt NP. It occurs as a fairly heterogeneous mixture of vegetation on the sparsely vegetated badlands and many of the slopes and ridges. These shrublands occur in close association with the Badlands Sparse Vegetation Complex and the *Artemisia tridentata* spp. *wyomingensis* / *Pascopyrum smithii* Shrubland.

Globally

This sagebrush shrubland occurs in the northwestern Great Plains (especially in badlands regions).

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

This shrubland is found throughout Theodore Roosevelt NP on moderately steep to steep slopes of nearly all aspects, with the possible exception of steep north facing slopes dominated by *Juniperus scopulorum* and the unvegetated steep south facing slopes. The soils are undeveloped but slightly less eroded than the Badlands Sparse Vegetation Complex.

Globally

Within badlands landscapes this type is found on shallow, heavy-textured, and highly erosive soils, and on terrace/alluvial fan landscapes it is associated with excessively-drained substrates, often of a calcareous nature. Soils have consistently high pH and high conductivity values (within the range found for some *Sarcobatus vermiculatus* communities) and are derived from sedimentary parent materials. In badland settings, occupied slopes range from shallow to steep (>80%) with all aspects represented. For Montana sites the known range of elevation is from 3,000 to 4,700 ft. Landscape position and site parameters have been cursorily described, at best, for the Wyoming and North Dakota occurrences.

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Shrub	*Artemisia tridentata, Atriplex confertifolia, Gutierrezia sarothrae*
Herbaceous	*Pascopyrum smithii, Bouteloua gracilis, Muhlenbergia cuspidata*

Globally

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Artemisia tridentata, Atriplex confertifolia, Gutierrezia sarothrae

Globally

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Species composition of this matrix is generally quite consistent with *Artemisia tridentata* as the major species of varying densities. Total foliar cover usually ranges from 20-40% and the plants are typically less than 0.5 m in height. *Atriplex confertifolia, Gutierrezia sarothrae,* and *Sueda depressa* are the usual secondary shrub species. The herbaceous layer consists primarily of *Bouteloua gracilis, Pascopyrum smithii,* and *Muhlenbergia cuspidata*.

Globally
The visual aspect of this association, especially where it occurs on badlands and eroded surfaces, is often that of a depauperate shrubland. Though shrub canopy cover for the modal expression of the type is less than the 25 percent required for a shrubland descriptor, the cover of all other layers is even less, rendering this type a shrubland. *Atriplex tridentata ssp. wyomingensis* and *Atriplex confertifolia* constitute from 5 to 25 percent combined cover, with *Artemisia tridentata* strongly dominant. In the Bighorn Basin and Bighorn Sedimentary Mountains Sections of Montana, other shrubs with greater than 50 percent constancy (but <5 percent canopy cover) include *Atriplex nuttallii, Sarcobatus vermiculatus, Krascheninnikovia (= Ceratoides) lanata*, and *Chrysothamnus nauseosus*. Subshrubs *Eriogonum brevicaule* and *E. pauciflorum* are relatively constant on a regional basis. There is little consistency to the composition of the herbaceous layer, which varies site to site and evidences regional variation as well. The graminoids constitute the next most abundant component, but their combined cover usually does not exceed 5 percent; those grasses with the highest constancy are *Oryzopsis hymenoides, Stipa comata*, and *Aristida purpurea. Phlox hoodii, Sphaeralcea coccinea* and *Opuntia polyacantha* appear to have the highest constancy values, but seldom exceed 1 percent cover. ^If one accepts the descriptions and data reported in three separate papers (Brown 1971, Knight et al. 1987, DeVelice and Lesica 1993) as representing variants of one given type, then there is considerable vegetation, habitat and geographic variability manifest within this type. This community usually occurs as small patches but ranges to large patches on less precipitous terrain. The eastern Montana badland expressions, as well as those of Bighorn Canyon National Recreation Area, tend to have lower total canopy cover (13 percent average) with widely spaced individuals of the diagnostic species *Artemisia tridentata (ssp. wyomingensis*, G.P. Jones pers. comm. 1998) and *Atriplex confertifolia*. Conversely, the Pryor Mountains expressions average upwards of 30 percent canopy cover for the shrub component alone. A melange of undergrowth forbs is present with the representation depending upon the local flora, however *Opuntia polyacantha* is common to all expressions of the type, as are the grasses, *Oryzopsis hymenoides, Aristida purpurea* and *Stipa comata*.

CONSERVATION RANK G4. Though the type occurs in small patches and its area of occupancy is small, it is apparently secure due to both its inaccessible landscape position, lack of palatable plants and lack of extractable resources.

DATABASE CODE CEGL000993

COMMENTS
If one accepts the two types listed by Brown (1971) as equivalent to this type, then some stands may have *Atriplex confertifolia* as a dominant and *Artemisia tridentata* as the subdominant, and other stands may have them reversed.

REFERENCES

Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrubland

COMMON NAME	Wyoming Big Sagebrush / Western Wheatgrass Shrubland
SYNONYM	Big Sagebrush / Western Wheatgrass Shrubland
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.A.4.N)
FORMATION	Microphyllous evergreen shrubland (III.A.4.N.a)
ALLIANCE	ARTEMISIA TRIDENTATA SSP. WYOMINGENSIS SHRUBLAND ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

Wyoming Big Sagebrush / Western Wheatgrass Shrublands are widely but sporadically distributed throughout Theodore Roosevelt National Park. Typically, these shrublands are found on the nearly level benches associated with the Badlands Sparse Vegetation Complex and on the rounded tops of small buttes.

Globally

This type is found throughout the northern Great Plains.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Stands typically occur on nearly level sites with moderately deep clay, clay loam, and silt loam soils. On south and west facing slopes, the stands are found below steep badlands slopes. Under these conditions, the sites probably receive supplemental moisture in the form of runoff from the adjacent slopes. North and east facing slopes tend to be more mesic and community development is not dependent upon runoff from adjacent slopes.

Globally

Stands occur on gently rolling uplands or upper parts of stream terraces and drainageways. Drier examples may be on more exposed slope positions. Soils are moderately deep clays, clay loam, silt loam and loam. Soil moisture conditions are relatively mesic. Soil pH ranges from 5.8 to 7.8 (Hirsch 1985, Hansen and Hoffman 1988, Thilenius et al. 1995).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Shrub	*Artemisia tridentata, Atriplex confertifolia, Chrysothamnus nauseosus*
Herbaceous	*Pascopyrum smithii,, Stipa comata, Bouteloua gracilis*

Globally

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Artemisia tridentata, Pascopyrum smithii

Globally

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

The shrubs are relatively wide-spaced, less than 0.5 m in height, and usually produce just slightly over 25% foliar cover. Composition of the shrubs consists of *Artemisia tridentata, Atriplex confertifolia, Chrysothamnus nauseosus,* and *Gutierezzia sarothrae.* Foliar cover of the herbaceous is often relatively high. The primary herbaceous species is *Pascopyrum smithii* with *Stipa comata, Bouteloua gracilis,* and *Koeleria macrantha* as the usual secondary species.

Globally

The vegetation contains an open short shrub layer, approximately 0.5 m tall, dominated by microphyllous-leaved shrubs, and a dense herbaceous layer dominated by medium-tall graminoids. Shrub cover averages between 15 and 30% (Hirsch 1985, Hansen and Hoffman 1988, Thilenius et al. 1995). *Artemisia tridentata ssp. wyomingensis* dominates the shrub layer. The dense herbaceous layer has a canopy cover of over 75%. *Pascopyrum smithii* is the leading dominant. Important associates include *Koeleria macrantha, Poa secunda, and Stipa viridula*. In drier or more heavily grazed phases, *Bouteloua gracilis, Stipa comata*, and *Carex filifolia* may be more common, along with the succulent *Opuntia polyacantha*. Forbs contribute low cover, often less than 10%, and are typically of low constancy. More constant species (>50%) include *Artemisia frigida, Sphaeralcea coccinea*, and *Vicia americana*. Grassy leaf litter cover over 75% of the ground; stones and bare soil comprise the remainder. Non-vascular plants are rare (Hirsch 1985, Hansen and Hoffman 1988, Thilenius et al. 1995).

CONSERVATION RANK G4.

DATABASE CODE CEGL001047

COMMENTS
Artemisia tridentata ssp. *wyomingensis* can vary in height from 0.1 m to over 1 m in height.

REFERENCES

Shepherdia argentea Shrubland [Provisional]

COMMON NAME	Silver Buffalo-berry Shrubland
SYNONYM	Buffaloberry Shrubland
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.B.2.N)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d)
ALLIANCE	SHEPHERDIA ARGENTEA TEMPORARILY FLOODED SHRUBLAND ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

The buffaloberry shrubland is scattered as small patches throughout the project area. It is usually best developed on sites grazed by domestic livestock. Stands occur as distinct patches on the upper slopes and shoulders of upland draws.

Globally

This community is found in Colorado, Wyoming, Montana, southern Saskatchewan, and possibly North Dakota.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Silver buffalo-berry shrublands appear most frequently on north and east facing upper slopes and shoulders of upland draws. In some cases, the shrubland forms the upper slope boundary between the *Fraxinus pennslyvanica* (*Ulmus americana*) Woodland and the upland grasslands. The density of *Shepherdia argentea* appears to increase on sites outside Theodore Roosevelt National Park that are grazed by cattle.

Globally

This community is found on stream terraces, rolling uplands, and badlands. It occurs where moisture is more plentiful than on the surrounding landscape, such as in swales, ravines, near streams, and on northwest to east facing slopes (Hansen and Hoffman 1988, DeVelice *et al*. 1995). This trend is more pronounced in Wyoming where Jones and Walford (1995) only found this community near streams and may be less pronounced in Saskatchewan and northern Montana. Soils are loamy sand, sandy loam, silty loam, or loam and are derived from glacial drift, siltstone, or sandstone (USFS 1992, DeVelice *et al*. 1995). This community does not flood often, but some sites show evidence of a high water table (DeVelice *et al*. 1995).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Tree	*Fraxinus pennsylvanica*
Shrub	*Shepherdia argentea, Symphoricarpos occidentalis, Prunus virginiana*
Herbaceous	*Poa pratensis, Pascopyrum smithii*

Globally

Stratum	Species
Shrub	*Shepherdia argentea*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Shepherdia argentea

Globally

Shepherdia argentea

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Shepherdia argentea is the dominant shrub usually about 2 m in height and occurring in distinct patches on the upper slopes and shoulders of upland draws. In some cases, shrub density and over is relatively high making the stands almost impenetrable by large animals. The secondary species associated with *Shepherdia argentea* often reflects a combination of species from adjacent communities (both upland draws and grasslands, for example). The number of shrub species occurring in the shrub layer is often fairly high, with *Symphoricarpos occidentalis* as the most frequent associate. The herbaceous understory is also quite diverse with no obvious dominant species.

Globally

This community is dominated by a moderate to dense canopy of medium-tall shrubs. The most abundant of these, *Shepherdia argentea*, is typically 1.5-3 m tall. Other species commonly found in the shrub layer are *Juniperus horizontalis, Prunus virginiana, Ribes spp., Rhus aromatica, Rosa woodsii*, and *Symphoricarpos occidentalis*. Herbaceous species are not important in this community. Graminoids and forbs may have only half the coverage of the shrub layer (Hansen and Hoffman 1988, USFS 1992). Graminoids include *Poa pratensis, Pascopyrum smithii*, and *Bromus* spp. Common forbs are *Achillea millefolium, Artemisia ludoviciana*, and *Parietaria pennsylvanica*. Litter may accumulate in this community (DeVelice et al. 1995).

CONSERVATION RANK G3G4. The number of occurrences is unknown. The community is reported from Montana (where it is ranked S3?), Wyoming (?), Colorado (S1), Saskatchewan (S?), and possibly North Dakota (SP).

DATABASE CODE CEGL001128

SIMILAR ASSOCIATIONS
Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana Woodland (The similarity is based on overall composition, but there are few *Fraxinus pennsylvanica* individuals in CEGL001128.)

COMMENTS
Livestock and deer frequent these thickets and and establish numerous trails throughout. The disturbances open the stands for the invasion of such species as *Symphoricarpos occidentalis, Toxicodendron rydbergii, Achillea millefolium*, and *Artemisia ludovicia*.

REFERENCES
DeVelice, R. L., S. V. Cooper, J. T. McGarvey, J. Lichthardt, and P. S. Bourgeron. 1995. Plant communities of northeastern Montana: A first approximation. Montana Natural Heritage Program, Helena, MT. 116 p.

Hansen, P., K. Boggs, R. Pfister. 1991. Classification and management of riparian and wetland sites in Montana. Unpublished draft version prepared for Montana Riparian Association, Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula, MT. 478 pp.

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Jones, G. P., and G. M. Walford. 1995. Major riparian vegetation types of eastern Wyoming. A Report Submitted to the Wyoming Department of Environmental Quality, Water Quality Division. Grant 9-01136. 244 pp.

Kittel, G., R. Rondeau, N. Lederer and D. Randolph. 1994. A classification of the riparian vegetation of the White and Colorado River basins, Colorado. Final report submitted to Colorado Department of Natural Resources and the Environmental Protection Agency. Colorado Natural Heritage Program, Boulder, Colorado. 166 pp.

Kittel, G.M. and N.D. Lederer. 1993. A preliminary classification of the riparian vegetation of the Yampa and San Miguel/Dolores River Basins. Unpublished report prepared for Colorado Department of Health and the Environmental Protection Agency by The Nature Conservancy, Colorado Field Office, Boulder, CO.

