Part I: Conservation Assessment

PART I. CONSERVATION ASSESSMENT

A. DESCRIPTION OF NORTHWEST COLORADO GREATER SAGE-GROUSE TAXONOMY AND LIFE HISTORY, AND MORTALITY FACTORS

Area Description

Moffat County is located in the extreme northwest corner of Colorado (Figure 1) and is bordered by Routt County on the east, Rio Blanco County to the south, Utah on the west and Wyoming to the north. This Conservation Plan addresses a contiguous greater sage-grouse population centered in Moffat County with outlying areas extending into western Routt County and northwestern Rio Blanco County (Figure 2). Moffat County supports the vast majority of breeding greater sage-grouse in the Northwest Colorado population. Routt County also supports several significant concentrations of birds, while habitat in Rio Blanco County is used only incidentally by small numbers of sage grouse or during winter months. This greater sage-grouse population is the largest in the state of Colorado. The boundary for this Conservation Plan was drawn along topographic divides and other natural features to the extent possible to provide clear boundaries and to separate greater sage-grouse populations covered by this Plan from adjacent planning areas. The area covered by this Conservation Plan includes 4,275,964 acres of land and 2,563,033 acres of occupied sage grouse habitat. Table 1 identifies the amount of area and sage grouse habitat by county. Greater sage-grouse populations in southern Routt County and the Meeker and Piceance Creek portions of Rio Blanco County are not covered by this Plan.

Table 1. Northwest Colorado greater sage-grouse habitat by county

	Moffat Cty	Routt Cty	Rio Blanco Cty	Total
Acres in County	3,042,348	1,516,623	2,063,727	6,622,698
County Acres in Plan Area	2,997,451	628,567	649,946	4,275,964
% of County in Plan Area	98.5%	41.4%	31.5%	N/A
% of Plan Area in County	70.1%	14.7%	15.2%	100.0%
Acres of Occupied SG Habitat in County	2,286,225	176,849	99,959	2,563,033
% of County in Occupied SG Habitat	75.1%	11.7%	4.8%	N/A
% of Occupied SG Habitat in County	89.2%	6.9%	3.9%	100.0%

Figure 1. Location Map—Northwest Colorado greater sage-grouse population

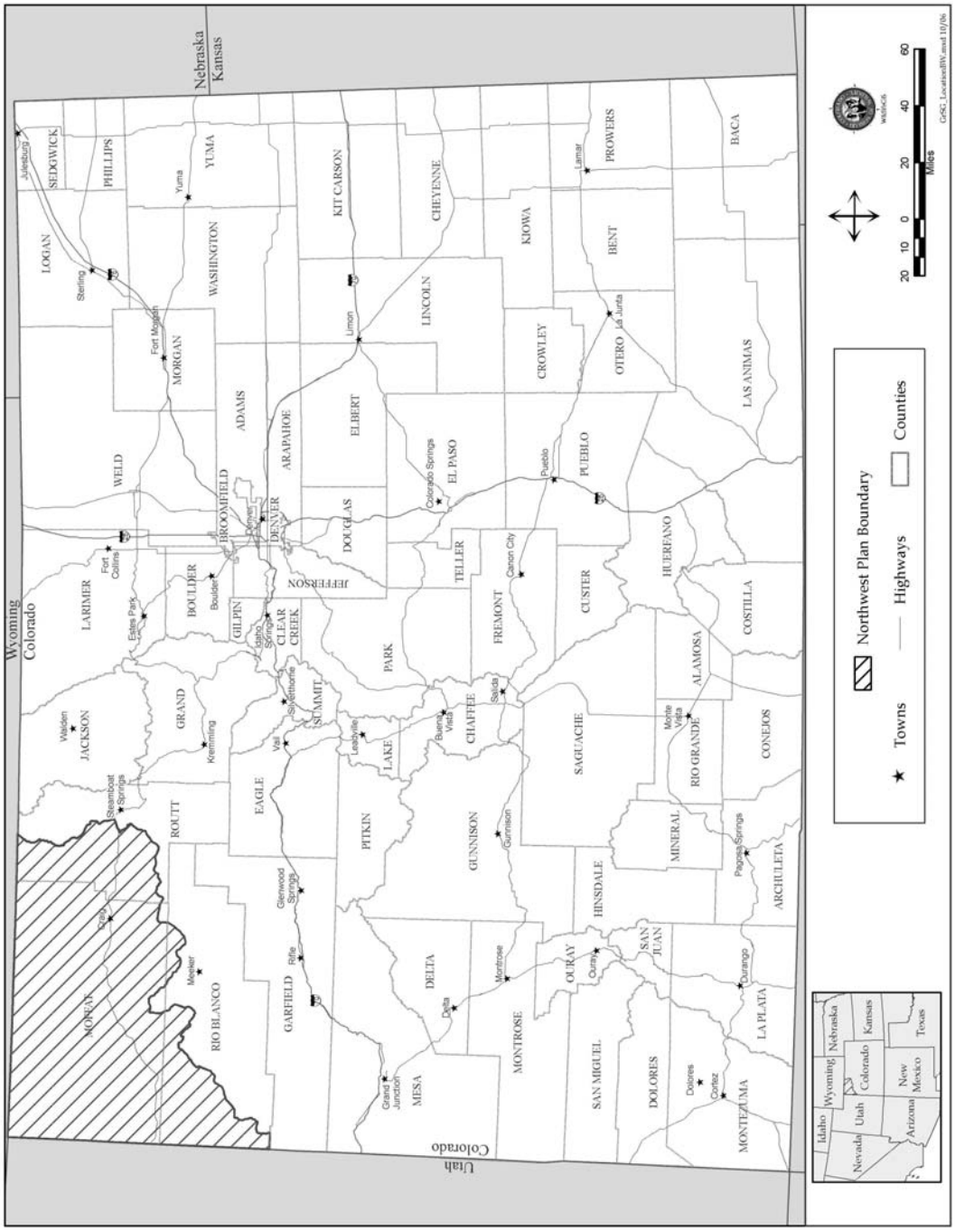
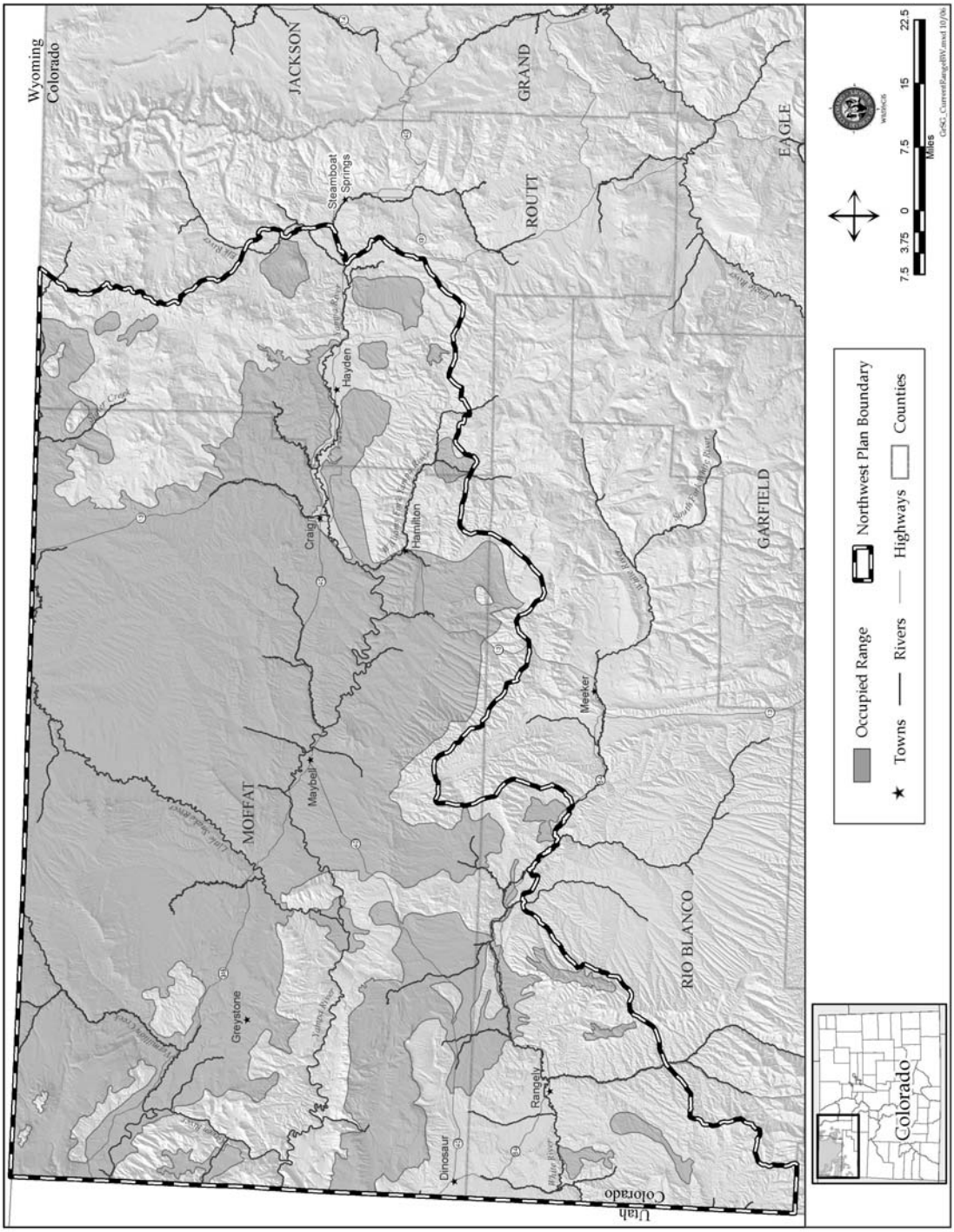


Figure 2. Distribution of the Northwest Colorado greater sage-grouse population across Moffat, Routt, and Rio Blanco counties



Land ownership in the Plan area is mixed, with BLM owning a substantial majority of lower elevation lands in the western portion of the area. Private ownership increases to the east and often includes the highest quality sage grouse habitats in the area. Several substantial state land parcels support greater sage-grouse. The Routt National Forest, Browns Park National Wildlife Refuge and Dinosaur National Monument are located on the periphery of occupied range and provide only limited habitat. Table 2 describes land ownership within the Plan area by ownership category. Land ownership is presented in map form in Figure 3.

Table 2. Northwest Colorado greater sage-grouse habitat by land ownership

Land Ownership	Acres in Plan Area	% of Plan Area	Acres in Occupied SG Habitat	% of Occupied SG Habitat
Private	1,623,001	37.9%	1,046,144	40.8%
BLM	2,076,885	48.6%	1,277,072	49.8%
National Forest	146,657	3.4%	3,311	0.1%
State Land Board	237,411	5.6%	197,564	7.7%
State Wildlife Area (CDOW)	17,138	0.4%	14,122	0.6%
National Wildlife Refuge (FWS)	12,170	0.3%	11,964	0.5%
National Monument (NPS)	157,249	3.7%	9,869	0.4%
Other or No Data	5,453	0.1%	2,987	0.1%
Total	4,275,964	100.0%	2,563,033	100.0%

The climate of Northwest Colorado is arid to semi-arid in the western half and semi-arid in the foothills and mountains of the eastern half. Annual precipitation ranges from approximately 10-22 inches, though desert areas west of Rangely fall below 8 inches/year and northeastern portions of occupied range in the Plan area exceed 27 inches/year (Figure 4). Depending on locale, precipitation occurs mainly as snow during the winter and early spring. The region's complex topography creates numerous micro-climates with considerable variation in site-specific temperature, precipitation, and surface winds. Topographic influences are generally less significant on plateaus than in the valleys (BLM 1986).

