Climate

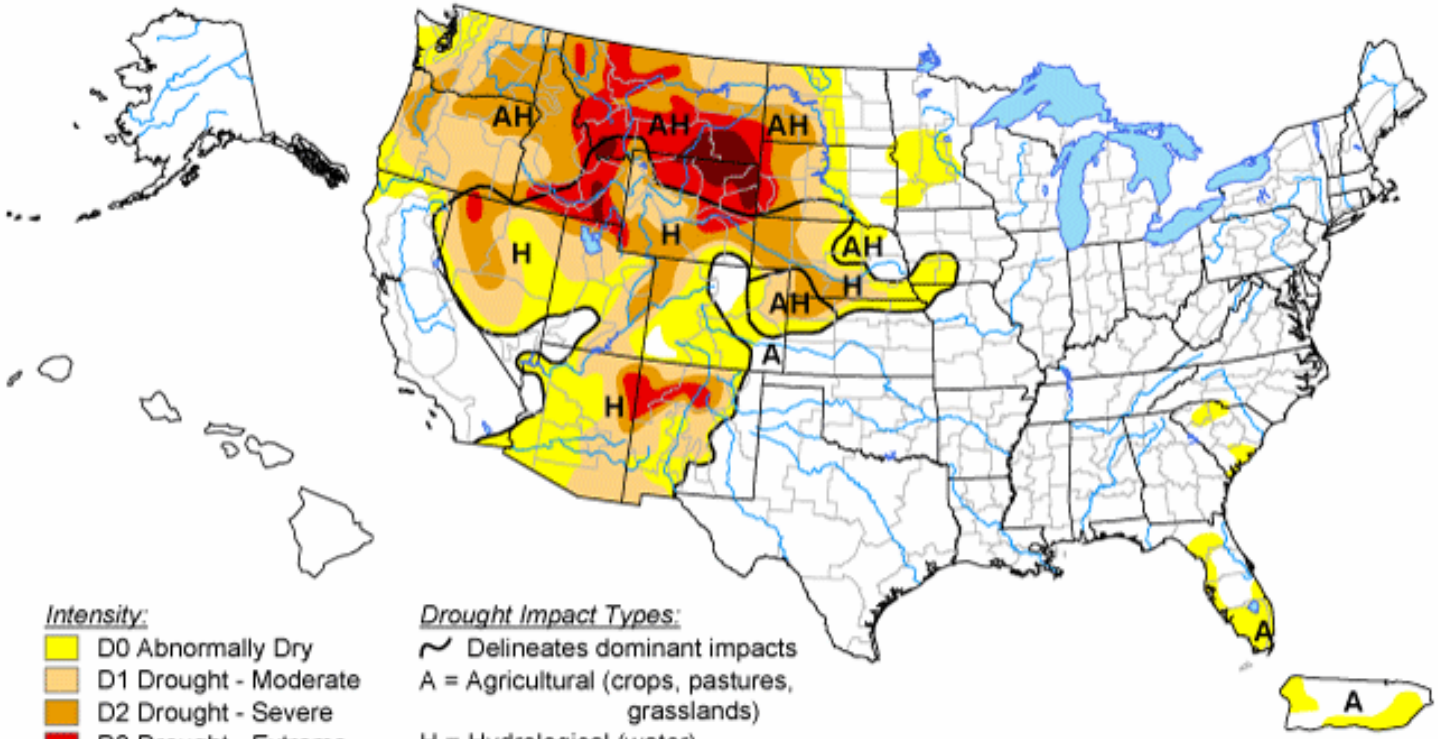
The climate of the Gardiner Basin is described as long, cold winters with short dry summers, and is characteristic of an arid to semi-arid cold desert. Climate data for the area is represented by a U.S. Weather Bureau station maintained in the town of Gardiner, MT (Table 1) at an elevation of 5,280 ft. The average summer maximum temperature peaks in July at 85°F, although temperatures in July and August occasionally exceed 100°F. Average winter minimum temperature of 14°F occurs in January, but low temperatures in the range of -20°F can occasionally occur from late November through mid-February. Precipitation averages slightly over 10 inches annually, with 33% of the total received from March through June. Snowfall averages around 40 inches annually, but is patchy and intermittent and seldom persists throughout the winter months.

Table 1: Summary data for the U.S. Weather Bureau climate station in Gardiner, MT for the 30-yr period 1971-2000. Data obtained from the Western Region Climate Center website, complements of P. Farnes.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Ave. Max. Temp. (F)	33.3	39.2	47.5	56.6	66.5	76.4	84.7	84.0	74.2	60.5	41.7	33.2	58.3
Ave. Min. Temp. (F)	13.8	18.0	24.3	30.7	38.6	45.6	51.4	50.8	42.0	33.4	22.6	15.1	32.3
Ave. Total Precip. (in.)	0.38	0.42	0.65	0.77	1.48	1.45	1.08	0.93	0.93	0.79	0.70	0.48	10.06

U.S. Drought Monitor

February 22, 2005
Valid 7 a.m. EST



Intensity:
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:
- ~ Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)
- (No type = Both impacts)

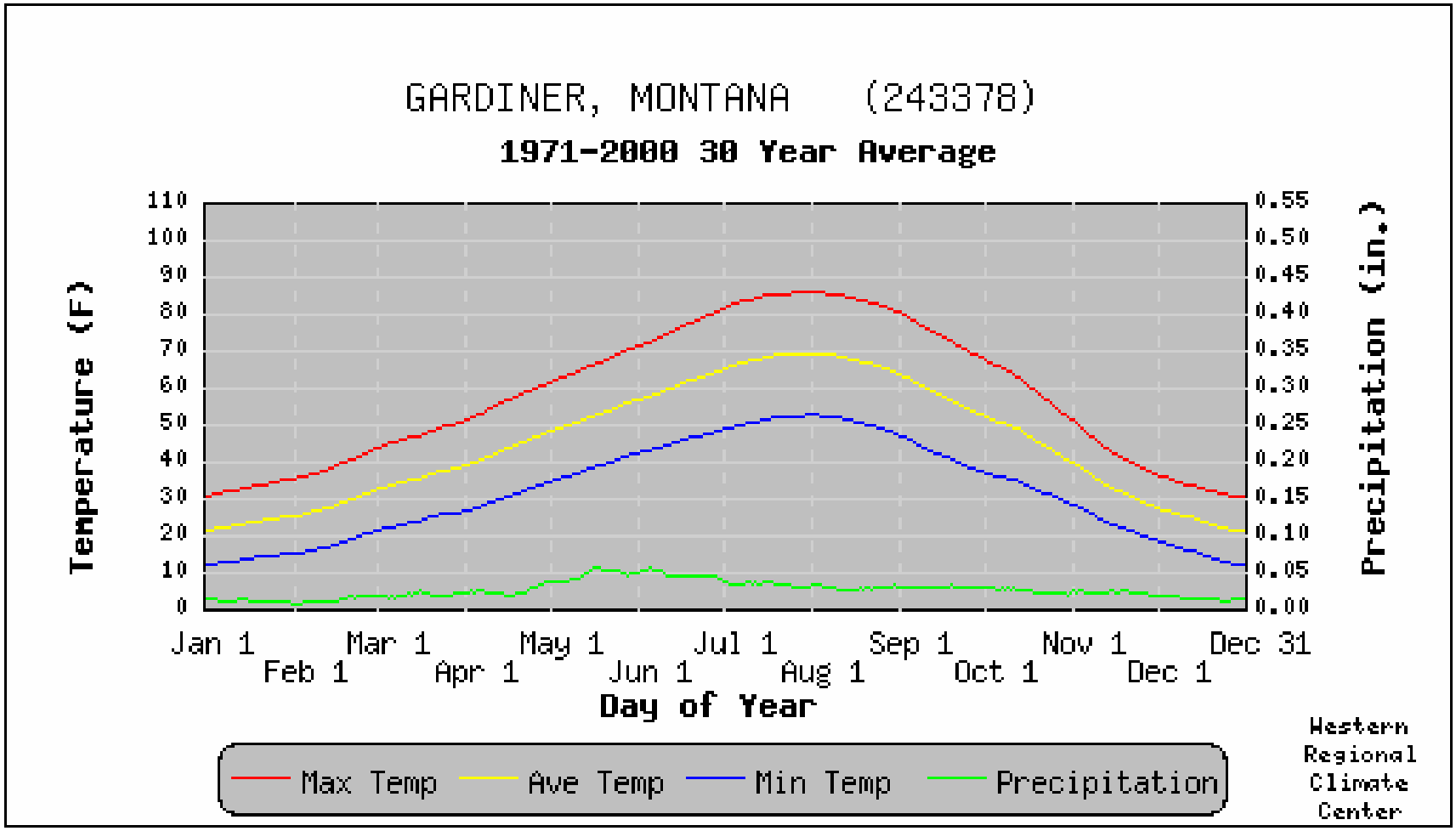
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

USDA National Drought Mitigation Center

Released Thursday, February 24, 2005

Authors: Richard Heim/Candace Tankersley, NOAA/NESDIS/NCDC


GARDINER, MONTANA (243378)
1971-2000 30 Year Average
Temperature (F)
Precipitation (in.)
110
100
90
80
70
60
50
40
30
20
10
0
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 1
Feb 1
Mar 1
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Nov 1
Dec 1
Dec 31
Day of Year
Max Temp
Ave Temp
Min Temp
Precipitation
Western Regional Climate Center

VEGETATION OF THE GARDINER BASIN WITHIN YELLOWSTONE NATIONAL PARK

Nestled in the Rocky Mountains on the northern boundary of Yellowstone National Park, is the Gardiner Basin. While most of the park is subalpine forest and meadows, the Gardiner Basin represents the lowest elevation (5189 feet) and driest portion of the park. This mountain basin, which contains many species typical of the middle Rocky Mountains, also harbors species more commonly encountered in the short grass prairie of the Great Plains to the east and species that are representative of the Great Basin to the west. For example, spiny hopsage (*Grayia* spinosa), a typical component of the Great Basin flora, is a common shrub in the area, though its rarity in Montana means that it is a species of special concern (rare) in the state. In contrast, high plains species such as groundplum (*Astragalus crassicarpus* var. *paysonii*) and blue grama (*Bouteloua* gracilis) also occur in the area. Together these diverse elements create the present vegetation of the Gardiner Basin.

The highest edges of the mountains surrounding the basin are forested with woodlands of limber pine *(Pinus flexilis)* and Douglas-fir *(Pseudotsuga menziesii).* With increasing elevation, or in wooded areas with a relatively recent fire history, there are extensive forests of lodgepole pine. Below the forests and woodlands, sagebrush steppe dominates the landscape. At higher elevations such as around Mammoth Hot Springs, the vegetation is a sagebrush steppe community dominated by mountain big sage (*Artemisia tridentata* var. *vaseyana*) and Idaho fescue (*Festuca idahoensis*). Traveling lower in elevation the Idaho fescue begins to drop out, being replaced by more and more bluebunch wheatgrass (*Elymus spicatus*). Eventually at the lowest elevations in the Gardiner Basin, the mountain big sage is replaced by Wyoming big sage (*Artemisia tridentata* var. *wyomingensis*) with an understory community of bluebunch wheatgrass, prairie junegrass, and Sandberg's bluegrass.

Along the permanent stream courses and river beds the riparian vegetation varies considerably from site to site. The Gardiner River has very few cottonwoods along the river, instead on the adjacent slopes in the drainage is an open woodland with limber pines, Rocky Mountain juniper (*Juniperus scopulorum*), Douglas-fir, and squawbush (*Rhus aromatica* var. *trilobata*). Immediately adjacent to the river are water birch (*Betula occidentalis*), and willows (*Salix* spp.), but there is little or no streamside meadow. In contrast, Reese Creek has a significant cottonwood presence (*Populus* spp.) along with western birch, willows, and a small riparian strip of riparian forbs and graminoids. The riparian zone along the Yellowstone River is characterized by coyote willow (*Salix exigua*), with very occasional cottonwoods. Since the streams and rivers travel through alluvial deposits, with a lot of coarse material and very little fine material, there is little development of graminoid dominated wetlands on the edges of the watercourses.

The vegetation of the landslide deposits and the massive alluvial fans, though blighted by many exotic species, it is still primarily composed of native species. Don Despain (1990)

recognized a bluebunch wheatgrass/Sandberg's bluegrass habitat type with the Sandberg's bluegrass phase on the better soils of the mudflows and the needle-and-thread phase mainly on the river deposited sands and gravels (Despain, 1990). Additionally, Despain recognized the presence of a big sagebrush/bluebunch wheatgrass habitat type in the Gardiner Basin. The treatment of western Montana habitat types by Mueggler and Stewart (1980) besides recognizing the above types also described an *Agropyron spicatum/Agropyron smithii* habitat type which is present in small areas. Conspicuous wildflower shows occur in spring and early summer with extensive stands composed of species such as bitterroot (*Lewisia rediviva*), lava aster (*Ionactis alpina*), textile onion (*Allium textile*), and Hood's phlox (*Phlox hoodii*).

The relatively flat areas present in the area between the landslide deposits and the alluvial fan deposits were homesteaded and cultivated for an extensive period of time around the turn of the twentieth century. These tilled fields were added to the park primarily in the 1930's. Crested wheatgrass (*Agropyron cristatum*) was eventually planted in a poorly conceived attempt to revegetate the area in a palatable species that could be utilized by the native ungulates. Today these former fields are almost exclusively dominated by exotics. The most common exotic species in the area is desert alyssum (*Alyssum desertorum*) which forms areas that are almost pure monocultures, punctuated by stands and patches of crested wheatgrass. Other commonly encountered species on these old fields include summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), Russian thistle (*Salsola tragus* syn. = *S. iberica, S. kali, S. pestifer*), annual wheatgrass (*Agropyron triticeum*), fanweed (*Thlaspi arvense*), littlepod falseflax (*Camelina microcarpa*), flixweed (*Descurainia sophia*), cheatgrass (*Bromus tectorum*), and Japanese brome (*Bromus japonicus*).

The big question about the vegetation of the Gardiner Basin is what was the original plant community (or plant communities) on the formerly tilled fields. The only information on the original vegetation comes from Augustus Doane's journal from 1870 which states about the campsite by the Gardiner River that "This was our first poor camping place, grass being very scarce, and the slopes of the range covered entirely with sagebrush." Earlier in the day, he commented that they had passed through a "…dead level alkali plain to a succession of plateaus covered slightly with a sterile soil through which the limestones cropped out constantly." Additionally, he describes the area as a "desert region enclosed by mountains…" (Bonney and Bonney, 1970).

One of the possibilities is that at least some of these former fields may have supported extensive stands of greasewood (*Sarcobatus vermiculatus*) perhaps similar to *Sarcobatus vermiculatus/Elymus cinereus* or *Sarcobatus vermiculatus/Agropyron smithii* habitat types of Mueggler and Stewart (1980). There are small areas near Rattlesnake Butte that could be characterized in this manner. Another possibility is that some or all of these sites may have been areas dominated by big sagebrush (*Artemisia tridentata* var. *tridentata*) with a western wheatgrass (*Elymus smithii* syn = *Pascopyrum smithii*) or perchance another type of understory. Or conceivably these areas were actually different than any of the commonly recognized habitat types or community types due to the disparate elements of the Great Basin and Great Plains present in this basin.

Bonney, Orrin H. and Lorraine Bonney. 1970. Battle Drums and Geysers: The Life and Journals of Lt. Gustavus Cheyney Doane, Soldier and Explorer of the Yellowstone and Snake River Regions. The Swallow Press, Inc. Chicago, Illinois. Pp 236-237.

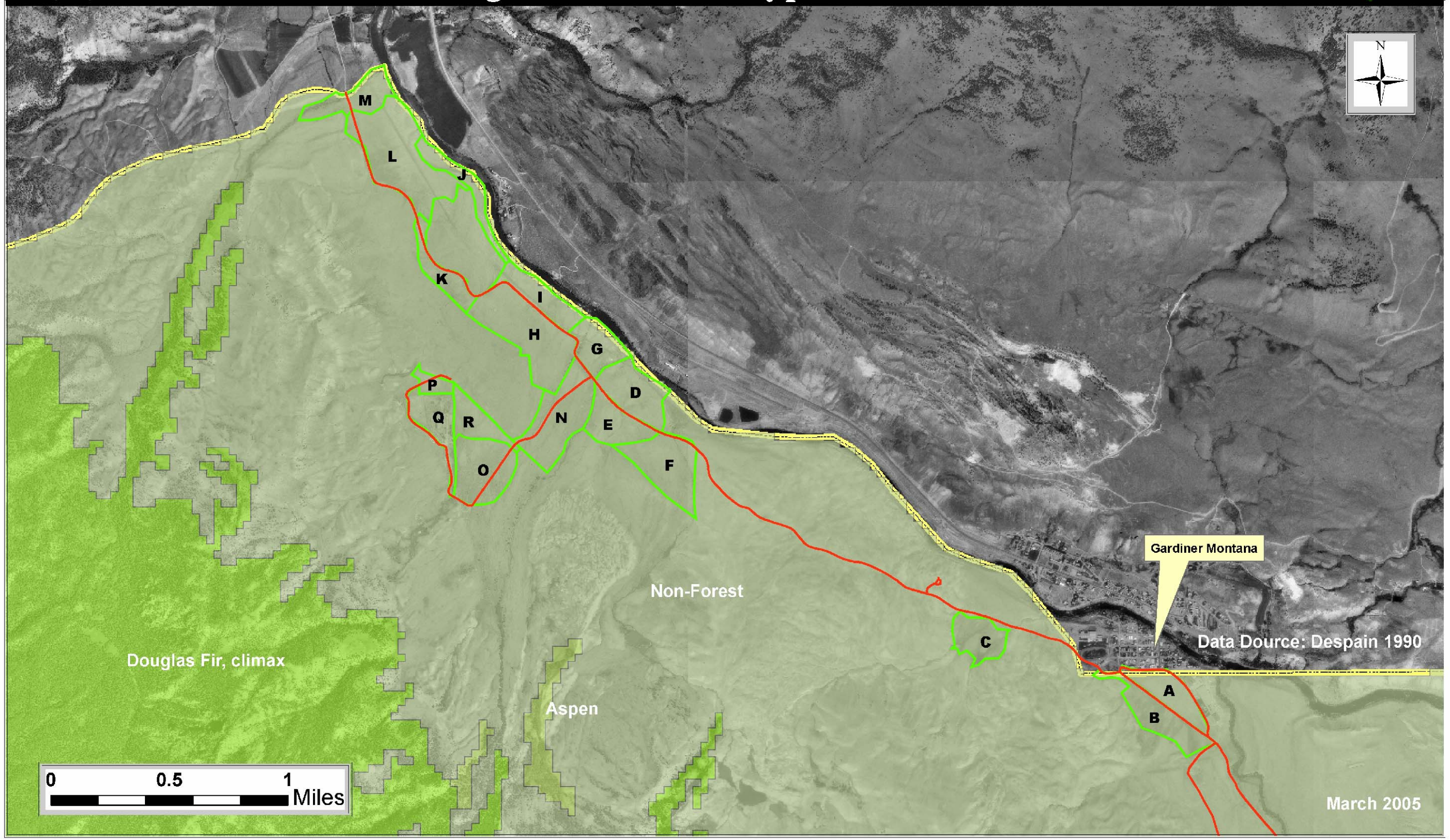
Despain, Don G. 1990. Yellowstone Vegetation: Consequences of Environment and History in a Natural Setting. Robert Rinehart Publishers. Boulder, Colorado.