Osborn, R., G. Kittel, and M. Reid. 1998. Colorado Riparian Plant Associations and Western States Vegetation Classification. CDROM. U.S. Geological Survey, Mid-Continent Ecology Research Center, Fort Collins, CO.

United States Forest Service. 1992. Draft habitat types of the Little Missouri National Grasslands. Medora and McKenzie Ranger Districts, Custer National Forest. Dickinson, ND.

Chrysothamnus nauseosus / Pseudoroegneria spicata Shrubland

COMMON NAME	Rubber Rabbitbrush / Bluebunch Wheatgrass Shrubland
SYNONYM	Common Rabbitbrush/Bluebunch Wheatgrass Shrub Prairie
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (III.A.4.N)
FORMATION	Microphyllous evergreen shrubland (III.A.4.N.a)
ALLIANCE	CHRYSOTHAMNUS NAUSEOSUS SHRUBLAND ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
Chrysothamnus nauseosus is a common shrub on steep slopes along roadcuts; however, the majority of these sites are below the minimum mapping unit.

Globally
This Common Rabbitbrush shrubland type may occur across the northern Great Plains.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This shrubland is uncommon in Theodore Roosevelt NP and is usually restricted to only a few slumped slopes in the South Unit. The largest stand occurs just below the Painted Canyon Visitors Center.

Globally
As described from the Dakotas, stands occur either on dry, steep slopes along roadcuts or in heavily grazed floodplains.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Tree	*Juniperus scopulorum*
Shrub	*Chrysothamnus nauseosus, Prunus virginiana, Symphoricarpos occidentalis*
Herbaceous	*Pascopyrum smithii, Agropyron trachycaulum, Melilotus officinalis*

Globally

Stratum	Species
Shrub	*Chrysothamnus nauseosus*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Chrysothamnus nauseosus

Globally
Chrysothamnus nauseosus, Pseudoroegneria spicata

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Chrysothamnus nauseosus is the dominant shrub with *Prunus virginiana, Symphoricarpos occidentalis*, and *Juniperus scopulorum* as the usual secondary woody species. Shrub density is generally low and height range from 0.5 to 1 m. Herbaceous cover may be quite high on slumped areas. In contrast, herbaceous cover in stands along roadsides tends to be fairly sparse. *Pascopyrum smithii* is usually the major contributor to the herbaceous layer.

In the Dakotas, the vegetation has an open structure, with clumps of shrubs around 0.5 to 1 m tall scattered over a medium-tall herbaceous layer. *Chrysothamnus nauseosus* is the dominant shrub. Other less common shrubs include *Prunus virginiana* and *Symphoricarpos occidentalis*. The herbaceous layer may contain the graminoids *Elymus trachycaulus* ssp. *trachycaulus* and *Pascopyrum smithii*. Forbs include *Melilotus officinalis*. Stands may contain a variety of other weedy species, such as *Bromus japonicus* and *Bromus tectorum* (Von Loh et al. 1999). Further west, in Montana, the type may occur in entirely natural habitats, and the dominant graminoid is *Pseudoroegneria spicata*.

CONSERVATION RANK G3Q. Type may be weedy (semi-natural) as well as natural, making ranking difficult.

DATABASE CODE CEGL001330

SIMILAR ASSOCIATIONS

COMMENTS

Chrysothamneus nauseosus increases in abundance in heavily grazed floodplain stands of cottonwood (Thilenius *et al*. 1995). Stands in Montana contain *Pseudoroegneria spicata*. It's possible that the weedy stands in South Dakota should not be assigned.

REFERENCES

Lesica, P. and R.L. DeVelice. 1992. Plant communities of the Pryor Mountains. Preliminary Report prepared by the Montana Natural Heritage Program, Helena, MT.

Thilenius, J. F., G. R. Brown, and A. L. Medina. 1995. Vegetation on semi-arid rangelands, Cheyenne River Basin, Wyoming. General Technical Report RM-GTR-263. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 60 pp.

Calamovilfa longifolia - Carex inops ssp. heliophila Herbaceous Vegetation

COMMON NAME	Prairie Sandreed - Long-stolon Sedge Herbaceous Vegetation
SYNONYM	Prairie Sandreed - Sedge Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Tall sod temperate grassland (V.A.5.N.a)
ALLIANCE	CALAMOVILFA LONGIFOLIA HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
These grasslands occupy the sandy ridges of upland draws and hillslopes throughout Theodore Roosevelt NP. The majority of the stands are less than 0.5 ha in size.

Globally
This community is found in 3 ecoregional sections in Wyoming, Montana, North Dakota, South Dakota, and Saskatchewan.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Calamovilfa longifolia grasslands occur most commonly as small, nearly monotypic patches on the coarse-textured soils found on the slopes and shoulders of draws and steep slopes. The soils are, because of their texture and location on the landscpe, well drained.

Globally
Stands are found on gently rolling uplands with little to moderate slopes (typically between 0 and 20%, but occasionally as high as 39%, Hirsch 1985, Hansen and Hoffman 1988). The soils are sand, sandy loam, or loamy sand and there is rarely substantial soil horizon development (Hanson and Whitman 1938). The parent material is sandstone (USFS 1992). Moisture levels may be high deep in the profile.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Calamovilfa longifolia, Carex filifolia*

Globally

Stratum	Species
Graminoid	*Calamovilfa longifolia, Carex filifolia, Carex inops ssp heliophila*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Calamovilfa longifolia, Carex filifolia

Globally
Calamovilfa longifolia, Carex filifolia, Carex inops ssp *heliophila*

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Foliar cover usually ranges between 15 -30% in most stands. *Calamovilfa longifolia* is the dominant species while *Carex filifolia* is the more common associate. *Stipa spartea* occurs less frequently than *C. filifolia* but typically has higher cover values. Species composition of this community can be fairly rich.

Globally
The vegetation structure is somewhat open, with cover averaging 65 percent in parts of its range (USFS 1992). The vegetation is dominated by graminoids, with two strata, one of mid- to tall-grasses, the other of dense short sedges. In the taller grass layer, the most abundant species is *Calamovilfa longifolia*. Other species found in this layer include *Koeleria macrantha, Schizachyrium scoparium*, and *Stipa comata*. *Pascopyrum smithii* may be present on some stands with finer soil textures. The short graminoid layer

is composed chiefly of *Carex filifolia* and *Carex inops ssp. heliophila*, which may have high cover values. Other upland Carices, such as *Carex duriuscula (=Carex eleocharis)*, as well as *Bouteloua gracilis* and *Muhlenbergia pungens*, may also be present. Forb species diversity is moderate, but they do not contribute greatly to the cover (Hanson and Whitman 1938, USFS 1992). The forbs that are typical of this community include *Artemisia dracunculus, Artemisia frigida, Artemisia ludoviciana, Chenopodium album, Chenopodium leptophyllum, Lathyrus spp., Liatris punctata, Lygodesmia juncea, Phlox hoodii*, and *Psoralidium lanceolatum*. Shrubs are uncommon. When shrubs are present they are short shrubs such as *Yucca glauca, Rosa spp*., and *Artemisia frigida* (a shrub by some authors; also listed as a forb above).

CONSERVATION RANK G3. No occurrences have been documented, but the community is reported in 3 ecoregional subsections in Wyoming, Montana, North Dakota, South Dakota, and Saskatchewan. It is a very uncommon community in Badlands National Park, South Dakota.

DATABASE CODE CEGL001471

SIMILAR ASSOCIATIONS
Calamovilfa longifolia - Stipa comata Herbaceous Vegetation

COMMENTS

REFERENCES
Hansen, P.L. 1985. An ecological study of the vegetation of the Grand River/Cedar River, Sioux, and Ashland Districts of the Custer National Forest. Unpublished dissertation, South Dakota State University. 257 pp.

Spartina pectinata - Carex spp. Herbaceous Vegetation

COMMON NAME	Prairie Cordgrass - Sedge species Herbaceous Vegetation
SYNONYM	Prairie Cordgrass - Sedge Wet Meadow
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Temporarily flooded temperate or subpolar grassland (V.A.5.N.j)
ALLIANCE	SPARTINA PECTINATA TEMPORARILY FLOODED HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
Spartina pectinata grasslands are rare within Theodore Roosevelt National Park. They are usually restricted to poorly drained depressions within the floodplain of the Little Missouri River. Most are less than 0.5 ha in size.

Globally
This type is found in the northwestern Great Plains in eastern Montana and western North and South Dakota.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
The development of *Spartina pectinata* grasslands occurs best in poorly drained depressions that are saturated for at least part of the growing season. Such conditions are rare in Theodore Roosevelt NP and are generally restricted to the floodplain of the Little Missouri River. However, smaller pactches of *S. pectinata* grasslands can be found near upland seeps and springs.

Globally
At Wind Cave NP in South Dakota, stands occur in drainage bottoms where the soil is wet for at least part of the growing season (H. Marriot personal communication 1999). At Theodore Roosevelt and Badlands National Parks, stands occur in poorly drained depressions within floodplains of major rivers.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Spartina pectinata, Pascopyrum smithii, Hordeum jubatum*

Globally

Stratum	Species
Graminoid	*Spartina pectinata*

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Spartina pectinata is the dominant species. Species richness is generally low in most stands. *Hordeum jubatum* and *Pascopyrum smithii* are typically the most common secondary species.

Globally
At Wind Cave NP in South Dakota, this type has dense herbaceous cover, greater than 75 percent. Species dominance is patchy within stands, with various graminoids locally abundant, often to the exclusion of other species. In the single sampled stand, *Spartina pectinata, Carex nebrascensis*, and *Eleocharis palustris* were locally dominant. *Epilobium ciliatum* was common in shallow water (H. Marriott pers. comm. 1999). At Theodore Roosevelt National Park in North Dakota *Spartina pectinata* is the dominant species. Species richness is generally low. *Hordeum jubatum* and *Pascopyrum smithii* are the most prominent secondary species (J. Butler personal communication 1999).

CONSERVATION RANK G3?. This type has a relatively restricted distribution, and occurs in somewhat specialized wetland habitats in an arid climate. In addition, many such wetland sites are subject to heavy grazing pressure by cattle, who favor these moist locations. No element occurrences have been documented for this type, but at least several stands occur within three National Parks in the western Dakotas.

DATABASE CODE CEGL001477

SIMILAR ASSOCIATIONS
Spartina pectinata - Calamagrostis stricta - Carex spp. Herbaceous Vegetation (This is the northern tallgrass region equivalent of 1477.)

Spartina pectinata - Scirpus pungens Herbaceous Vegetation (This association may simply be need to split between a *Scirpus pungens* association and a *Spartina pectinata* association.)

COMMENTS
Sites may occasionally flood from rivers or ponding up of depressions.

REFERENCES
Culwell, L.D. and K.L. Scow. 1982. Terrestrial vegetation inventory: Dominy Project Area, Custer County, Montana 1979-1980. Unpublished technical report for Western Energy Company by Westech, Helena, Montana. 144 pp. + 15 pp. Appendix.

Rhus trilobata / Carex filifolia Shrub Herbaceous Vegetation

COMMON NAME	Ill-scented Sumac / Threadleaf Sedge Shrub Herbaceous Vegetation
SYNONYM	Ill-scented Sumac / Thread-leaved Sedge Shrub Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.7.N)
FORMATION	Medium-tall temperate or subpolar grassland with a sparse cold-deciduous shrub layer (V.A.7.N.g)
ALLIANCE	RHUS TRILOBATA SHRUB HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This community is found sporadically on moderately steep (10-25%) so somewhat steep (26-49%) slopes of virtually any aspect. Typically, stands occur as long, narrow bands on the upper slopes and shoulders of scoria ridges.

Globally
This community is found in eastern Montana, western North Dakota, and western South Dakota.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Individual plants of *R. trilobata* can be found associated with a wide variety of shrubland and woodland types. Stands of *Rhus trilobata* / *Carex filifolia* Shrub Herbaceous Vegetation are most common on steep scoria slopes that show little, if any, soil development. Aspect does not appear to play a major role in the development of distinct communities.

Globally
This community occurs on moderate to steep slopes on protected ridgetops and upper slopes of draws (Johnston 1987, USFS 1992). Hansen and Hoffman (1988) found four stands in western South Dakota on sandy loam soil. In Badlands National Park, South Dakota, sparse stands of ill-scented sumac occur most commonly on very steep slopes, where the upper butte cliffs meet the well-vegetated butte top and along the edge of draws. The geologic formation of cliff faces is predominantly Brule siltstone that is rapidly eroding, resulting in small ledges, nearly vertical faces, and steep slopes with rocks and fine sediments. Dense stands of ill-scented sumac occur sporadically within Badlands National Park, but are a regular landscape feature along the breaks of the Cheyenne River, northwest of the park. They typically occupy ridgetops and hillslopes with gravelly to sandy soils, though a few stands are located in old oxbows along the White and Cheyenne Rivers (Von Loh et al. 1999).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Shrub	*Rhus trilobata, Prunus virginiana*
Herbaceous	*Muhlenbergia cuspidata, Melilotus officinalis*

Globally

Stratum	Species
Short Shrub	*Rhus trilobata*
Graminoid	*Bouteloua curtipendula, Carex filifolia*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Rhus trilobata, Muhlenbergia cuspidata

Globally
Carex filifolia, Muhlenbergia cuspidata, Rhus trilobata

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Rhus trilobata is the dominant species. Individual plants usually appear as fairly large and distinct patches on the ridgeline. Shrub

density and height is fairly low and foliar cover is usually between 15-25%. *Muhlenbergia cuspidata* is the usual associate that dominates the sparse herbaceous layer. *Melilotus officinalis* is also fairly frequent.