Figure 3. Northwest Colorado land ownership map

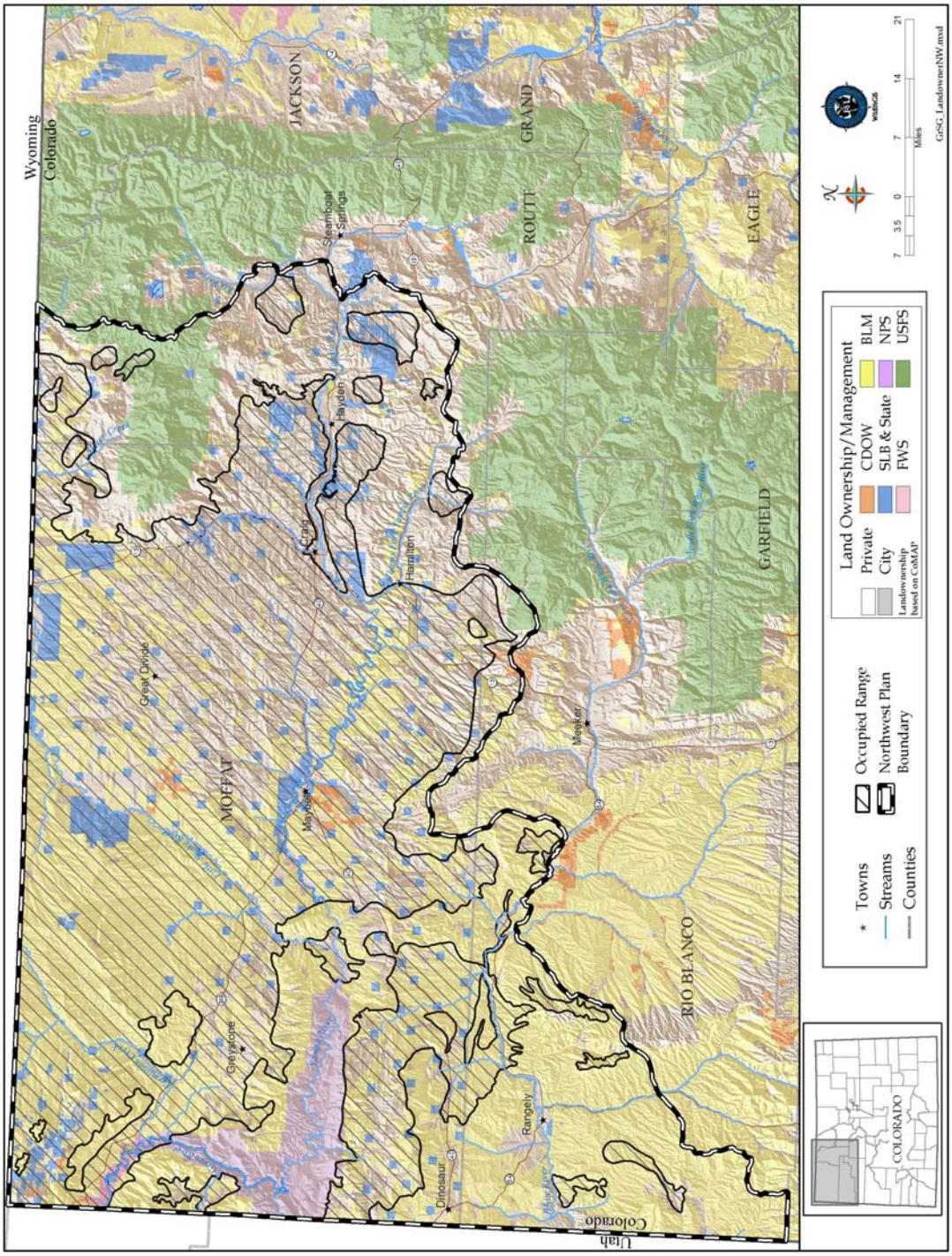
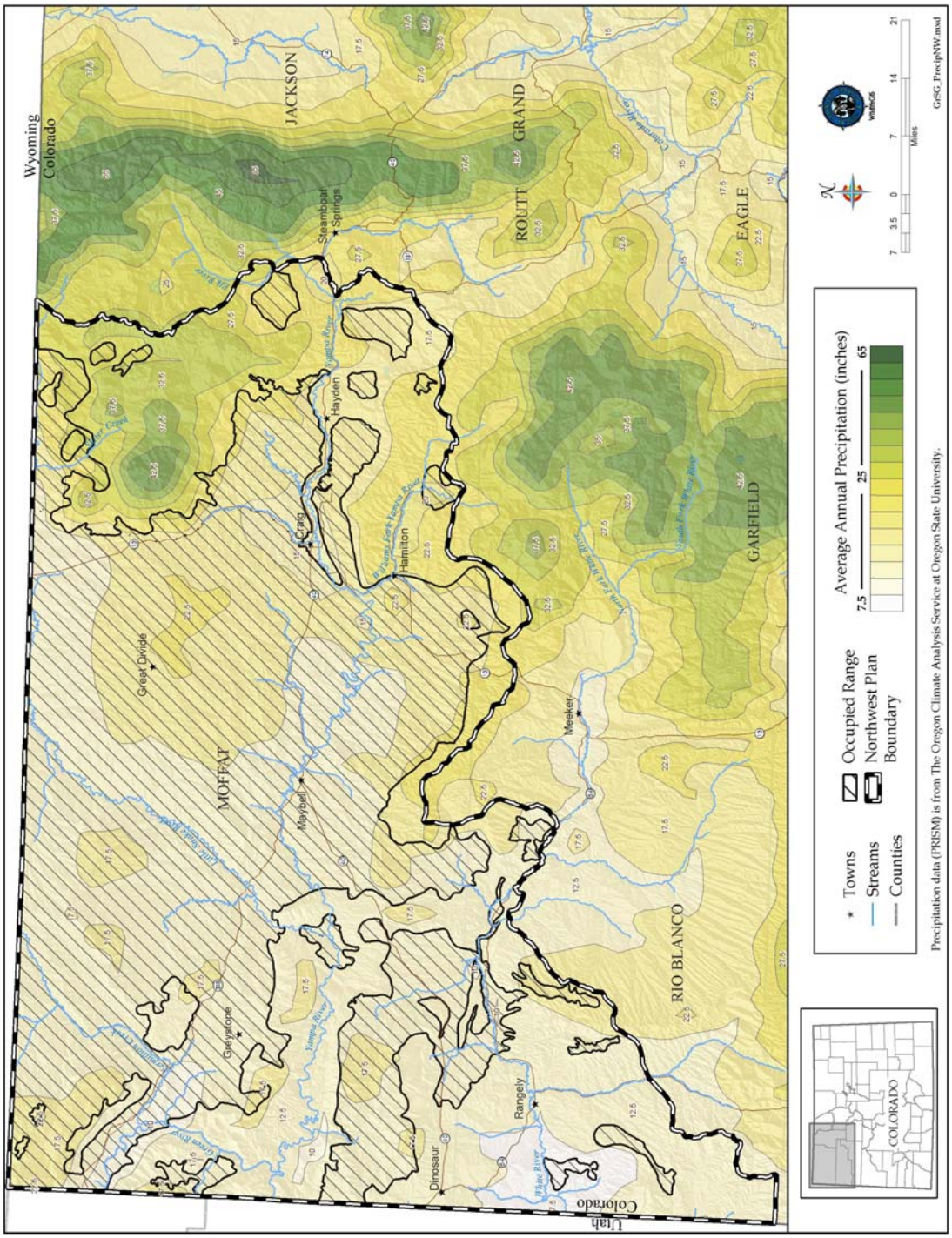


Figure 4. Precipitation map of Northwest Colorado



Vegetation
Vegetation within Northwest Colorado varies greatly, depending on soils, climate, aspect, elevation, and topography. Precipitation, elevation, and soils are the natural factors most responsible for distribution of vegetation. Table 3 reports the acreage of major vegetation types in Northwest Colorado. The distribution of these vegetation types is displayed in Figure 5.

In general, plant associations that include sagebrush as part of the natural plant community can be characterized by a mixture of shrubs dominated by big sagebrush, with a variable understory of perennial grasses and herbaceous broad-leaved species (forbs). According to ecological site descriptions used by the Natural Resource Conservation Service (NRCS) and the Bureau of Land Management (BLM), big sagebrush should generally make up 15-30 % (by weight) of the potential natural communities. The balance of these plant communities should consist of grasses with a relatively smaller forb component. The presence and variety of annual plants fluctuates from year to year depending primarily on precipitation and past grazing history. In some areas of Northwest Colorado, the dominance of sagebrush is causing depression of herbaceous plant production.

Sagebrush communities often intergrade with juniper woodlands. In some areas, juniper is invading sagebrush communities. Sagebrush communities also intergrade with mountain shrub communities at higher elevations and with salt desert shrub and greasewood communities at lower elevations. Shrub layers vary in density and height. Several combinations of plant structure and plant associations within the sagebrush type support a variety of wildlife species. Winward (2004) describes sagebrush species and subspecies found in Colorado. Field evaluations in the summer of 2003 found that most species of sagebrush found in Colorado are located in Northwest Colorado, leading to a high level of sagebrush community diversity and wide variety in these communities from site to site. The sagebrush communities in Northwest Colorado are further complicated by suspected widespread hybridization between subspecies and species of sagebrush over extensive areas. Miller and Eddleman (2000) also describe the inherent variability of sagebrush sites and caution that site specific conditions must be considered when managing sagebrush sites.

Description of Greater Sage-Grouse
The greater sage-grouse (*Centrocercus urophasianus*) is a member of the family Phasianidae (grouse and ptarmigan) and is characterized by long, tapering tail feathers, legs that are covered with soft, down-like feathers extending to the toes, upper parts that are mottled brown, buff, and black, pale flanks, and a black abdominal patch. During the breeding season, males have 2 yellow ocher patches on the lower throat and breast that are inflated. Breeding males display conspicuous neck plumes, long, spiked tail feathers, and inflated air sacs during the courtship display. Males weigh between 3.75 – 6.4 lbs. while females weigh between 2.2 – 3.4 lbs. (Schroeder et al. 1999). Adult and yearling (grouse approximately 10 months old) grouse also have differing weights. In Colorado, adult males weigh between 6.4 – 7.0 lbs. while yearling

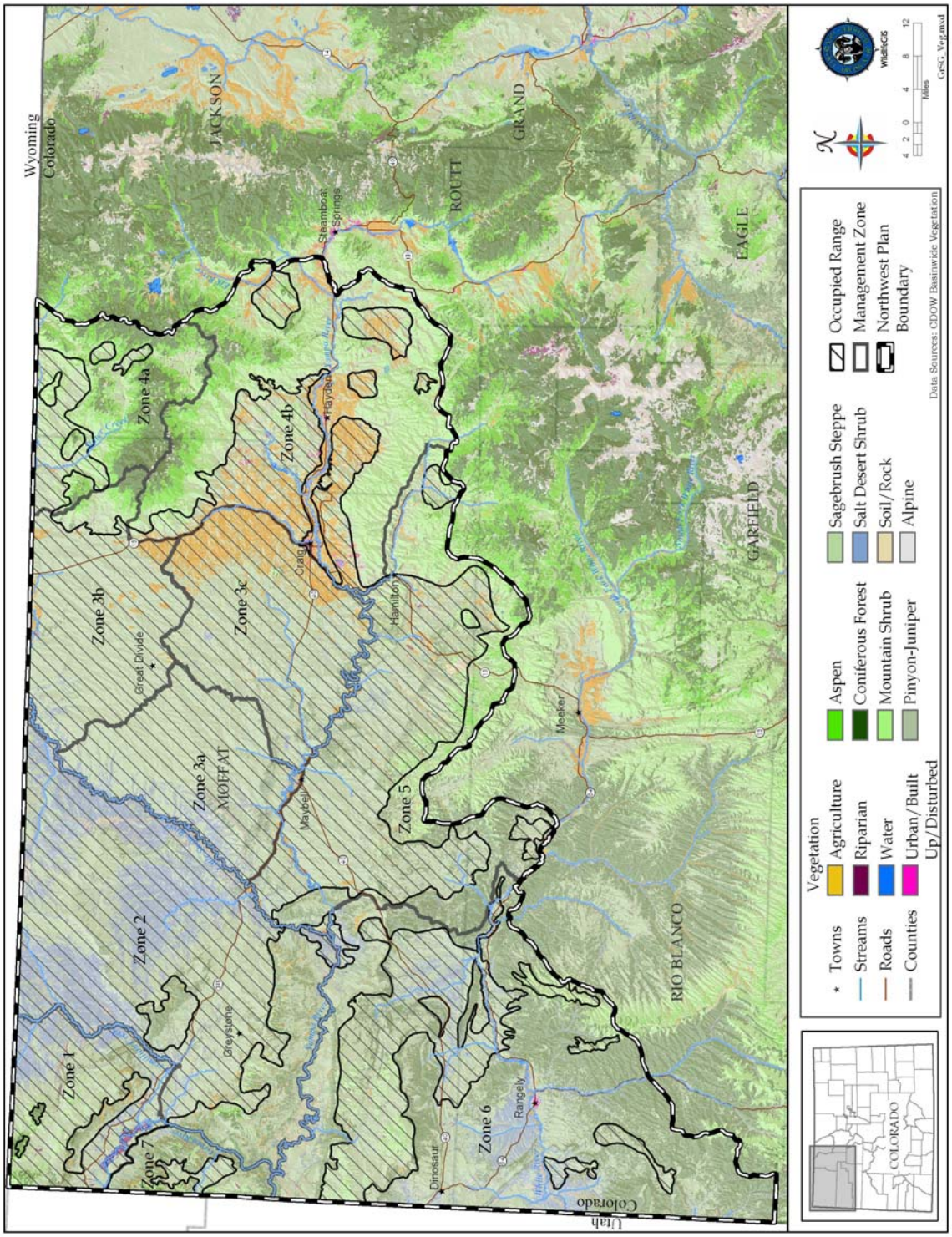
Table 3. Vegetation types in Northwest Colorado