Mueggler, W. F. and W. L. Stewart. 1980. Grassland and shrubland habitat types of Western Montana. USDA Forest Service General Technical Report INT-66.

Yellowstone National Park
ID, MT, WY

Vegetation Cover Types

National Park Service
U.S. Department of the Interior



GARDINER BASIN AREA – WILDLIFE USE

Pronghorn

Yellowstone pronghorn (*Antilocapra americana*) face a serious risk of extirpation because isolation, low abundance, and reductions in the quantity and quality of available winter range have increased their susceptibility to random, naturally occurring catastrophes (e.g., severe winter weather, droughts, disease epidemics). This population was one of the few not exterminated or decimated by the early 20th century. Consequently, Yellowstone pronghorn were the source for re-establishing or supplementing populations of pronghorn in numerous western states during the first half of last century. Yellowstone pronghorn express much of the genetic variation formerly widespread in the species, but no longer present elsewhere. The population has also retained some of its historic seasonal migration patterns and is an integral part of the unique predator:prey ecosystem of Yellowstone National Park (Yellowstone). Given this historical and biological significance, in 1998-1999 Yellowstone identified pronghorn as a Species of Special Concern, listed their conservation as a high-priority need in the park's Resource Management Plan, and implemented a rigorous monitoring program of abundance, limiting factors, and demographic rates. The following information was coalesced from Barmore (2003), Boccadori (2002), Byers (2002), Houston (1982), Keating (2002), Yellowstone Center for Resources (unpublished data), and references cited therein.

Abundance and Distribution.—Pronghorn were once numerous and widely distributed in the upper Yellowstone drainage and thousands migrated down the Yellowstone River from higher-elevation summer ranges in what is now Yellowstone National Park to lower-elevation winter ranges in the Paradise Valley and near Livingston, Montana. However, settlement (i.e., development, hunting, mining, agriculture, livestock, fencing, railroad terminus) greatly reduced pronghorn abundance and effectively eliminated their migration north from the park sometime before 1920. Management actions during 1886-1934 designed to keep pronghorn in the park (e.g., feeding, irrigated alfalfa, fencing, predator control) further reduced their distribution by apparently inducing some pronghorn to remain on the winter range year-round, likely creating a non-migratory subpopulation that still exists today.

A dramatic shift in pronghorn management occurred in the late 1940s when habitat objectives were emphasized rather than herd protection. In 1946, park managers approved a plan to reduce the population from 800 to 400 pronghorn and a further reduction to 100-125 pronghorn was planned in 1953. At least 1,144 pronghorn were removed during 1947-1967 and numbers remained <400. After the reduction program ended, pronghorn counts remained relatively stable between 102 and 165 animals for the next 15 years. There were serious concerns about the long-term viability of Yellowstone pronghorn during this period given their relatively low numbers and apparent isolation, but no management actions were taken to augment the population. Counts increased to 310 animals in 1983 and then to 588 animals by 1991. Possible explanations for this increase included: 1) favorable weather and forage conditions; 2) increased predator harvest outside the park; and 3) increased irrigated cropland (>190 acres) outside the

park. None of these explanations were strongly supported, however, and the precise factors driving this increase in abundance remain unknown.

Pronghorn counts decreased from 536 to 235 animals during 1992-1995. Possible explanations for this rapid decrease included: 1) wolf predation; 2) increased coyote predation; 3) disease or parasites; 4) fencing of the park's northern boundary; 5) disturbances associated with bison management activities; and 6) pronghorn hunting outside the park. Complaints from private landowners in the Gardiner basin resulted in the damage-control harvest of approximately 190 Yellowstone pronghorn during 1985-2000. None of these possible explanations were strongly supported, however, and the precise factors driving this rapid decrease in abundance remain unknown. Pronghorn counts remained between 204 and 229 animals during 1996-2004. Yellowstone pronghorn now congregate in a relatively small, high-elevation basin near Gardiner, Montana, during December through March where they are apparently isolated from other pronghorn populations. In late March or early April, approximately two-thirds of the pronghorn migrate over Mt. Everts to widely dispersed summer ranges at higher elevations in the Blacktail Deer Plateau, Oxbow Creek slopes, Hellroaring slopes, Specimen Ridge, and Lamar Valley. The remaining animals summer in the Gardiner basin.

Habitat Use.— Cover types on the winter range of Yellowstone pronghorn include (Figure 1, Appendix A): 1) grasslands (40%); 2) old agricultural fields/pastures (16%); 3) grassland-sagebrush mix (11%); 4) sagebrush (25%); 5) rabbitbrush (4%); 6) greasewood (<1%); and 7) other (e.g., alfalfa, riparian, Douglas fir; 4%). Radiocollared females selected rabbitbrush (*Chrysothamnus* spp.) and greasewood (*Sarcobatus* spp.) types more than grassland during winters 2000-2001, while less selection was shown for old agricultural fields/pastures, cover types where sagebrush (*Artemisia* spp.) was common, and other cover types. Studies in the late 1960s and late 1980s also found pronghorn selected for xeric grasslands and generally avoided sagebrush grasslands and old fields during winter. However, old fields were frequently used during autumn, likely in response to regrowth of forbs and annual grasses. This continued selection against sagebrush, which is highly selected and important to other pronghorn populations in Montana and Wyoming, may reflect decreasing quality of sagebrush habitat on the northern Yellowstone winter range.

None of the cover types in the Gardiner basin winter range are extremely productive, as indicated by the low percent canopy cover of herbaceous plants and shrubs (9.8-38.3%). Thus, observations of pronghorn activity during 2000-2001 did not indicate any cover type as most important for feeding and/or bedding. Rabbitbrush and greasewood types had a larger combined percent canopy cover for herbaceous plants and shrubs than any other cover type. Rabbitbrush had the highest percent canopy cover for forbs (12%), while greasewood had the highest percent shrub canopy cover (17%). Sagebrush had 14% shrub canopy cover. Thus, even the most productive cover type on the winter range cannot support sustained feeding by pronghorn and they must meet their nutritional needs from a combination of cover types.

Yellowstone pronghorn prefer to forage in areas with <8 cm of snow and no pronghorn were observed feeding in snow >15 cm deep, except during the severe winter of 1967-68 when 21% of observed pronghorn fed in snow 15-30 cm deep. Thus, lower elevation habitats in the Gardiner basin, both inside and outside the park, are vital to the

persistence of this population; especially during severe winters when deep snow pack forces animals to lower elevations. Major movements of pronghorn out of Yellowstone in response to deep snow conditions occurred in 1967-68 when all but 40 of an estimated 210 pronghorn left the park and again in November-December 1985 when 90% of the pronghorn remained outside the park for approximately 3 weeks until the snow began to melt. During winters 1997-2001, pronghorn activity outside the park accounted for 13-51% of total habitat use. Approximately 43% of pronghorn observations outside the park during winter 1997 were in irrigated hay or fenced pastures, 35% were in grass/shrub habitats, and 22% were in grass/forb habitats.

Diet and Nutrition.—Pronghorn are selective feeders and studies indicate they prefer forbs in all seasons, likely due to their high digestibility and nutritional value. However, shrubs are important for pronghorn survival during winters with deeper snows. The quantity and quality of winter range for Yellowstone pronghorn has been a chronic concern for more than a century owing to settlement and land use changes in the Gardiner basin. However, rigorous, long-term studies of forage availability and selection have not been conducted. Microhistological analysis of fecal pellets during 2000-2001 indicated the majority of pronghorn winter diet was comprised of four browse species (rabbitbrush, Gardner saltbush [*Atriplex gardneri*], winterfat [*Cerotoides lanata*], and Rocky Mountain juniper [*Juniperus scopulorum*]), with rabbitbrush comprising $\geq$58%. This method tends to under-estimate the extent of forbs in the diet, but two forb taxa, granite gilia (*Leptodactylon pungens)* and bladderpod (*Lesquerella* spp.), were consistently used through winter. No graminoid taxa were consistently used during winter. In contrast, pronghorn consumed mainly sagebrush (*Artemisia tridentata*, *A. frigida*) and relatively little rabbitbrush or greasewood during winter in the 1930s, 1960s, and 1980s. Due to heavy browsing by elk over the past century, however, subdominant sprouting shrubs such as rabbitbrush have dominated on the winter range, while the quality and quantity of sagebrush plants has decreased. Thus, the diet composition of Yellowstone pronghorn may have gradually changed during recent decades.

Data collected during 2000-2001 suggests that Yellowstone pronghorn are obtaining adequate nutrition and have relatively good body condition. Mean body mass for Yellowstone females (47 kg) captured during February 1999 and March 2000 was significantly lighter than for females captured during summer at the National Bison Range, Montana (57 kg) where forage conditions and nutrition are known to be high. Also, the mean birth mass of Yellowstone fawns (3.1 kg) was significantly lighter than for fawns at the National Bison Range (3.6 kg). However, the relationship between body mass and skeletal size for both adults and fawns was similar between these two areas, suggesting that body condition was similar. Also, the ratio of litter mass to maternal mass, which is an index of the amount of resources a mother allocates to her offspring, was similar between pronghorn at Yellowstone and the National Bison Range. Essentially all adult Yellowstone females become pregnant and produce twins each year, regardless of whether they raised fawns to weaning in the previous year. Birth mass was not related to survival, suggesting that poor fawn condition is not a significant source of mortality.

Reproduction, Recruitment, and Survival.—Productivity appears to be relatively high in Yellowstone pronghorn, with measured ratios of 1.96 fetuses per doe during 1965-1966 and $\geq$1.8 fawns per doe at birth during 1999-2001. However, fawn survival has

been chronically low since at least the mid-1960s, with high neonatal mortality regardless of pronghorn density. Fawn survival was <10% during 2000-2001 and the frequency distribution of age at death was bimodal, with a peak 3-5 days after birth and another smaller peak approximately 18 days after birth when fawns transitioned from hiding to being up and visible for increasing amounts of time. Coyote predation was implicated as the major source of fawn mortality.

Annual survival of radiocollared adult females (n = 33) in Yellowstone ranged between 0.76 and 0.92 during 1999-2004. These estimates are somewhat low compared to those in most unhunted populations where prime-aged females typically have high (>0.95) and constant survival. Causes of mortality included predation by coyotes, mountain lions, and wolves (n = 12), birthing complications (n = 1), and unknown determinations due to scavenging or deterioration of the carcasses (n = 7). No winter-kill (i.e., starvation) was detected during these relatively mild winters.

Disease.—Numerous diseases and parasites have been documented in Yellowstone pronghorn. Samples from 32 pronghorn captured in 1999 revealed low parasite loads and no evidence of exposure to significant levels of arsenic or lead, *Brucella abortus*, bluetongue virus, epizootic hemorrhagic disease, *Mycobacterium avium paratuberculosis* (Johne's disease), or *Leptospira interrogans*. Tests revealed that 75% of the animals had been exposed to *Chlamydia psitacci*, 59% to parainfluenza type 3, 9% to bovine viral diarrhea virus, and 3% to bovine respiratory syncytial virus. Overall, the Wyoming State Veterinary Laboratory concluded that "there are no obvious health problems detectable by antemortem sampling in this pronghorn herd," but that the high incidence of *Chlamydia* exposure warrants further study.

Elk

The high mountains and plateaus of Yellowstone provide summer range for an estimated 25,000-30,000 elk (*Cervus elaphus*) from eight herds. The largest of these herds winters on the grasslands and shrub steppes of the northern range, which extends along the northern boundary of the park and into the Gardiner basin and Paradise Valley of Montana. The following information was coalesced from Boyce et al. (2003), Cook et al. (2004), Coughenour and Singer (1996), Fortin et al. (2005), Houston (1982), Mao (2003), Montana Fish, Wildlife, and Parks (unpublished data), National Research Council (2002), Singer et al. (1997), Smith et al. (2004), Taper and Gogan (2002), White and Garrott (2005), Yellowstone Center for Resources (unpublished data), and references cited therein.

Abundance.—Northern Yellowstone elk have inspired one of this century's most productive, if sometimes bitter, dialogues on the management of a wild-land ecosystem. For more than 50 years this debate focused on whether there were too many elk on the northern range. During 1930-1968, 26,403 elk were culled or removed from the park and another 44,927 elk were harvested outside the park due to concerns about overgrazing. As a result, counts decreased from 12,000 to <4,000 elk. In 1969, Yellowstone instituted a moratorium on elk removals and has since let a combination of weather, predators, range conditions, and outside-the-park hunting and land uses influence elk abundance. In the absence of culling, and with a much-reduced harvest (i.e., <210 elk per year), the population grew achieved a 20% annual growth rate and counts increased to approximately 12,000 elk by the mid-1970s. The annual growth rate of the population

slowed to 3% during 1976 to 1994 as counts increased to 16,000 elk by 1982 and 19,000 elk during 1988-1994. This slowed growth rate was interpreted as the population approaching its "carrying capacity" between 20,000 and 25,000 elk, with fewer available resources per elk contributing to lower reproductive and survival rates of younger animals. However, increased hunting removals during 1980-1994 (mean = 1,055 elk per year; range = 133-2,409 elk per year) may have contributed to the apparent leveling-off of abundance.

During 1995 and 1996, 31 wolves (*Canis lupus*) were released into Yellowstone. This restored population rapidly increased in abundance and distribution throughout the greater Yellowstone ecosystem. The presence of wolves in the ecosystem changed the debate from concerns about too many elk to speculation about there being too few elk in the future owing to wolf predation. Elk are the most abundant ungulate in the park and comprised more than 85% of documented wolf kills during 1997 to 2004. The winter count for the northern Yellowstone elk population was approximately 17,000 elk when wolves were first reintroduced during 1995 and 1996. The count decreased to an estimated 11,000-12,000 elk in 1998 following a substantial winter-kill and harvest of >3,300 elk outside the park during the severe winter of 1997. Counts varied between approximately 11,500 and 14,500 elk during 1999-2001, but decreased to approximately 9,500 elk during 2002-2005. Predation by wolves and other large carnivores, as well as moderate human harvests of antler-less elk during the Gardiner Late Elk Hunt were the primary factors contributing to this decreasing trend, though drought-related effects on pregnancy and survival may have contributed to an unknown extent. Predictions of future trends in elk abundance based on data collected since wolf restoration range from elk being maintained at low densities (i.e., <6,000-7,000 elk) owing, in part, to predation to elk numbers fluctuating around a mean of approximately 10,000 elk with long-term oscillations. Given the lack of a functional or numerical response by wolves to a 50% decrease in elk numbers during 1995-2005, combined with an efficient harvest of prime-aged female elk, it is likely that elk numbers will likely continue to decrease until: 1) levels of harvest and/or predation decrease sufficiently; 2) there is sufficient time for recruitment of calves to prime breeding age; and 3) there is a numerical response of wolves to fewer elk.

Harvests.— Northern Yellowstone elk that migrate out of the park may be legally harvested during 4 hunts managed by the Montana Department of Fish, Wildlife, and Parks: archery season, early season backcountry rifle hunt, general autumn rifle hunt, and limited-access (i.e., permit drawing) late rifle hunt. The archery, backcountry, and general seasons occur during September through November and are focused primarily on bulls. These hunts typically occur prior to the winter migration of northern Yellowstone elk and, as a result, few adult females are harvested. In contrast, the late rifle hunt, which consists of 4-day hunting periods per week over 45 to 60 days in December/January (1976-1991) or January/February (1992-2004), is highly biased towards harvesting females because its primary objective is to help regulate the number of elk that winter north of Yellowstone at levels that will sustain winter habitat. The number of antlerless elk permits issued annually for the late hunt depends primarily on the size and migratory portion of the northern Yellowstone elk population.

Snow pack strongly influences elk vulnerability to hunting through its effects on the number of animals migrating outside the park and hunter success. The number of elk

migrating outside the park was directly proportional to snow water equivalent and harvests were directly proportional to the number of elk wintering north of the park. Hunter success decreased as numbers of elk migrating outside the park decreased. However, hunter success exceeded 95% during years with high levels of snow water equivalent prior to and during the late hunt, compared to a mean hunter success of 64% during 1976-2004. Due to this strong influence of snow pack on migration and hunter success, harvests during 1990-2002 were essentially frequency dependent, with a relatively high and constant proportion (27 $\pm$ 5%) of elk migrating north of the park being harvested regardless of density. A constant harvest rate by hunters would be expected if elk aggregated in specific places where hunters can maintain very high hunting success until elk numbers decrease to low levels. Late hunts in temperate mountain environments typically have relatively high hunter success because snow pack causes elk to aggregate in lower elevation areas that are more accessible by hunters and, as a result, elk are more vulnerable. Elk migration outside the park remained relatively high and proportionately increased as total elk counts (inside and outside the park) decreased during 1994-2004.

Montana Fish, Wildlife, and Parks did not reduce harvests of antler-less elk in a density dependent manner following wolf restoration to compensate for additional off-take by wolves. Rather, they maintained the number of antler-less permits during the late hunt between 2,660 permits in 1995 and 2,882 permits in 2000, when wolves reached their biological recovery level in Yellowstone. Thus, antler-less elk removals during the post-wolf restoration years of 1996-2004 (mean = 1,297 elk; range = 717-2,465 elk) remained similar to removals during the pre-wolf restoration years of 1987-1995 (mean = 1,148 elk; range = 273-2,409 elk). This consistent and efficient harvest regime significantly decreased the survival rates of prime-aged females with high reproductive value and, in turn, the growth rate of the population. In essence, hunters and wolves were in direct competition for decreasing numbers of elk, thereby resulting in accelerated rate of decrease in abundance. As a result, the proportions of elk harvested each year increased as total elk numbers (both inside and outside the park) decreased during 1990-2002. However, antler-less permits for the late hunt were gradually reduced to 1,100 permits by 2005. As a result, harvest rates during 2003-2005 departed from this anti-regulatory trend and decreased from approximately 14% to 8% of the total annual count. Montana Fish, Wildlife, and Parks has proposed to reduce late hunt antler-less permits to 100 next year, which should increase the survival of prime-aged females with their high reproductive value.

Distribution.—Northern Yellowstone elk winter on approximately 1,500 km^2 of foothills and valley bottoms along the Gardiner, Lamar, and Yellowstone rivers between the northeast entrance of Yellowstone near Cooke City and Dome Mountain/Dailey Lake in the Paradise Valley of Montana (outside the park). During the 1980s, northern Yellowstone elk expanded their winter range north of Dome Mountain and more than doubled the extent of their winter range from 22,179 hectares to 53,262 hectares. Between 832 and 4,547 elk have wintered north of Dome Mountain since 1989, which represents 39-90% of the elk wintering north of Yellowstone. Relatively few elk remain on the northern range throughout the year. The majority of northern Yellowstone elk migrate to summer ranges along the east-central boundary of the park, north of the park onto the Buffalo Plateau, and as far south as Lewis Lake (50 km).

Since the 1960s, scientists have reported spatial structuring of elk sex/age classes across the winter range for northern Yellowstone elk, with older cows and males occupying the more easterly, higher elevation areas within the park and adult females with calves and yearlings tending to migrate to lower elevation areas inside and outside the park. The causes of this apparent spatial structuring of the population are not understood, but may include individual fidelity to seasonal movement patterns and/or age- or reproductive-specific seasonal movement patterns. Regardless, the predominant mortality forces are dramatically different for elk occupying higher-elevation winter range within the park, where wolf densities are the highest, compared to elk occupying lower-elevation winter range within and outside the park. Elk within the middle- to higher-elevation winter ranges of the park experience no measurable hunter-induced mortality, but are subject to strong predation pressures by wolves and other predators for calves and older age classes of adult female elk (i.e., mean age ~14 years). In contrast, wolf densities on those areas of the northern range at lower elevations within and outside the park are modest, reducing potential for predator mortality. However, elk occupying the area outside the park during the winter have been subject to intense hunting mortality, which primarily removes prime-aged females (i.e., mean age ~8 years).