Globally

This community is dominated by herbaceous vegetation, overtopped by a shrub canopy of 10-25%. The tallest shrubs are typically 0.6 m tall (Hansen and Hoffman 1988). Total coverage is moderate; exposed mineral soil is common. The USFS (1992) found an average vegetation cover of 70% on 10 stands in western North Dakota, most of that graminoids and shrubs. The most abundant shrub is *Rhus trilobata*, with lesser amounts of *Artemisia frigida, Gutierrezia sarothrae, Rosa arkansana*, and *Symphoricarpos occidentalis*. The most abundant herbaceous species is *Carex filifolia*, usually accompanied by *Koeleria macrantha, Muhlenbergia cuspidata*, and *Stipa comata. Carex inops ssp. heliophila* and *Elymus lanceolatus* are found in the shade of shrubs. Forbs have very low coverage. Common forbs include *Artemisia dracunculus, Echinacea angustifolia, Dalea purpurea, Opuntia polyacantha*, and *Phlox andicola*. ^In Badlands National Park, South Dakota, this sparse shrubland is found along with more densely shrubby variant. The dense shrubland variant has moderate to dense vegetative cover, depending on the landscape location. Sites with extra available soil moisture, such as seeps and slumps or old river oxbows, support dense vegetative cover in the 75-100% range. Sites on ridges and hilltops support less vegetative cover, in the 50-75% range. *Rhus trilobata* is typically the overstory dominant, but in terms of vegetative cover, *Symphoricarpos occidentalis, Toxicodendron rydbergii*, and *Prunus virginiana* can contribute nearly equal amounts. Understory grasses often include *Schizachyrium scoparium, Bouteloua curtipendula*, and *Poa pratensis* (Von Loh et al. 1999).

CONSERVATION RANK G3. This community has a relatively restricted range, being found in three states. It is relatively small patch in scale. It was considered to be an infrequent type in National Forest areas sampled in the western Dakotas and southeastern Montana (Hansen and Hoffman 1988).

DATABASE CODE CEGL001504

SIMILAR ASSOCIATIONS

Rhus trilobata / Festuca idahoensis Shrub Herbaceous Vegetation

Rhus trilobata / Pseudoroegneria spicata Shrub Herbaceous Vegetation

Rhus trilobata / Schizachyrium scoparium Shrub Herbaceous Vegetation

COMMENTS

Although stands of ill-scented sumac in Badlands National Park are classified as the *Rhus trilobata / Carex filifolia* Shrub Herbaceous Vegetation type, they appear to contain very little *Carex filifolia*. They may fit better with other *Rhus trilobata* shrublands.

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Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation

COMMON NAME	Greasewood / Western Wheatgrass - (Streamside Wildrye) Shrub Herbaceous Vegetation
SYNONYM	Greasewood / Western Wheatgrass Shrub Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.7.N)
FORMATION	Intermittently flooded temperate or subpolar grassland with a sparse xeromorphic (evergreen and/or deciduous) shrub layer (V.A.7.N.n)
ALLIANCE	SARCOBATUS VERMICULATUS INTERMITTENTLY FLOODED SHRUB HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

Individual *Sarcobatus vermiculatus* plants occur throughout Theodore Roosevelt National Park; however, the association was found on only one site located adjacent to the loop road in the South Unit.

Globally

This community is found in eastern Wyoming, Montana, southern Saskatchewan, western North Dakota, western South Dakota, and western Nebraska.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Because the development of the community in Theodore Roosevelt NP is so rare, it is difficult to generalize about the environmental characteristics.

Globally

This community is found on flat to gently sloping alluvial fans, terraces, lakebeds, and floodplains (Mueggler and Stewart 1978, Hansen and Hoffman 1988). Dodd and Coupland (1966) found *Sarcobatus vermiculatus* in association with *Pascopyrum smithii* only on the most arid parts of southwest Saskatchewan. The soil is usually deep clay, silty clay, sandy clay, or loam (Hirsch 1985, Jones and Walford 1995), although coarse soils are possible (USFS 1992, Thilenius *et al*. 1995). They are saline or alkaline but salt crusts on the surface are absent (Thilenius *et al*. 1995, but see Steinauer and Rolfsmeier 1997). Parent material is usually alluvium. Flooding during the spring is possible.

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Short Shrub	*Sarcobatus vermiculatus*
Herbaceous	*Pascopyrum smithii*

Globally

Stratum	Species
Short Shrub	*Sarcobatus vermiculatus*
Graminoid	*Pascopyrum smithii*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Pascopyrum smithii, Sarcobatus vermiculatus

Globally

Pascopyrum smithii, Sarcobatus vermiculatus

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Individual plants of *S. vermiculatus* are about 1 m in height and widely spaced. Herbaceous cover is well developed and dominated by *Pascopyrum smithii*. Overall, species richness is low.

Globally

This community has moderate to dense vegetation cover (Jones and Walford 1995, Thilenius et al. 1995). Medium-tall (0.5-1.5 m) shrubs are scattered throughout, with a total shrub canopy of 10-25% (Hansen and Hoffman 1988, USFS 1992). The shrub layer is dominated by *Sarcobatus vermiculatus*, with *Atriplex confertifolia, A. argentea, Artemisia tridentata*, and *Chrysothamnus viscidiflorus* in smaller amounts. *Symphoricarpos occidentalis* and *Rhus aromatica* are sometimes found in more mesic microhabitats within this community (Hirsch 1985). Herbaceous cover is sparse beneath the shrubs and moderate to dense in between. The dominant species are typically 0.5-1 m tall. The most abundant species is *Pascopyrum smithii*, usually accompanied by *Bouteloua gracilis, Bromus japonicus, B. tectorum*, and *Stipa comata*. Few forbs are found in this community. *Achillea millefolium* and *Opuntia polyacantha* are the only species with high constancy. Other species present may include *Grindella squarrosa*. Overall species diversity in this community is low (Hansen and Hoffman 1988, Von Loh et al. 1999).

CONSERVATION RANK G4.

DATABASE CODE CEGL001508

SIMILAR ASSOCIATIONS
Sarcobatus vermiculatus / Elymus elymoides - Pascopyrum smithii Shrubland

COMMENTS
Some authors recognize a *Sarcobatus vermiculatus / Pseudoroegneria spicata* Shrub Herbaceous Vegetation (Hansen and Hoffman 1988, MTNHP 1988, USFS 1992) in addition to or combined with *S. vermiculatus / Pascopyrum smithii* Shrub Herbaceous Vegetation (Brown 1971).

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Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation

COMMON NAME	Western Wheatgrass - Blue Grama - Threadleaf Sedge Herbaceous Vegetation
SYNONYM	Western Wheatgrass - Blue Grama - Threadleaf Sedge Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall sod temperate or subpolar grassland (V.A.5.N.c)
ALLIANCE	PASCOPYRUM SMITHII HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

GLOBAL RANGE
Theodore Roosevelt National Park
Stands of *Pascopyrum smithii - Bouteloua gracilis* are widespread throughout Theodore Roosevelt National Park. The best development appears to occur on the gently sloping footslopes associated with the upland draws.

Globally
This community is found in Colorado, Wyoming, Montana, North Dakota, South Dakota, and Saskatchewan. Details of its distribution within these states are not available.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This coummunity can be found in a wide variety of topographic situations where ths oil tends to be fine textured. The sites are generally flat to gently sloping and occur in all aspects.

Globally
This community is found on flat or gently sloping terrain. Many stands are on floodplains or gentle valley slopes, others are on uplands. Surface layers of soils are usually clay loams, although stands of this type may also be found on loams, silt loams, silty clays and clays (Hanson and Whitman 1938, Hansen and Hoffman 1988). In Alberta and Saskatchewan this association grows on solonetzic soils (with an elluvial horizon above a dense clay horizon high in sodium salts) developed on thin glacial till over Cretaceous shale (Coupland 1961). This community does not appear to be found in mountain valleys (Hanson and Dahl 1956, Jones 1992).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Short Shrub	*Artemisia cana*
Herbaceous	*Pascopyrum smithii, Bouteloua gracilis, Nasella viridula*

Globally

Stratum	Species
Graminoid	*Bouteloua gracilis, Carex filifolia, Elymus lanceolatus, Pascopyrum smithii*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Pascopyrum smithii, Bouteloua gracilis

Globally
Bouteloua gracilis, Buchloe dactyloides, Carex filifolia, Elymus lanceolatus, Pascopyrum smithii

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Pascopyrum smithii is the dominant species, sometimes appearing to occur as pure stands. *Artemisia cana* is a common shrub associate but with cover <25%. *Artemisia frigida* and *Bouteloua gracilis* are the major secondary species on drier sites, while *Nassela viridula* increases on the slightly concave sights that tend to be somewhat more mesic. The abundance of *Nassela viridula* tends to decrease on grazed sites while *Bouteloua gracilis* tends to increase.

Globally

This community is dominated by medium and short graminoids. Total vegetation cover is usually high (Hanson and Dahl 1956, Hansen et al. 1984). *Pascopyrum smithii* or *Elymus lanceolatus* or both (the two species are similar both morphologically and ecologically) and *Bouteloua gracilis* usually contribute the most cover; however, *Bouteloua gracilis* may contribute little cover and it may be absent locally. *Carex filifolia, Carex duriuscula (=Carex eleocharis), and Carex pensylvanica* often are secondary species, but in many stands they contribute little cover and they may be absent locally. *Stipa comata* usually is present as a secondary species, but it often codominates on sandy loam soils; this species never contributes more cover than do *Pascopyrum smithii* or *Elymus lanceolatus*. In Alberta and Saskatchewan, *Stipa spartea var. curtiseta* may be as common as *Stipa comata. Koeleria macrantha* is present in most stands and may contribute substantial cover. The forbs most likely to be found in this association are *Phlox hoodii, Sphaeralcea coccinea, Polygonum ramosissimum, Plantago patagonica, Opuntia polyacantha, Artemisia frigida, Antennaria microphylla*, and *Hedeoma hispida*. In southeastern Montana, western North Dakota, and northeastern Wyoming, stands of this association often contain *Artemisia tridentata ssp. wyomingensis*. Exotic brome grasses, especially *Bromus commutatus* and *B. tectorum*, are present in many stands of this association and they commonly contribute substantial cover (Hanson and Dahl 1956, Coupland 1961, Hansen et al. 1984, Hansen and Hoffman 1988).

CONSERVATION RANK G4. The G4 rank is based on the broad geographic range of this type, and its status as a common vegetation type within that geographic range.

DATABASE CODE CEGL001579

SIMILAR ASSOCIATIONS

Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation (is similar to this type but occurs in the southern portion of the Great Plains (where *Carex filifolia* is not as prevalent.)

Pascopyrum smithii - Nassella viridula Herbaceous Vegetation (Drier graminoids, such as *Bouteloua gracilis* or *Carex filifolia* are rare or absent in this type.)

Pascopyrum smithii - Stipa comata Central Mixedgrass Herbaceous Vegetation

Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation (*Stipa comata* contributes more cover than do *Pascopyrum smithii* or *Elymus lanceolatus*, and the association grows on soils of loam or coarser textural classes.)

COMMENTS

The coverage of *Pascopyrum smithii* varies more with use than geographic range. *Bouteloua gracilis* and *Buchloe dactyloides* have been observed to increase with grazing as *Pascopyrum smithii* decreases. This type, as currently understood by MRO, is equivalent to the *Pascopyrum smithii / Carex filifolia* Herbaceous Vegetation in the Western Region's 1994 classification (Bourgeron and Engelking 1994). Fire was likely a common event in this type historically.

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Pascopyrum smithii - Nassella viridula Herbaceous Vegetation

COMMON NAME	Western Wheatgrass - Green Needlegrass Herbaceous Vegetation
SYNONYM	Western Wheatgrass - Green Needlegrass Mixedgrass Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall sod temperate or subpolar grassland (V.A.5.N.c)
ALLIANCE	PASCOPYRUM SMITHII HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM

GLOBAL RANGE

Theodore Roosevelt National Park

Stands of *Pascopyrum smithii - Nassela viridula* occur throughout Theodore Roosevelt NP as small patches in swales, moderate slopes, and drainages with fine-textured soils.

Globally

This community is found in Wyoming, Montana, Saskatchewan, Manitoba, North Dakota, and South Dakota.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

This community is found on the deep, well-developed, fine textured soils associated with slight concave depressions on the uplands, and level or nearly level slopes that occur below moderately steep slopes of any aspect.

Globally

This community is found at the bottom of narrow valleys, on stream terraces, and on rolling uplands (Jones 1992, USFS 1992). Soils are fine-textured (clays, silty clays, clay loams, or rarely loams) and well-drained. The soil profile is typically well developed. The parent material is siltsone and mixed sedimentary rock (USFS 1992). This community usually occurs on level or nearly level ground but sometimes may be on moderate slopes of any aspect.

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Nassella viridula, Pascopyrum smithii*

Globally

Stratum	Species
Graminoid	*Nassella viridula, Pascopyrum smithii*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Nassella viridula, Pascopyrum smithii

Globally

Nassella viridula, Pascopyrum smithii

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

This community typically has relatively high foliar cover (>50%). *Pascopyrum smithii* and *Nassella viridula* are the dominant species. The relative contribution of these two species varies with moisture regime. *Nassella viridula* cover increases on the more mesic sites while *Pascopyrum smithii* increases on the somewhat more drier sites. *Bouteloua gracilis* and *Artemisia ludoviciana* are common secondary species and follow a similar pattern with *B. gracilis* becoming more prominent on the drier sites and *A. ludoviciana* on the more mesic sites. This community is often closely associated with *Symphoricarpos occidentalis* communities.