Major Vegetation Type	Original Basinwide Vegetation Class (CDOW Satellite Imagery)	Acres in Plan Area	% of Plan Area	Acres of Occupied Habitat	% of Occupied Habitat
Urban/Built up/Disturbed	Urban/Built Up, Residential, Commercial, Barren Land	5,598	0.2%	2,205	0.1%
Agriculture	Agriculture Land, Dryland Ag, Irrigated Ag, Orchard, Grass/Forb Mix	237,773	5.6%	173,696	6.8%
Sagebrush Steppe	Sagebrush Community, Sagebrush/Grass Mix, Sagebrush/Rabbitbrush Mix, Rangeland, Grass/Forb Rangeland, Snakeweed/Shrub Mix, Grass Dominated, Forb Dominated, Mid Grass Prairie, Shortgrass Prairie, Sand Dune Complex, Foothill and Mountain Grasses, Disturbed Rangeland, Shrub/Brush Rangelands, Snakeweed, Snowberry, Bitterbrush Community, Shrub/Grass/Forb Mix, Rabbitbrush/Grass Mix, Bitterbrush/Grass Mix, Grass/Misc. Cactus Mix, Grass/Yucca Mix	2,043,537	47.8%	1,562,674	61.0%
Salt Desert Shrub	Saltbush Community, Greasewood, Salt Desert Shrub Community, Sagebrush/Greasewood, Winterfat/Grass Mix	466,061	10.9%	357,359	13.9%

Mountain Shrub	Sagebrush/Gamble Oak Mix, Snowberry/Shrub Mix, Sagebrush/Mesic Mountain Shrub Mix, Gambel Oak, Xeric Mountain Shrub, Mesic Mountain Shrub, Serviceberry Shrub Mix, Upland Willow/Shrub Mix, Manzanita	468,164	10.9%	148,230	5.8%
Pinyon-Juniper Woodlands	Pinyon-Juniper, Juniper, PJ-Oak Mix, PJ-Sagebrush Mix, PJ-Mountain Shrub Mix, Sparse PJ/Shrub/Rock Mix, Sparse Juniper/Shrub/Rock Mix, Juniper/Sagebrush Mix, Juniper/Mountain Shrub Mix	640,709	15.0%	204,962	8.0%
Aspen	Aspen, Aspen/Mesic Mountain Shrub Mix	137,407	3.2%	14,135	0.6%
Coniferous Forest	Ponderosa Pine, Engleman Spruce/Fir Mix, Douglas Fir, Lodgepole Pine, Sub-alpine Fir, Spruce/Fir Regeneration, Spruce/Lodgepole Pine Mix, Bristlecone Pine, Ponderosa Pine/Douglas Fir Mix, Limber Pine, Lodgepole/Spruce/Fir Mix, Fir/Lodgepole Pine Mix, Douglas Fir/Engleman Spruce Mix, Mixed Forest Land, Spruce/Fir/Aspen Mix, Ponderosa Pine/Gambel Oak Mix, Ponderosa Pine/ Aspen Mix,	113,186	2.6%	8,207	0.3%

	Douglas Fir/Aspen Mix, Ponderosa Pine/Aspen/Gamble Oak Mix, Lodgepole Pine/Aspen Mix, Spruce/Fir/Lodgepole/Aspen Mix, Ponderosa Pine/Mesic Mountain Shrub, Ponderosa Pine/Aspen/Mesic Mtn Shrub				
Alpine	Alpine Meadow, Alpine Forb Dominated, Alpine Grass Dominated, Alpine Grass/Forb Mix, Sub-alpine Shrub Community, Snow, Sub-alpine Meadow, Sub-alpine Grass/Forb Mix	4,172	0.2%	0	0%
Soil/Rock	Sparse Grass/Blowouts, Rock, Talus Slopes/Rock Outcrops, Soil, Disturbed Soil	81,683	1.9%	49,545	1.9%
Riparian	Riparian, Forested Riparian, Cottonwood, Conifer Riparian, Shrub Riparian, Willow, Exotic Riparian Shrubs, Herbaceous Riparian, Sedge	57,583	1.3%	28,219	1.1%
Water	Water	13,701	0.3%	8,579	0.3%
No Data	No Data	6,389	0.2%	5,223	0.2%

Figure 5. Northwest Colorado vegetation distribution map



males weigh between 5.5 – 6.2 lbs. (Beck and Braun 1978, Hupp and Braun 1991). Females are smaller and adult females weigh 3.5 – 3.7 lbs. while yearlings weigh 2.5 – 3.5 lbs. (Beck and Braun 1980, Hupp and Braun 1991). In Moffat County, in 2001 – 2002, Hausleitner (2003) found that yearling females weighed approximately 2.85 lbs. Adult females weighed between 3.13 – 3.25 lbs. (Hausleitner 2003).

The greater sage-grouse species has been considered to consist of two weakly taxonomically described subspecies. The western subspecies of greater sage-grouse (*C. u. phaios*) has been described in Washington, much of eastern Oregon, and extreme western Idaho (Aldrich 1946, 1963, Aldrich and Duvall 1955, Am. Ornithol. Union 1957). The eastern subspecies of greater sage-grouse (*C. u. urophasianus*) has been described from Oregon, east, north, and south through the remainder of the species range (Aldrich 1946, Aldrich 1963, Aldrich and Duvall 1955, Am. Ornithol. Union 1957). Recent genetic investigations do not support this subspecific delineation (Oyler-McCance et al. 2005).

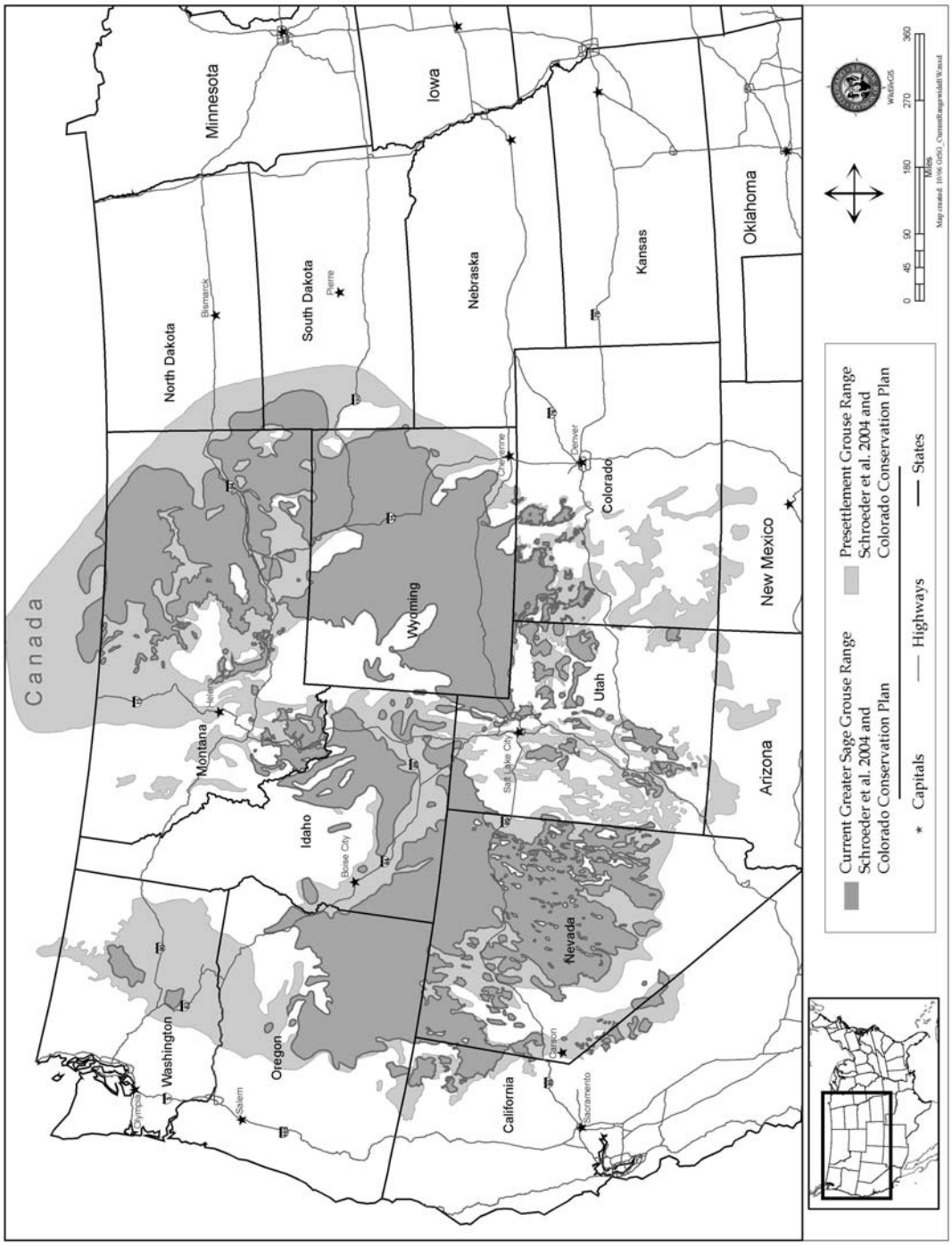
A separate species of sage grouse, the Gunnison sage-grouse, inhabits southwestern Colorado, including most of Gunnison County, and parts of Saguache, Montrose, San Miguel, Mesa, and Dolores Counties of Colorado and extreme southeastern Utah (Young et al. 2000). It is not found in northwestern Colorado.

Range and Distribution

The greater sage-grouse was historically one of the most widely distributed and abundant of the native upland game birds in the western United States (Patterson 1952). Because sagebrush communities furnish most of its needs, the distribution of greater sage-grouse is intimately associated with the distribution and range of sagebrush (Beetle 1960, Patterson 1952, Braun et al 1977, Braun 1995, Schroeder et al. 1999). Greater sage-grouse are currently confined to the Great Basin and Intermountain West regions of the United States and Canada. Historically, greater sage-grouse occurred in 13 states and 3 provinces in western North America, but now inhabit only 11 states and 2 provinces, having been extirpated in British Columbia, Arizona (inconclusive), Nebraska, and New Mexico (Braun 1995). The current range of greater sage-grouse includes the southernmost portions of Alberta and Saskatchewan on the north; western North and South Dakota on the east; California, Nevada, Utah, and western Colorado to the south; and eastern Oregon, Washington, and California to the west (Schroeder et al. 1999). Figure 6 shows historic and current distribution of greater sage-grouse in the western United States.