Habitat Use.—The vegetation of the northern winter range is primarily open grassland-sagebrush steppe (37%) with interspersed upland grasslands, wet meadows, and non-vegetated areas. Dominant plant species include Idaho fescue (*Festuca idahoensis*), blue-bunch wheatgrass (*Pseudoroegneria spicata*), and big sagebrush (*Artemisia tridentata*). Coniferous forests of Douglas fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), and whitebark pine (*Pinus albicaulis*) are interspersed (44%) and occur at higher elevations. Large-scale fires during 1988 burned approximately 40% of the range, creating a complex mosaic of burned and unburned forests at different stages of succession.

Northern Yellowstone elk are habitat generalists that use virtually every vegetation type on the northern range during winter. During winter, elk move to lower elevations where snow water equivalents are low and select landscapes with a mix of forest and open vegetation at all spatial scales. Elk select less diverse areas on winter range, compared to summer when areas of high vegetation diversity are selected at large spatial scales. Elk also use forests that burned 12–14 years earlier less than expected by chance during winter, compared to summer when these burned areas are selected. Habitat selection patterns by northern Yellowstone elk changed between 1985-1990 and 2000-2002, likely due to a combination of wolf restoration, post-fire succession, and other environmental factors. In summer, when wolf activity is centered at dens and rendezvous sites, elk avoid wolves by selecting higher elevations, less open habitat, more burned forest, and steep slopes in high wolf density areas. In winter, elk cannot spatially separate themselves from wolves and, compared to pre-wolf times, select for more open habitats. Thus, elk appear to use habitat selection to avoid wolves in summer, but rely on behavioral anti-predator strategies (e.g., grouping) in winter. Elk also respond to changes in the spatial distribution of wolves on their winter range by shifting their habitat selection. In low wolf-use areas, the relative preference of elk for movement destinations was: aspen stands > open areas > conifer forest areas. As the risks of wolf encounter increased, however, the preference of elk for aspen stands gradually decreased, and

selection became strongest for movements ending in conifer forest areas under high risks of encountering wolves.

Diet and Nutrition.—Elk are primarily grazers, but also browse in autumn and winter. During the 1960s and 1980s, winter diets on the northern range consisted of approximately 75-80% grasses (*Agropyron spicatum, F. idahoensis, Poa* spp., *Koeleria macrantha, Calamagrostis* spp.), 8-11% shrubs (*A. tridentate* and *A. frigida, Chrysothamnus* spp., *Salix* and *Populus* spp.), 3-5% conifers, 2-8% sedges, 1-3% rushes, and 3% forbs. Thus, northern Yellowstone elk consumed a relatively low quality diet during winter, with the consumption of browse increasing during severe winters and the consumption of forbs increasing during spring.

Body fat of 96 adult female elk during mid- to late winter, 2000-2002, averaged 9.5% ± 0.4 (range: 1.8–16.0%), while loin muscle thickness averaged 5.6 cm ± 0.1 (range: 4.3–6.6 cm). Eighty-five percent of the animals had body fat levels ≥5%, which indicates relatively good condition during these mild to normal winters. Only 4% of the females had <2% fat, which indicates elevated protein catabolism and increased chance of winter-kill. Body condition was unrelated to age, but significantly influenced by lactational status, with lactating cows having 50% less fat than non-lactating cows. This suggests some nutritional limitations occurred on summer ranges, with digestible energy intake insufficient to support both lactation and fat accretion. Probability of pregnancy followed a logistic curve as a function of body fat levels, with pregnancy unlikely at <6% body fat. Most non-pregnant elk were either lactating at time of capture or >14 years old.

Reproduction.— Pregnancy rates for prime-age females (3-15 years) during 2000-2003 when elk densities on the winter range varied between 8-12 elk/km^2 were high (0.90) and similar to those prior to wolf restoration (1950-1967) when elk densities varied between 5-9 elk/km^2. The onset of reproductive senescence occurred at approximately 15-16 years old and older elk (n = 21) had relatively low pregnancy rates of 0.50. Thus, a biologically significant increase in fecundity is unlikely if elk numbers continue to decrease. Most documented stochastic and density-dependent variation in reproduction by ungulates has been attributed to changes in average age of first reproduction. It is unlikely that this mechanism has resulted in any biologically significant demographic compensation in the northern Yellowstone elk population because recruitment rates have been depressed (12-14 calves per 100 adult females) in recent years following wolf recovery (2002-2004). Thus, few immature female elk are entering the population each year.

Recruitment.—Calf survival is sensitive to changes in limiting factors, regardless of whether the variation is caused by changes in population density or stochastic environmental factors. Thus, recruitment varies considerably from year to year in response to the effects of environmental variation and its strong interaction with density on juvenile survival and fecundity. Recruitment in northern Yellowstone elk during 1986-1996 varied markedly among years (CV = 44%) and played a substantial role in population dynamics because high recruitment during good environmental conditions led to relatively rapid population growth following weather- or human-induced decreases in abundance. Recruitment estimates during 1998-2004 continued to show marked temporal variation (CV = 41%), but only ranged between 12-14 calves per 100 adult females during 2002-2004 after wolves reached high densities and the ratio of wolves to elk increased on the northern range. Wolf abundance was likely too low during the initial

years following wolf restoration to have a detectable effect on elk recruitment. However, decreasing elk abundance concurrent with increasing wolf abundance gradually resulted in a dramatic change in the ratio of wolves to elk, from approximately 3 wolves per 1,000 elk at the onset of wolf restoration to a current ratio of nearly 13 wolves per 1,000 elk. The potential contribution of drought to the lower elk recruitment during recent years cannot be discounted because spring/summer precipitation was below the historic average for 7 of the 8 post-wolf years. However, a substantial increase in the wolf-elk ratio has likely magnified the demographic effects of wolves on recruitment of elk.

Survival.—Populations that are increasing or holding at nearly constant levels exhibit high (>0.95) adult female survival. Prior to the implementation of moderate to liberal harvests and the restoration of wolves, the survival of adult female Yellowstone elk was typically high (0.99) and relatively constant. The primary cause of mortality for adult female elk was hunter harvest of elk that migrated out of the park and winter-kill. Survival of calves and senescent females decreased as snow pack severity increased, but survival of prime-aged females was not directly affected except during the most extreme winters. However, increasing snow pack indirectly influenced the survival of prime-aged females by increasing the number of elk wintering at relatively lower elevations outside the park and, in turn, the number of elk harvested. During 1996-2003, mean annual survival for adult female elk 1-18 years old was approximately 0.85 (95% CI = 0.81 to 0.87). This reduced survival of adult female elk suggests an ongoing decrease in abundance. Cause-specific mortality for radiocollared adult female elk during 2000-2003 was hunter harvest (10 of 27 deaths), wolf predation (9 deaths), unknown determinations due to scavenging or deterioration of the carcasses (5 deaths), and mountain lion predation (3 deaths). Both hunters and wolves concentrated heavily on the adult segment of the population, with adults comprising approximately 59% of the female elk killed by wolves and 86% of the late hunt harvest of females. Most off-take of adult females was likely additive owing to the very high survival rates of prime-age females at population levels well below carrying capacity and in the absence of hunting and major predators. Also, the increasingly depressed survival rates of elk >16 years old due to physiological senescence do not translate into large numbers of animals dying each year because only a relatively small proportion of the population was composed of these senescent animals. Thus, a large proportion of all wolf off-take and hunter harvest directly influenced the decreasing trajectory of the elk population.

Harvests of elk that migrated outside the park exceeded or approximated conservative estimates of wolf off-take (0.05 kills/wolf/day during winter) from 1995-2002 with hunters concentrating on prime-age females with high reproductive value and wolves focusing on calves and older animals with lower reproductive value. The differential selection and removal of prime-age females by hunters likely had a relatively greater effect on the population dynamics of elk than wolves during the initial years following wolf restoration. However, wolves on the northern range maintained high kill rates and rapid population growth despite a 50% decrease in elk counts from approximately 17,000 in 1995 to 9,500 in 2005. Thus, conservative estimates of wolf off-take (>1,000 elk) exceeded harvests of elk during 2003 and 2004. This trend is likely to continue in the near future as the Montana Department of Fish, Wildlife, and Parks reduces harvests in response to lower elk numbers. Also, it is likely that wolf predation on prime-age females will intensify if the relative availability of calves and senescent elk decreases.

Thus, it is likely that wolves will have a relatively stronger influence on the population dynamics of these elk in coming years.

Disease.—Parasites and diseases can, at times, lead to large die-offs of ungulates. At least 25 different parasites and pathogens have been documented in elk in the greater Yellowstone area. Winter ticks are relatively common external parasites and heavily infested elk are occasionally observed. Tapeworms and lungworms are relatively common internal helminth parasites and *Dictyocaulus* sp. were found in 14% of fecal specimens collected from northern Yellowstone elk during 1991-1993. Less is known about the incidence and pathogenic effects of bacterial diseases or protozoan infections. Brucellosis occurs in northern Yellowstone elk, but its incidence appears to be relatively low (1%).

No disease epidemics or population-impairing parasite infestations have been documented in Yellowstone elk. However, chronic wasting disease was detected during winter 2004 approximately 130 miles from the southeastern boundary of Yellowstone near an area where elk that summer in the park could commingle with mule deer (*Odocoileus hemionus*) during winter. Chronic wasting disease is a fatal neurologic disease of mule deer, white-tailed deer (*O. virginianus*), and Rocky Mountain elk from the family of diseases known as the transmissible spongiform encephalopathies or prion diseases. Chronic wasting disease can contribute to substantial decreases in abundance and, possibly, even local extinctions of infected deer or elk populations if left unmanaged. Thus, this disease poses an imminent and fundamental threat to elk in the greater Yellowstone area.

Bighorn Sheep

Bighorn sheep in and adjacent to the northern boundary of Yellowstone are organized into 10-13 bands that appear to function as a metapopulation with periodic movements and gene flow among groups, primarily owing to male dispersal. The total number of sheep counted in these bands ranged between 3 and 48 sheep during spring 2003. Given this relatively low abundance, these bands are susceptible to local extirpation due to random, naturally occurring catastrophes such as severe winter weather, droughts, or disease epidemics. The following information was coalesced from Barmore (2003), Lemke (2003), Meagher (1992), Ostovar (1998), Singer and Norland (1994), Yellowstone Center for Resources (unpublished data), and references cited therein.

Abundance and Distribution.—An estimated 100-400 sheep inhabited the northern Yellowstone winter range during 1890 to the mid-1960s. Counts gradually increased to 487 sheep by 1981. During the winter of 1981-82, however, an outbreak of infectious keratoconjunctivitis (i.e., "pinkeye") caused by *Chlamydia* sp. resulted in the direct and indirect mortality of at least 60% of these sheep. Counts have not increased significantly during the 22 years since this die-off, with only 127 sheep counted in this area during spring 2003. In addition, spring counts of a core band of sheep wintering on the Mount Everts range decreased from 71 to 47 sheep during 1992-2003. There is currently no sign of *Chlamydia* in sheep wintering on the Mount Everts range. Thus, other unknown factors appear to be limiting population growth.

Winter ranges of sheep on the northern range appear to have remained strikingly constant for more than 30 years. Several bands of northern Yellowstone bighorn sheep winter in or near the Gardiner basin at the following locations: 1) Mount

Everts/Rattlesnake Butte; 2) Travertine/Bear Creek/Deckard Flats; 3) Yellowstone River (Black Canyon-Specimen Ridge); 4) Cinnabar Mountain/Beattie Gulch; 5) Yankee Jim Canyon/Corwin Springs/LaDuke; 6) Point of Rocks; and 7) Tom Miner basin. Most sheep are migratory, but some remain in each of these areas throughout the year. Timing of spring migration varies among years depending on the timing and extent of snow melt and plant green-up. Mount Everts is an important wintering area for resident and migratory bighorn sheep. Sheep congregate on this area for breeding in November and December, and remain until lambing in May. Three groups of ewes with distinct summer lambing areas (i.e., McMinn Bench, Rattlesnake Butte, Mount Washburn [50 km migration]) use the Mount Everts winter range. Rams that use the Mount Everts winter range include both year-round residents and migratory animals, some of which move 25 kilometers southwest to the Gallatin Mountains to summer.

Harvests.—Bighorn sheep are hunted north of Yellowstone in Hunting Districts (HD) 300, 303, and 305. HD 300 is located in the Gallatin Mountain range between the Gallatin and Yellowstone Rivers from the park boundary north to Moose Creek on the Gallatin side and Big Creek on the Yellowstone River side. The sheep season in HD 300 runs for 10 days in early September, beginning the day after Labor Day holiday. HD 303 is in the Absaroka Mountains north of the park between the Yellowstone River and Hellroaring Creek. The sheep season in HD 303 runs from September 15 to October 31. Sheep hunting in units 300 and 303 is regulated by an unlimited access season with a set harvest quota. During autumn 2002, HDs 300 and 303 each had a quota of 2 legal rams. HD 305 runs from Beattie Gulch to Sphinx Creek in the Gallatin Range. The sheep season in HD 305 runs from September 15 to October 31. HD 305 was opened in autumn 2000 and is limited to one license per year by drawing. Hunters can take only mature "legal rams." By Montana's definition, a ram is legal when a straight line extending from the front base of the horn through any portion of the eye intercepts any portion of the horn. Most legal rams are at least 3-4 years old. A hunter killing a legal ram is required to present the complete head and cape intact within 48 hours to any Montana Fish, Wildlife, and Parks' office, game warden, or designated employee. The season closes on a 48-hour notice when the quota is reached.

Since 1988, 1-7 rams have been harvested annually in HDs 300 and 303. During this period, sheep regulations in HD 303 remained relatively unchanged, while HD 300 experienced several short-term changes dealing with season length and quota numbers. Not all of the rams observed during count surveys in these hunting districts are present during the hunting seasons. These two unlimited access sheep seasons are supported by a small number of resident rams and some rams that migrate out of Yellowstone during the hunting season. Hunting success in HD 300 varies based largely on the distribution of sheep during the short 10-day season. Since the limited-entry HD 305 was created in 2000, two of a possible 3 rams have been harvested.

Habitat Use and Diet.—Northern Yellowstone bighorn sheep selected ridge tops and steep south- and west-facing slopes during studies in the 1960s and 1980s, suggesting that escape terrain was significant to habitat selection. Bighorn sheep are grazers and 80% of all feeding during the late 1960s was in xeric grasslands on ridge tops or moderate and steep slopes of varied exposure. During the 1980s, however, sheep increased their use of level terrain and sagebrush habitats. Winter diets consisted of approximately 58-66% grasses (*A. spicatum, F. idahoensis, Poa* spp., *K. macrantha*,

Stipa comata), 22-33% shrubs (*Ceratoides lanata, A. tridentate* and *A. frigida, Chrysothamnus* spp.), 7-17% forbs, 1-5% sedges, and 0-2% conifers. Most sheep fed in nearly snow-free areas with <8 cm snow and <5% fed in snow 15-30 cm deep.

Interspecific competition with elk is often cited as detrimental to northern Yellowstone bighorn sheep and has been suggested as the cause of low recruitment during 1980-present and the inability of the population to recover from the *Chlamydia* epizootic during 1981-82. Diet and habitat overlaps between northern Yellowstone bighorn sheep and elk were high and increased during the 1960s to 1980s (diet: 0.62-0.73; habitat: 0.48-0.78) as elk numbers increased substantially and bighorn sheep numbers decreased. This increased overlap was primarily due to increased diet and habitat breadth by bighorn sheep, not elk. Between the 1960s and 1980s, sheep increased their use of sagebrush cover type and consumed more grasses commonly found in the sagebrush type. Bighorn sheep do not prefer tall shrubs and their increased use of the sagebrush type during the 1980s may reflect interspecific competition with elk. However, increases in elk numbers during 1969-1980 (i.e., prior to the *Chlamydia* epizootic in sheep) were positively correlated with bighorn sheep numbers and unrelated to bighorn sheep numbers during 1967-1988.

Reproduction, Recruitment, and Survival.—There is no recent data on reproductive rates for northern Yellowstone bighorn sheep. Bighorn sheep in the upper Yellowstone do not typically have robust recruitment. Recruitment has been relatively low since the die-off in 1981-82, with an annual mean of 20 lambs per 100 ewes observed north of Mammoth since 1992. However, recruitment has been somewhat higher (21-32 lambs per 100 ewes) during 1999-2003. Predation by coyotes, mountain lions, and eagles has been suggested as contributing factors. Also, field observations of coughing sheep and necropsies suggest that pneumonia-lungworm complex may contribute to low recruitment at times.

During 1998-2002, mean annual survival for 14 adult females and 4 adult males that wintered on the Mount Everts range was 0.89 (range = 0.83 to 0.94). Cause-specific mortality for these radiocollared sheep included mountain lion predation (3 of 12 deaths), unknown predator (1 death), winter-kill (1 death), lightning strike (1 death), poaching on Deckard flats (1 death), and unknown determinations due to scavenging or deterioration of the carcasses (5 deaths).

Disease.—Serological tests of samples collected from 18 bighorn sheep captured on the Mount Everts winter range in 1997 revealed positive antibody reactions for bovine respiratory syncytial virus (n = 16), parainfluenza-3 (n = 12), and leptospirosis 8 serovars (n = 1). No antibody reactions were detected for *Brucella abortus, B. ovis,* blue tongue, infectious bovine rhinotracheitis, bovine virus diarrhea, bovine viral diarrhea type II, or ovine progressive pneumonia.

During the winter of 1981-82, an outbreak of infectious keratoconjunctivitis (i.e., "pinkeye") caused by *Chlamydia* sp. resulted in the direct and indirect mortality of at least 60% of the approximately 500 bighorn sheep in the northern Yellowstone population. There is currently no sign of *Chlamydia* in sheep wintering on the Mount Everts range, suggesting that other factors are limiting population growth. Lamb pneumonia may be one underlying reason for periodically low or non-existent recruitment of bighorn sheep in and near Yellowstone. Lamb deaths from pneumonia have been documented north of the park from LaDuke south to Gardiner, Montana.

Many dramatic pneumonia epizootics have implicated lungworms (e.g., *Protostrongylus* spp.) as the predisposing factor contributing to respiratory disease. The prevalence of lungworm infection in known individual bighorn sheep wintering on the Mount Everts range was 96% during 1997-98 and 86% during 2002. Two sheep from this population that died during 1995 and 1996 had high lungworm infections. However, verminous pneumonia in lambs has not been established as a significant factor depressing the long-term performance of the northern Yellowstone bighorn sheep population. Nor has lungworm prevalence been linked as a causative factor in higher rates of lamb pneumonia. During winter 2004, the incidence of lungworm infection in 78 fecal samples from unmarked bighorn sheep using areas on the Mount Everts winter range (e.g., McMinn Bench, Rattlesnake Butte, and the northwest end of Mount Everts) was not remarkably high (49%) and the overall intensity of infection was remarkably low (mean larvae per gram = 1.1; SD = 3.7; range = 0-31). The relatively low intensity of infection could increase in future years given the current incidence rate of approximately 49%. Lungworm prevalence and intensity in bighorn sheep wintering near LaDuke Hot Springs during 2002 and 2003 ranged between 29-88% and 0-707 larvae per gram, respectively. No lungworms were detected in feces collected from bighorn sheep wintering near Cinnabar Mountain during 2002.