Globally

This community is dominated by midgrasses, generally between 0.6 and 1 m tall. The vegetation cover tends to be moderate to high, with almost all of the canopy provided by graminoids (Redmann 1975, USFS 1992). The dominant species are *Pascopyrum smithii* and *Nassella viridula*, although *Elymus lanceolatus* (another rhizomatous wheatgrass that is similar in morphology and ecology to *Pascopyrum smithii*) is the dominant species in some stands. At least 5% canopy cover of *Nassella viridula* may be diagnostic for this association. Other common grasses are *Stipa comata, Koeleria macrantha, Poa secunda (=Poa juncifolia), Poa pratensis, Sporobolus cryptandrus*, and, on sandier soils, *Calamovilfa longifolia*. Shorter graminoids are less common, but may include *Bouteloua gracilis, Carex duriuscula (=Carex eleocharis), Carex filifolia, C. inops ssp. heliophila*, and *C. pensylvanica*. These species are present in many stands, but they usually contribute little cover. The wheatgrass basin association of Nebraska (Steinauer and Rolfsmeier 1997), which may belong to this association, also contains *Schizachyrium scoparium*. Cheatgrasses (*Bromus commutatus, Bromus japonicus, Bromus tectorum*) are present in many stands and contribute substantial cover in some. The forbs *Aster falcatus, Astragalus spp., Achillea millefolium, Sphaeralcea coccinea, Artemisia ludoviciana, Lepidium densiflorum*, and *Vicia americana* are also typical of this community. *Artemisia cana ssp. cana* or *Artemisia tridentata ssp. wyomingensis* may be present, often as scattered shrubs contributing little cover. Stands with denser shrubs are transitional to shrub-herbaceous vegetation.

CONSERVATION RANK G3G4. The G4 rank is based on the broad geographic distribution and the relatively broad environmental requirements of this association. The prevalence of cheatgrass in many stands, though, may necessitate a review of this rank.

DATABASE CODE CEGL001583

SIMILAR ASSOCIATIONS
Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation (Drier graminoids, such as *Bouteloua gracilis* or *Carex filifolia*, tend to predominate in this association.)

COMMENTS

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Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation

COMMON NAME	Little Bluestem - (Sideoats Grama, Blue Grama) - Threadleaf Sedge Herbaceous Vegetation
SYNONYM	Northern Great Plains Little Bluestem Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall sod temperate or subpolar grassland (V.A.5.N.c)
ALLIANCE	SCHIZACHYRIUM SCOPARIUM - BOUTELOUA CURTIPENDULA HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This community is generally found in small patches (< 0.5 ha) on course textured soils that often occur on the slopes and shoulders of upland draws. Stands of *Schizachyrium scoparium* can also be located on gentle to moderately steep slopes.

Globally
This community is found in western North Dakota, western South Dakota, eastern and northern Wyoming, central and eastern Montana, southern Saskatchewan, and southern Manitoba.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Soils associated with stands of *Schizachyrium scoparium* tend to be farily deep loamy sand and sandy loam. Typically, stands are associated with shoulders and gently sloping backslopes of upland draws and drainages.

Globally
This community is usually found on gentle to steep slopes with variable aspects (Hansen et al. 1984, Johnston 1987, Hansen and Hoffman 1988). The soil may be loamy sand, sandy loam, loam, or clay loam. There may be a substantial component of gravel. Hansen et al. (1984) found 7-36% gravel by weight in 16 stands in western North Dakota. The soils are typically shallow and occur over sandstone or limestone (Johnston 1987, Thilenius et al. 1995).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Schizachyrium scoparium, Bouteloua curtipendula, Carex filifolia*

Globally

Stratum	Species
Graminoid	*Bouteloua curtipendula, Bouteloua gracilis, Schizachyrium scoparium*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Schizachyrium scoparium, Bouteloua curtipendula

Globally
Bouteloua curtipendula, Bouteloua gracilis, Carex filifolia, Schizachyrium scoparium

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Foliar cover on these sites is typically 75-100%. *Schizachyrium scoparium* is the dominant species and is usually less than 1 m in height. *Carex filifolia* is usually a major constituent on most sites while *Bouteloua curtipendula* is a minor secondary species

Globally
This community is predominantly composed of graminoid species less than 1 m tall. Occasional *Pinus ponderosa* are scattered throughout the type. The vegetation cover is moderate to high. Thilenius et al. (1995) found that vegetation cover was 44 percent in

Wyoming, and Hansen and Hoffman (1988) found 75 percent cover in North Dakota. The dominant species is *Schizachyrium scoparium* with *Bouteloua curtipendula, Bouteloua gracilis*, and *Carex filifolia* as associates or codominants. *Andropogon gerardii, Carex inops ssp. heliophila, Carex duriuscula (= Carex eleocharis), Koeleria macrantha* and *Calamovilfa longifolia* are often present. *Calamovilfa longifolia* may be abundant on sandier soils. *Muhlenbergia cuspidata, Stipa comata, Pascopyrum smithii*, and *Nassella viridula* may also be present. *Pseudoroegneria spicata* may be found in the western portions of this community (Jones 1992). In Manitoba, the graminoids *Festuca ovina* and *Elymus trachycaulus* and the lichen *Selaginella densa* are more abundant (Greenall 1995). Forbs do not contribute greatly to the canopy, but many species may be found in this community (Hanson and Whitman 1938). Among the forbs that may be found are *Echinacea angustifolia, Aster oblongifolius, Aster ericoides, Gaura coccinea, Lygodesmia juncea, Helianthus pauciflorus ssp. pauciflorus, Rosa arkansana, Liatris punctata, Pediomelum argophyllum (=Psoralea argophyllum), Dalea purpurea, Phlox hoodii*, and *Campanula rotundifolia*. There are very few woody species; those that are present are usually short shrubs such as *Artemisia frigida, Juniperus horizontalis*, and *Yucca glauca*. Litter often accumulates and may cover more than 50 percent of the ground (Hirsch 1985).

CONSERVATION RANK G3G4.

DATABASE CODE CEGL001681

SIMILAR ASSOCIATIONS
Pinus ponderosa / Schizachyrium scoparium Woodland (has similar composition to this type; the presence of *Pinus ponderosa* is the best distinguishing characteristic.)

COMMENTS
This type occurs on variable aspects throughout its range. Hansen et al. (1984) and McAdams et al. (1998) report this type on southerly aspects for western South Dakota and southwestern North Dakota. Butler et al. (1986) found that, in a ravine in western North Dakota, the most abundant species on a south-facing footslope were *Bouteloua curtipendula* and *Carex filifolia*. Other species that were abundant were *Schizachyrium scoparium* and *Calamovilfa longifolia*. Fire probably played a major role in this type, whereby periodic fires would increase graminoid production and deter tree growth.

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Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation

COMMON NAME	Needle-and-Thread - Blue Grama - Threadleaf Sedge Herbaceous Vegetation
SYNONYM	Needle-and-Thread - Blue Grama Mixedgrass Prairie
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall sod temperate or subpolar grassland (V.A.5.N.c)
ALLIANCE	STIPA COMATA - BOUTELOUA GRACILIS HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 1

USFWS WETLAND SYSTEM

GLOBAL RANGE

Theodore Roosevelt National Park

Stipa comata - Bouteloua gracilis - Carex filifolia grassland occupy sites that are, topographically, the greatest distance from the Little Missouri River. In the South Unit of Theodore Roosevelt National Park, the largest stands occur on the Petrified Forest Plateau.

Globally

This community is common in Montana, Wyoming, and is in Nebraska, North Dakota, South Dakota, southern Saskatchewan, and southern Manitoba. In Nebraska it is apparently absent from extreme northwestern and east-central regions (Steinauer and Rolfsmeier 1997).

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

This community is generally found on the level and gently rolling uplands with deep soils. The soils found under this grassland type tend to be more coarse textured compared to *Pascopyrum smithii* grasslands.

Globally

Stands occur on flat to rolling topography with deep (40- 100 cm) sandy loam to loam soils. They are typically associated with uplands, though they may also occur lower in the landscape, such as coulee and draw bottoms, if soils are sufficiently coarse (usually sandstone derived). Even though it is a major association in the Northern Plains, it does not occur in areas dominated exclusively by shale and mudstone parent materials, from which heavy soils are derived. This type is found at elevations ranging from 2000 to 5500 feet; average annual precipitation associated with these elevation parameters ranges from slightly less than 10 to slightly more than 20 inches. This association and the *Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* association could be considered the most common plant associations in the Northern Great Plains (Martin et al. 1998). These two associations, cited by many authors as the climatic climax communities for this region, are manifested by matrix or large patch occurrences frequently found dominating whole landscapes. The *Stipa comata* defined community is more associated with uplands and the *Pascopyrum smithii* defined type characterizes sites with higher moisture status, generally occurring at lower positions in the landscape.

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Stipa comata, Bouteloua gracilis, Carex filifolia*

Globally

Stratum	Species
Graminoid	*Bouteloua gracilis, Carex filifolia, Stipa comata*

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Stipa comata, Bouteloua gracilis, Carex filifolia

Globally

Bouteloua gracilis, Carex filifolia, Stipa comata

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

Foliar cover is generally quite high (75-100%) on most sites. The vegetation is dominated by *Stipa comata* and *Bouteloua gracilis* that are usually less than 0.5 m in height. On some sites, dominance between these two species is shared almost equally, while on other sites one species is a clear dominant over the other. *Carex filifolia* is usually a major contributor within these grasslands followed closely by *Artemisia frigida*. *Koeleria macrantha* is another major graminoid within this community type.

Globally

The vegetation is dominated by graminoids that are usually between 0.5 and 1 m tall. Total cover is moderate. On 19 stands in west-central Montana the cover by the different strata was as follows: shrubs 6 percent, graminoids 67 percent, forbs 11 percent, bryophytes 14 percent, litter 55 percent, rock 4 percent, bare soil 9 percent (Mueggler and Stewart 1978). Thilenius et al. (1995) found that the average cover on 14 stands in eastern Wyoming was 42 percent. Tolstead (1942) described this community as the climax on the level lands of the northern part of Cherry County, Nebraska. *Stipa comata* is the tallest of the dominant species, sending seed heads to a maximum height of approximately 1 m. The rhizomatous graminoids, *Bouteloua gracilis* and *Carex filifolia*, the other two dominant/codominant species, do not usually exceed 0.5 meter. *Calamovilfa longifolia* is often found with high cover values on sandier soils and *Koeleria macrantha* cover increases on degraded sites. There are regionalized expressions of variability with *Carex inops var. heliophila* surpassing *Carex filifolia* in Colorado and *Calamagrostis montanensis* being at least as important as the diagnostic species in north-central Montana. *Pascopyrum smithii* is consistently present and reaches the same height as *Stipa comata*. For woody species, subshrub forms (*Artemisia frigida, Gutierrezia sarothrae, Rosa arkansana*) have the highest cover and constancy but their total cover does exceed more than 5 percent, except on overgrazed sites. Regardless of the geographic region of this broadly distributed type, cover values for forbs are low (the exception being *Selaginella densa*), though geographic setting does influence forb composition to some degree. *Sphaeralcea coccinea, Phlox hoodii, Heterotheca villosa, Gaura coccinea*, and *Liatris punctata*, at least in the northern distribution of this type, have high constancy values; the constancy of *Lygodesmia juncea, Opuntia polyacantha, Artemisia dracunculus* and *Ratibida columnifera* seems to increase to the eastern and southern portions of the type's distribution.

CONSERVATION RANK G5. This is an exceedingly common type, manifesting any number of permutations, some of which are related to disturbance and some of which appear to be related to the expected geographic distinctions in such a broadly distributed type. The only reason to consider it a G4 is that it has received, and continues to receive, significant grazing pressure which, combined with the surge in alien weed populations, pose a significant threat to its quality.

DATABASE CODE CEGL002037

SIMILAR ASSOCIATIONS

Bouteloua gracilis - Buchloe dactyloides Xeric Soil Herbaceous Vegetation (On degraded sites, or on intermediate habitats, this type can be confused with CEGL002037.)

Pascopyrum smithii - Stipa comata Central Mixedgrass Herbaceous Vegetation

COMMENTS

Vast (singly and in the aggregate) prairie dog (*Cynomys ludovicianus, C. leucurus*) "towns" once developed on the favorable substrates of this type and exploited its vegetation. Prairie dog populations have undergone a precipitous decline since settlement, so much of this type could be in various states of secondary succession, returning from a somewhat denuded state and altered composition created by the prairie dogs (and attendant bison that found nutritious forage here). Fire, both aboriginal- and lightening-caused, was a regular part of this landscape. Fire-return intervals have been considerably lengthened since settlement by European-Americans.

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Tolstead, W. L. 1941. Plant communities and secondary succession in south-central South Dakota. Ecology. 22(3):322-328.

Tolstead, W. L. 1942. Vegetation of the northern part of Cherry County, Nebraska. Ecol. Monographs. 12(3):257-292.

Typha spp. Great Plains Herbaceous Vegetation

COMMON NAME	Cattail species Great Plains Herbaceous Vegetation
SYNONYM	Northern Great Plains Cattail Marsh
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Semipermanently flooded temperate or subpolar grassland (V.A.5.N.l)
ALLIANCE	TYPHA (ANGUSTIFOLIA, LATIFOLIA) - (SCIRPUS SPP.) SEMIPERMANENTLY FLOODED HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 2

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This community is very rare in Theodore Roosevelt National Park and restricted to the few areas where standing water is present on a somewhat permanent basis.

Globally
This community type is found in shallow to deep marshes throughout the Northern Great Plains.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Stands are rare and restricted to toeslope springs and seeps.