Greater sage-grouse habitat in Colorado consists of a relatively small appendage to the southern edge of the species' range. In Colorado, greater sage-grouse historically occurred in at least 13 counties (Braun 1995). Currently, greater sage-grouse are found in 9 Colorado counties and are considered secure in 4 counties. Braun (1995) considered populations with greater than 500 breeding greater sage-grouse (total of males and females in the spring) as secure. Braun (1995) concluded that secure populations were found in Jackson, Moffat, Rio Blanco, and Routt counties. Six populations of greater sage-grouse are currently recognized in Colorado:

Figure 6. Historic and current distribution of greater sage-grouse in the western United States



Northwest Colorado, North Park, Middle Park, Parachute-Piceance-Roan, Eagle-South Routt, and Meeker/White River. Figure 7 shows the relative locations of these populations.

Greater sage-grouse in Northwest Colorado are found in nearly all suitable sagebrush and other associated vegetative communities available in the area, and generally range between 5,500 and 8,500 ft in Northwest Colorado, though summer use may occur above 9,000 ft in elevation (Rogers 1964). There has been relatively little range contraction from potential pre-settlement occupancy to current occupancy of greater sage-grouse. Figure 8 compares potential pre-settlement and current distribution of greater sage-grouse in the Northwest Colorado population. With the exception of southwestern Routt County, most of the apparent difference between potential pre-settlement and current occupancy has occurred along the margin of suitable habitat for greater sage-grouse. This pattern may document real range contraction through vegetation succession, habitat fragmentation or loss of habitat or may merely result from different map scales used to construct the two maps. Southwestern Routt County is an exception, as changing land use patterns do appear to have broken suitable habitat for greater sage-grouse into smaller parcels in this area. Similar appearing patches of habitat in western Rio Blanco County represent small sagebrush parks in a broader matrix of pinyon-juniper woodlands and are not evidence of recent range contraction.

Greater sage-grouse range is mapped by the Colorado Division of Wildlife under a series of specific definitions. Occupied habitat includes areas of suitable habitat known to be used by sage grouse within the last 10 years from the date of mapping. Areas of suitable habitat contiguous with areas of known use, which do not have effective barriers to sage grouse movement from known use areas, are mapped as occupied habitat unless specific information exists that documents the lack of sage grouse use. It is mapped from any combination of telemetry locations, sightings of sage grouse or sage grouse sign, local biological expertise, GIS analysis, or other data sources. Vacant or unknown habitat is defined as suitable habitat for sage grouse that is separated (not contiguous) from occupied habitats that has either not been adequately inventoried, or has not had documentation of sage grouse presence in the past 10 years. Potentially suitable habitat represents unoccupied habitats that could be suitable for occupation by sage grouse if practical restoration was applied. Soils or other historic information (photos, maps, reports, etc.) indicate sagebrush communities occupied these areas. As examples, these sites include areas overtaken by pinyon-juniper invasions or converted rangelands. Figure 9 shows the distribution of occupied habitat, vacant/unknown habitat, and potentially suitable habitat for greater sage-grouse in Northwest Colorado. Areas of vacant/unknown and potentially suitable greater sage-grouse habitat are quite small compared to the large adjacent areas of occupied habitat.

The large size, wide distribution, varied potential, and differential land use of the Northwest Colorado greater sage-grouse population make even application of conservation efforts across the entire population difficult. The Northwest Colorado Greater Sage-Grouse Work Group has divided the Northwest Colorado population area into 10 Management Zones (called Zones or Management Zones throughout the Plan) to allow more precise monitoring of populations and

Figure 7. Location map of Colorado greater sage-grouse populations

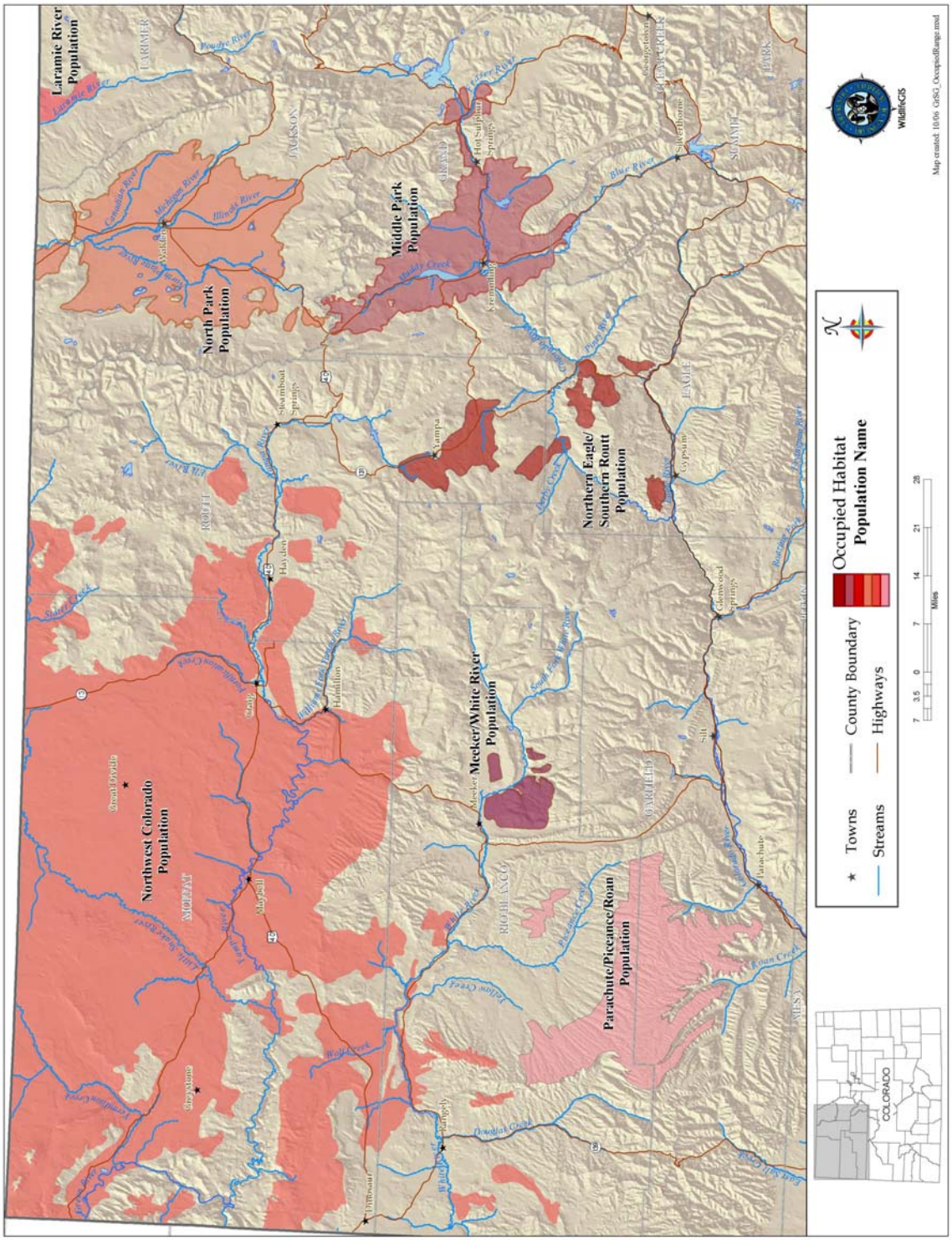


Figure 8. Comparison map of potential pre-settlement and current greater sage-grouse distribution in Northwest Colorado

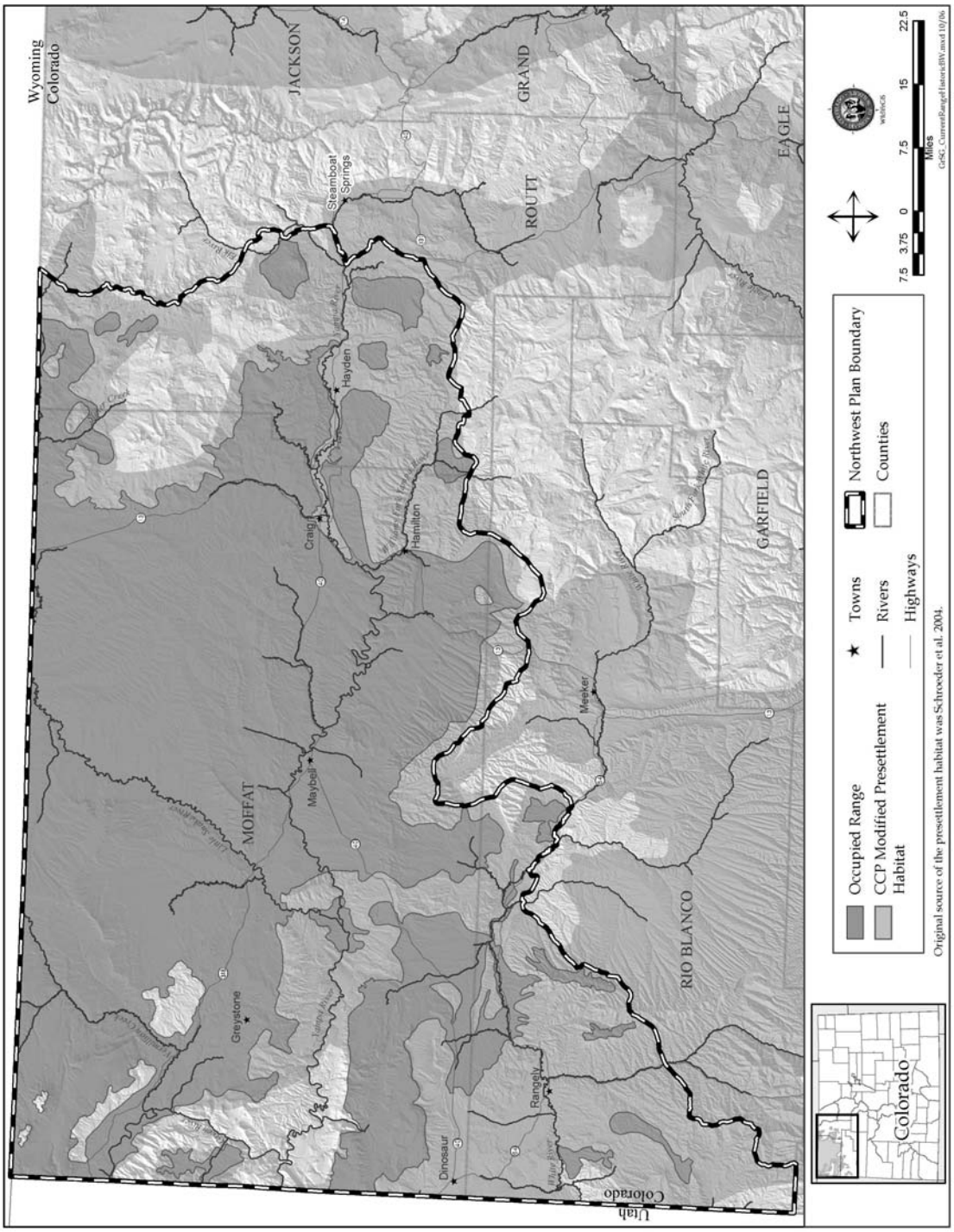
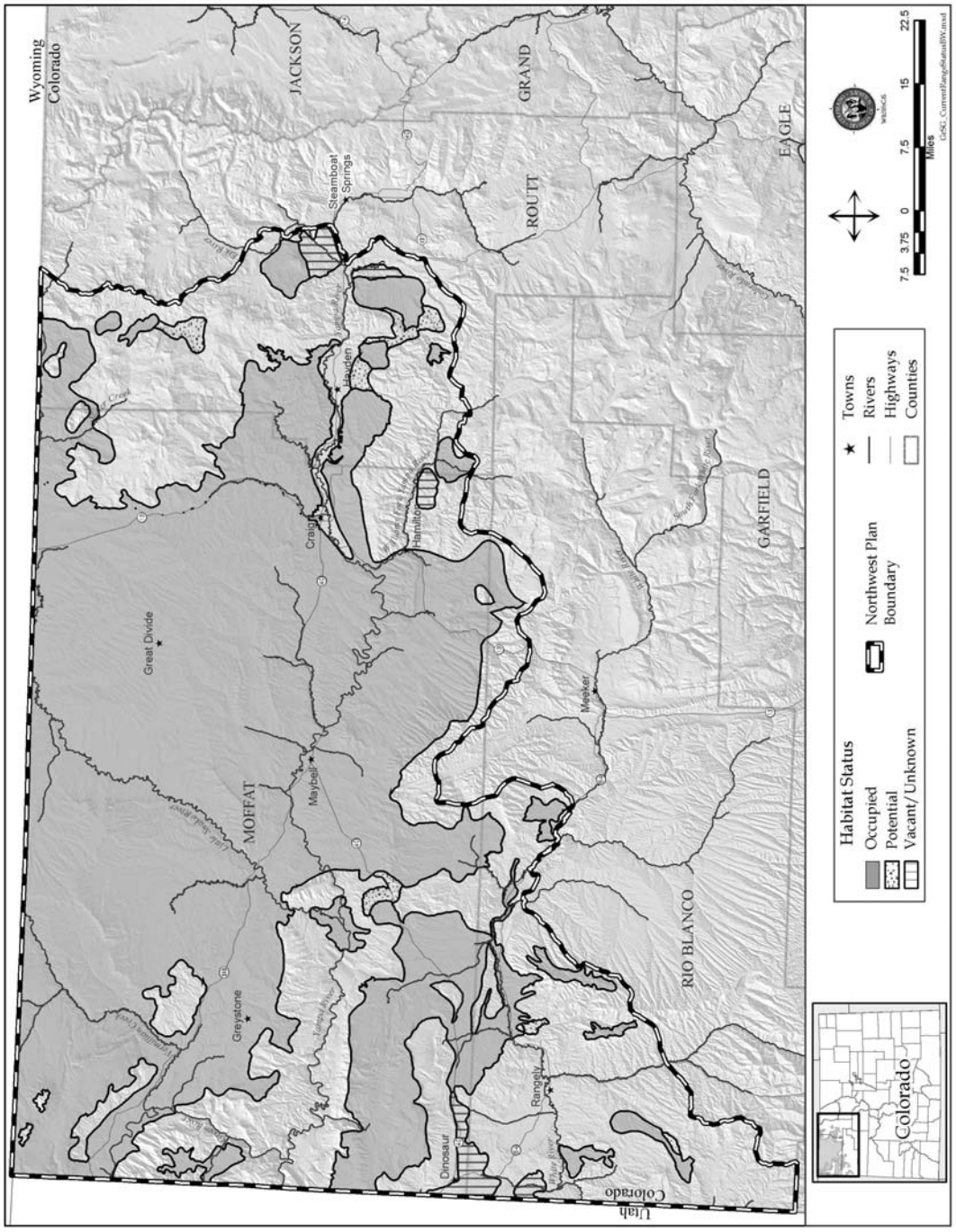