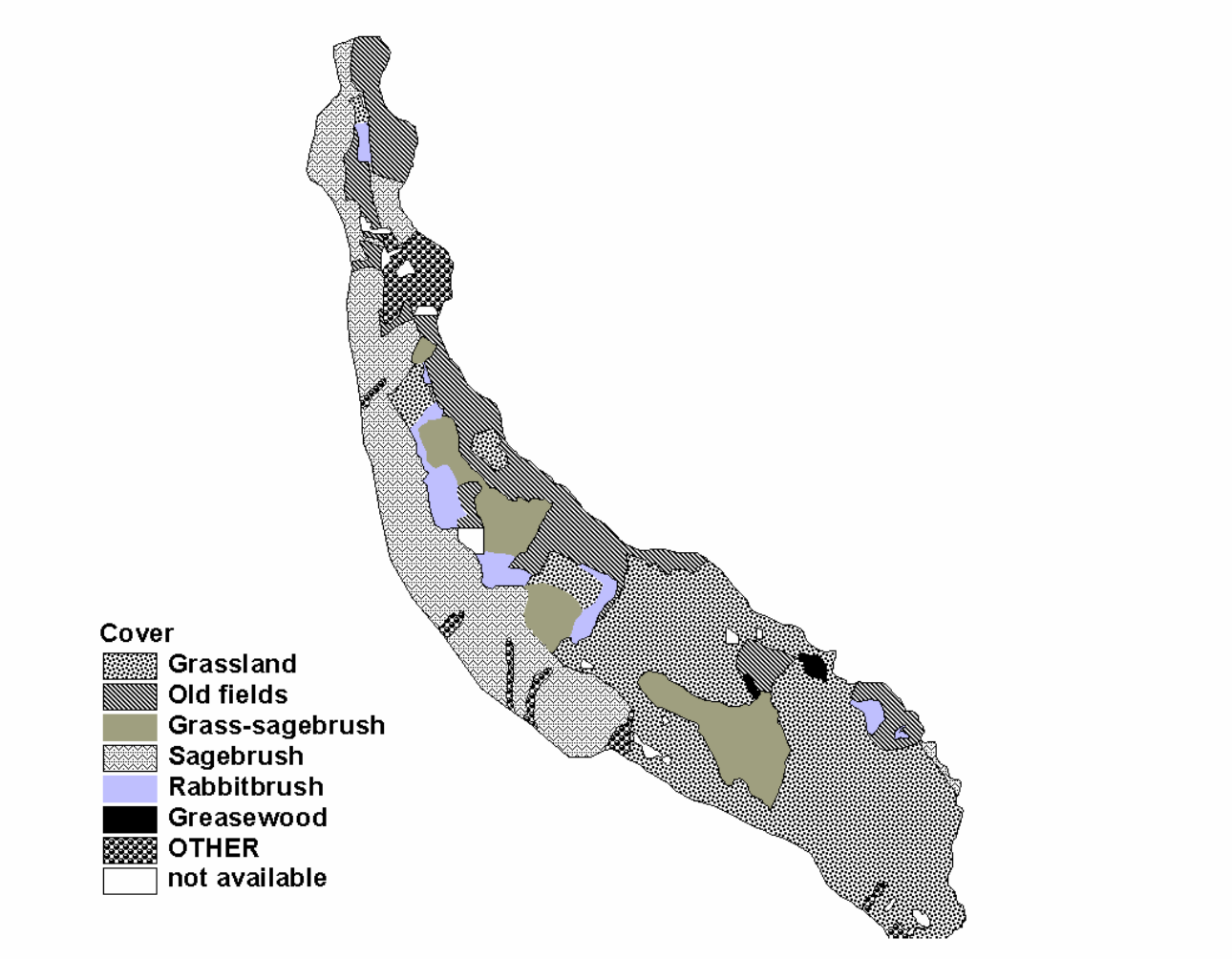


Figure 1. Cover map of the current pronghorn winter range in Yellowstone National Park, Wyoming, from Boccadori (2002).

Appendix A. Cover types of the current pronghorn winter range in Yellowstone National Park, Wyoming, from Boccadori (2002).

Grasslands.—This cover type occurred on any slope and exposure below 1,850 m. Dominant grass species were Sandberg bluegrass (*Poa secunda*), Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria macrantha*), and bluebunch wheatgrass (*Agropyron spicatum*). Other dominant species were prickly pear cactus (*Opuntia polyacantha*), fringed sage (*Artemisia frigida*), alyssum (*Alyssum desertorum*), and sandwort (*Arenaria hookeri*). Most frequent species were Sandberg bluegrass, fringed sage, and sandwort. Herbaceous plant cover was low (8.8%) relative to other cover types and a moderate to high proportion of ground surface was bare soil, gravel, or rock. This cover type comprised 40% of the current winter range.

Old fields/current pasture.—Old fields were cultivated and/or irrigated prior to park acquisition in 1932. This category also includes an area within the park that had been planted in alfalfa during the early 1900's. Current pastureland lies outside the north boundary of the park on private land. These two types were combined because the vegetation structure and plant types were similar. Both occur below 1,650 m on level terrain. The dominant grass species was crested wheatgrass (*Agropyron cristatum*), with some annual wheatgrass (*Agropyron triticeum*) and alyssum. The most frequent species was crested wheatgrass (97.5% frequency). Herbaceous plant cover was moderate (17.8%) relative to other cover types. This cover type comprised 16% of the current winter range.

Grassland-sagebrush mix.—This type occurred between 1,500 and 1,850 m elevation. The overstory was dominated by Wyoming big sagebrush (*Artemisia tridentata wyomingensis*), with varying amounts of rubber rabbitbrush (*Chrysothamnus nauseosus*) and green rabbitbrush (*C. viscidiflorus*; 0.2 – 4.5% cover). The understory was dominated by Sandberg bluegrass, prairie junegrass, annual wheatgrass, and alyssum. The most frequent species were Sandberg bluegrass and prairie junegrass. Total herbaceous canopy cover was moderate (15.8%) relative to other cover types. Shrub canopy cover was low (8.1%) relative to other shrub cover types; 1.6% of the canopy was comprised of dead sagebrush, and 1% of dead rubber rabbitbrush. This cover type made up 11% of the current winter range.

Sagebrush.—This category occurred between 1,500 and 1,850 m elevation within and out of the park. The overstory was dominated by basin big sagebrush (*Artemisia tridentata tridentata*) and Wyoming big sagebrush. The understory was dominated by Sandberg bluegrass, prairie junegrass, and bluebunch wheatgrass; these species also were the most frequent. Live shrub canopy cover was among the highest (14.1%) relative to other shrub cover types; 3.5% of the canopy was comprised of dead sagebrush. Herbaceous plant cover was moderate (17.6%) relative to other cover types. This cover type comprised 25% of the current winter range.

Rabbitbrush.—This type occurred below 1,650 m elevation on level terrain and was characterized by areas where rubber rabbitbrush and green rabbitbrush were the dominant

overstory shrubs. The understory was dominated by crested wheatgrass, alyssum, dandelion (*Taraxacum officinale*), and stickseed (*Lappula redowskii*). The most frequent herbaceous species were crested wheatgrass, alyssum, and stickseed. Shrub canopy cover was among the highest (15.0%) relative to other shrub cover types; 6.6% of the canopy was comprised of dead rabbitbrush species. Herbaceous plant cover was high (23.3%) relative to other cover types. This cover type comprised 4% of the current winter range.

Greasewood.—This category occurred below 1,650 m elevation on level terrain. Greasewood was the dominant overstory shrub. The understory was dominated by annual wheatgrass and Sandberg bluegrass. The most frequent herbaceous species were annual wheatgrass, Sandberg bluegrass, and alyssum. Shrub canopy cover was among the highest (17.0%) of the other shrub cover types; 6.7% of the canopy was comprised of dead greasewood. Herbaceous plant cover was moderate (15.2%) relative to other cover types. This cover type comprised <1% of the current winter range.

Other.—This category includes current agricultural fields planted in alfalfa (*Medicago sativa*), riparian areas, and Douglas fir (*Pseudotsuga menzeisii*) patches. Combined, these areas make up 4.3% of the current winter range.

Bison

Introduction

Bison abundance in Yellowstone National Park has fluctuated widely during the last century (USDI and USDA 2000). However, the population is beginning to show some stability during the last 20 years (Fig 1). Some years, winter conditions can be very harsh in the interior of the park on both the northern range and in the central plateau region. Consequently during the more severe winters bison will move to lower elevation winter ranges where forage is more accessible. Bison have expanded their traditional areas of use on the northern range to more routinely use the northern boundary lands area (NBLA). Few bison used this area during winter from the 1940's up until the severe winter of 1975/1976 (Meagher 1989a). Meagher (1989a) noted that the unusually severe winter of 1975/1976 provided the "impetus" for the exploratory behavior to pioneer into rarely used habitats by approximately 35% of the northern range subpopulation that winter. With this learned behavior in the

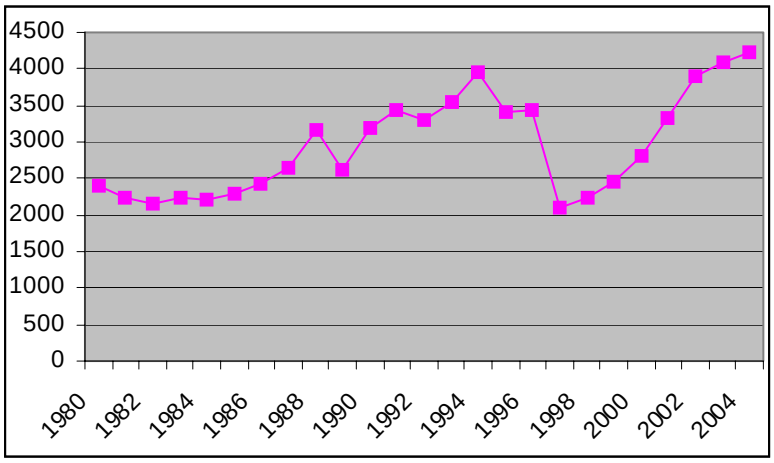


Figure 1. Yellowstone Bison population abundance from 1980 to present

subpopulation's memory, the pattern of use increased to greater than 85% of the northern range bison moving to habitats north of Gardiner during severe winters from the mid 1980's to the late 1990's and a lower percentage likely to move to the boundary lands area most years (Meagher 1989a, USDI and USDA 2000).

Prior to the mid 1990's the bison that used the boundary lands area were thought to be strictly from the northern range sub population with animal movements being primarily along the Yellowstone River corridor and the corridor from Tower Falls vicinity across the Blacktail Deer Plateau to Mammoth and downhill to Gardiner (Meagher 1989a, Meagher 1989b). Wallen and Plumb (2004) noted that bison that were intensively managed at the northern boundary lands area during the late winter of 2003/2004 were primarily from the central plateau area of the park and that the northern range subpopulation remained east of Hellroaring Creek. Consequently, use of the NBLA continues to be used by bison from multiple locations within the summer ranges of the park and the long term prediction is that this use pattern will only become more routine. Bison now begin arriving in the Mammoth area in autumn long before snow conditions would drive movements north from the central portions of the park.

Bison have a unique ability to subsist on low-protein, relatively low quality forage and supplement their energetic requirements with stored fat reserves deposited the previous growing season (Shaw and Meagher 2000, Plumb and Dodd 1993). They tend to forage most often in sedge bottoms during winter time where such habitats are available (Meagher 1973, Bison Ecology and Management Office personal observations). However, Singer and Norland (1994) described the diet composition of northern range bison as 53% grasses and 44% sedges and rushes. Bison diet in the NBLA would be expected to be heavily weighted toward grasses as sedge dominated plant communities are sparse.

<u>Issues of concern in the NBLA</u>

Currently Yellowstone National Park and the Gallatin National Forest collaborate with three other state and federal agencies to manage bison that enter a Special Management Area that includes nearly all of the NBLA (USDI and USDA 2000). A record of decision guides management decisions in this area. Currently very little bison use of this area is acceptable. However, as a bison vaccination program is developed and fully implemented, and when cattle no longer occupy the lower valley sections associated with GNF and private lands between Reese Creek and Yankee Jim Canyon greater use of this area by bison will occur. The Interagency Bison Management Plan provides a mechanism for tolerance of up to 100 bison

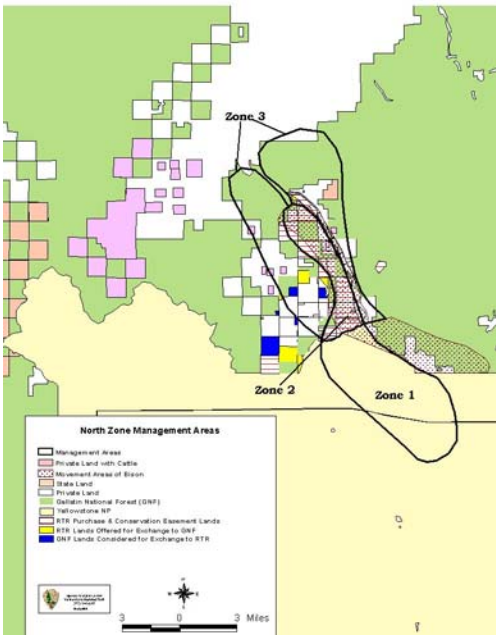


Figure 2. Special Management Area for bison that includes much of the Northern Boundary Lands Area.

north of Reese Creek and consequently greater use of the area between Reese Creek and the Power Line Flats meadow. Bison are expected to use this area primarily between about December and mid April (for shorter time periods during winters when snow fall is below average). Bison are not expected to summer in this portion of their range.

Restoration of plant communities will thus be very vulnerable to hoof action by bison during the winter months if precautions are not considered. Fencing to exclude bison has been successful in many locations. Four or five strand smooth wire fence to approximately 2 meters in height has been successful on the Lower Bruel Indian Reservation in South Dakota. Some ranchers have been successful with shorter fences and combining wire with a single strand of electrical wire extending approximately one meter inside the smooth wire fence. The gold standard bison fence is constructed of large diameter poles and 10 to 15 centimeter woven wire to a height of approximately 3 meters (re: National Elk Refuge near Jackson, Wyoming). The Stephens Creek Corral has been successful in keeping bison from entering the horse holding paddocks and in keeping groups of up to 200 bison from exiting the paddocks. This style is something the local population is familiar with and may not be challenged. The range exclosures across the northern range have generally been successful in keeping bison off of protected plant communities as long as the fence was maintained.

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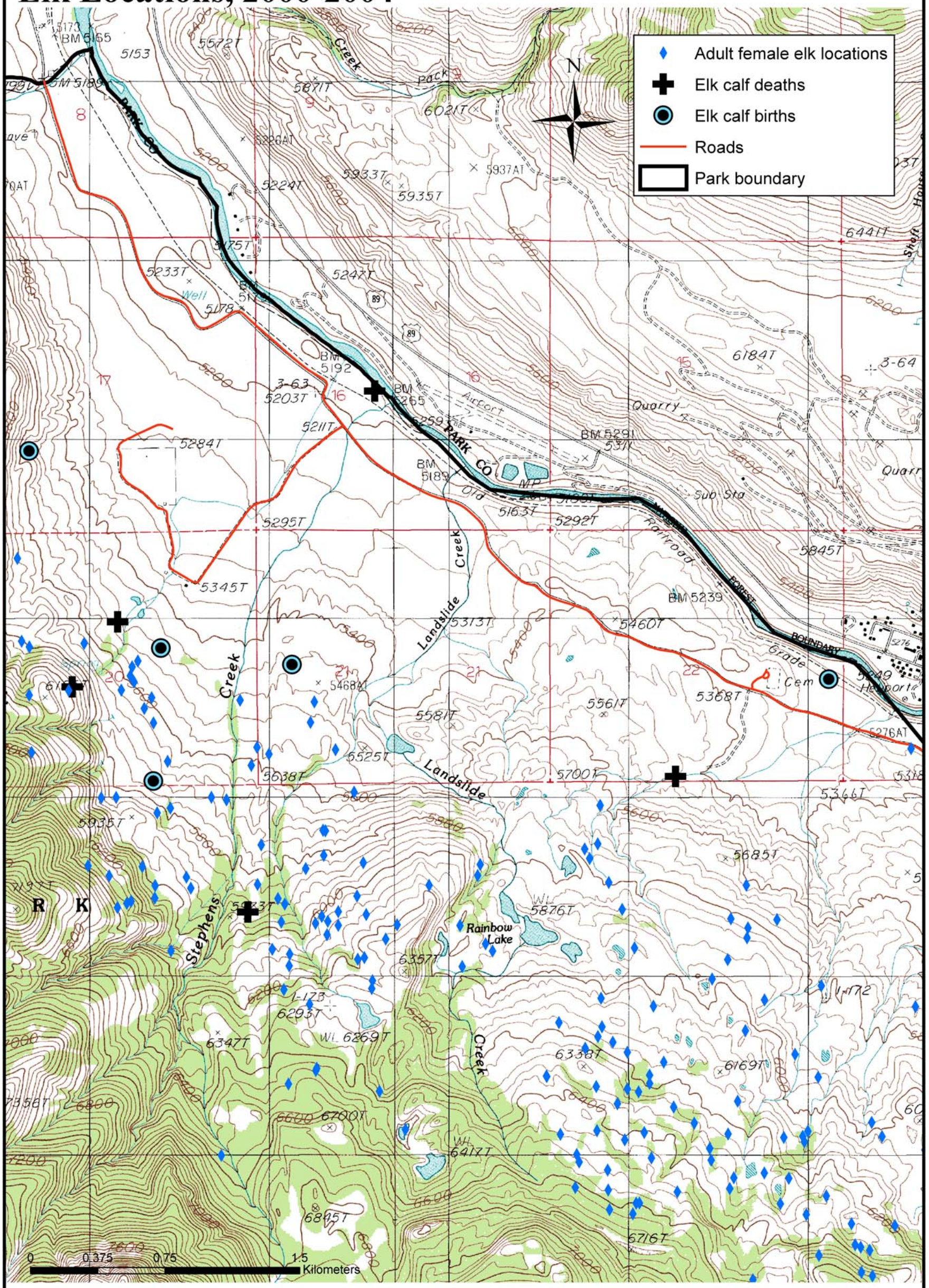
Yellowstone National Park
MT/WY/ID