Globally
Stands occur in shallow (< 0. 5 m) or deep depressions, ponds, and seepy drainages. Stands may originate from human-related disturbance, including heavy grazing of wetlands or creation of wetlands for watering cattle (stock ponds).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Graminoid	*Typha angustifolia*

Globally

Stratum	Species
Graminoid	*Typha angustifolia*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park

Globally
Typha angustifolia, Typha latifolia

VEGETATION DESCRIPTION
Globally
The vegetation is dominated by relatively pure stands of *Typha spp*., either *Typha latifolia* or *Typha angustifolia* or both. Many associates could occur. This type may simply be a less diverse variation of *Typha spp - Scirpus spp*. Mixed Herbs Great Plains Herbaceous Vegetation (CEGL002228).

CONSERVATION RANK G4G5. Type is widespread throughout the plains, but most examples show evidence of disturbance. It is possible that the type originates primarily from human-related disturbances, and perhaps the rank should be GW.

DATABASE CODE CEGL002389

SIMILAR ASSOCIATIONS
Scirpus acutus - Typha latifolia - (Scirpus tabernaemontani) Sandhills Herbaceous Vegetation

Typha latifolia Southern Herbaceous Vegetation (southeastern states)

Typha latifolia Western Herbaceous Vegetation (western states)

Typha spp. - *Scirpus* spp. - Mixed Herbs Great Plains Herbaceous Vegetation (A more species diverse association.)

COMMENTS

REFERENCES

Cirsium arvense - Weedy Forb Great Plains Herbaceous Vegetation [Provisional]

COMMON NAME	Canada Thistle - Weedy Forb Great Plains Herbaceous Vegetation
SYNONYM	Great Plains Weedy Meadows
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial forb vegetation (V.B)
PHYSIOGNOMIC GROUP	Temperate or subpolar perennial forb vegetation (V.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.B.2.N)
FORMATION	Tall temperate or subpolar perennial forb vegetation (V.B.2.N.a)
ALLIANCE	(CIRSIUM ARVENSE, EUPHORBIA ESULA, MELILOTUS SPP.) - MIXED FORBS HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

GLOBAL RANGE
Theodore Roosevelt National Park
This type is generally widely distributed throughout Theodore Roosevelt NP, especially in the South Unit. It usually occurs as small patches (< 0.5 ha) on the toeslopes of draws and small depressions on north and east facing slopes.

Globally
This type is widely naturalized in the northern United States and Canada.

ENVIRONMENTAL DESCRIPTION
Patches of *Cirsium arvense* occur throughout Theodore Roosevelt NP in a wide variety of habitats independent of disturbance.

Globally
Stands occur on a variety of open disturbed habitats, including pastures, ditches, bottomlands, and waste areas (Great Plains Flora Association 1986).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Cirsium arvense*

Globally

Stratum	Species

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Cirsium arvense

Globally

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
The density and cover of *Cirsium arvense* is high with very few native species found within infested sites. Plant height on the more mesic sites approaches 1 m.

Globally
The vegetation is dominated by medium-tall (0.5 - 1 m) forbs. The dominant forb is *Cirsium arvense*, a naturalized species from Eurasia (Great Plains Flora Association 1986). Other weedy species may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie grasses, such as *Pascopyrum smithii* and *Stipa comata*, as well as others.

CONSERVATION RANK GW. This type is widely naturalized from Eurasia across the northern United States and Canada, where it has invaded on disturbed areas (Great Plains Flora Association 1986). It is not planted by humans.

DATABASE CODE CEGL005260

SIMILAR ASSOCIATIONS
COMMENTS
This type could be defined very broadly to include almost any *Cirsium arvense* dominated stand, in which case the variability of the

minor species associated with the type may be very high.

REFERENCES

Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation

COMMON NAME	Smooth Brome - (Western Wheatgrass) Semi-natural Herbaceous Vegetation
SYNONYM	
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d)
ALLIANCE	BROMUS INERMIS SEMI-NATURAL HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
These grasslands are widespread throughout Theodore Roosevelt NP. They are especially prominent along road right-of-ways.

Globally
This type occurs widely throughout the northern Great Plains, and perhaps more widely in the Midwest, depending on how the type is defined.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This grassland can be found in a wide variety of habitats in Theodore Roosevelt NP. It was probably planted for soil stabilization along road right-of-ways in the Park. It is a very aggressive exotic that has expanded into disturbed and undisturbed areas.

Globally
This type can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. It is also widely planted for cover, pasture, and hay, and has escaped into a variety of habitats.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Bromus inermis*

Globally

Stratum	Species
Graminoid	*Bromus inermis*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park

Globally
Bromus inermis, Pascopyrum smithii

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
These grasslands consist of a nearly monotypic stand of *Bromus inermis* that is usually less than 1 m in height. Other exotics such as *B. tectorum* and *B. japonicus*, are often associates. However, in well developed communities foliar cover of native species is usually less than 10% (Trammell and Butler 1995).

Globally
The vegetation is dominated by medium-tall (0.5 - 1 m) graminoids. The dominant grass is *Bromus inermis*, a naturalized species from Europe and Asia. Other weedy species may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie grasses, such as *Pascopyrum smithii* and *Stipa comata*, as well as others.

CONSERVATION RANK GW. This is a naturalized type from Europe and Asia, widely planted for cover, pasture, and hay, and has escaped into a variety of habitats.

DATABASE CODE CEGL005264

SIMILAR ASSOCIATIONS

COMMENTS

This type could be defined very broadly to include almost any *Bromus inermis* dominated stand, in which case the variability of the minor species associated with the type may be very high.

REFERENCES

Trammel, M.A. and J.L. Butler. 1995. Effects of exotic plants on native ungulate use of habitat. Journal of Wildlife Management. 59:804-815.

Poa pratensis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation

COMMON NAME	Kentucky Bluegrass - (Western Wheatgrass) Semi-natural Herbaceous Vegetation
SYNONYM	
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d)
ALLIANCE	POA PRATENSIS SEMI-NATURAL HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This type is widespread throughout Theodore Roosevelt National Park. It is probably best developed in the toeslopes of upland draws and drainages (Trammel 1994).

Globally
This type is potentially widespread throughout the Great Plains and into the Midwest, depending on how the type is defined.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This community is usually found on deep, well developed, fine textured soils that are topographically situated as to receive supplemental moisture in the form of runoff from adjacent slopes. This type is also common in situations where snow may accumulate or where snowmelt may be delayed somewhat in the spring. Such conditions exist in the toeslopes of upland draws and drainages, and in shallow depressions on north and east facing nearly level slopes. The development of this community in Theodore Roosevelt NP appears to be independent of disturbance.

Globally
This type can occur in a wide variety of human-disturbed and native habitats.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Poa pratensis*

Stratum	Species
Graminoid	*Poa pratensis*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Poa pratensis

Globally
Pascopyrum smithii, Poa pratensis

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Foliar cover in this community is usually > 75% and the herbaceous vegetation is less than 0.5 in height. The dominant species is *Poa pratensis*. A wide variety of secondary species can be found in association with *P. pratensis* depending upon habitat. In the toeslopes of draws, *Symphoricarpos occidentalis* and *Carex sprengelii* are common constituents of the community. *Nasella viridula* and *Pascopyrum smithii* are the usual associates in the upland depressions in addition to *S. occidentalis.*

Globally
The vegetation is dominated by medium-tall (0.5 - 1 m) graminoids. The dominant grass is *Poa pratensis*, considered to be both a native and naturalized species from Eurasia (Great Plains Flora Association 1986, Gleason and Cronquist 1991). Other native species may occur as well, but they are generally less than 10% cover. Native species may include mixed-grass prairie grasses, such as *Pascopyrum smithii* and *Stipa comata*, as well as others.

CONSERVATION RANK GW. This is primarily a naturalized type from Europe and Asia, widely planted for lawns and pasture, and it has escaped into a variety of habitats (Great Plains Flora Association 1986, Gleason and Cronquist 1991). Although native populations do exist,and may be integral parts of some prairie and other native habitats, most stands that are thoroughly dominated by *Poa pratensis* are a result of human modifications to the habitat.

DATABASE CODE CEGL005265

COMMENTS

REFERENCES

Gleason, H.A., and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden, Bronx, NY. 910 pp.

Great Plains Flora Association. 1986. Flora of the Great Plains. University of Kansas Press, Lawrence. 1392 pp.

Trammell, M.A. 1994. Exotic plants of Theodore Roosevelt National Park: Extent, distribution, and ecological impact. M.A. Thesis. University of South Dakota. Vermillion, SD.

Agropyron cristatum - (Pascopyrum smithii, Stipa comata) Semi-natural Herbaceous Vegetation

COMMON NAME	Crested Wheatgrass - (Western Wheatgrass, Needle-and-Thread Grass) Semi-natural Herbaceous Vegetation
SYNONYM	
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d)
ALLIANCE	AGROPYRON CRISTATUM SEMI-NATURAL HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

GLOBAL RANGE
Theodore Roosevelt National Park
This community is probably best represented on the upland grassland areas adjacent to the eastern boundary of the South Unit of Theodore Roosevelt National Park.

Globally
This type occurs most commonly in the northern Great Plains of the United States and Canada.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This introduced grassland can occur in a wide variety of habitats in the Park. It is most commonly found adjacent to Park boundaries where the *Agropyron cristatum* was planted on private land to enhance forage production.

Globally
This type can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. It is also widely planted to revegetate pastures and rangelands.

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Agropyron cristatum*

Globally

Stratum	Species
Graminoid	*Agropyron cristatum*

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Agropyron cristatum

Globally
Agropyron cristatum, Pascopyrum smithii

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
This grassland is characterized by a almost pure stand of *Agropyron cristatum* less than 0.5 m in height. The litter layer is usually very dense. There are generally only a few native species associated with this type, mostly *Pascopyrum smithii*. Other exotic graminoids such as *Poa pratensis* and *Bromus inermis* can sometimes found in close association.

Globally
The vegetation is dominated by medium-tall (0.5 - 1 m) graminoids. The dominant grass is *Agropyron cristatum*, a naturalized species from Europe. Other weedy species may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie grasses, such as *Pascopyrum smithii* and *Stipa comata*, as well as others.

CONSERVATION RANK GW. This is a naturalized type from Europe, widely planted to revegetate roadsides and pastures.

DATABASE CODE CEGL005266

COMMENTS
Hansen and Hoffman (1988, p 6, Fig. 6) show a seral stand of *Agropyron cristatum*, with signs of succession leading to the Stipa comata / Carex filifolia habitat type.

REFERENCES
Hansen, P.L. and G.R. Hoffman. 1988. The vegetation of the Grand River/Cedar River, Sioux, and Ashland Districts of the Custer National Forest: a habitat type classification. USDA Forest Service General Technical Report RM-157, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Euphorbia esula Herbaceous Vegetation

COMMON NAME	Leafy Spurge Herbaceous Vegetation
SYNONYM	Leafy Spurge Meadow
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial forb vegetation (V.B)
PHYSIOGNOMIC GROUP	Temperate or subpolar perennial forb vegetation (V.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (V.B.2.N)
FORMATION	Tall temperate or subpolar perennial forb vegetation (V.B.2.N.a)
ALLIANCE	(CIRSIUM ARVENSE, EUPHORBIA ESULA, MELILOTUS SPP.) - MIXED FORBS HERBACEOUS ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

GLOBAL RANGE

Theodore Roosevelt National Park

Although a few patches of *Euphorbia esula* can be found in the North Unit of Theodore Roosevelt National Park, the community type is best developed in the South Unit. It is especially prominent along the floodplain of the Little Missouri River and its major tributaries, especially west of the River. Stands are becoming increasingly more common on the upland sites in the area of the Petrified Forest Plateau of the South Unit.

Globally

Stands dominated by *Euphorbia esula* are increasingly common across the northern Great Plains.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Euphorbia esula is the most aggressive and troublesome exotic plant within the Park. Although stands can be found in almost any environmental setting in Theodore Roosevelt NP, the highest incidence of *E. esula* occurs along the floodplain of the Little Missouri River and its major tributaries. The more mesic soil moisture conditions associated with these habitats greatly facilitates the establishment and growth this species. Further, seed dispersal is enhanced by flowing water associated with these systems, which greatly accelerates the expansion of *E. esula* throughout the drainages and into the uplands.

Globally

Stands occur in fields, roadsides, stream valleys, open woodlands, waste places, and native prairie, on a variety of soils (Great Plains Flora Association 1986).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

<u>Stratum</u>	<u>Species</u>
Herbaceous	*Euphorbia esula*

Globally

<u>Stratum</u>	<u>Species</u>

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Euphorbia esula

Globally

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

The community is dominated almost exclusively by *Euphorbia esula*. The plants, depending on soil moisture conditions, are 0.5 to 2.0 m in height. Foliar cover is usually 100% in well developed patches. There are only a few native species, most notably *Carex filifolia*, that are able to persist in heavily infested areas (Trammell 1994). Native ungulates in the Park avoid sites heavily infested with leafy spurge (Trammell and Butler 1995).

Globally

The vegetation is dominated by medium-tall (0.5 - 1 m) forbs. The dominant forb is *Euphorbia esula*, a naturalized species from

Eurasia (Great Plains Flora Association 1986). Other weedy species may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie grasses, such as *Pascopyrum smithii* and *Stipa comata*, as well as others. This type is a serious pest of rangeland, since it is unpalatable to cattle.

CONSERVATION RANK GW. This type is widely naturalized from Eurasia across the northern United States and Canada, where it has invaded on disturbed areas (Barkley 1986). It is not planted by humans.

DATABASE CODE CEGL005268

COMMENTS

REFERENCES

Trammell, M.A. 1994. Exotic plants of Theodore Roosevelt National Park: Extent, distribution and ecological impact. M.A. Thesis. University of South Dakota. Vermillion, SD.