Figure 9. Greater sage-grouse occupied, vacant/unknown, and potentially suitable habitat in Northwest Colorado



habitats and application of conservation efforts. These Management Zones are shown in Figure 10. Management Zones are addressed in detail in **Part IV: Implementation and Monitoring** of this Plan.

Life History and Habitat Requirements

Introduction

Greater sage-grouse utilize extensive landscapes throughout the year and can move great distances or have annual migratory patterns (Beck 1975, Wallestad 1975, Hulet 1983, Berry and Eng 1985, Connelly et al. 1988, Wakkinen 1990, Fischer 1994). The Northwest Colorado greater sage-grouse population occupies approximately 2,563,033 acres of habitat, 60% of the area within this Conservation Plan boundary. Sage grouse are wide ranging because they require a diversity of habitats seasonally (Connelly et al. 2000) and have specialized dietary requirements (see Schroeder et al. 1999 for numerous citations). Greater sage-grouse may use small portions of many different landscape types during different life stages (Connelly et al. 2000), or movements between small seasonal ranges may be extensive.

Habitat requirements may differ by season (Connelly et al. 2000). Connelly et al. (2000) segregated habitat requirements into 4 seasons, breeding habitat, summer-late brood-rearing, fall habitat, and winter habitat. In some situations, fall and summer-late brood-rearing habitats are indistinguishable depending on the population movements and habitat availability. Breeding habitat includes lekking, pre-laying female, nesting and early brood-rearing habitat. Summer-late brood-rearing habitat includes male, unsuccessful female and brood habitat. Fall habitat is essentially "transition" range from late-summer to winter and can include a variety of habitats. These include habitats used by males and females with and without broods. Winter habitat is used by segregated flocks of males and females (Beck 1977). Management of greater sage-grouse habitats should include all habitat types necessary for fulfillment of life history needs.

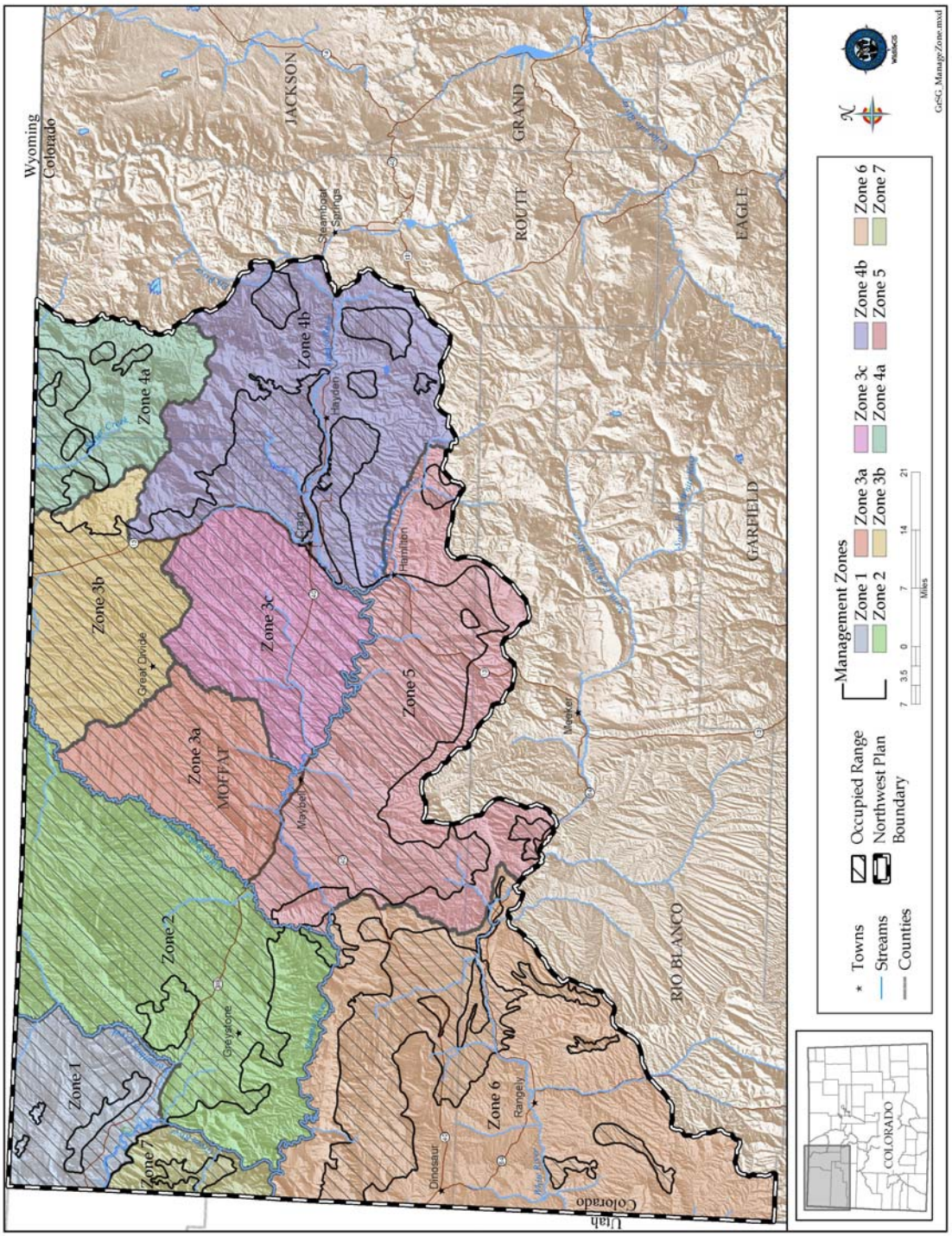
Breeding Habitat

Strutting Grounds

In the spring, greater sage-grouse gather on traditional breeding areas often referred to as "strutting grounds," but more generally called "leks" (Patterson 1952, Gill 1965). In Colorado, this occurs from mid-March through early June depending on elevation (Rogers 1964). Lek sites can be very traditional and sage grouse can display in the very same location from year to year. Some Northwest Colorado leks are known to have been in use since the 1950's (Rogers 1964, CDOW unpublished data). Leks are usually located in small open areas adjacent to stands of sagebrush with canopy cover of 20% or greater (Klott and Linzey 1989). Openings may be natural or human created, including but not limited to small burns, drill pads, and roads (Connelly et al. 1981, Gates 1985).

Males establish territories on leks in early March, but the timing varies annually by 1-2 weeks and depends on weather condition, snow melt and day-length. Males assemble on the leks approximately one hour before dawn, and strut until approximately one hour after sunrise each day for about six weeks (Scott 1942, Lumsden 1968, Wiley 1970, Hartzler 1972, Eng 1963,

Figure 10. Greater sage-grouse Management Zones



Gibson and Bradbury 1985, and Gibson et al. 1991). The greater sage-grouse mating system is polygamous (one male mates with several females). A few males, occupying the most advantageous sites near the center of the lek (Scott 1942, Lumsden 1968, Wiley 1973, Hartzler and Jenni 1988), breed most of the females visiting the lek. Most females arrive on leks after the males each morning and depart while the males are still displaying. When a hen is ready to mate she invites copulation by spreading her wings and crouching on the lek (Scott 1942, Hartzler 1972, Wiley 1978, Boyce 1990).

Superficially, lek sites do not appear limiting (Schroeder et al. 1999) in Northwest Colorado, but solitude, escape cover, and quality sagebrush (Patterson 1952, Gill 1965, Connelly et al. 1988, Connelly et al. 2000) may be limiting in areas. The amount of land needed for males to strut can vary greatly. Sites chosen for display are typically close to sagebrush > 6 inches tall with canopy cover >20% (Wallestad and Schadweiler 1974). Usually leks are located in the vicinity of nesting habitat (Wakkinen et al. 1992) and are in areas intersected by high female traffic (Bradbury and Gibson 1983, Bradbury et al. 1986, Gibson et al. 1990, Gibson 1992, Gibson 1996). These sagebrush areas are used for feeding, roosting, and escape from inclement weather and predators. Lek sites are usually flat to gently sloping areas of <15% slope in broad valleys or on ridges (Hanna 1936, Patterson 1952, Hartzler 1972, Giezentanner and Clark 1974, Wallestad 1975a, Dingman 1980, Autenrieth 1981, Klott and Lindzey 1989). Lek sites have good visibility and low vegetation structure (Tate et al. 1979, Connelly et al. 1981, Gates 1985) for predator detection and acoustical qualities so sounds of breeding displays will carry (Patterson 1952, Hjorth 1970, Hartzler 1972, Wiley 1973b, 1974, Bergerud 1988a, Phillips 1990). The absence of taller shrubs/trees or other obstructions appears to be important for continued use of these sites by displaying male greater sage-grouse. Daytime movements of adult males during the breeding season range between 0.2 and 0.9 mi. from leks, with a maximum cruising radius of 0.9 to 1.2 mi. (Wallestad and Schladweiler 1974). Males are usually found roosting in sagebrush stands with canopy cover of 20-30% (Wallestad and Schladweiler 1974).

CDOW maintains lek count data for the purpose of monitoring greater sage-grouse populations. Lek sites are classified as active, unknown, inactive, or historic. Active leks are display areas that have had 2 or more males counted in 2 or more of the previous 5 years. Unknown leks are "potentially active" leks for which there is insufficient information to accurately categorize the site (insufficient counts, etc.). Additionally, leks with male sage grouse displaying or breeding in the last 5 years but that do not have 2 or more males in 2 or more years in the previous 5 years are considered to have unknown status. Inactive leks are display areas that have not been utilized (no male sage grouse) for display or breeding in the last 5 years. Historic leks are display areas that have not been utilized for display or breeding in the last 10 years. Figure 11 shows the distribution of active, unknown, inactive, and historic lek sites in Northwest Colorado. Leks of unknown status are displayed as active leks. Figure 12 shows active lek distribution weighted by the number of males on each active lek and areas with higher density of strutting males.