National Park Service
U.S. Department of the Interior

Elk Locations, 2000-2004

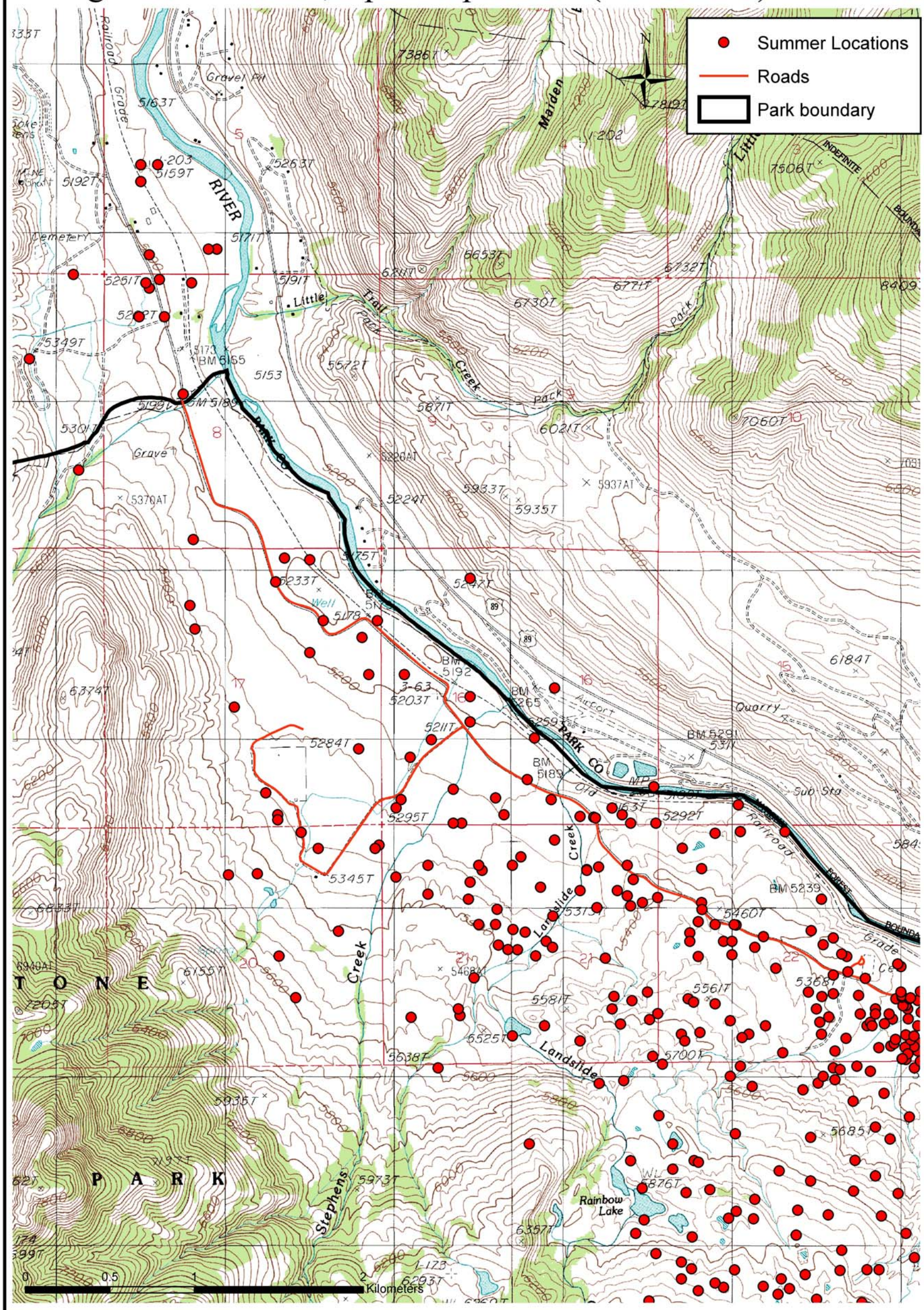


Produced by T Davis, Ungulate Program, 3/05

Yellowstone National Park
MT/WY/ID

National Park Service
U.S. Department of the Interior

Pronghorn Locations, April-September (1999-2005)

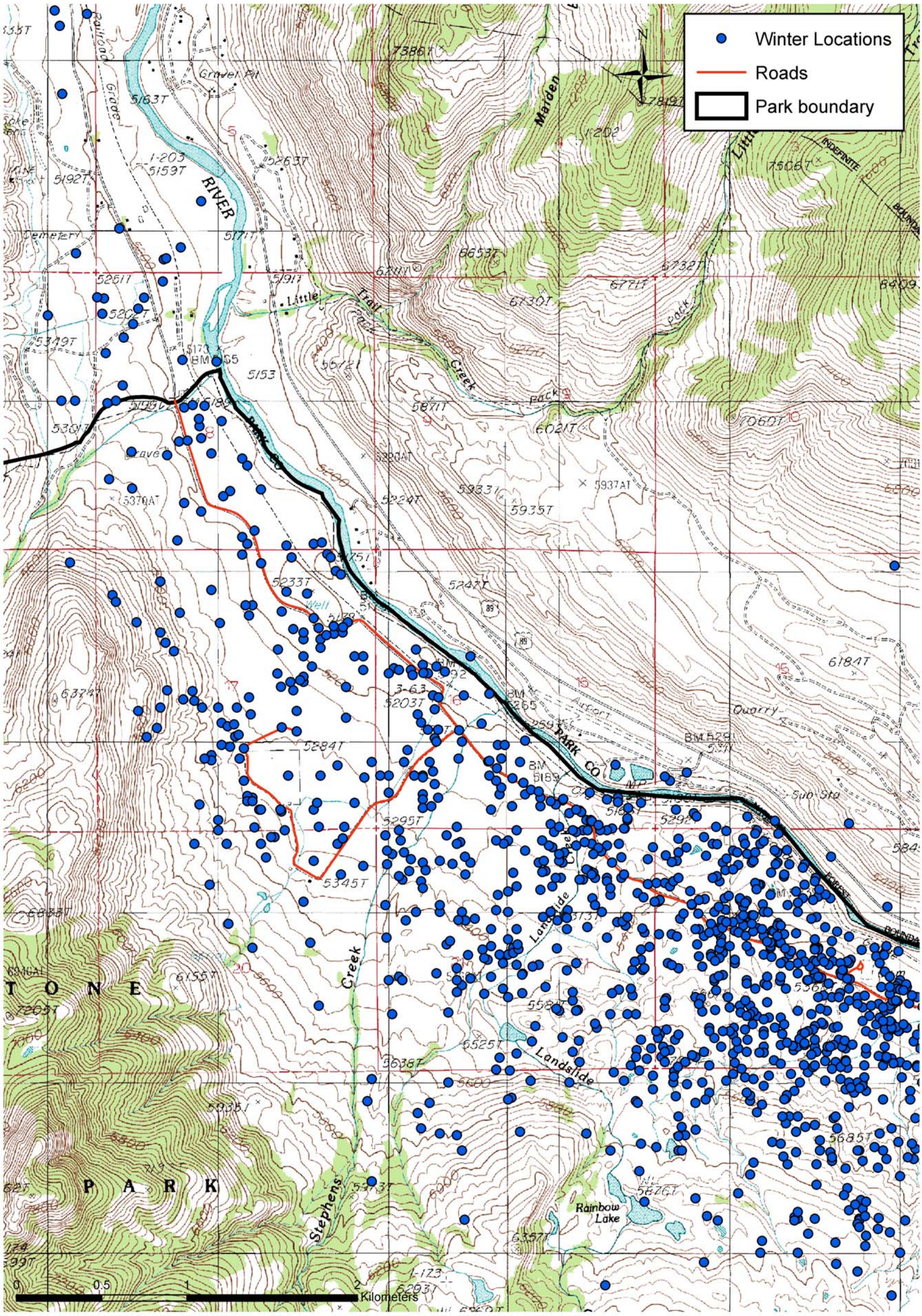


Produced by T Davis, Ungulate Program, 3/05

Yellowstone National Park
MT/WY/ID

National Park Service
U.S. Department of the Interior

Pronghorn Locations, November - March (1999-2005)

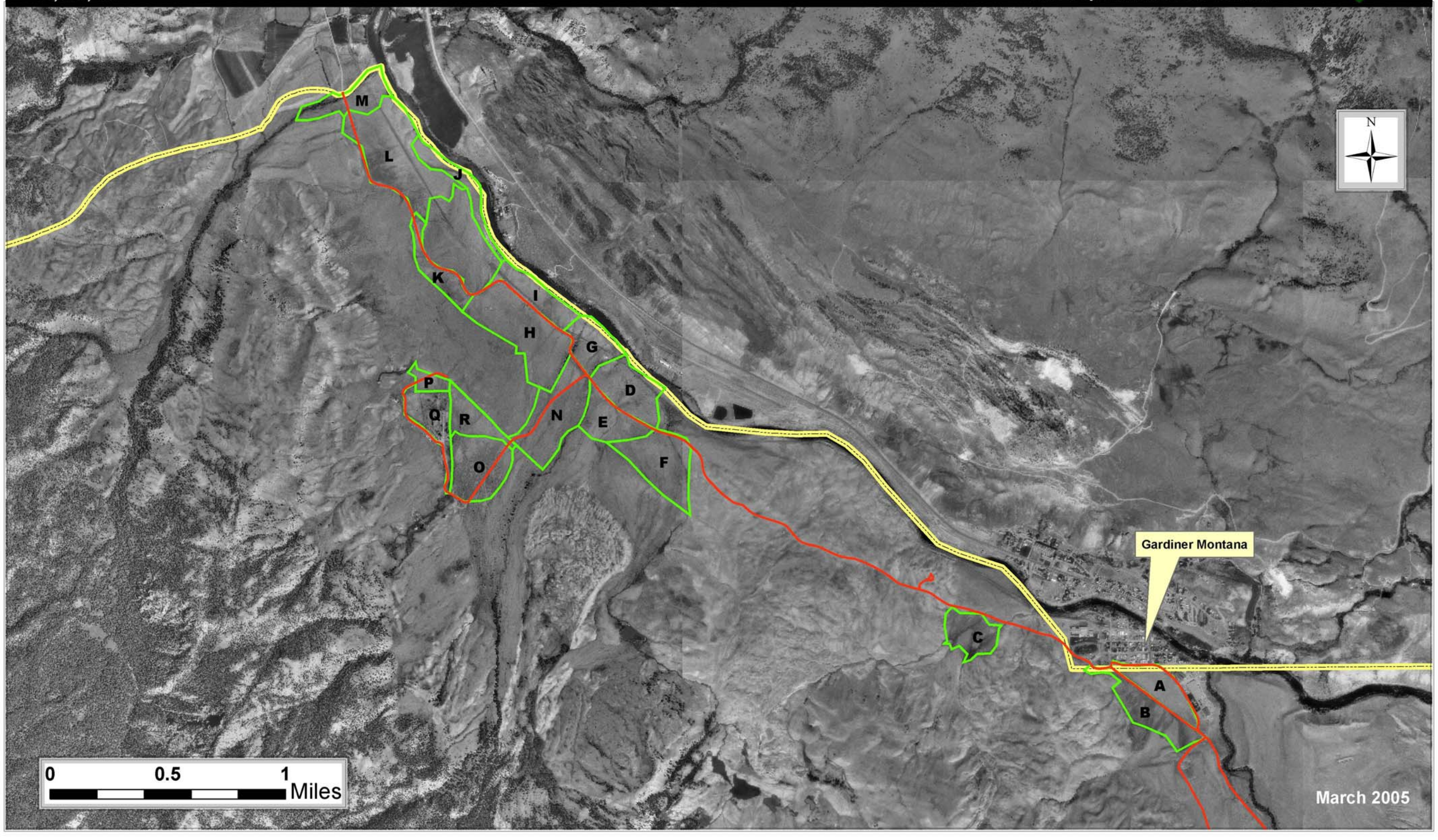


Produced by T Davis, Ungulate Program, 3/05

Yellowstone National Park
ID, MT, WY

Landforms/Fields

National Park Service
U.S. Department of the Interior



Field A

2/16/04

Size: 24.65 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. The area was tilled, planted to alfalfa and oats, irrigated, and harvested annually beginning in 1904 for the purpose of winter wildlife feeding or otherwise holding animals within park boundaries. Together with the adjacent field on the opposite side of the entrance road (Field B), this area was historically known as the Gardiner Hay Ranch. Horses were occasionally pastured here during late winter/early spring as well. Annual hay harvests stopped in the mid-1930's as the NPS contemplated the feasibility of converting the fields back to native vegetation. At one point, tour busses were parked on the north/northeast edge of the field while the alfalfa/oat community was still present to accommodate the needs of the concessions transportation department.

The area was seeded to crested wheatgrass (*Agropyron cristatum*) sometime after 1939 from seed stalk collected from revegetation efforts in the Game Preservation Ranch farther north. Smooth brome (*Bromus inermis*), western needlegrass (*Agropyron tenerum = A. caninum*), and alsike clover (*Trifoluim* hybridum) were part of the seed mix. Over time, the crested wheatgrass was replaced by exotic annuals. In response to a bumper crop of Russian thistle (*Salsola tragus syn. = S. kali, S. pestifer*), exotic vegetation control and experimental revegetation trials were initiated in 1998 (see Renkin et al. 1999, in the vegetation bibliography section). A 1% solution of Roundup was applied to 11 acres in August of 1998, May 1999, July 1999, and June 2000. A prescribed burn was carried out in October of 1998 on the scattered piles and congregations of Russian thistle skeletons to reduce the seedbank as well as prevent an unwanted/uncontrollable fire from occurring. Since no planted native seed germination occurred, experimental sites were

pulled in June 2001 in preparation for additional seeding and irrigating in 2002 (See Reid 2002 in the vegetation bibliography section).

The central portion is flat and free from rocks, while the east and west ends are rockier, suggesting that these areas probably were not cleared for agriculture. The “triangle" is dominated by exotic annual weeds, especially the center flat area, which this vegetation description will focus on. The most abundant species dominating large areas of the flat portion include summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), Russian thistle and desert alyssum (*Alyssum desertorum*). Summer cypress currently dominates the area forming extensive areas of monoculture, but Russian thistle was the dominant species previous to the attempt to establish native vegetation by seeding and watering starting in 2002.

There are numerous other exotic species within the triangle area including patches and scattered individuals of crested wheatgrass (*Agropyron cristatum*). Several other exotic grasses are also present including quackgrass (*Elymus repens syn. = Agropyron repens, Elytrigia repens*) which is primarily near some of the old ditches and the road from the arch to the entrance station, and smooth brome (*Bromus inermis*) also along the roadbed. Additionally, there are some areas where a few Russian wildrye (*Elymus junceus*) are encountered, which were planted in the early 1970’s following excavation for a local water line. The most common exotic grass is annual wheatgrass (*Agropyron triticeum*) which is quite abundant in some areas, along with a few small patches of cheatgrass (*Bromus tectorum*).

Additional exotic species include scattered plants of fanweed (*Thlaspi arvense*), flixweed (*Descurainia sophia*), littlepod falseflax (*Camelina microcarpa*), Loesel's tumblemustard (*Sisymbrium loeselii*), white pigweed (*Amaranthus albus*), rough pigweed (*Amaranthus retroflexus*), prickly lettuce (*Lactuca serriola*), and yellow sweetclover (*Melilotus officinalis*). Two different species of whitetop, (*Cardaria pubescens* and *Cardaria chalepensis*) at one time were encroaching from the road edge near the Xanterra warehouses into the flat portion of the area. This infestation was sprayed, and currently is represented by a few sparse remnants. Two other noxious weeds, spotted knapweed (*Centaurea maculosa*) and Dalmatian toadflax (*Linaria dalmatica*) are present along the eastern road edge in very small numbers.

Prior to the seeding effort, there were a few greasewood (*Sarcobatus vermiculatus*) and rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) present, especially near the road. Plains prickly pear (*Opuntia polyacantha*) is quite common on the rockier areas on the northwest and southeast part of the "triangle" along with some scattered plants of saltsage (*Atriplex gardneri*). The rocky area on the northwest near the Roosevelt Arch appears to be a portion of the landslide deposit with several native species that are typical of the hills above the arch. Lambsquarters (*Chenopodium bierlandieri*) and povertyweed (*Monolepis* nuttalliana) were present in relatively large numbers on the flat. Other native species that were also present in extremely low numbers on the flat area prior to seeding include western stickseed (*Lappula redowskii*), ellisia (*Ellisia nyctalea*), silverscale (*Atriplex argentea*), cowboy's delight (*Sphaeralcea*

coccinea), gumweed (*Grindelia squarrosa)*, Sandberg's bluegrass (*Poa secunda* var. secunda syn. =*Poa* sandbergii) and western wheatgrass (*Elymus smithii*, syn. =*Agropyron smithii*, *Pascopyrum smithii*).

The various seeding efforts in recent years have led to numerous native species present in this area, some of which probably would not have been expected in the area originally. All of these species are very sparse and relatively inconspicuous in the middle of the weed dominated area. Native species present in summer 2004 not mentioned previously include yarrow (*Achillea millefolium*), Indian ricegrass (*Achnatherum hymenoides* syn. = *Oryzopsis hymenoides*), fringed sage (*Artemisia frigida*), basin wild rye (*Elymus cinereus*), bluebunch wheatgrass (*Elymus spicatus* syn. = *Agropyron spicatum*), needle-and-thread (*Hesperostipa comata* syn. = *Stipa comata*), foxtail (*Hordeum jubatum*), and green needlegrass (*Nassella viridula* syn. = *Stipa viridula*).

Field A

Soils/Geology

Soils Map Unit FMF (from Shovic et al 1991):

Topography: The landforms are coalescing alluvial fans with broad, convex slopes. Slopes range from 2% to 10%. The drainage patterns are weakly radial.

Parent Material (geology): The source material for the fans is Cretaceous sandstone, siltstone, mudstone, and Pleistocene glacial till.

Soil Description: Less than 5% of the surface is covered by angular gravels. The soils are well drained with medium textures and light colored surface layers. The surface textures are mainly loams. Soil reaction (pH) is between 7.8 and 8.3. The accumulation of calcium carbonate can occur from the surface down to 30 centimeters below the surface. The soil fertility is high. Rock fragments within the profile vary from 0% to 20%, abundance usually increases with depth. They are rounded and generally small in size. Pedon 111 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
111	A	loam	41	41	18	2.56
	Bk	loam	45	39	16	1.53
	Btk	loam	37	44	19	1.47
	Bn	loam	37	43	20	1.08

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
111	A	7.9	12.3	0.1	1	11	2.8	0.8	0.7
	Bk	8.2	12	0.1	0.8	21	2.7	0.8	0.8
	Btk	8.3	14.7	0.3	0.6	19.1	3.8	2	0.7
	Bn	7.8	12.7	1	0.4	26.9	4.5	7.9	2.1

Soil Distribution: The percentage of sand and rock fragments in the soil generally increases upslope toward the apex of the fan and within fan channels.

SOIL DESCRIPTION 111 - Typic Eutroboralf; fine-loamy, mixed, calcareous

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-8 cm) Light grayish brown (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure breaking to moderate fine granular structure; soft, very friable, nonsticky, nonplastic; many very fine and fine roots, and common medium roots; moderately alkaline (pH 7.9); abrupt smooth boundary.

Bk (8-17 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure breaking to moderate fine subangular blocky structure; soft, friable, slightly sticky, nonplastic; many very fine and fine roots; moderately alkaline (pH 8.2); strongly effervescent; abrupt smooth boundary.

Btk (17-50 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, friable, sticky, slightly plastic; common very fine and fine roots, and few medium roots; moderately alkaline (pH 8.3); strongly effervescent; diffuse smooth boundary.

Bn (50-70 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, very friable, slightly sticky, nonplastic; few very fine and fine roots; mildly alkaline (pH 7.8); strongly effervescent.

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 524570 east 4983030 north. The pedon has formed in fan deposits derived from sedimentary bedrock. The slope is 2 %. Aspect is southwest. Elevation is 1800 m. The habitat type is bluebunch wheatgrass/Sandberg bluegrass (AGSP/POSA) with 60 % vegetative cover.

Notes: Rock fragments make up 1 % of the soil surface. Soil described by Ann Rodman and Liz Colvard on 7/19/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 295F or the unit Field A was mapped as.

Field B

6/16/04

Size: 30.69 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. The area was tilled, planted to alfalfa and oats, irrigated, and harvested annually beginning in 1904 for the purpose of winter wildlife feeding or otherwise holding animals within park boundaries. Together with the adjacent field on the opposite side of the entrance road (Field A), this area was historically known as the Gardiner Hay Ranch. Horses were occasionally pastured here during late winter/early spring as well and a quarterhorse racetrack was temporarily situated on the eastern edge of the field. Annual hay harvests stopped in the mid-1930's as the NPS contemplated the feasibility of converting the fields back to native vegetation. The area was seeded to crested wheatgrass (*Agropyron cristatum*) sometime after 1939 from seed stalk collected from revegetation efforts in the Game Preservation Ranch farther north. Smooth brome (*Bromus inermis*), slender wheatgrass (*Agropyron tenerum = A. caninum*), and alsike clover (*Trifolium hybridum*) were part of the seed mix. No other known revegetation efforts were attempted in this field.