Trammell, M.A. and J.L. Butler. 1995. Effects of exotic plants on native ungulate use of habitat. Journal of Wildlife Management. 59:808-815.

Artemisia longifolia Badlands Sparse Vegetation

COMMON NAME	Longleaf Sage Badlands Sparse Vegetation
SYNONYM	Badlands Longleaf Sage Steppe
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (VII.C.3.N)
FORMATION	Dry slopes (VII.C.3.N.b)
ALLIANCE	ARTEMISIA LONGIFOLIA SPARSELY VEGETATED ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE

Theodore Roosevelt National Park

The *Artemisia longifolia* Badlands Sparse Vegetation is relatively rare in Theodore Roosevelt National Park. It appears to be more common in the North Unit where occupies the dark gray, bentonite outcrops among rapidly eroding badlands formations.

Globally

This type is found in the Badlands regions of the northern Great Plains.

ENVIRONMENTAL DESCRIPTION

Theodore Roosevelt National Park

Stands appear to be restricted to the level and nearly level bentonite clay ridges associated with the rapidly eroding badlands formations. Soil development is nonexistent. During rainfall events, the clay typically swells which substantially reduces water infiltration and increases runoff. Consequently, these sites tend to be more xeric than the surrounding badland slopes.

Globally

Stands, which may be less than 0.1 ha in size (at least in Badlands National Park, South Dakota, are found on sparsely vegetated eroding slopes or flat clay ridges. Some slopes may be acidic, others more alkaline. Soils are poorly consolidated clays and silts. Stands may be particularly common on bentonite clay bands found on the ridges and slopes of the badlands (Von Loh et al. 1999).

MOST ABUNDANT SPECIES

Theodore Roosevelt National Park

Stratum	Species
Short Shrub	*Artemisia longifolia*

Globally

Stratum	Species

CHARACTERISTIC SPECIES

Theodore Roosevelt National Park

Artemisia longifolia

Globally

Artemisia longifolia, Eriogonum pauciflorum, Gutierrezia sarothrae

VEGETATION DESCRIPTION

Theodore Roosevelt National Park

This is an extremely sparsely vegetated community type. *Artemisia longifolia* is often the only species present. Foliar cover is typically less than 5% and the shrubs are less than 0.25 m in height. The only other species found on these sites were *Chrysothamnus nauseous* and *Pascopyrum smithii*.

Globally

The vegetation is sparse, often much less than 10% cover, and species richness is very low. Short shrubs are the most conspicuous. *Artemisia longifolia* is the most frequent, and it may be associated with *Atriplex nuttallii*, Eriogonum pauciflorum, or Gutierrezia sarothrae.

CONSERVATION RANK G?.

DATABASE CODE CEGL002195

SIMILAR ASSOCIATIONS
Badlands Sparse Vegetation Complex (This badlands complex includes this association.)

Eroding Great Plains Badlands Sparse Vegetation (This type contains virtually no vegetation.)

COMMENTS
In Badlands National Park, South Dakota, a two hectare stand of *Atriplex canescens* is included in this type. It occupies a large badlands flat and erosion fan, consistingof hardpacked silty clay. This area collects and holds run-off water for a period

REFERENCES
Von Loh, J., D. Cogan, D. Faber-Langendoen, D. Crawford, and M. Pucherelli. 1999. USGS-NPS Vegetation Mapping Program, Badlands National Park, South Dakota (Final Report). Technical Memorandum No. 8260-99-02. U.S. Bureau of Reclamation Technical Service Center. Denver CO.

Eroding Great Plains Badlands Sparse Vegetation

COMMON NAME	Eroding Great Plains Badlands Sparse Vegetation
SYNONYM	Eroding Great Plains Badlands
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (VII.C.3.N)
FORMATION	Dry slopes (VII.C.3.N.b)
ALLIANCE	LARGE ERODING BLUFFS SPARSE VEGETATION ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

RANGE
Theodore Roosevelt National Park
This type is widespread throughout Theodore Roosevelt National Park and is one of the most sparsely vegetated or unvegetated types examined. It is probably best represented on steep, south facing badlands slopes.

Globally
This type is found in the badlands formations of the western Great Plains of the United States and Canada.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
Badlands type topography is the product of a long history of erosion. Stratified beds of soft shales that are extremely susceptible to erosion characterize these steep, almost vertical, slopes. The combined effects of low infiltration, high runoff, very limited soil development, and south facing aspect severely restrict vegetation development on these sites.

Globally
Badlands are produced by a combination of factors, including elevation, type of rainfall, carving action of streams, and a particular material. Badlands are basically a type of mature dissection with a finely-textured drainage pattern and steep slopes. Badlands can only form where the land lies well above its local base level. The land must also be easily erodable, or vegetation cover will stabilize the surface. An arid climate will also discourage vegetation growth and will tend to have infrequent, but torrential, rains with great eroding action. In the Great Plains, the geologic formations are from Cretaceous shales, Oligocene siltstones, sandstones, and clayey mudstones (Von Loh et al. 1999). The soils in the Great Plains badlands are generally poorly consolidated clays with bands of sandstone or isolated conglomerates (Froiland 1990).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Information not available	

Globally

Stratum	Species

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Information not available

Globally
Eriogonum pauciflorum, Grindelia squarrosa, Gutierrezia sarothrae

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
This type is virtually devoid of any vegetation, typically less than 1% foliar cover. The few plants that may be present (*Gutierrezia sarothrae*, *Atriplex confertifolia*, *Distichlis spicata*) are less than 15 cm tall and widely spaces.

Globally
The clay soils of the badland eroding slopes and walls are almost devoid of vegetation. Widely scattered individuals of *Grindelia squarrosa*, *Gutierrezia sarathroe*, or *Eriogonum pauciflorum* may be present (Froiland 1990).

CONSERVATION RANK G4G5.

DATABASE CODE CEGL002050

SIMILAR ASSOCIATIONS
Artemisia longifolia Badlands Sparse Vegetation

Badlands Sparse Vegetation Complex (This complex includes this association.)

Eriogonum pauciflorum - Gutierrezia sarothrae Badlands Sparse Vegetation

Shale Barren Slopes Sparse Vegetation

COMMENTS

REFERENCES

Froidland, S.G. 1990. Natural history of the Black Hills and Badlands. The Center for Western Studies, Augustana College, Sioux Falls, South Dakota. 225 pp.

Frolick, A.L., and F.D. Keim. 1933. Native vegetation in the prairie hay district of north central Nebraska. Ecology 14:298-305.

Steinauer, G. and S. Rolfsmeier. 1997. Terrestrial natural communities of Nebraska. Draft - October 28, 1997. Nebraska Game and Parks Commission, Lincoln, NE. 117 p.

Von Loh, J., D. Cogan, D. Faber-Langendoen, D. Crawford, and M. Pucherelli. 1999. USGS-NPS Vegetation Mapping Program, Badlands National Park, South Dakota (Final Report). Technical Memorandum No. 8260-00-02, U.S. Bureau of Reclamation Technical Service Center. Denver CO.

Riverine Sand Flats - Bars Sparse Vegetation

COMMON NAME	Riverine Sand Flats - Bars Sparse Vegetation
SYNONYM	Riverine Sand Flats
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C)
PHYSIOGNOMIC GROUP	Sparsely vegetated sand flats (VII.C.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural (VII.C.2.N)
FORMATION	Temporarily flooded sand flats (VII.C.2.N.c)
ALLIANCE	SAND FLATS TEMPORARILY FLOODED SPARSE VEGETATION ALLIANCE

CLASSIFICATION CONFIDENCE LEVEL 3

USFWS WETLAND SYSTEM

GLOBAL RANGE
Theodore Roosevelt National Park
This type is restricted to the newly formed sandbars associated with the Little Missouri River.

Globally
This type stretches from the western Great Plains to the eastern portions of the Midwest.

ENVIRONMENTAL DESCRIPTION
Theodore Roosevelt National Park
This is a very sparsely vegetated community that occurs on newly exposed and deposited material generated from the receding water that of the Little Missouri River.

Globally
This community is a sparsely vegetated community that occurs along river shorelines, islands, pointbars, and flats. These sandbars form when receding floodwaters deposit sand and lesser amounts of clay, silt, and cobbles in the stream bed. Soils are often undeveloped due to the ephemeral nature of the stands. Drainage depends on depth above the water level (Nelson 1985, Steinauer and Rolfsmeier 1997).

MOST ABUNDANT SPECIES
Theodore Roosevelt National Park

Stratum	Species
Herbaceous	*Xanthium spinosum, Arctium minus*

Globally

Stratum	Species

CHARACTERISTIC SPECIES
Theodore Roosevelt National Park
Information not available

Globally

VEGETATION DESCRIPTION
Theodore Roosevelt National Park
Because these sites consist of newly exposed or deposited material that is very dynamic, vegetation is generally very sparse and tends to be somewhat weedy. Species richness is very low and consists primarily of *Xanthium spinosum* and/or *Arctium minus*.

Globally
Vegetation is very sparse, highly dynamic and irregular in structure because of constantly changing conditions on the river. Herbaceous species shared in Missouri and Nebraska include *Cyperus spp. (C. erythrorhizos, C. odoratus, C. squarrosus), Eragrostis hypnoides, Eragrostis trichodes, Leptochloa fascicularis, Polygonum spp*. (including *Polygonum lapathifolium), Rorippa sinuata, Sporobolus cryptandrus*, and *Xanthium strumarium*. Other species listed for Nebraska and Missouri alone can be found in Nelson (1985) and Steinauer and Rolfsmeier (1997). Woody cover is generally absent in the first year of establishment but can increase if the site does not flood. A broader description including other Midwest and Great Plains sites is needed.

CONSERVATION RANK G4G5.

DATABASE CODE CEGL002049

COMMENTS
Given the dynamic nature of the habitat and lack of information from across the range of this type, it is not clear which species are most constant in the Great Plains. This community can be very short-lived. For example, in Nebraska, it rarely persists for more than a single season before it is either destroyed by flooding or succeeds to other communities such as *Salix exigua* communities (Steinauer and Rolfsmeier 1997).

REFERENCES

APPENDIX L.

Prairie Dog Mapping Protocols

(referenced on page 4-11)

Date: August 8, 1997

Reply To Attn Of: Glen Plumb, Ph.D., Wildlife Biologist, Badlands NP

Subject: Badlands National Park and Wall District 1997 Prairie Dog Aerial Photo Interpretation

To: Bruce Bessken, Chief RM Badlands National Park
Greg Schenbeck, USFS Nebraska National Forest
Jim Vonloh, US Bureau Reclamation
Tim Langer, North Carolina State University

On August 6, 1997, we met at Cedar Pass Park HQ library to develop simple, qualified and consistent methodology for interpreting prairie dog colonies from a series of June 1997 1:12,000 CIR aerial photos covering Badlands National Park and a large portion of USFS Wall District, Buffalo Gap National Grassland. The principal purpose of these photos is to support development of a plant community map of Badlands NP. An additional goal of the NPS and USFS is to produce a digital map delineating prairie dog colonies. After three hours of discussions we agreed on the following photo interpretation criteria.

1. There will be no minimum size threshold for interpreting prairie dog colonies, in contrast to the 0.5 hectare minimum size for other plant communities.

2. Prairie dog colonies are to be considered as distinct plant communities characterized principally by concentrations of whitened stipples indicative on mounded prairie dog burrows. Depending on disturbance story, soils and yearly climate, differences in the reflectance signature between prairie dog colony plant communities and adjacent uncolonized plant communities will vary substantially. It may be that the lack of apparent change in reflectance signature between the area of concentrated burrow mounds and adjacent area with no burrow mounds will indicate no change in predominate plant community classification while retaining a prairie dog colony classification. As such, two potential classesof prairie dog colonies will likely be interpreted. Photo interpretation criteria should include:

a) Prairie dog colony with substantial change in plant community: the linear edge is delineated by eliminating whitened stipples indicative of mounded prairie dog burrows which are greater than 0.10" (30 meters) from the contiguous concentration of whitened stipples indicative of mounded prairie dog burrows accompanied by an obvious whitened color change from surrounding plant community reflectance signature(s), or

b) Prairie dog colony with little apparent change in plant community: the linear edge is delineated by eliminating whitened stipples indicative of mounded prairie dog burrows which are greater than 0.10" (30 meters) from the contiguous concentration of whitened stipples indicative of mounded prairie dog burrows characterized by greater than 35 whitened mounded burrows per hectare and **not** accompanied by an obvious whitened color change from surrounding plant community reflectance signature(s).

3. When appropriate, prairie dog colony delineation will also incorporate physical features such as surface roads (not 2 track roads), erosion features, ephemeral gullies and washes, permanent water sources (i.e. creeks and stock dams) and major badlands topographic features (i.e. spires, ridges).

4. In the case where the two above classifications are contiguous, final prairie dog colony map could combine different but contiguous prairie dog colony plant communities.

APPENDIX M

Table
of
Vegetation Studies
performed at
Theodore Roosevelt National Park

(referenced on page 3-3)

Comparison of Vegetation Map Classes Across Four Studies.