Figure 11. Distribution of lek sites in Northwest Colorado

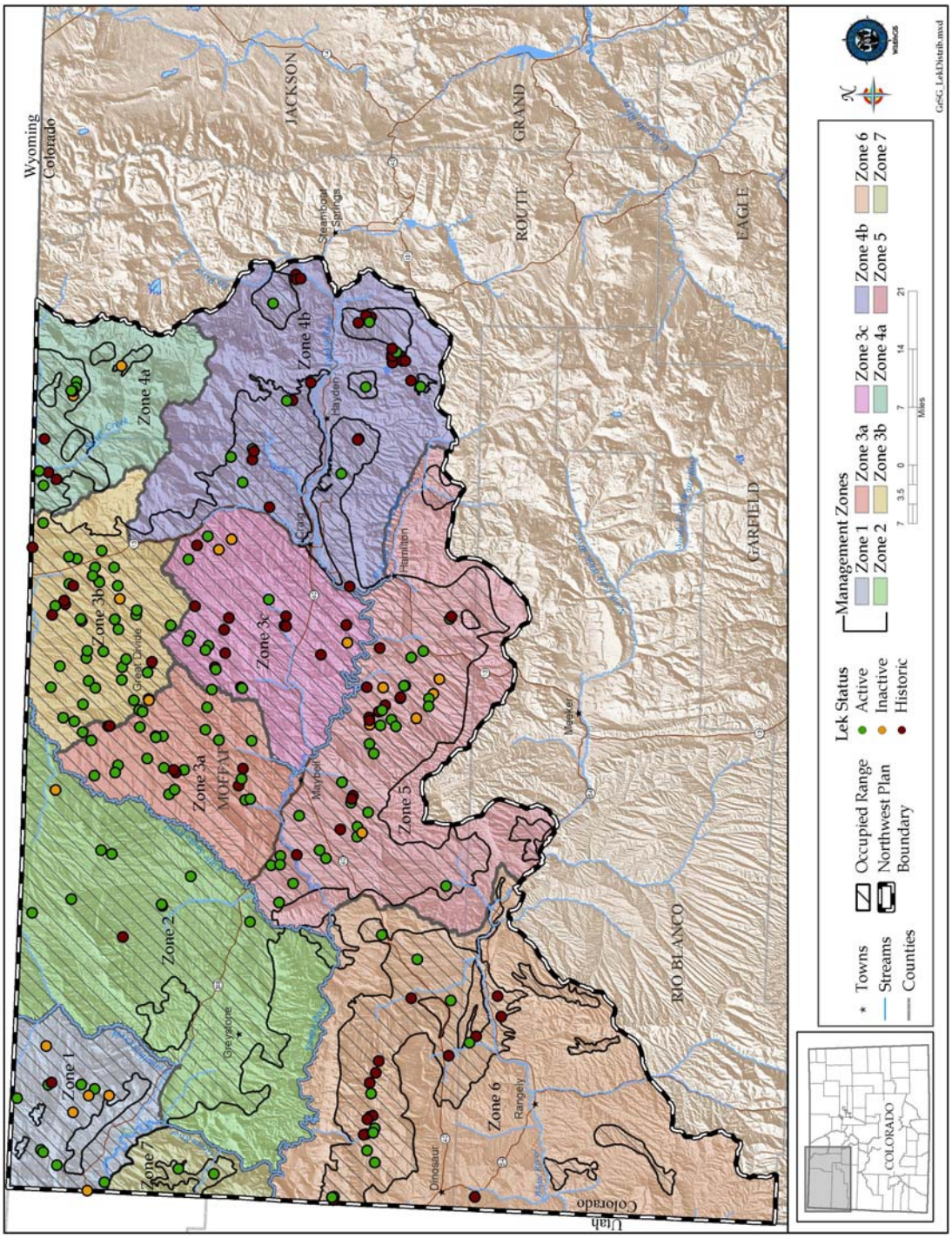
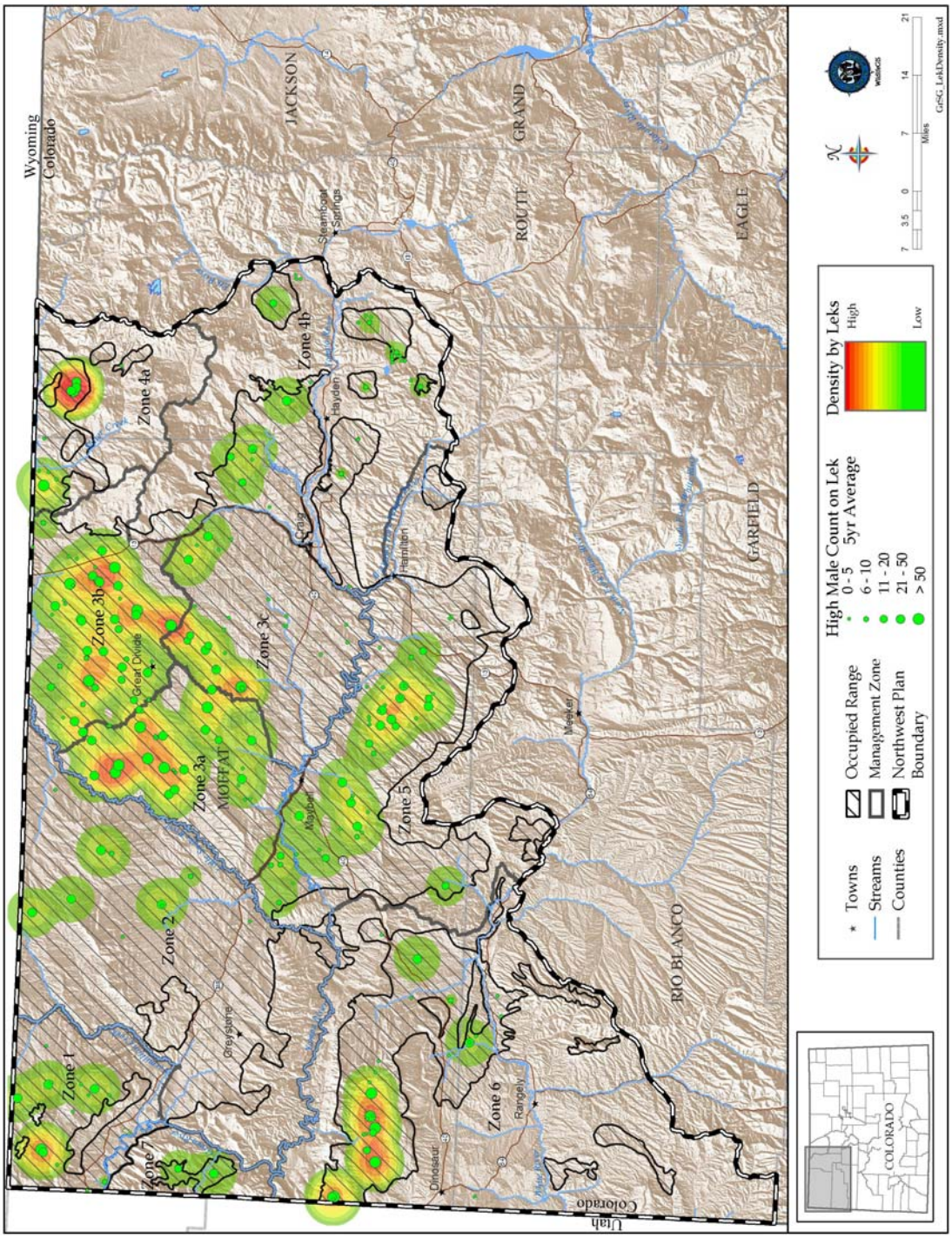


Figure 12. Relative size of active lek sites in Northwest Colorado



Pre-laying Habitat
Connelly et al. (2000) recommends that breeding habitat should include pre-laying habitat. Little is known or understood about pre-laying habitat. It has been suggested that pre-laying habitats should provide a diversity of vegetation to meet the nutritional needs of females during the egg development period. Barnett and Crawford (1994) suggest for pre-laying females in Oregon, that the habitat contain a diversity of forbs that are rich in calcium, phosphorous and protein.

Nesting Habitat
Greater sage-grouse prefer to nest under tall (11 – 31 inches) (Connelly et al. 2000) sagebrush plants. Peterson (1980) found in North Park, Colorado that nest bushes averaged approximately 20 inches high. In Northwest Colorado this value is slightly higher and ranges from 30 – 32 inches (Hausleitner 2003). Often, the actual nest bush is taller than the surrounding sagebrush plants (Keister and Willis 1986, Wakkinen 1990, Apa 1998). In Northwest Colorado, the nest bush was nearly 10 inches taller than surrounding shrubs (Hausleitner 2003). The canopy cover of sagebrush around the nest ranges from 15 - 38% (Patterson 1952, Gill 1965, Gray 1976, Wallestad and Pyrah 1974, Connelly et al. 1991, Keister and Willis 1986, Wakkinen 1990, Apa 1998, Connelly et al. 2000). Measurements in Moffat County are similar and sagebrush canopy cover averages approximately 27% (Hausleitner 2003).

Nests are not uniformly distributed within nesting habitat (Bradbury et al. 1989a, Wakkinen et al. 1992). Initial greater sage-grouse habitat guidelines were built on research that indicated 70-80% of all nests often occur within 2 miles of an active lek (Braun et al. 1977, Bradbury et al. 1989a, Wakkinen et al. 1992). This number may vary depending on whether an active lek or lek of capture measurement is used and by area. From 2001-2002 in Northwest Colorado, 169 female grouse were captured and radio-tagged. Female movements were more extensive than those earlier reported, with 46% ($\underline{n}$ = 78/169) of the radio-tagged females nesting within 1.8 miles of the lek of capture. Seventy six percent ($\underline{n}$ = 128/169) nested within 4 miles and 88% (n = 148/169) nested within 5.8 miles of the lek of capture (Hausleitner 2003, A. D. Apa, unpublished data). Analysis of 6 studies in Colorado, Wyoming and Idaho, including a total of 1,164 nests located with radio telemetry, demonstrates that 79% of nests were located within 4 miles of the female's lek of capture. Only 52% were found within 2 miles of the lek of capture (A.D. Apa, unpublished data). In Northwest Colorado, female grouse have been documented moving as far as 15-20 miles from the lek site of capture (assumed to be the lek upon which they bred). Sites at higher elevations typically have more moisture resulting in more robust grasses and forbs. Sand Wash, Powder Wash, and perhaps Axial Basin, are examples of areas where some nesting does take place on winter and breeding ranges.

Good quality nesting habitat consists of live sagebrush of sufficient canopy cover, with substantial grasses and forbs in the understory (Connelly et al. 2000). Few herbaceous plants are growing in April when nesting begins, so residual herbaceous cover from the previous growing season is important for nest success in most areas (Connelly et al. 2000), although the level of herbaceous cover depends largely on the potential of the sagebrush community (Connelly et al.