Currently, the former field is a complex mosaic of numerous different species, some native but mostly exotic. The area near the outwash and the road is mostly dominated by smooth brome, with a conspicuous component of rubber rabbitbrush (*Ericameria nauseosa* syn = *Chrysothamnus nauseosus*). Also present in the same area is quackgrass (*Elymus repens*). Scattered across the area are extensive patches of crested wheatgrass, summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), desert alyssum (*Alyssum desertorum*), and Russian thistle (*Salsola tragus* L). Other exotic components include fanweed (*Thlaspi arvense*), littlepod falseflax (*Camelina microcarpa*), rough pigweed (*Amaranthus* retroflexus), spear orach (*Atriplex patula*), cheatgrass (*Bromus tectorum*), and yellow sweetclover (*Melilotus officinalis*). Noxious weeds that are currently present

include whitetop, (*Cardaria pubescens* and *Cardaria chalepensis*) which spread from the roadbed on the western portion of the old field, was treated, and persists in scattered locations. Also present, mostly along the roadbed are very small numbers of spotted knapweed (*Centaurea maculosa*) and Dalmatian toadflax (*Linaria dalmatica*).

The most conspicuous component of the plant community that is native is rubber rabbitbrush (*Ericameria nauseosa* syn.= *Chrysothamnus nauseosus*). There are also a few greasewood (*Sarcobatus vermiculatus*). The annual species lambsquarters (*Chenopodium bierlandieri*) and povertyweed (*Monolepis nuttalliana*) were present in relatively large numbers. Other native species that are present in small numbers or limited areas include deep root (*Iva axillaris*), western stickseed (*Lappula redowskii*), gumweed (*Grindelia squarrosa*), plains prickly pear (*Opuntia polyacantha*), cowboy's delight (*Sphaeralcea coccinea*), and Sandberg's bluegrass (*Poa secunda* var. *secunda* syn.=*Poa sandbergii*). The only discernible pattern was the presence of rubber rabbitbrush associated with the outwash from the drainage above.

Field B

Soils/Geology

Soils Map Unit FMF (from Shovic et al 1991):

Topography: The landforms are coalescing alluvial fans with broad, convex slopes. Slopes range from 2% to 10%. The drainage patterns are weakly radial.

Parent Material (geology): The source material for the fans is Cretaceous sandstone, siltstone, mudstone, and Pleistocene glacial till.

Soil Description: Less than 5% of the surface is covered by angular gravels. The soils are well drained with medium textures and light colored surface layers. The surface textures are mainly loams. Soil reaction (pH) is between 7.8 and 8.3. The accumulation of calcium carbonate can occur from the surface down to 30 centimeters below the surface. The soil fertility is high. Rock fragments within the profile vary from 0% to 20%, abundance usually increases with depth. They are rounded and generally small in size. Pedon 111 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
111	A	loam	41	41	18	2.56
	Bk	loam	45	39	16	1.53
	Btk	loam	37	44	19	1.47
	Bn	loam	37	43	20	1.08

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
111	A	7.9	12.3	0.1	1	11	2.8	0.8	0.7
	Bk	8.2	12	0.1	0.8	21	2.7	0.8	0.8
	Btk	8.3	14.7	0.3	0.6	19.1	3.8	2	0.7
	Bn	7.8	12.7	1	0.4	26.9	4.5	7.9	2.1

Soil Distribution: The percentage of sand and rock fragments in the soil generally increases upslope toward the apex of the fan and within fan channels.

SOIL DESCRIPTION 111 - Typic Eutroboralf; fine-loamy, mixed, calcareous

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-8 cm) Light grayish brown (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure breaking to moderate fine granular structure; soft, very friable, nonsticky, nonplastic; many very fine and fine roots, and common medium roots; moderately alkaline (pH 7.9); abrupt smooth boundary.

Bk (8-17 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure breaking to moderate fine subangular blocky structure; soft, friable, slightly sticky, nonplastic; many very fine and fine roots; moderately alkaline (pH 8.2); strongly effervescent; abrupt smooth boundary.

Btk (17-50 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, friable, sticky, slightly plastic; common very fine and fine roots, and few medium roots; moderately alkaline (pH 8.3); strongly effervescent; diffuse smooth boundary.

Bn (50-70 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, very friable, slightly sticky, nonplastic; few very fine and fine roots; mildly alkaline (pH 7.8); strongly effervescent.

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 524570 east 4983030 north. The pedon has formed in fan deposits derived from sedimentary bedrock. The slope is 2 %. Aspect is southwest. Elevation is 1800 m. The habitat type is bluebunch wheatgrass/Sandberg bluegrass (AGSP/POSA) with 60 % vegetative cover.

Notes: Rock fragments make up 1 % of the soil surface. Soil described by Ann Rodman and Liz Colvard on 7/19/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field C

2/28/04

Size: 22.00 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently the field varies from a stand of greasewood (*Sarcobatus vermiculatus*) on the western edge, to areas that are usually bare ground throughout the summer. The outwash areas from the drainages are dominated by smooth brome (*Bromus inermis*) and quackgrass (*Elymus repens*). Extensive areas, especially away from the outwash zones are dominated by fanweed (*Thlaspi arvense*), Russian thistle (*Salsola tragus syn. = S. kali, S. pestifer*)), and desert alyssum (*Alyssum desertorum*). Other exotic components of the vegetation include annual wheatgrass (*Agropyron triticeum*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), flixweed (*Descurainia sophia*), littlepod falseflax (*Camelina microcarpa*), Japanese brome (*Bromus japonicus*), and whitetop (*Cardaria chalepensis*) which is along the road edge.

Greasewood (*Sarcobatus vermiculatus*) forms a conspicuous stand on the western side and southern edge of the flat. Scattered around the area are a few patches of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*). The only natives that are commonly encountered are the goosefoots (*Chenopodium* spp.). Natives that are present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*), Sandberg's bluegrass (*Poa secunda var. secunda* syn.= *Poa sandbergii*), gumweed (*Grindelia squarrosa*), Baltic rush (*Juncus arcticus* var. *balticus* syn. *Juncus balticus*), fringed sage (*Artemisia frigida*), western wheatgrass (*Elymus smithii*, syn.=*Agropyron smithii, Pascopyrum smithii*), and silverscale (*Atriplex argentea*). Baltic rush and western wheatgrass are associated with the drainages, otherwise there are no discernible patterns that can be determined in regards to the distribution of the rare individuals of the native flora within the field.

Field C

Soils/Geology

Soils Map Unit FMF (from Shovic et al 1991)

Topography: The landforms are coalescing alluvial fans with broad, convex slopes. Slopes range from 2% to 10%. The drainage patterns are weakly radial.

Parent Material (geology): The source material for the fans is Cretaceous sandstone, siltstone, mudstone, and Pleistocene glacial till.

Soil Description: Less than 5% of the surface is covered by angular gravels. The soils are well drained with medium textures and light colored surface layers. The surface textures are mainly loams. Soil reaction (pH) is between 7.8 and 8.3. The accumulation of calcium carbonate can occur from the surface down to 30 centimeters below the surface. The soil fertility is high. Rock fragments within the profile vary from 0% to 20%, abundance usually increases with depth. They are rounded and generally small in size. Pedon 111 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
111	A	loam	41	41	18	2.56
	Bk	loam	45	39	16	1.53
	Btk	loam	37	44	19	1.47
	Bn	loam	37	43	20	1.08

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
111	A	7.9	12.3	0.1	1	11	2.8	0.8	0.7
	Bk	8.2	12	0.1	0.8	21	2.7	0.8	0.8
	Btk	8.3	14.7	0.3	0.6	19.1	3.8	2	0.7
	Bn	7.8	12.7	1	0.4	26.9	4.5	7.9	2.1

Soil Distribution: The percentage of sand and rock fragments in the soil generally increases upslope toward the apex of the fan and within fan channels.

SOIL DESCRIPTION 111 - Typic Eutroboralf; fine-loamy, mixed, calcareous

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-8 cm) Light grayish brown (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure breaking to moderate fine granular structure; soft, very friable, nonsticky, nonplastic; many very fine and fine roots, and common medium roots; moderately alkaline (pH 7.9); abrupt smooth boundary.

Bk (8-17 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure breaking to moderate fine subangular blocky structure; soft, friable, slightly sticky, nonplastic; many very fine and fine roots; moderately alkaline (pH 8.2); strongly effervescent; abrupt smooth boundary.

Btk (17-50 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, friable, sticky, slightly plastic; common very fine and fine roots, and few medium roots; moderately alkaline (pH 8.3); strongly effervescent; diffuse smooth boundary.

Bn (50-70 cm) Light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, very friable, slightly sticky, nonplastic; few very fine and fine roots; mildly alkaline (pH 7.8); strongly effervescent.

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 524570 east 4983030 north. The pedon has formed in fan deposits derived from sedimentary bedrock. The slope is 2 %. Aspect is southwest. Elevation is 1800 m. The habitat type is bluebunch wheatgrass/Sandberg bluegrass (AGSP/POSA) with 60 % vegetative cover.

Notes: Rock fragments make up 1 % of the soil surface. Soil described by Ann Rodman and Liz Colvard on 7/19/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field E

5/6/04

Size: 25.36 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently, the field is dominated by desert allysum (*Allysum desertorum*), which is forming a mono-culture stand in extensive areas of the field. There are also extensive patches of a monoculture of crested wheatgrass (*Agropyron cristatum*). Together these two species totally dominate the area today. Other exotic components of the vegetation include fanweed (*Thlaspi arvense*), flixweed (*Descurainia sophia*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), cheatgrass (*Bromus* tectorum), tumblemustard (*Sisymbrium altissimum*), yellow sweetclover (*Melilotus officinalis*) and littlepod falseflax (*Camelina microcarpa*).

There are very few native species present except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present throughout the old field. Along and near the drainages there is a conspicuous presence of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*). There are also a few dead skeletons of sagebrush (*Artemisia tridentata*), basin wildrye (*Elymus cinereus*), and a couple of live Rocky Mountain Juniper (*Juniperus scopulorum*). Also present in the mesic strip immediately adjacent to Stephen's Creek is smooth brome (*Bromus inermis*), common timothy (*Phleum pratense*), prickly lettuce (*Lactuca serriola*), gumweed (*Grindelia squarrosa*), and fowl bluegrass (*Poa palustris*). Away from the drainages, perennial natives that are present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*), Sandberg's bluegrass (*Poa secunda var. secunda* syn.= *Poa sandbergii*),and Indian ricegrass (Achnatherum hymeniodes syn. = Oryzopsis hymenoides) . Other then the association of some species with the drainages and flood deposits immediately adjacent to them, there are no discernible patterns that can be determined in regards to the distribution of the rare individuals of the native species within the field.

Field E

Soils/Geology

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field F

6/07/04

Size: 41.06 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently, the field is dominated by desert alyssum (*Alyssum desertorum*), which is forming a mono-culture stand in extensive areas of the field. There are also scattered patches of remnant monoculture of crested wheatgrass (*Agropyron cristatum*). Together these two species totally dominate the area today. There are also localized patches of Russian thistle (*Salsola tragus* syn. = *S. kali*, *S. pestifer*). Other exotic components of the vegetation include fanweed (*Thlaspi arvense*), flixweed (*Descurainia sophia*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), annual wheatgrass (*Agropyron triticeum*), rough pigweed (*Amaranthus retroflexus*), and littlepod falseflax (*Camelina microcarpa*).

Landslide Creek flows through the polygon, with a mixed assemblage of exotic and native species that are indicative of the presence of water. The strip of more mesic vegetation is very narrow and includes smooth brome (*Bromus inermis*), Rocky Mountain Iris (*Iris missouriensis*), basin wildrye (*Elymus cinereus*), gumweed (*Grindelia squarrosa*), reed canary grass (*Phalaris arundinacea*), fowl bluegrass (*Poa palustris*), and prickly lettuce (*Lactuca serriola*).

There are very few native species present away from the creek except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present. The most conspicuous perennial native is rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) which is most commonly encountered near Landslide Creek, though there are patches away from the drainage. Perennial natives that are present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*) and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). Besides the presence of rubber rabbitbrush along the Landslide Creek

drainage (where many individuals are being girdled by jackrabbits/cottontails), there are no discernible patterns that can be determined in regards to the distribution of either plains prickly pear or Sandberg's bluegrass, though often there are several bluegrass plants present in a particular area.

Field F

Soils/Geology

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field G

7/21/04

Size: 23.59 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently, the field is dominated by crested wheatgrass (*Agropyron cristatum*), with extensive areas of desert alyssum (*Alyssum desertorum*). Together these two species totally dominate the area today. There are also localized patches of Russian thistle (*Salsola tragus* syn. = *S. kali*, *S. pestifer*) peppered across the field. Other exotic components of the vegetation present in extremely low numbers include fanweed (*Thlaspi arvense*), flixweed (*Descurainia sophia*), tumblemustard (*Sisymbrium altissimum*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), and littlepod falseflax (*Camelina microcarpa*). A 5-acre eastern portion of this field was plowed, planted with bluebunch wheatgrass and needle-and-thread, and harrowed in October 1994 in an attempt to grow native seed for further revegetation efforts. No successful native seed germination was observed, and the field reverted back to crested wheatgrass within 1-2 years.

There are very few native species present except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.). The only perennial native that is a conspicuous component of the vegetation is plains prickly pear (*Opuntia polyacantha*). Also present in extremely low numbers is Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). There are no discernible patterns that can be determined in regards to the distribution of the rare individuals of the native species within the field away from the gullies/drainages.

Spring Creek flows through the polygon and Stephens Creek and the Yellowstone River form the western and northern edges respectively, so there are several narrow areas of

mesic to riparian vegetation present. In the mesic and wetland sites, the vegetation is composed of a mixed assemblage of exotic and native species. Exotic components along the riparian/mesic strip of Spring Creek and Stephens Creek dominate the drainage and include smooth brome (*Bromus inermis*), common timothy (*Phleum pratense*), fowl bluegrass (*Poa palustris*), and white sweet-clover (*Melilotus albus*). Following the drainages is a conspicuous scattering of Rocky Mountain Juniper (*Juniperus scopulorum*) along with other native species such as rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*), and big sagebrush (*Artemisia tridentata* var. *tridentata*). Native species in or immediately adjacent to the riparian/mesic strip next to the creeks include common spike-rush (*Eleocharis palustris*), sweet evening-primrose (*Oenothera villosa* var. *strigosa*), field mint (*Mentha arvensis*), gumweed (*Grindelia squarrosa*), and American vetch (*Vicia americana* var. *minor*).

Field G

Soils/Geology

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field H

10/07/04

Size: 62.55 acres

Vegetation:

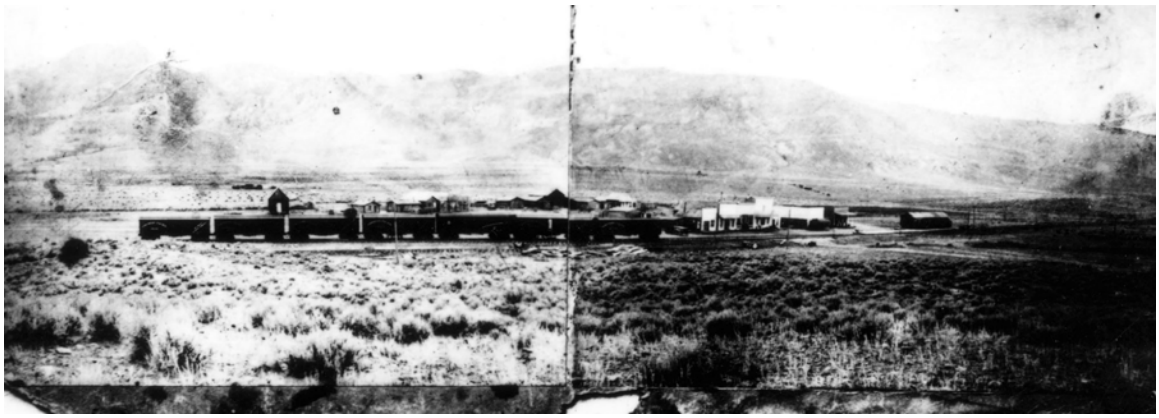
There is no known information about the original vegetation pre Euro-American influence. During the 1980's this field was known as the crested wheatgrass (*Agropyron cristatum*) field because the entire field was a monoculture of crested wheatgrass (the experimental revegetation trials, identified as the crested wheatgrass field in the bibliography on vegetation, were located here). Apparently, the crested wheatgrass is slowly dying out. Today, the field is primarily dominated by desert alyssum (*Alyssum desertorum*), which is forming a monoculture stand in extensive areas of the field. There are also some large patches of crested wheatgrass. Together these two species totally dominate the area today. Other minor components of the vegetation that are exotic include fanweed (*Thlaspi arvense*), flixweed (Descurainia sophia), and summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*).

There are very few native species present except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present throughout the old field. There are a couple of patches of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) out in the center of the field. Perennial natives that are present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*) and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). There are no discernible patterns that can be determined in regards to the distribution of the rare individuals of the native species within the field.

This is the former location of the town of Cinnabar, Montana. In 1883, the Northern Pacific Railroad built a spur track from Livingston, Montana to a point three miles from Gardiner, Montana. (The railroad had intended to go all the way to Gardiner but the owner of the land in the path of the railroad refused to sell.) The town of Cinnabar sprang

up at the railroad terminus and for 20 years served the local residents and railroad passengers who were visiting the park. When the railroad was finally extended to Gardiner in 1902/03, Cinnabar was quickly dismantled. It lasted only 20 years.

Cinnabar, Montana ca. 1900



Cinnabar, Montana date unknown

Both pictures were taken in present day “Field I” looking west towards Cinnabar, Montana (Field H) with Electric Peak in the background.

Field H

Soils and Geology

Soils Map Unit D16 (from Shovic et al 1991):

Topography: The landform is mainly a flood plain with some gently rolling terrain. This unit is located in the Yellowstone River valley bottom. Slopes vary from 0% to 5%. Remains of irrigation ditches cross the surface.

Parent Material (geology): The unit is composed of silty and sandy alluvium. Irrigated agriculture has altered the top 9 centimeters with additions of organic matter and fertilizers.

Soil Description: Surface rock fragments make up 0% to 2% of the soil surface. Soils are well drained with medium textures and dark colored surface layers. The surface texture is loam. The soil reaction pH is 8.1 at the surface, and varies between 8.3 and 7.6 in the subsurface. These soils have moderate fertility. Rock fragments in the soil make up less than 5% of the profile. Pedon 141 is typical of this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
141	Ap	loam	34	46	20	1.96
	Bt1	loam	28	48	24	1.4
	Bt2	loam	24	50	26	0.9
	Bt3	loam	32	46	22	1.05

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
141	Ap	8.1	25	0.3	1.1	17.7	7.7	1.2	0.6
	Bt1	8.3	29.3	0.7	0.3	21.2	9	2.4	0.6
	Bt2	7.6	33.1	0.9	0.3	22.5	11.1	2.7	0.6
	Bt3	8.2	32.8	0.9	0.3	21.6	10.3	2.7	0.5

Soil Distribution: The unit have been heavily impacted and altered by irrigated agriculture. The plow layer (top 9 centimeters) has had the most additions of fertilizer and organic matter. Plowing may also have compacted the soil below 9 centimeters. The mode of deposition has resulted in textural variations with depth. These different layers are affected differently by the irrigation process and result in various vegetation patterns.