USGS/BRD 1999	Hager 1997	Norland 1984	Hansen 1984
Prairie Dog Town Complex	Prairie Dog Town	Prairie Dog Towns	(Not Described)
Badlands Sparse Vegetation Complex	Bare Ground, Big Sagebrush/Spiny Saltbush	Breaks, Steep Scoria Complex	(Not Described)
Scoria Sparse Vegetation Complex	Rolling Scoria, Steep Scoria	Breaks, Scoria Hills, Rolling Scoria Complex, Steep Scoria Complex	(Not Described)
Long-leaved Sagebrush Sparse Vegetation Alliance	Bare Ground	Breaks	(Not Described)
Leafy Spurge Herbaceous Alliance	(Separate Map)	(Not Mapped)	(Not Described)
Canada Thistle Herbaceous Alliance	(Separate Map)	(Not Mapped)	(Not Described)
Prairie Sand-reed Grass Herbaceous Alliance	(Not Mapped)	(Not Mapped)	(Not Described)
Prairie Cordgrass Temporarily Flooded Herbaceous Alliance	River Bottom	River Bottoms	(Not Described)
Emergent Wetland (Cattail Great Plains Herbaceous Vegetation)	Marsh	Marsh	(Not Described)
Little Bluestem-Sideoats Grama Herbaceous Alliance	Little Bluestem	Upland Grasslands, Rolling Grasslands, Achenbach Hills, Ridge and Ravine, Scoria Hills, Achenbach Hills	*Andropogon scoparius/Carex filifolia* Habitat Type

USGS/BRD 1999	Hager 1997	Norland 1984	Hansen 1984
		Complex, Petrified Forest Complex, Rolling Scoria Complex, Steep Scoria Complex	
Western Wheatgrass Herbaceous Alliance	Western Wheatgrass-Green Needlegrass, Western Wheatgrass-Needle-and-Thread, Grassed Sand Floodplain	Upland Grasslands, Old River Terraces, Grassland Flats, Bottom Grasslands, Toe Slopes, Rolling Grasslands, Achenbach Hills, Ridge and Ravine, River Bottoms, Achenbach Hills Complex, Petrified Forest Complex, Rolling Scoria Complex, Steep Scoria Complex	*Agropyron smithii/Carex filifolia* Habitat Type
Introduced Grassland Herbaceous Alliance	Introduced Grassland	Introduced Grasses	(Not Described)
Needle-and-Thread Herbaceous Alliance	Needle-and-Thread-Blue Grama	Upland Grasslands, Old River Terraces, Grassland Flats, Toe Slopes, Rolling Grasslands, Achenbach Hills, Ridge and Ravine, Scoria Hills, Achenbach Hills Complex, Petrified Forest Complex, Rolling Scoria Complex, Steep Scoria Complex	*Stipa comata/Carex filifolia* Habitat Type

USGS/BRD 1999	Hager 1997	Norland 1984	Hansen 1984
Horizontal Juniper Dwarf Shrub Alliance	Little Bluestem/Creeping Juniper	Achenbach Hills, Ridge and Ravine, Scoria Hills, Achenbach Hills Complex, Rolling Scoria Complex, Steep Scoria Complex	*Juniperus horizontalis/ Andropogon scoparius* Habitat Type
Silver Sagebrush / Western Wheatgrass Shrubland	Dwarf Sagebrush	Sagebrush Bottoms	*Artemisia cana/Agropyron smithii* Habitat Type
Rabbitbrush Shrubland Alliance	Brush	Toe Slopes	(Not Described)
Three-leaved Sumac Shrubland Alliance	Rolling Scoria, Steep Scoria	Ridge and Ravine, Scoria Hills, Rolling Scoria Complex, Steep Scoria Complex	(Not Described)
Silver Buffaloberry Shrubland Alliance	Brush, River Bottoms	Wooded Draws, River Bottoms	(Not Described)
Wolfberry Temporarily Flooded Shrubland Alliance	Brush, River Bottoms	Wooded Draws, Toe Slopes, Achenbach Hills, Sagebrush Bottoms, River Bottoms	*Symphoricarpos occidentalis* Community
Sandbar Willow Temporarily Flooded Shrubland Alliance	River Bottoms, Willows	River Bottoms, Willows	(Not Described)
Greasewood Shrub Herbaceous Vegetation	Brush	(Not Described)	(Not Described)

USGS/BRD 1999	Hager 1997	Norland 1984	Hansen 1984
Cottonwood - Peachleaf Willow Floodplain Woodland	River Bottoms, Willows	Cottonwood Forests, River Bottoms, Willows	(Not Described)
Cottonwood - Rocky Mountain Juniper Floodplain Woodland	Cottonwood/Rocky Mountain Juniper	Cottonwood Forests, River Bottoms	(Not Described)
Cottonwood Temporarily Flooded Woodland Alliance	River Bottoms	Cottonwood Forests, River Bottoms	(Not Described)
Green Ash - American Elm Woodland Alliance	Hardwood Draw, Achenbach Hills Complex	Wooded Draws, Toe Slopes, Achenbach Hills, Ridge and Ravine	*Fraxinus pensylvanica/Prunus virginiana* Habitat Type
Green Ash - American Elm Temporarily Flooded Woodland Alliance	River Bottoms	River Bottoms	*Fraxinus pensylvanica/ Symphoricarpos occidentalis* Habitat Type
Quaking Aspen Woodland Alliance	Quaking Aspen/Mountain Birch	Wooded Draws	*Populus tremuloides/Betula occidentalis* Habitat Type
Rocky Mountain Juniper Woodland Alliance	Rocky Mountain Juniper/Ricegrass, Achenbach Hills Complex	Toe Slopes, Achenbach Hills, Ridge and Ravine, Scoria Hills	*Juniperus scopulorum/ Oryzopsis micrantha* Habitat Type
Ponderosa Pine Woodland Alliance	(Not Described - Outside Park)	(Not Described - Outside Park)	(Not Described - Outside Park)

APPENDIX N.

1997 Species List
for
Theodore Roosevelt National Park

Summarized by family from the sampled plot data.

Nomenclature taken from the Natural Resources Conservation Service (NRCS) PLANTS database.

(Created by Dan Cogan, USBR/ACS)

1997 Species List for Theodore Roosevelt National Park
Summarized by family from the sampled plot data.

SCIENTIFIC NAME
COMMON NAME

Aceraceae
Acer negundo L.
boxelder

Agavaceae
Yucca glauca Nutt.
small soapweed

Amaranthaceae
Amaranthus albus L.
prostrate pigweed

Anacardiaceae
Rhus trilobata Nutt.
three-leaved sumac
Toxicodendron rydbergii (Small ex Rydb.)
western poison ivy

Apiaceae
Osmorhiza claytonii (Michx.) C.B. Clarke
Clayton's sweetroot

Apocynaceae
Apocynum androsaemifolium L.
spreading dogbane
Apocynum cannabinum L.
Indianhemp

Asclepiadaceae
Asclepias L.
milkweed
Asclepias speciosa Torr.
showy milkweed
Asclepias verticillata L.
whorled milkweed

Asteraceae
Achillea millefolium L.
common yarrow
Acroptilon repens (L.) DC.
hardheads
Agoseris Raf.
agoseris
Agoseris glauca (Pursh) Raf.
pale agoseris
Ambrosia artemisiifolia L.
annual ragweed
Ambrosia psilostachya DC.
Cuman ragweed
Antennaria Gaertn.
pussytoes
Antennaria microphylla Rydb.
littleleaf pussytoes
Antennaria parvifolia Nutt.
smallleaf pussytoes
Antennaria rosea Greene
rosy pussytoes
Arctium minus Bernh.
lesser burdock
Arnica frigida C.A. Mey. ex Iljin
snow arnica
Artemisia absinthium L.
absinth sagewort
Artemisia cana Pursh
silver sagebrush
Artemisia dracunculus L.
wormwood
Artemisia dracunculus ssp. dracunculus L.
wormwood
Artemisia frigida Willd.
fringed sagewort
Artemisia longifolia Nutt.
longleaf sagebrush
Artemisia ludoviciana Nutt.
Louisiana sagewort
Artemisia tridentata Nutt.
big sagebrush
Aster L.
aster
Aster ericoides L.
heath aster
Aster laevis L.
smooth aster
Chrysothamnus nauseosus
(Pallas ex Pursh) Britt.
rubber rabbit brush
(Ericameria nauseosa ssp. nauseosa
var. nauseosa)
Cirsium arvense (L.) Scop.
Canadian thistle
Cirsium undulatum (Nutt.) Spreng.
wavyleaf thistle
Conyza canadensis (L.) Cronq.
Canadian horseweed
Dyssodia papposa (Vent.) A.S. Hitchc.
fetid marigold
Echinacea angustifolia DC.
blacksamson echinacea
Erigeron L.
fleabane
Erigeron strigosus Muhl. ex Willd.
prairie fleabane
Grindelia squarrosa (Pursh) Dunal
curlycup gumweed
Gutierrezia sarothrae (Pursh)
Britt. & Rusby
broom snakeweed
Helianthus L.
sunflower
Helianthus annuus L.
common sunflower
Helianthus pauciflorus ssp.
pauciflorus Nutt.
stiff sunflower
Heterotheca villosa var. villosa
(Pursh) Shinners
hairy goldenaster
Iva axillaris Pursh
povertyweed
Iva xanthifolia Nutt.
giant sumpweed
Lactuca serriola L.
prickly lettuce
Lactuca tatarica var. pulchella
(Pursh) Breitung
blue lettuce

SCIENTIFIC NAME
COMMON NAME

(Lactuca oblongifolia)
Liatris punctata Hook.
dotted gayfeather
Lygodesmia juncea (Pursh) D. Don ex Hook.
rush skeletonplant
Machaeranthera canescens (Pursh) Gray
hoary aster
Oligoneuron rigidum var. rigidum (L.) Small
rigid goldenrod
(Solidago rigida)
Ratibida columnifera (Nutt.) Woot. & Standl.
upright prairie coneflower
Solidago L.
goldenrod
Solidago canadensis L.
Canada goldenrod
Solidago gigantea Ait.
giant goldenrod
Solidago missouriensis Nutt.
Missouri goldenrod
Solidago mollis Bartl.
velvety goldenrod
Taraxacum officinale G.H. Weber ex Wiggers
common dandelion
Tetraneuris acaulis var. acaulis (Pursh) Greene
stemless hymenoxys
Tragopogon dubius Scop.
yellow salsify
Xanthium strumarium L.
rough cocklebur

Betulaceae
Betula occidentalis Hook.
water birch

Boraginaceae
Lappula occidentalis var. occidentalis (S. Wats.) Greene
desert stickseed
Lithospermum L.
stoneseed

Brassicaceae
Arabis L.
rockcress
Arabis holboellii Hornem.
Holboell's rockcress
Brassica L.
mustard
Brassica juncea (L.) Czern.
India mustard
Camelina microcarpa DC.
littlepod falseflax
Descurainia pinnata (Walt.) Britt.
western tansymustard
Descurainia sophia (L.) Webb ex Prantl
herb sophia
Erysimum capitatum var. capitatum (Dougl. ex Hook.) Greene
sanddune wallflower
Erysimum cheiranthoides L.
wormseed wallflower
Lepidium L.
pepperweed

SCIENTIFIC NAME
COMMON NAME

Lepidium densiflorum Schrad.
common pepperweed
Lepidium montanum Nutt.
mountain pepperweed
Lesquerella alpina (Nutt.) S. Wats.
alpine bladderpod
Lesquerella arenosa (Richards.) Rydb.
Great Plains bladderpod
Sisymbrium altissimum L.
tall tumblemustard
Sisymbrium loeselii L.
small tumbleweed mustard
Thlaspi arvense L.
field pennycress

Cactaceae
Opuntia fragilis (Nutt.) Haw.
brittle pricklypear
Opuntia humifusa var. austrina (Small) Dress
common pricklypear
Opuntia polyacantha Haw.
plains pricklypear

Campanulaceae
Campanula rotundifolia L.
bluebell bellflower

Cannabaceae
Humulus lupulus L.
common hop

Capparaceae
Polanisia dodecandra (L.) DC.
roughseed clammyweed

Caprifoliaceae
Lonicera tatarica L.
Tatarian honeysuckle
Symphoricarpos albus (L.) Blake
common snowberry
Symphoricarpos occidentalis Hook.
western snowberry

Chenopodiaceae
Atriplex L.
saltbush
Atriplex argentea Nutt.
silverscale saltbush
Atriplex canescens (Pursh) Nutt.
fourwing saltbush
Atriplex confertifolia (Torr. & Frem.) S. Wats.
shadscale saltbush
Atriplex nuttallii S. Wats.Nuttall's
saltbush
Chenopodium L.
goosefoot
Chenopodium album L.
lambsquarters
Chenopodium leptophyllum (Moq.) Nutt. ex S. Wats.
narrowleaf goosefoot
Kochia scoparia (L.) Schrad.
common kochia
Krascheninnikovia lanata (Pursh)
Guldenstaedt   winterfat

SCIENTIFIC NAME
COMMON NAME

Monolepis nuttalliana (J.A. Schultes) Greene
Nuttall's povertyweed
Salsola kali L.
prickly Russian thistle
Salsola kali ssp. tragus (L.) Celak.
prickly Russian thistle
Sarcobatus vermiculatus (Hook.) Torr.
greasewood
Suaeda calceoliformis (Hook.) Moq. Pursh
seepweed

Convolvulaceae
Convolvulus arvensis L.
field bindweed

Cornaceae
Cornus L.
dogwood
Cornus sericea ssp. sericea L.
redosier dogwood

Cupressaceae
Juniperus communis L.
common juniper
Juniperus horizontalis Moenc
creeping juniper
Juniperus scopulorum Sarg.
Rocky Mountain juniper

Cyperaceae
Carex L.
sedge
Carex brevior (Dewey) Mackenzie
fescue sedge
Carex duriuscula C.A. Mey.
needleleaf sedge
(Carex eleocharis)
Carex filifolia Nutt.
threadleaf sedge
Carex inops ssp. heliophila Mackenzie) Crins
sun sedge
Carex sprengelii Dewey ex Spreng.
Sprengel's sedge
Eleocharis R. Br.
spikerush