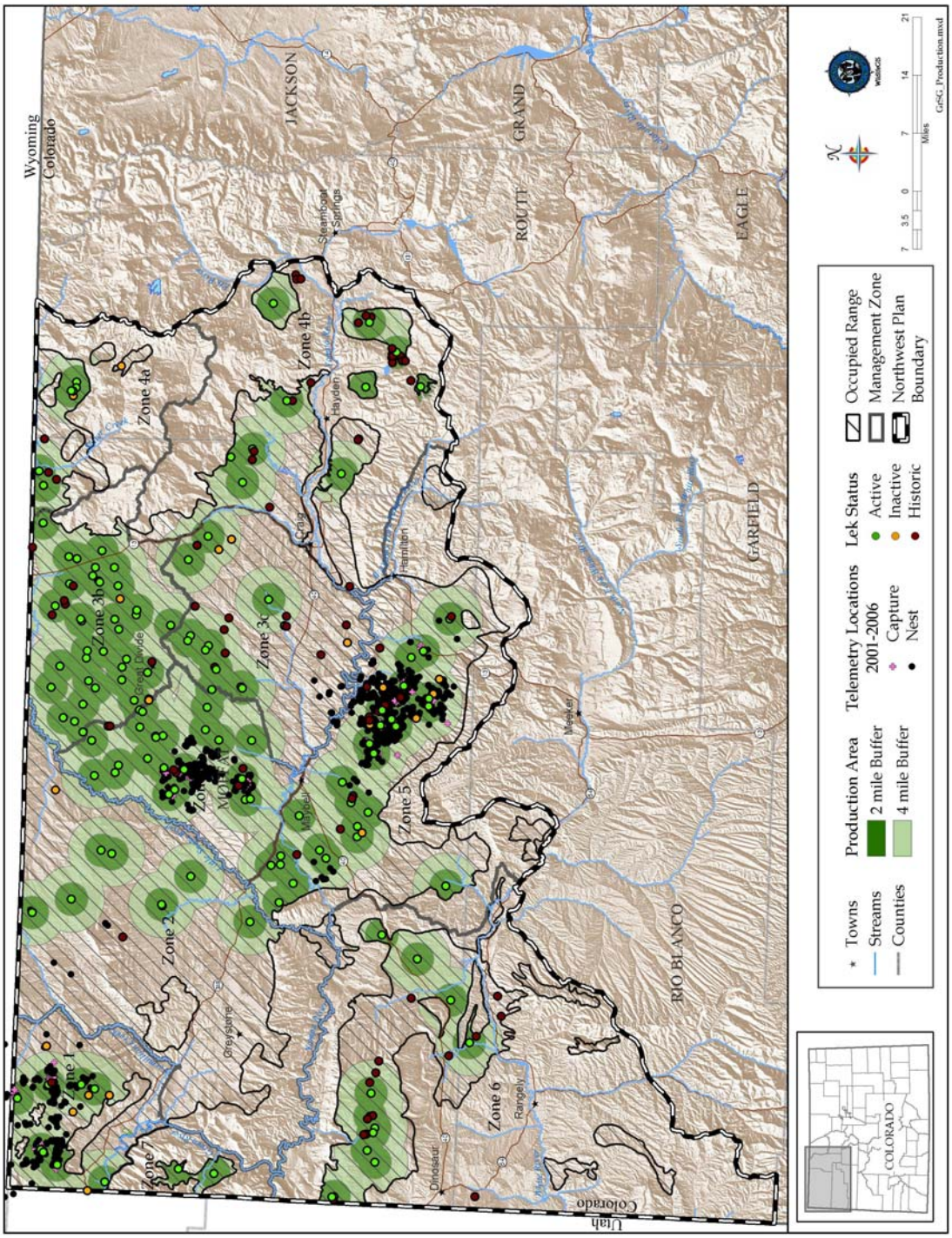
2000). Local woody and herbaceous requirements need to be developed that are reasonable and ecologically defensible (Connelly et al. 2000).

Nearly all nests are located beneath sagebrush plants (Patterson 1952, Gill 1965, Gray 1967, Wallestad and Pyrah 1974) and sage grouse nesting under sagebrush plants have greater nest success than grouse that nest under plants other than sagebrush (Connelly et al. 1991). Sage grouse nests also have an important component of herbaceous vegetation (Connelly et al. 2000). Grass heights are variable. They have been measured across the West and range from 5 – 13 inches in height at nest sites (Connelly et al. 2000). In addition, grass cover measurements are also variable and range from 4 – 51% cover. These measurements are similar to Northwest Colorado data. Hausleitner (2003) reported grass heights at nests ranging from 5-6 inches. Grass cover averaged approximately 4% while forb cover averaged about 7% (Hausleitner 2003).

Clutch size ranges from 6 to 10 eggs with 7 to 9 being the most common (Wallestad and Pyrah 1974, Connelly et al. 1993, Gregg et al. 1994, Schroeder 1997). In Northwest Colorado, clutch size is typical and ranges from 5.7 eggs for yearling females to 7.0 eggs for adult females (overall average was 6.7 eggs) (Hausleitner 2003). Incubation does not start until the last egg is laid and eggs are incubated 27 to 28 days (Patterson 1952). Greater sage-grouse have one of the lowest nest success rates of all the upland game bird species (Schroeder 1997). Reported nest success rates vary from 63% in Montana to 10% in Oregon (Drut 1994, Connelly et al. 2000). In Northwest Colorado, nest success in 2001-02 ranged from 45% - 60% (Hausleitner 2003, A. D. Apa unpublished data). Greater sage-grouse nest abandonment is not uncommon if the hen is disturbed. While re-nesting is infrequent, it does occur (Patterson 1952, Eng 1963, Hulet 1983, Connelly et al. 1991). Clutch size of re-nesting attempts varies from 4 to 7 eggs (Schroeder 1997). Hatching begins around mid-May and usually ends by July. Most eggs hatch in June, with a peak between June 10 and June 20. In Northwest Colorado, the mean clutch initiation date was April 26 in 2001 and April 21 in 2002 (Hausleitner 2003).

CDOW maps nesting (production) areas, which are defined as areas that include the majority, approximately 80%, of important greater sage-grouse nesting habitat. Production areas are currently mapped as radii around active and unknown status lek sites. CDOW has traditionally assumed that 80% of nests were located within 2 miles of leks, but currently considers 80% of nests to be located within 4 miles of leks based on the nest distribution information referred to above (A.D. Apa unpublished data). Nesting habitat within 2 miles of active leks includes 715,889 acres, 30% of occupied habitat. Nesting habitat within 4 miles of leks includes 2,292,709 acres, 89% of occupied habitat. Nesting habitats are mapped in Figure 13, showing both 2-mile and 4-mile radii from leks of active or unknown status. Nesting season radio-telemetry points collected from 2001 into 2006 are also portrayed in Figure 13 (A.D. Apa unpublished data).

Figure 13. Greater sage-grouse nesting (production) areas in Northwest Colorado



Early Brood-rearing Habitat

Early brood-rearing habitat is generally found relatively close to nest sites (Connelly et al. 2000), but individual females with broods may move large distances (Connelly 1982, Gates 1983). Early brood-rearing habitat is typically characterized by sagebrush stands with 10-15% canopy cover of sagebrush (Martin 1970, Wallestad 1971) with herbaceous understories that exceed 15% cover (Sveum et al. 1998a, Lyon 2000). In Northwest Colorado, sagebrush stands average about 11% canopy cover with herbaceous understories averaging about 14% (Hausleitner 2003). High plant species diversity is also a typical characteristic (Dunn and Braun 1987, Klott and Lindzey 1990, Drut et al. 1994a, Apa 1998). Sagebrush heights ranged from 6 to 18 inches in Montana (Sveum et al. 1998b, Lyon 2000) and about 23 inches in Northwest Colorado (Hausleitner 2003). Adjacent shrub areas of 20-25% canopy cover are preferred for escape and roosting (Wallestad 1971, Dunn and Braun 1987), but night roosting sites in Northwest Colorado had only 4% sagebrush canopy cover and were only 20 inches tall.

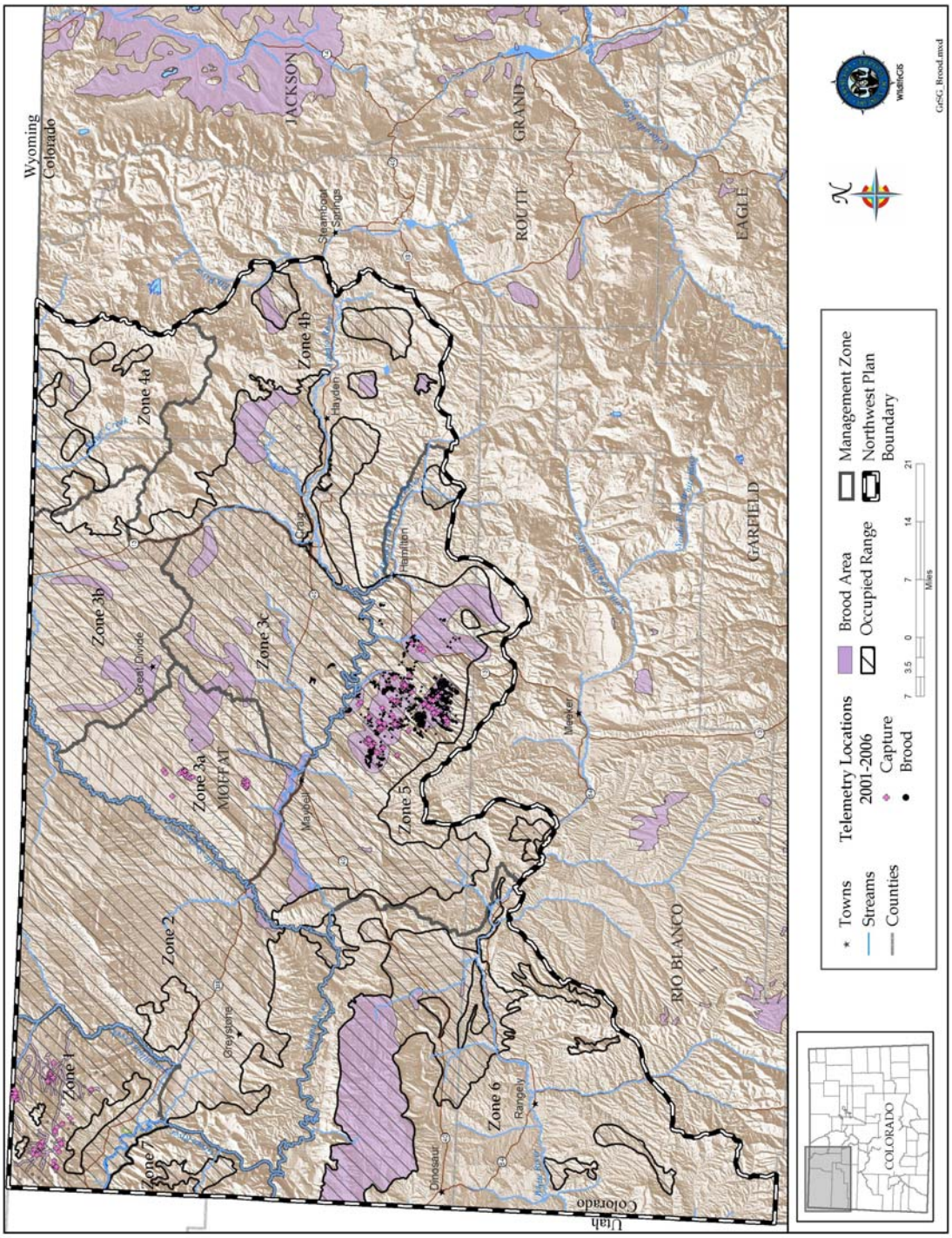
In early summer, the size of the area used appears to depend on the interspersion of sagebrush types that provide an adequate amount of food and cover. Females and broods can select riparian habitats in the sagebrush type that have abundant forbs and moisture (Gill 1965, Klebenow 1969, Savage 1969, Connelly and Markham 1983, Gates 1983, Connelly et al. 1988, Fischer et al. 1996b). Hens with broods remain in sagebrush uplands as long as the vegetation remains succulent, but can move to wet meadows as vegetation desiccates (Fischer 1994). Hens with broods use these areas from mid-May to September. Depending on precipitation and topography, some broods may stay in sagebrush/grass communities all summer while others shift to lower areas (riparian areas, hay meadows, or alfalfa fields) as upland plant communities desiccate (Wallestad 1975).

Summer-Late Brood-rearing Habitat

As sagebrush communities begin to dry out and many forbs complete their life-cycle, grouse typically respond by moving to a variety of more appropriate habitats (Patterson 1952). Grouse can begin movements in late-June and early July (Gill 1965, Klebenow 1969, Savage 1969, Connelly and Markham 1983, Gates 1983, Connelly et al. 1988, Fischer et al. 1996b). By late summer and into the early fall, grouse with broods and unsuccessful hens, and groups of males become more social and flocks are more concentrated (Patterson 1952).