SOIL DESCRIPTION 141 - Typic Argiboroll; fine-loamy, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

Ap (0-10 cm) Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; soft, very friable, nonsticky, slightly plastic; many very fine and few fine roots; very few clay films in pores; 2 percent gravel; moderately alkaline (pH 8.1); abrupt smooth boundary.

Bt1 (10-32 cm) Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine roots; few clay films in pores; 2 percent gravel; moderately alkaline (pH 8.3); clear smooth boundary.

Bt2 (32-50 cm) Grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine roots; few moderately thick clay films; 2 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

Bt3 (50-58 cm) Grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak coarse subangular blocky structure; slightly hard, very friable, sticky, slightly plastic; common very fine roots; many moderately thick clay films in pores; 2 percent gravel; moderately alkaline (pH 8.2).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 5188200 east 4988610 north. The pedon has formed in fine textured flood deposits. The slope is 2 %. Elevation is 1580 m. Vegetation is introduced exotic species such as crested wheatgrass and mustards. Vegetative cover is 35 %.

Notes: The surface 5 cm is dry and loose. Soil described by Henry Shovic on 6/21/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Map Unit D3

Topography: This area is flat, or gently sloping, abandoned building sites.

Parent Material (geology): Mainly the same as map unit GTM, with one small area similar to LSP. Superficial deposits of glacial till make up most of this unit. These deposits are Pleistocene in age and are derived from a variety of rock types, including Precambrian crystalline rocks, Tertiary volcanic rocks, Mississippian limestones, travertine, and Cretaceous sedimentary rocks.

Soil Description and Distribution: Rock fragments make up greater than 35% of the soil surface. Soils are moderately coarse textured, shallow, and underlain by asphalt or rock foundations. Subsoil is exposed. Similar to map unit GTM. Surface soil reaction (pH) is between 7.0 and 8.0, and is usually slightly higher with depth. Calcium carbonate is common in subsurface layers, and sometimes occurs in the surface soil. Salt and /or sodium accumulations can occur in the subsoil, usually 20 centimeters or more below the soil surface. The soils usually have high fertility. Pedon 107 is typical of the soils in this map unit.

SOIL DESCRIPTION 107 - Typic Argiboroll; loamy-skeletal, mixed, calcareous

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-6 cm) Grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate coarse granular structure; soft, very friable, slightly sticky, slightly plastic; many very fine and fine roots; 10 percent gravel; mildly alkaline (pH 7.7); abrupt smooth boundary.

Bt (6-26 cm) Brown (10YR 4/3) very bouldery sandy clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; few thin clay films lining pores; 40 percent boulders; mildly alkaline (pH 7.4); diffuse irregular boundary.

Bk (26-52 cm) Light grayish brown (10YR 6/2) very gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; weak coarse subangular blocky structure; soft, very friable, nonsticky, nonplastic; common very fine and fine roots; 40 percent gravel; mildly alkaline (pH 7.4); strongly effervescent.

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518240 east 4988250 north. The pedon has formed in glacial till. The slope is 9 %. Aspect is northeast. Elevation is 1605 m. The habitat type is bluebunch wheatgrass/Sandberg bluegrass (AGSP/POSA) with 50 % vegetative cover.

Notes: Boulders, stones, and gravels make up 40 % of the soil surface. Soil described by Ann Rodman and Liz Colvard on 7/18/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Field I

10/8/04

Size: 24.20 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. The town site of Cinnabar occurred here, and the field is bisected by the old railroad bed. Currently, this area is dominated by crested wheatgrass (*Agropyron cristatum*), with extensive areas of desert alyssum (*Alyssum desertorum*). Together these two species totally dominate the area today. There are also localized patches of Russian thistle (*Salsola tragus* syn. = *S. kali, S. pestifer*). Other minor exotic components of the vegetation include fanweed (*Thlaspi arvense*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), and tumblemustard (*Sisymbrium altissimum*).

There are very few annual native species present except for western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present throughout the old field. Along the railroad grade and otherwise quite scattered is rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*). There are also a couple of short greasewood (*Sarcobatus vermiculatus*) and green rabbitbrush (*Chrysothamnus viscidiflorus*) shrubs. Scattered throughout the area, especially in slight swales are patches of narrow-leaved sedge (*Carex stenophylla*), otherwise the only native perennial species out on the flats is the occasional plant of plains prickly pear (*Opuntia polyacantha*). The only recognizable pattern in regards to the native vegetation is the tendency for narrow-leaved sedge to occur in minor swales.

Field I

Soils/geology

Soils Map Unit D16 (from Shovic et al 1991)

Topography: The landform is mainly a flood plain with some gently rolling terrain. This unit is located in the Yellowstone River valley bottom. Slopes vary from 0% to 5%. Remains of irrigation ditches cross the surface.

Parent Material (geology): The unit is composed of silty and sandy alluvium. Irrigated agriculture has altered the top 9 centimeters with additions of organic matter and fertilizers.

Soil Description: Surface rock fragments make up 0% to 2% of the soil surface. Soils are well drained with medium textures and dark colored surface layers. The surface texture is loam. The soil reaction pH is 8.1 at the surface, and varies between 8.3 and 7.6 in the subsurface. These soils have moderate fertility. Rock fragments in the soil make up less than 5% of the profile. Pedon 141 is typical of this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
141	Ap	loam	34	46	20	1.96
	Bt1	loam	28	48	24	1.4
	Bt2	loam	24	50	26	0.9
	Bt3	loam	32	46	22	1.05

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
141	Ap	8.1	25	0.3	1.1	17.7	7.7	1.2	0.6
	Bt1	8.3	29.3	0.7	0.3	21.2	9	2.4	0.6
	Bt2	7.6	33.1	0.9	0.3	22.5	11.1	2.7	0.6
	Bt3	8.2	32.8	0.9	0.3	21.6	10.3	2.7	0.5

Soil Distribution: The unit have been heavily impacted and altered by irrigated agriculture. The plow layer (top 9 centimeters) has had the most additions of fertilizer and organic matter. Plowing may also have compacted the soil below 9 centimeters. The mode of deposition has resulted in textural variations with depth. These different layers are affected differently by the irrigation process and result in various vegetation patterns.

SOIL DESCRIPTION 141 - Typic Argiboroll; fine-loamy, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

Ap (0-10 cm) Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; soft, very friable, nonsticky, slightly plastic; many very fine and few fine roots; very few clay films in pores; 2 percent gravel; moderately alkaline (pH 8.1); abrupt smooth boundary.

Bt1 (10-32 cm) Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine roots; few clay films in pores; 2 percent gravel; moderately alkaline (pH 8.3); clear smooth boundary.

Bt2 (32-50 cm) Grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine roots; few moderately thick clay films; 2 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

Bt3 (50-58 cm) Grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak coarse subangular blocky structure; slightly hard, very friable, sticky, slightly plastic; common very fine roots; many moderately thick clay films in pores; 2 percent gravel; moderately alkaline (pH 8.2).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 5188200 east 4988610 north. The pedon has formed in fine textured flood deposits. The slope is 2 %. Elevation is 1580 m. Vegetation is introduced exotic species such as crested wheatgrass and mustards. Vegetative cover is 35 %.

Notes: The surface 5 cm is dry and loose. Soil described by Henry Shovic on 6/21/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field J

11/18/04

Size: 19.22 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently, the field is dominated by crested wheatgrass (*Agropyron cristatum*) which is forming a mono-culture stand throughout the entire extent of the field. There are also a few localized patches of Russian thistle (*Salsola tragus*). The other exotic components of the vegetation include large patches of desert alyssum (*Alyssum desertorum*) and summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), especially on and around some of the clay openings/slicks.

There are some rare clay openings/slicks that have a very minor presence of native species present such as saltsage (*Atriplex gardneri* var. *gardneri*) and greasewood (*Sarcobatus vermiculatus*. Rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) is very scattered, especially in the western part of the field where many of the individuals were dead. Perennial natives that are present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*) and western wheatgrass (*Elymus smithii* syn. = *Agropyron smithii, Pascopyrum smithii*) which appears in some of the slight depressions.

Field J

Soils/geology

Soils Map Unit D2 (from Shovic et al 1991)

Topography: This area is mainly a flood plain with some gently rolling terrain. This unit is located in the Yellowstone River valley bottom. Slopes vary from 0% to 5%. Remains of irrigation ditches cross the surface.

Parent Material (geology): The unit is composed of silty, clayey, and sandy alluvium. Irrigated agriculture has altered the top 9 centimeters with plowing, and additions of organic matter and fertilizers.

Soil Description: Surface rock fragments make up 0% to 2% of the soil surface. Soils are well drained with fine textures and dark colored surface layers. Surface soil texture is silty clay loam. The soil reaction (pH) is 8.0 at the surface, and 7.5 or slightly above in the subsurface. These soils have moderate fertility. Rock fragments in the soil make up less than 5% of the profile. Pedon 140 is typical of this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
140	Ap	silty clay loam	7	54	39	8.30
	Bt	silty clay	6	49	45	2.51
	2Bk	clay loam	35	25	40	0.62
	2Bc	sandy clay loam	50	26	24	0.45

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
140	Ap	8.0	30.7	0.2	5.9	21.1	6.8	0.7	1.5
	Bt	7.5	27.6	0.4	1.8	23.3	6.2	1.4	0.6
	2Bk	7.5	25.8	0.7	0.8	20.2	6.8	2.7	0.5
	2Bc	7.8	18.3	0.6	0.4	38.7	5	3.3	0.6

Soil Distribution: The unit has been altered by irrigated agriculture. The plow layer (top 9 centimeters) has had the most additions of fertilizer and organic matter. Plowing may also have compacted the soil below 9 centimeters. The mode of deposition has resulted in textural variations with depth. These different layers are affected differently by the irrigation process and result in various vegetation patterns.

SOIL DESCRIPTION 140 - Typic Ustochrept; fine, mixed, calcareous

Pedon Description: (Colors are for dry soil unless otherwise stated.)

Ap (0-9 cm) Brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure parting to weak fine granular structure; soft, very friable; common very fine and fine roots; 1 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bt (9-23 cm) Light brownish gray (10YR 6/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable; common very fine and few fine roots; mildly alkaline (pH 7.5); gradual smooth boundary.

2Bk (23-61 cm) Pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; moderate coarse angular blocky structure; slightly hard, very friable; few very fine roots; few thin clay films in pores; mildly alkaline (pH 7.5); slightly effervescent; abrupt wavy boundary.

2Bc (61-70 cm) Light gray (10YR 7/2) sandy clay loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure; soft, very friable; few fine roots; moderately alkaline (pH 7.8).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518200 east 4989310 north. Elevation is 1580 m. The pedon has formed in alluvial deposits on a floodplain in an area of historic irrigated agriculture. Vegetation is introduced exotic species with 35 percent vegetative cover.

Notes: Soil described by Ann Rodman and Dean Neprud on 5/4/89.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field K

3/0/05

Size: 10.00 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently, the field is dominated by patches of desert alyssum (*Alyssum desertorum*) and crested wheatgrass (*Agropyron cristatum*). Together these two species totally dominate the area today. Crested wheatgrass is more prevalent along the old ditch courses. There are also some large patches of fanweed (*Thlaspi arvense*).

There are very few native species present except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present throughout the old field. There are a couple of patches of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) associated with an ephemeral drainage off of the adjacent bench. Perennial natives that are present in extremely low numbers include Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*) and plains prickly pear (*Opuntia polyacantha*), both of which are more prevalent in the western portion of the old field.

Field K

Soils/Geology

Soils Map Unit D16 (from Shovic et al 1991):

Topography: The landform is mainly a flood plain with some gently rolling terrain. This unit is located in the Yellowstone River valley bottom. Slopes vary from 0% to 5%. Remains of irrigation ditches cross the surface.

Parent Material (geology): The unit is composed of silty and sandy alluvium. Irrigated agriculture has altered the top 9 centimeters with additions of organic matter and fertilizers.

Soil Description: Surface rock fragments make up 0% to 2% of the soil surface. Soils are well drained with medium textures and dark colored surface layers. The surface texture is loam. The soil reaction pH is 8.1 at the surface, and varies between 8.3 and 7.6 in the subsurface. These soils have moderate fertility. Rock fragments in the soil make up less than 5% of the profile. Pedon 141 is typical of this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
141	Ap	loam	34	46	20	1.96
	Bt1	loam	28	48	24	1.4
	Bt2	loam	24	50	26	0.9
	Bt3	loam	32	46	22	1.05

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
141	Ap	8.1	25	0.3	1.1	17.7	7.7	1.2	0.6
	Bt1	8.3	29.3	0.7	0.3	21.2	9	2.4	0.6
	Bt2	7.6	33.1	0.9	0.3	22.5	11.1	2.7	0.6
	Bt3	8.2	32.8	0.9	0.3	21.6	10.3	2.7	0.5

Soil Distribution: The unit have been heavily impacted and altered by irrigated agriculture. The plow layer (top 9 centimeters) has had the most additions of fertilizer and organic matter. Plowing may also have compacted the soil below 9 centimeters. The mode of deposition has resulted in textural variations with depth. These different layers are affected differently by the irrigation process and result in various vegetation patterns.

SOIL DESCRIPTION 141 - Typic Argiboroll; fine-loamy, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

Ap (0-10 cm) Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; soft, very friable, nonsticky, slightly plastic; many very fine and few fine roots; very few clay films in pores; 2 percent gravel; moderately alkaline (pH 8.1); abrupt smooth boundary.

Bt1 (10-32 cm) Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine roots; few clay films in pores; 2 percent gravel; moderately alkaline (pH 8.3); clear smooth boundary.

Bt2 (32-50 cm) Grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine roots; few moderately thick clay films; 2 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

Bt3 (50-58 cm) Grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak coarse subangular blocky structure; slightly hard, very friable, sticky, slightly plastic; common very fine roots; many moderately thick clay films in pores; 2 percent gravel; moderately alkaline (pH 8.2).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 5188200 east 4988610 north. The pedon has formed in fine textured flood deposits. The slope is 2 %. Elevation is 1580 m. Vegetation is introduced exotic species such as crested wheatgrass and mustards. Vegetative cover is 35 %.

Notes: The surface 5 cm is dry and loose. Soil described by Henry Shovic on 6/21/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field L

11/19/04

Size: 72.48 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently, the field is dominated by desert alyssum (*Alyssum desertorum*), which is forming a mono-culture stand in extensive areas of the field. In a few scattered areas the vegetation consists of some remnant monocultures of crested wheatgrass (*Agropyron cristatum*). There are also localized patches of Russian thistle (*Salsola tragus* syn. = *S. kali, S. pestifer*) peppered across the field. Other exotic components of the vegetation include fanweed (*Thlaspi arvense*), flixweed (*Descurainia sophia*), tumblemustard (*Sisymbrium altissimum*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), annual wheatgrass (*Agropyron triticeum*), and littlepod falseflax (*Camelina microcarpa*).

There are very few native species present except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present in the weedy mustard stand that currently dominates the old field. Perennial natives that are present in extremely low numbers include rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*), plains prickly pear (*Opuntia polyacantha*), Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*), and narrow-leaved sedge (*Carex stenophylla*). There are no discernible patterns that can be determined in regards to the distribution of the rare individuals of the native species within the field.

Soils/geology

Soils Map Unit D2 (from Shovic et al 1991)

Topography: This area is mainly a flood plain with some gently rolling terrain. This unit is located in the Yellowstone River valley bottom. Slopes vary from 0% to 5%. Remains of irrigation ditches cross the surface.

Parent Material (geology): The unit is composed of silty, clayey, and sandy alluvium. Irrigated agriculture has altered the top 9 centimeters with plowing, and additions of organic matter and fertilizers.

Soil Description: Surface rock fragments make up 0% to 2% of the soil surface. Soils are well drained with fine textures and dark colored surface layers. Surface soil texture is silty clay loam. The soil reaction (pH) is 8.0 at the surface, and 7.5 or slightly above in the subsurface. These soils have moderate fertility. Rock fragments in the soil make up less than 5% of the profile. Pedon 140 is typical of this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
140	Ap	silty clay loam	7	54	39	8.30
	Bt	silty clay	6	49	45	2.51
	2Bk	clay loam	35	25	40	0.62
	2Bc	sandy clay loam	50	26	24	0.45

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
140	Ap	8.0	30.7	0.2	5.9	21.1	6.8	0.7	1.5
	Bt	7.5	27.6	0.4	1.8	23.3	6.2	1.4	0.6
	2Bk	7.5	25.8	0.7	0.8	20.2	6.8	2.7	0.5
	2Bc	7.8	18.3	0.6	0.4	38.7	5	3.3	0.6

Soil Distribution: The unit has been altered by irrigated agriculture. The plow layer (top 9 centimeters) has had the most additions of fertilizer and organic matter. Plowing may also have compacted the soil below 9 centimeters. The mode of deposition has resulted in textural variations with depth. These different layers are affected differently by the irrigation process and result in various vegetation patterns.

SOIL DESCRIPTION 140 - Typic Ustochrept; fine, mixed, calcareous

Pedon Description: (Colors are for dry soil unless otherwise stated.)

Ap (0-9 cm) Brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure parting to weak fine granular structure; soft, very friable; common very fine and fine roots; 1 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bt (9-23 cm) Light brownish gray (10YR 6/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure; slightly hard, very friable; common very fine and few fine roots; mildly alkaline (pH 7.5); gradual smooth boundary.

2Bk (23-61 cm) Pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; moderate coarse angular blocky structure; slightly hard, very friable; few very fine roots; few thin clay films in pores; mildly alkaline (pH 7.5); slightly effervescent; abrupt wavy boundary.

2Bc (61-70 cm) Light gray (10YR 7/2) sandy clay loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure; soft, very friable; few fine roots; moderately alkaline (pH 7.8).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518200 east 4989310 north. Elevation is 1580 m. The pedon has formed in alluvial deposits on a floodplain in an area of historic irrigated agriculture. Vegetation is introduced exotic species with 35 percent vegetative cover.

Notes: Soil described by Ann Rodman and Dean Neprud on 5/4/89.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field M

5/04/04

Size: 25.05 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Reese Creek, a perennial stream, flows through this old field and homestead site. The vegetation on the east side of the road and south of Reese Creek is primarily dominated by exotics, with crested wheatgrass (*Agropyron cristatum*) and desert alyssum (*Alyssum desertorum*) dominating the area. Additionally, several annual exotics are also present including annual wheatgrass (*Agropyron triticeum*), Russian thistle (*Salsola tragus syn. = S. kali, S. pestifer*), tumblemustard (*Sisymbrium altissimum*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), and flixweed (*Descurainia sophia*). Through this area there is a stretch of rocks that runs from near the road towards the Yellowstone River. Usually in rocky areas there is an increased presence of native species tucked in and amongst the boulders. In contrast, this rocky area has an extremely impoverished native flora primarily restricted to western stickseed (*Lappula redowskii*) and plains prickly pear (*Opuntia polyacantha*).