Dryopteridaceae
Dryopteris Adans.
woodfern
Woodsia oregana D.C. Eat.
Oregon woodsia
Woodsia R. Br.
woodsia

Elaeagnaceae
Elaeagnus angustifolia L.
Russian olive
Shepherdia argentea (Pursh) Nutt.
silver buffaloberry

Equisetaceae
Equisetum L.
horsetail
Equisetum hyemale L.
scouringrush horsetail
Equisetum laevigatum A. Braun
smooth horsetail

Ericaceae
Arctostaphylos uva-ursi (L.) Spreng.
kinnikinnick, bearberry

Euphorbiaceae
Chamaesyce geyeri var. geyeri (Engelm.)
(Euphorbia geyeri)
Chamaesyce missurica (Raf.) Shinners
prairie sandmat
Euphorbia L.
spurge
Euphorbia missurica
Euphorbia esula L.
leafy spurge
Euphorbia spathulata Lam.
warty spurge

Fabaceae
Astragalus L.
milkvetch
Astragalus crassicarpus Nutt.
groundplum milkvetch
Astragalus gilviflorus var. gilviflorus Sheldon
plains milkvetch
Dalea candida var. candida Willd.
white prarieclover
(Petalostemon candidus Michx.)
Dalea purpurea var. purpurea Vent.
(Petalostemon purpureus var. mollis (Rydb.) Boivin)
Glycyrrhiza lepidota Pursh
American licorice
Hedysarum boreale Nutt.
northern sweetvetch
Medicago lupulina L.
black medic
Medicago sativa L.
alfalfa
Melilotus alba Medikus
white sweetclover
Melilotus officinalis (L.) Lam.
yellow sweetclover
Oxytropis DC.
crazyweed
Oxytropis lambertii Pursh
Lambert's crazyweed
Pediomelum argophyllum (Pursh) J. Grimes
silverleaf scurfpea
Pediomelum esculentum (Pursh) Rydb.
breadroot scurfpea
Psoralidium lanceolatum (Pursh) Rydb.
lemon scurfpea
Thermopsis rhombifolia (Nutt. ex Pursh) Nutt. ex Richards.
prairie thermopsis
Vicia L.
vetch
Vicia americana Muhl. ex Willd.
American vetch

Geraniaceae
Geranium L.
geranium

SCIENTIFIC NAME
COMMON NAME

Geranium richardsonii Fisch. & Trautv.
Richardson's geranium

Grossulariaceae
Ribes aureum var. villosum DC.
golden currant
(Ribes odoratum H. Wendl.)
Ribes missouriense Nutt.
Missouri gooseberry
Ribes oxyacanthoides ssp. setosum (Lindl.) Sinnott
inland gooseberry
(Ribes setosum Lindl.)

Iridaceae
Sisyrinchium montanum Greene
mountain blueeyed grass

Lamiaceae
Agastache foeniculum (Pursh) Kuntze
blue giant hyssop
Hedeoma hispida Pursh
rough falsepennyroyal
Mentha arvensis L.
wild mint
Monarda bradburiana Beck
eastern beebalm
Monarda fistulosa L.
wildbergamot beebalm

Liliaceae
Allium textile A. Nels. & J.F. Macbr.
textile onion
Asparagus officinalis L.
garden asparagus
Maianthemum racemosum (L.) Link
feathery false Solomon's seal
Maianthemum stellatum (L.) Link
starry false Solomon's seal

Linaceae
Linum lewisii Pursh
prairie flax
Linum rigidum Pursh
stiffstem flax

Loasaceae
Mentzelia decapetala (Pursh ex Sims) Urban & Gilg ex Gilg
tenpetal blazingstar

Malvaceae
Sphaeralcea coccinea (Nutt.) Rydb.
scarlet globemallow

Oleaceae
Fraxinus pennsylvanica Marsh.
green ash

Onagraceae
Calylophus serrulatus (Nutt.) Raven
yellow sundrops
Gaura coccinea Nutt. ex Pursh
scarlet beeblossom
Oenothera L.
eveningprimrose
Oenothera villosa Thunb.
hairy eveningprimrose

SCIENTIFIC NAME
COMMON NAME

Oxalidaceae
Oxalis stricta L.
common yellow oxalis

Pinaceae
Pinus ponderosa P.& C. Lawson
ponderosa pine

Plantaginaceae
Plantago patagonica Jacq.
woolly plantain

Poaceae
Agropyron cristatum (L.) Gaertn.
crested wheatgrass
Alopecurus aequalis Sobol.
shortawn foxtail
Andropogon gerardii Vitman
big bluestem
Aristida purpurea Nutt.
purple threeawn
Bouteloua curtipendula (Michx.) Torr.
sideoats grama
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths
blue grama
Bromus L.
brome
Bromus inermis Leyss.
smooth brome
Bromus japonicus Thunb. ex Murr.
Japanese brome
Bromus tectorum L.
cheatgrass
Buchloe dactyloides (Nutt.) Engelm.
buffalograss
Calamovilfa longifolia (Hook.) Scribn.
prairie sandreed
Dactylis glomerata L.
orchardgrass
Dichanthelium wilcoxianum (Vasey) Freckmann
fall panicum
Distichlis spicata (L.) Greene
inland saltgrass
Echinochloa crus-galli (L.) Beauv.
barnyardgrass
Elymus canadensis L.
Canada wildrye
Elymus elymoides ssp. elymoides (Raf.) Swezey
Elymus trachycaulus (Link) Gould ex Shinners
slender wheatgrass
Elymus virginicus L.
Virginia wildrye
Elytrigia repens var. repens (L.) Desv. ex B.D. Jackson
quackgrass
Hordeum jubatum L.
foxtail barley
Koeleria macrantha (Ledeb.) J.A. Schultes
prairie Junegrass
Muhlenbergia cuspidata (Torr. ex Hook.) Rydb.
plains muhly
Nassella viridula (Trin.) Barkworth
green needlegrass

SCIENTIFIC NAME
COMMON NAME

(Stipa viridula)
Oryzopsis asperifolia Michx.
roughleaf ricegrass
Oryzopsis hymenoides (Roemer & J.A. Schultes) Ricker ex Piper
Indian ricegrass
(Achnatherum hymenoides)
Oryzopsis micrantha (Trin. & Rupr.) Thurb.
littleseed ricegrass
(Piptatherum micranthum)
Panicum L.
panicum
Panicum capillare L.
witchgrass
Pascopyrum smithii (Rydb.) A. Love
western wheatgrass
Poa arida Vasey
plains bluegrass
Poa L.
bluegrass
Poa compressa L.
Canada bluegrass
Poa pratensis L.
Kentucky bluegrass
Poa secunda J. Presl
Sandberg bluegrass
Pseudoroegneria spicata (Pursh) A. Love
bluebunch wheatgrass
Puccinellia nuttalliana (J.A. Schultes) A.S. Hitchc.
Nuttall's alkaligrass
Schedonnardus paniculatus (Nutt.) Trel.
tumblegrass
Schizachyrium scoparium (Michx.) Nash
little bluestem
Spartina pectinata Link
prairie cordgrass
Sporobolus airoides (Torr.) Torr.
alkali sacaton
Sporobolus cryptandrus (Torr.) Gray
sand dropseed
Stipa comata Trin. & Rupr.
needle-and-thread
(Hesperostipa comata ssp. comata (Trin. & Rupr.) Barkworth)
Stipa spartea Trin.
porcupine grass
(Hesperostipa spartea (Trin.) Barkworth)
Vulpia octoflora (Walt.) Rydb.
sixweeks fescue
(Festuca octoflora Walt.)

Polemoniaceae
Phlox hoodii Richards.
spiny phlox

Polygalaceae
Polygala alba Nutt.
white milkwort

Polygonaceae
Eriogonum Michx.
eriogonum
Eriogonum flavum Nutt.
yellow eriogonum
Polygonum aviculare L.
prostrate knotweed

SCIENTIFIC NAME
COMMON NAME

Polygonum convolvulus L.
black bindweed
Rumex crispus L.
curly dock

Polypodiaceae
Polypodium L.
polypody
Polypodium hesperium Maxon
western polypody

Primulaceae
Lysimachia L.
loosestrife
Lysimachia ciliata L.
fringed loosestrife

Pyrolaceae
Pyrola L.
pyrola

Ranunculaceae
Actaea rubra (Ait.) Willd.
red baneberry
Anemone cylindrica Gray
candle anemone
Aquilegia canadensis L.
red columbine
Clematis ligusticifolia Nutt.
western white clematis
Clematis virginiana L.
devil's darning needles
Pulsatilla patens ssp. patens (L.) P. Mill.
American pasqueflower
(Anemone patens)
Thalictrum dasycarpum Fisch. & Ave-Lall.
purple meadowrue
Thalictrum venulosum Trel.
veiny meadowrue

Rosaceae
Agrimonia repens L.
creeping agrimony
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer
Saskatoon serviceberry
Crataegus chrysocarpa Ashe
fireberry hawthorn
Fragaria virginiana Duchesne
Virginia strawberry
Geum canadense Jacq.
white avens
Geum triflorum Pursh
prairiesmoke
Pentaphylloides floribunda (Pursh) A. Love
shrubby cinquefoil
Potentilla L.
cinquefoil
Prunus virginiana L.
common chokecherry
Rosa arkansana Porter
prairie rose
Rosa woodsii Lindl.
Woods' rose
Rubus idaeus L.
American red raspberry

SCIENTIFIC NAME
COMMON NAME

Rubiaceae
Galium L.
bedstraw
Galium aparine L.
stickywilly
Galium boreale L.
northern bedstraw

Salicaceae
Populus deltoides Bartr. ex Marsh.
eastern cottonwood
Populus tremuloides Michx.
quaking aspen
Salix amygdaloides Anderss.
peachleaf willow
Salix exigua Nutt.
sandbar willow

Santalaceae
Comandra umbellata (L.) Nutt.
bastard toadflax
Comandra umbellata ssp. pallida (A. DC.) Piehl
pale bastard toadflax

Saxifragaceae
Heuchera richardsonii R. Br.
Richardson's alumroot

Scrophulariaceae
Linaria dalmatica (L.) P. Mill.
Dalmatian toadflax
Orthocarpus luteus Nutt.
yellow owlclover
Penstemon Schmidel
penstemon

Selaginellaceae
Selaginella densa Rydb.
lesser spikemoss

Smilacaceae
Smilax herbacea L.
smooth carrionflower

SCIENTIFIC NAME
COMMON NAME

Solanaceae
Solanum rostratum Dunal
buffalobur nightshade
Solanum triflorum Nutt.
cutleaf nightshade

Ulmaceae
Ulmus americana L.
American elm
Ulmus pumila L.
Siberian elm

Verbenaceae
Verbena bracteata Lag. & Rodr.
bigbract verbena
Verbena lasiostachys var. lasiostachys Link
western vervain

Violaceae
Viola L.
violet

Vitaceae
Parthenocissus quinquefolia (L.) Planch.
Virginia creeper
Parthenocissus vitacea (Knerr) A.S. Hitchc.
woodbine

APPENDIX O.

Accuracy Assessment Confidence Interval Calculations

(referenced on page 4-31)

Accuracy Assessment Confidence Interval Calculations

1. Large Sampling Sizes (n gt 30).

Class	x	n	p	n x p	np ge 5?	n(1-p)	n(1-p) ge 5?	.2 It p It .8?	Result
2 (Samples)	43	49	0.8776	43	True	6	True	False	Use 1a
18 (Samples)	63	98	0.6429	63	True	35	True	True	Use 1b
44 (Samples)	26	32	0.8125	26	True	6	True	False	Use 1a
2 (Ref.)	43	48	0.8958	43	True	5	True	False	Use 1a
18 (Ref.)	63	66	0.9545	63	True	3	False	False	Use 1a
Overall	257	346	0.7428	257	True	89	True	True	Use 1b

x = Number of correct classifications; n = Total samples; p = Ratio of x/n

1a. When any test above was 'false', used the following table to calculate confidence intervals:

Class	x	n	Lower Confidence Limit Degrees of Freedom		Upper Confidence Limit Degrees of Freedom		Lower 90% Conf. Limit	Upper 90% Conf. Limit
			L1 v1	L1 v2	L2 v1	L2 v2		
2 (Samples)	43	49	14	86	88	12	0.773	0.945
44 (Samples)	26	32	14	52	54	12	0.663	0.915
2 (Ref.)	43	48	12	86	88	10	0.793	0.958
18 (Ref.)	63	66	8	126	128	6	0.887	0.987
	257	346	180	514	516	178	0.701	0.781

Formulas:

v1 for L1:	2*(n-x+1)	v1 for L2:	2*(X+1)	Lower CL L1: x/(x+(n-x+1)*FDIST(0.05,v1,v2,1))
v2 for L1:	2x	v2 for L2:	2*(n-x)	Upper CL L2: ((x+1)*F(.05,v1,v2,1))/(n-x+(x+1)*F(0.05,v1,v2,1))

1b. When all tests are true, used formulas in NBS report "Accuracy Assessment Procedures":

Class	x	n	z	p	Confidence Interval	Lower 90% Conf. Limit	Upper 90% Conf. Limit
18 (Samples)	63	98	1.645	0.64285714	0.084724	0.558133	0.727581
Overall	257	346	1.645	0.74277457	0.040101	0.702674	0.782875

CI Formula: z*SQRT((p*(1-p))/n))+1/(2*n)

2. For small sampling sizes (n le 30), used Table A-22 in Natrella, "Experimental Statistics" (1963).