On the opposite side of Reese Creek (north of the creek and east of the road) the most conspicuous component of the vegetation are scattered big sagebrush (*Artemisia tridentata* var. *tridentata*). There are also rabbitbrush scattered in the vicinity, both rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) and green rabbitbrush (*Chrysothamnus viscidiflorus*). The understory vegetation, though, is dominated by exotics, notably desert alyssum (*Alyssum desertorum*). Within the shrub community, crested wheatgrass (*Agropyron cristatum*) tends to dominate in the gaps between the shrubs. Additional exotic species present included patches of cheatgrass (*Bromus tectorum*) and flixweed (*Descurainia sophia*). There are rhizomatous native graminoids present, though, both western wheatgrass (*Elymus smithii* syn. = *Agropyron smithii, Pascopyrum smithii*) and narrow-leaved sedge (*Carex stenophylla*). Other native

species that were present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*), threadleaf phacelia (*Phacelia linearis*), and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*).

The riparian corridor along Reese Creek has a diverse assemblage of trees and shrubs including cottonwoods (*Populus* spp.), Rocky Mountain juniper (*Juniperus scopulorum*), and water birch (*Betula occidentalis*). Big sagebrush (*Artemisia tridentata* var. *tridentata*) occurs in the slightly drier areas on both side of the creek. The strip of more mesic vegetation is quite narrow and includes smooth brome (*Bromus inermis*), fowl bluegrass (*Poa palustris*), basin wildrye (*Elymus cinereus*), and various forbs.

The old homestead was on the south side of the road. There is an old apple tree that helps locate the disturbed area. Today, this site is a major weed patch with such species as desert alyssum (*Alyssum desertorum*), fanweed (*Thlaspi arvense*), crested wheatgrass (*Agropyron cristatum*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), Russian thistle (*Salsola tragus syn. = S. kali, S. pestifer*), annual wheatgrass (*Agropyron triticeum*), and cheatgrass (*Bromus tectorum*). The vegetation on the rocky, less disturbed area south of the homestead resembles the vegetation on the north side of Reese Creek, though the native flora is more intact so it wouldn't be considered for possible revegetation.

Field M

Soils/Geology:

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field N

6/15/04

Size: 83.10 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. This field area is divided both by the road to the Stephens Creek Corrals and by Spring Creek. There are also some older channels from Spring Creek and Stephens Creek in the area. Currently, the field is dominated by desert alyssum (*Alyssum desertorum*), which is forming a mono-culture stand in extensive areas of the field. (This field also contained the experimental revegetation trials for the *Alyssum* site as described in the bibliography on vegetation.) There are also extensive patches of crested wheatgrass (*Agropyron cristatum*). Together these two species totally dominate the area today. Other exotic components of the vegetation include fanweed (*Thlaspi arvense*), flixweed (*Descurainia sophia*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), and littlepod falseflax (*Camelina microcarpa*).

There are very few native species present except for annual western stickseed (*Lappula redowskii*) and goosefoots (*Chenopodium* spp.) which are occasionally present throughout the old field. Along and near the drainages there is conspicuous presence of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*). Also along the ravine associated with the Spring Creek drainage there are both live shrubs and dead skeletons of big sagebrush (*Artemisia tridentata* var. *tridentata*), basin wildrye (*Elymus cinereus*), and Rocky Mountain Junipers (*Juniperus scopulorum*). Away from the drainages, perennial natives that are present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*), and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). Other then the association of some species with the drainages and flood deposits immediately adjacent to them, there are no discernible patterns that can be determined in regards to the distribution of the rare individuals of the native species within the field.

Field N

Soils/Geology:

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field O

3/15/05

Size: 96.49 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Superficially, this old field looks like it is primarily vegetated with native species due to the extensive stand of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) that dominates especially the southern portion of the site. Another conspicuous part of the vegetation in some areas is the presence of scattered plants of big sagebrush (*Artemisia tridentata* var. *tridentata*). The understory vegetation, though, is almost totally dominated by exotics, notably desert alyssum (*Alyssum desertorum*). Desert alyssum also dominates the portion of the old field that is not vegetated with native shrubs. Within the rubber rabbitbrush community, crested wheatgrass (*Agropyron cristatum*) tends to dominate in the gaps between the shrubs. Together, desert alyssum and crested wheatgrass completely dominate the understory. Other native species that were present in extremely low numbers include plains prickly pear (*Opuntia polyacantha*) and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*).

This old field is situated close to the mountains with both Stephens Creek and Spring Creek drainages in the vicinity. Currently, the present route of Stephens Creek is outside of this old field, but there are previous streambeds within the field. Most of the water from Spring Creek is diverted for use at the Stephens Creek Corrals. There are also old ditches running through the area. Moister sites especially along the streambeds were dominated by smooth brome (*Bromus inermis* var. *inermis*) and Baltic rush (*Juncus balticus* syn. = *J. arcticus* var. *balticus*). Perhaps the different soil characteristics associated with the coarser debris from flood events or greater moisture availability has allowed rubber rabbitbrush and big sagebrush to be a conspicuous part of the vegetation.

Field O

Soils/Geology:

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field P

3/9/05

Size: 7.30 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. This old field is partially occupied by the bison capture facility, and an area used for constructing log buildings. Within the corral/construction area, the vegetation is dominated by an assemblage of weedy species including summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), fanweed (*Thlaspi arvense*), lambsquarters (*Chenopodium* spp.), and flixweed (*Descurainia sophia*).

Currently, the field outside the corral operation is dominated by desert alyssum (*Alyssum desertorum*), which is forming a monoculture stand in extensive areas of the field. There are also extensive patches of crested wheatgrass (*Agropyron cristatum*). Together these two exotic species totally dominate the area today. Additional exotic species include scattered plants of summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), Russian thistle (*Salsola tragus* syn. = *S. kali, S. pestifer*), pigweed (*Amaranthus* spp.), and Jim Hill tumblemustard (*Sisymbrium altissimum*).

There are only a few native species evident, especially near the slopes of the adjacent hillside, with scattered plants of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*), big sagebrush (*Artemisia tridentata* var. *tridentata*), and greasewood (*Sarcobatus vermiculatus*). All of these species are highly browsed, with several dead individuals in the area. Additional native species present include a few plants of plains prickly pear (*Opuntia polyacantha*) and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). There are no discernible patterns to the presence of the native species other than the higher incidence of shrubs in the area of the old field near the hillside.

Field O

Soils/Geology:

Soils Map Unit SCH (from Shovic et al 1991):

Topography: Landforms are stream bottom deposits, including channels, small terraces, and flood plains. Slopes range from 0% to 15%. They abut major streams and rivers.

Parent Material (geology): The unit is composed of alluvial material deposited from various sized streams and rivers. Material includes channel-fill, bar, and over-bank deposits. Near smaller streams, rock types are mainly local with some glacial erratics concentrated within stream channels. River deposits have a high concentration of reworked glacial drift.

Soil Description: Rock fragments make up 20% to 60% of the soil surface. Soils are well drained with medium to coarse textures and dark colored surface layers. Surface soil textures are mainly loam, with some sandy loam and loamy sand. Soil reaction (pH) is generally near 8.0. Soil fertility is moderate. Rock fragments within the profile vary from 5% to 70%. Soil texture and the percentage of rock fragments often varies abruptly with depth. Pedon 115 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
115	A	loam	Data not available			
	Bw1	loam				
	Bw2	loam				
	BC	loam				

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
115	A	8.0**	Data not available						
	Bw1	8.0**							
	Bw2	8.0**							
	BC	8.0**							

Soil Distribution: Rock fragments and sand in the surface layer become more abundant near channels. The mode of deposition causes soil textures and rock fragment abundance to be highly variable both laterally and with depth.

SOIL DESCRIPTION 115 - Typic Ustochrept; loamy-skeletal, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-21 cm) Light yellowish brown (10YR 6/4) loam, very dark grayish brown (10YR 3/2) moist; moderate coarse subangular blocky structure breaking to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine and fine roots; 5 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1 (21-32 cm) Very pale brown (10YR 7/4) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure breaking to moderate medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common very fine and few fine roots; 10 percent gravel; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2 (32-50 cm) Very pale brown (10YR 7/3) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate coarse angular blocky structure; soft, very friable, slightly sticky, slightly plastic; few very fine and fine roots; 15 percent gravel; moderately alkaline (pH 8.0); abrupt wavy boundary.

BC (50-60 cm) Brown (10YR 5/3) extremely gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; hard, very friable, nonsticky, nonplastic; common very fine and fine roots; 70 percent gravel and cobbles; moderately alkaline (pH 8.0).

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518860 east 4987110 north. The pedon has formed in stream deposits. The slope is 4 %. Aspect is north. Elevation is 1630 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 50 % vegetative cover.

Notes: Gravel and cobbles make up 20 % of the soil surface. Soil described by Ann Rodman on 7/20/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Field P

3/9/05

Size: 7.30 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. This old field is partially occupied by the bison capture facility, and an area used for constructing log buildings. Within the corral/construction area, the vegetation is dominated by an assemblage of weedy species including summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), fanweed (*Thlaspi arvense*), lambsquarters (*Chenopodium* spp.), and flixweed (*Descurainia sophia*).

Currently, the field outside the corral operation is dominated by desert alyssum (*Alyssum desertorum*), which is forming a monoculture stand in extensive areas of the field. There are also extensive patches of crested wheatgrass (*Agropyron cristatum*). Together these two exotic species totally dominate the area today. Additional exotic species include scattered plants of summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), Russian thistle (*Salsola tragus* syn. = *S. kali*, *S. pestifer*), pigweed (*Amaranthus* spp.), and Jim Hill tumblemustard (*Sisymbrium altissimum*).

There are only a few native species evident, especially near the slopes of the adjacent hillside, with scattered plants of rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*), big sagebrush (*Artemisia tridentata* var. *tridentata*), and greasewood (*Sarcobatus vermiculatus*). All of these species are highly browsed, with several dead individuals in the area. Additional native species present include a few plants of plains prickly pear (*Opuntia polyacantha*) and Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). There are no discernible patterns to the presence of the native species other than the higher incidence of shrubs in the area of the old field near the hillside.

Field P

Soils/Geology

Soils Map Unit FMC (from Shovic et al 1991):

Topography: Landforms are alluvial fans with broad, convex slopes. They are located on valley sides and bottoms. Slopes range from 8% to 20%. Drainage patterns are weakly radial to dendritic.
Parent Material (geology): The alluvial fan deposits are derived from local sandstone and rhyolitic bedrock. There are occasional glacial erratics within the soil.

Soil Description: Angular and subangular gravels and cobbles, with some subrounded stones make up from 2% to 40% of the soil surface. Soils are well drained, with medium to coarse textures and dark colored surface layers. Surface textures are mainly sandy loams with some loamy sands. Surface soil reaction (pH) varies between 7.3 and 8.1. Calcium carbonate may occur in the subsoil at depths greater than 10 centimeters. Salt and or/ sodium may occur in the soil profile. The soils have moderate fertility. Rock fragments are generally angular and subangular gravels and cobbles. The amount of rock fragments within the profile varies widely (5%-50%), but become more abundant with increasing depth. Pedon 106 is typical of the soils in this map unit.

Pedon#	Horizon	Texture	% Sand	% Silt	% Clay	% Organic Matter
106	A	sandy loam	61	31	8	1.88
	Bt	sandy loam	54	29	17	1.14
	Bk1	sandy loam	61	25	14	0.35
	Bk2	sandy loam	61	29	10	0.14

			Exchangeable (meq/100g)						
Pedon#	Horizon	pH	CEC	Na	K	Ca*	Mg*	ESP %	EC mmhos/cm
106	A	7.7	10.3	0.1	1.3	8.8	2.1	1	1.0
	Bt	7.9	14.1	0.2	0.6	11.4	3.3	1.4	0.8
	Bk1	8.2	11.2	0.4	0.3	30.6	3.3	3.6	0.7
	Bk2	7.7	11	0.8	0.5	28.8	3.5	7.3	0.6

Soil Distribution: Surface rock fragment percentage increases toward the head of slopes and within fan channels.

SOIL DESCRIPTION 106 - Typic Eutroboralf; coarse-loamy, mixed

Pedon Description: (Colors are for dry soil unless otherwise stated.)

A (0-10 cm) Brown (10YR 4/3) gravelly sandy loam, dark grayish brown (10YR 4/2) moist; strong fine granular structure; soft, loose, nonsticky, nonplastic; many very fine and fine roots, and few medium roots; 15 percent gravel; mildly alkaline (pH 7.7); abrupt smooth boundary.

Bt (10-33 cm) Brown (10YR 5/3) gravelly sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium granular structure; slightly hard, firm, slightly sticky, slightly plastic; common very fine and fine roots, and few coarse roots; 15 percent gravel; moderately alkaline (pH 7.9); abrupt wavy boundary.

Bk1 (33-51 cm) Light gray (10YR 7/2) very gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium angular blocky structure; slightly hard, firm, slightly sticky, slightly plastic; common very fine and fine roots; 40 percent gravel; moderately alkaline (pH 8.2); strongly effervescent; clear wavy boundary.

Bk2 (51-90 cm) Light gray (10YR 7/2) gravelly sandy loam, dark brown (10YR 3/3) moist; moderate coarse angular blocky structure breaking to moderate medium angular blocky structure; slightly hard, very friable, slightly sticky, nonplastic; few very fine roots; 20 percent gravel; mildly alkaline (pH 7.7); strongly effervescent.

Location and Topography: Southwestern Montana, Yellowstone National Park, UTM 518070 east 4988210 north. The pedon has formed in fan deposits derived from volcanic bedrock. The slope is 12 %. Aspect is east. Elevation is 1615 m. The habitat type is big sagebrush/bluebunch wheatgrass (ARTR/AGSP) with 45 % vegetative cover.

Notes: Gravels, cobbles and stones make up 9 % of the soil surface. Soil described by Ann Rodman and Liz Colvard on 7/18/88.

Soil data is on file at Division of Research, Yellowstone National Park, Box 168, Mammoth, WY 82190.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field Q

3/9/05

Size: 25.74 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Currently this old field is the location of the park's corral and nursery operations, and is a storage area for vehicles in the winter and old equipment. Consequently, this area is an interesting hodgepodge of corrals, buildings, nursery plantings, and vehicles. The one reality is the ubiquitous weed flora which includes summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), fanweed (*Thlaspi arvense*), smooth brome (*Bromus inermis*), Russian thistle (*Salsola tragus* syn. = *S. kali*, *S. pestifer*), desert alyssum (*Alyssum desertorum*), crested wheatgrass (*Agropyron cristatum*), and quackgrass (*Elymus repens* syn. = *Agropyron repens*, *Elytrigia repens*).

There is only a small area adjacent to the road that may represent a portion of the original plant community. The most conspicuous taxon is big sagebrush (*Artemisia tridentata* var. *tridentata*) which is very well-developed along the roadside strip. Associates in this plant community include the ubiquitous desert alyssum (*Alyssum desertorum*) and crested wheatgrass (*Agropyron cristatum*) along with rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), and plains prickly pear (*Opuntia polyacantha*).

Field Q

Soils/Geology

Soils Map Unit D10 (from Shovic et al 1991):

Topography: The area is gently sloping and contains abandoned irrigated fields and the settlement of Stephens Creek.

Parent Material (geology): The map unit has been influenced by a variety of depositional events. See descriptions for map units FMC and SFL, which are adjacent to Field Q.

Soil Description and Distribution: Soils are variable, but probably have been either plowed or compacted.

Map Unit FMC

Topography: Landforms are alluvial fans with broad, convex slopes. They are located on valley sides and bottoms. Slopes range from 8% to 20%. Drainage patterns are weakly radial to dendritic.
Parent Material (geology): The alluvial fan deposits are derived from local sandstone and rhyolitic bedrock. There are occasional glacial erratics within the soil.

Soil Description: Angular and subangular gravels and cobbles, with some subrounded stones make up from 2% to 40% of the soil surface. Soils are well drained, with medium to coarse textures and dark colored surface layers. Surface textures are mainly sandy loams with some loamy sands. Surface soil reaction (pH) varies between 7.3 and 8.1. Calcium carbonate may occur in the subsoil at depths greater than 10 centimeters. Salt and or/ sodium may occur in the soil profile. The soils have moderate fertility. Rock fragments are generally angular and subangular gravels and cobbles. The amount of rock fragments within the profile varies widely (5%-50%), but become more abundant with increasing depth. Pedon 106 is typical of the soils in this map unit (see Appendix D).

Soil Distribution: Surface rock fragment percentage increases toward the head of slopes and within fan channels.

Map Unit SFL

Topography: The landform is a broad, gently sloping floodplain from a stream. The slopes range from 0% to 2%. The drainage patterns are weakly parallel or braided.

Parent Material (geology): The material is primarily flood plain deposits from streams. This material was deposited on top of or against glacial flood deposits. The boundary area of the unit is a mixture of both types of deposit.

Soil Description and Distribution: Surface rock fragments only occur where the unit grades into glacial flood deposits (FLD) or stream deposits (SCH). In those areas, gravels and cobbles occupy up to 35% of the soil surface. The soils are well drained. Surface soils are coarse textured and dark colored. The surface soil texture is very fine sandy loam. The gradational areas referred to above have coarse sandy loam textures. Soil fertility is moderate. No pedon is given for this map unit.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.

Field R

3/9/05

Size: 96.49 acres

Vegetation:

There is no known information about the original vegetation pre Euro-American influence. Most of this old field is now within the corral system associated with the bison capture facility. Currently, the field is dominated by desert alyssum (*Alyssum desertorum*), which is forming a mono-culture stand in extensive areas of the field. There are also a few remnant patches of crested wheatgrass (*Agropyron cristatum*). Also scattered among the alyssum are fanweed (*Thlaspi arvense*), summer cypress (*Bassia sieversiana* syn. = *Kochia scoparia*), Russian thistle (*Salsola tragus* syn. = *S. kali*, *S. pestifer*), flixweed (*Descurainia sophia*), and lambsquarters (*Chenopodium* spp.).

The rocky areas within the corral harbor a few individuals of native species such as plains prickly pear (*Opuntia polyacantha*), Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*), winterfat (*Krascheninnikovia lanata* syn. = *Eurotia lanata*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and fringed sage (*Artemisia frigida*). Outside of the bison corral there are a few rubber rabbitbrush (*Ericameria nauseosa* syn. = *Chrysothamnus nauseosus*) near an old ditch and the Stephens Creek road along with a few scattered Sandberg's bluegrass (*Poa secunda var. secunda* syn. = *Poa sandbergii*). The only discernible pattern is the presence of a limited number of native species in rocky areas.

Field R

Soils/Geology

Soils Map Unit D10 (from Shovic et al 1991):

Topography: The area is gently sloping and contains abandoned irrigated fields and the settlement of Stephens Creek.

Parent Material (geology): The map unit has been influenced by a variety of depositional events.

Soil Description and Distribution: Soils are variable, but probably have been either plowed or compacted.

Map Unit SFL

Topography: The landform is a broad, gently sloping floodplain from a stream. The slopes range from 0% to 2%. The drainage patterns are weakly parallel or braided.

Parent Material (geology): The material is primarily flood plain deposits from streams. This material was deposited on top of or against glacial flood deposits. The boundary area of the unit is a mixture of both types of deposit.

Soil Description and Distribution: Surface rock fragments only occur where the unit grades into glacial flood deposits (FLD) or stream deposits (SCH). In those areas, gravels and cobbles occupy up to 35% of the soil surface. The soils are well drained. Surface soils are coarse textured and dark colored. The surface soil texture is very fine sandy loam. The gradational areas referred to above have coarse sandy loam textures. Soil fertility is moderate. No pedon is given for this map unit.

Please refer to the soil description taken from Soils of Yellowstone National Park in the Geology/Soil section for a more detailed description of the map unit 1721F or the unit Field A was mapped as.