CDOW maintains maps of potential late brood-rearing areas. These maps are developed principally from analysis of vegetative types and greater sage-grouse brood sightings. They focus on sites that are more mesic than average. Data from Northwest Colorado telemetry locations (Hausleitner 2003, A.D. Apa unpublished data) were used to refine this somewhat amorphous seasonal habitat. The brood area map is presented as Figure 14. Mapped brood areas in Northwest Colorado equate to 355,286 acres, 14% of occupied range. Brood season radio-telemetry locations collected from 2001 into 2006 are also shown in Figure 14 (A.D. Apa unpublished data). Identification of brood areas on this map does not signify that broods are only found in these areas or that the areas are used for brood-rearing in all years, but serve to identify some of the more likely late brood-rearing habitats in Northwest Colorado.

Figure 14. Identified greater sage-grouse brood areas in Northwest Colorado



From mid-September into November, greater sage-grouse prefer areas with more dense sagebrush (>15% canopy cover) and late green succulent forbs before moving to early transitional winter range where sexual segregation of flocks becomes notable (Beck 1977, Wallestad 1975, Connelly et al. 1988). In western and north-central Moffat County, drainage areas and adjacent areas of low sagebrush and winterfat continue to be heavily used until major snow events. During periods of heavy snow cover in late fall and early winter, use of mountain and Wyoming big sagebrush stands is extensive.

Winter Habitat

Seasonal movements by greater sage-grouse can be modified by local weather conditions. Greater sage-grouse winter range in Northwest Colorado varies according to snowfall, wind conditions, and suitable habitat (Rogers 1964). Greater sage-grouse may travel short distances or many miles between seasonal ranges. Movements in fall and early winter (September-December) can be extensive with some movements exceeding 20 miles. In North Park, Colorado, Schoenberg (1982) documented female greater sage-grouse moving more than 18 miles from winter to nesting areas. Winter movements and winter range use in Northwest Colorado have not been extensively studied and have been poorly understood until recently. General seasonal movements are being identified by recent and current radio-telemetry in portions of Northwest Colorado. Hausleitner (2003) found that female greater sage-grouse moved an average of 6 miles from nesting areas to winter sites. The range of movements was extensive and some female sage grouse moved from less than ½ mile to over 19 miles from nesting areas to winter habitat. The extent of movement varies with severity of winter weather, topography, and vegetation cover.

Winter habitat use depends upon snow depth and availability of sagebrush, which is used almost exclusively for both food and cover. Although no specific research has been conducted on winter habitat characteristics or food habitats of greater sage-grouse in Northwest Colorado, information collected in other parts of Colorado and throughout their range can be helpful. Sites used are typically characterized by sagebrush canopy cover greater than 25% and sagebrush greater than 12 - 16 inches tall (Shoenberg 1982) associated with drainages, ridges, or southwest aspects with slopes less than 15% (Gill 1965, Wallestad 1975, Beck 1977, Robertson 1991). In Colorado, greater sage-grouse have been documented using as little as 10% of available sagebrush habitat in severe winter conditions (Beck 1977, Hupp and Braun 1989 (for Gunnison sage-grouse)). When snow is more than 12 inches deep and covers over 80% of the winter range, greater sage-grouse have been shown in Idaho to rely on sagebrush greater than 16 inches in height in valleys for foraging (Robertson 1991). Lower flat areas and shorter sagebrush along ridge tops provide roosting areas.

During extreme winter conditions, greater sage-grouse will spend nights and portions of the day (when not foraging) burrowed into “snow roosts”. Sage grouse scratch with their feet or with wing movements when the snow has the proper texture to dig snow roosts.

Flock size in winter is variable (15-100+ birds), with flocks frequently being unisexual (Beck 1977, Hupp 1987). Many, but not all, flocks of greater sage-grouse males over-winter in the vicinity of their strutting grounds and by March are usually within 2-3 miles of breeding areas used the previous year. These movements depend on whether or not the population is non-migratory or 1 or 2-stage migratory (Connelly et al. 2000). A non-migratory population is one where breeding, summer-late brood-rearing, and winter habitats for the population are all within 6.2 miles (10 kilometers) of each other. A 1-stage migratory population occupies either a combined winter/breeding habitat with summer-late brood-rearing habitat located more than 6.2 miles (10 kilometers) away or winter range located more than that distance from combined breeding/summer-late brood-rearing habitat. Two-stage migratory populations occupy separate breeding, summer-late brood-rearing, and winter habitats each located more than 6.2 (10 kilometers) from the others. Hausleitner (2003) found that greater sage-grouse in the Axial Basin and Danforth Hills portions of south-central Moffat County were non-migratory, but data indicated that distances moved from summer-late brood-rearing to winter habitats closely approached the threshold for consideration as a 1-stage migratory population. Seasonal movements of these birds averaged 4.8 miles (7.8 kilometers) from breeding to summer-late brood-rearing habitat and 6.1 miles (9.9 kilometers) from summer-late brood-rearing habitat to winter habitat (Hausleitner 2003). Given the expanse of greater sage-grouse habitat in Northwest Colorado and the wide range of habitat capability within the area, it is highly likely that Northwest Colorado contains sage grouse populations of all three migratory characters.

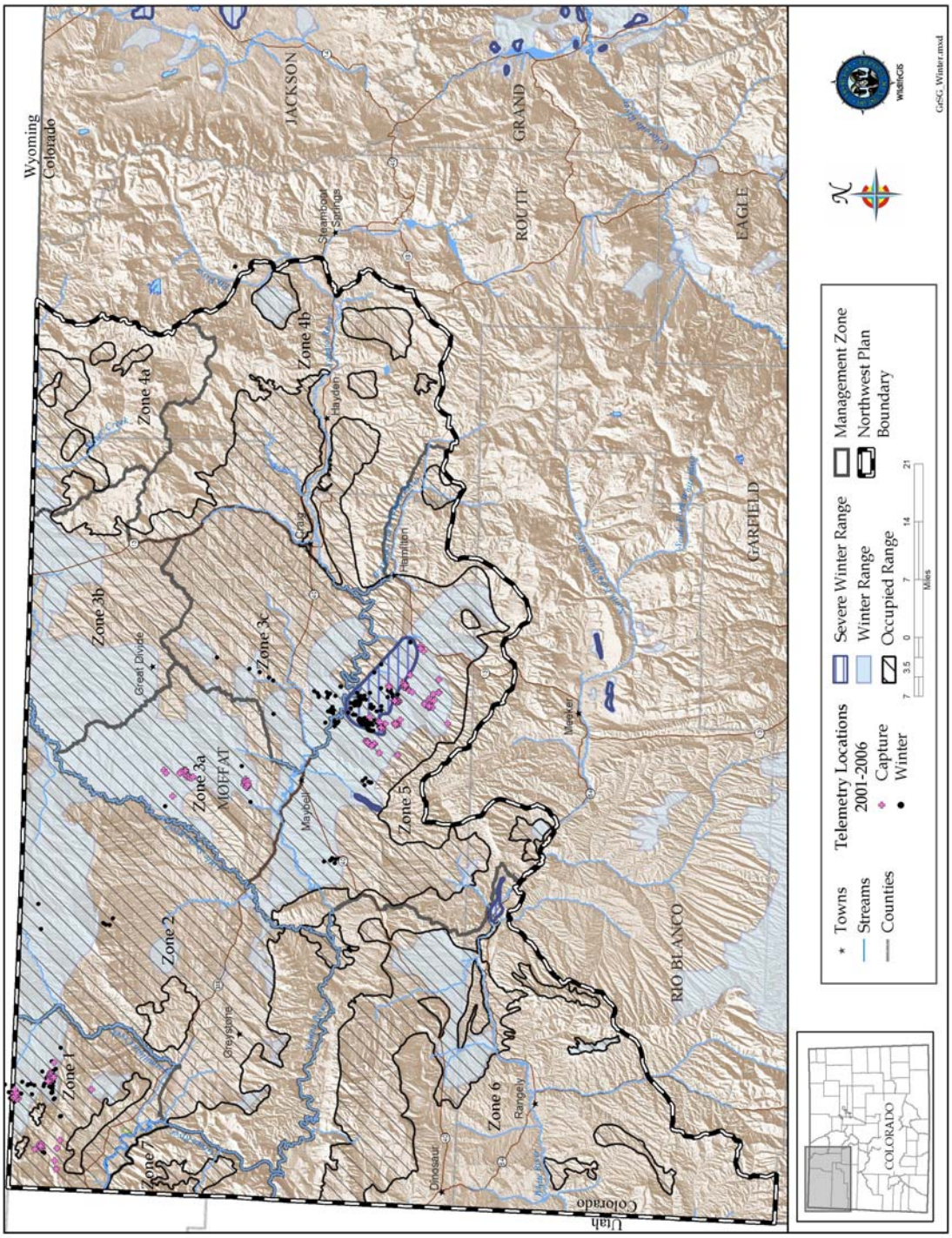
CDOW maintains maps of greater sage-grouse winter range. These maps are developed principally from winter sightings of greater sage-grouse. The map data have benefited from recent Northwest Colorado derived telemetry locations (Hausleitner 2003, A.D. Apa unpublished data) to refine this seasonal habitat. The winter range map is presented as Figure 15. Mapped greater sage-grouse winter range equals 887,625 acres, 35% of occupied range. Figure 15 also includes radio-telemetry locations collected from 2001 into 2006 (A.D. Apa unpublished data). Identification of winter range on this map does not signify that wintering greater sage-grouse are only found in these areas or that all areas are used as winter range in all years, but serve to locate more likely winter habitats in Northwest Colorado. Winter range may be much more widely distributed than currently mapped. Severe winter range (habitat for 90% or more of the birds in the worst two of ten winters) has not been mapped for most of the Northwest Colorado population due to the long interval since the last really hard winter in 1983-84. It has only been mapped in Management Zones 3c, 5 and 6 and totals only 32,593 acres, 1.3% of occupied range for the entire Northwest Colorado greater sage-grouse population.

Food Habits

Breeding Habitats-Yearlings/Adults/Juveniles

The availability of food and cover are key factors related to chick and juvenile survival. During the first 3 weeks after hatching, insects (beetles, ants, grasshoppers) are the primary food of greater sage-grouse chicks (Patterson 1952, Trueblood 1954, Klebenow and Gray 1968, Savage 1968, Peterson 1970, Johnson and Boyce 1990, Johnson and Boyce 1991, Drut et al. 1994b, Pyle

Figure 15. Greater sage-grouse winter range in Northwest Colorado



and Crawford 1996, Fischer et al. 1996a). Diets of 4 to 8 week old chicks were found to have more plant material (approximately 70% of the diet), of which 15% was sagebrush (Peterson 1970). Succulent forbs are predominant in the diet until chicks exceed 3 months of age, at which time sagebrush becomes a major dietary component (Gill 1965, Klebenow 1969, Savage 1969, Connelly and Markham 1983, Gates 1983, Connelly et al. 1988, Fischer et al. 1996a).

Insects are consumed by adult grouse although forbs and sagebrush comprise a majority of adult diet (Rasmussen and Griner 1938, Moos 1941, Knowlton and Thornely 1942, Patterson 1952, Leach and Hensley 1954). Fringed sagebrush is often a transitional food as grouse shift from summer to winter diets. Highly used forbs include common dandelion, prickly lettuce, hawksbeard, salsify, milkvetch, sweet clover, balsamroot, lupine, Rocky Mountain bee plant, alfalfa, and globemallow (Girard 1937, Knowlton and Thornley 1942, Batterson and Morse 1948, Patterson 1952, Trueblood 1954, Leach and Browning 1958, Wallestad et al. 1975, Barnett and Crawford 1994). During the pre-egg laying period, hens select forbs that are generally higher in calcium and crude protein than sagebrush (Barnett and Crawford 1994).

Summer-Late Brood-rearing Habitats-Yearlings/Adults/Juveniles
Unlike many other game birds, greater sage-grouse do not possess a muscular gizzard and therefore lack the ability to grind and digest seeds and only occasionally, by accident, consume grit (Griner 1938). With the exception of some insects in the summer, the year round diet of adult greater sage-grouse consists of leafy vegetation (Wallestad 1975). The amount of forbs in adult greater sage-grouse diets in summer varies with location.

Winter Habitats-Yearlings/Adults/Juveniles
Sagebrush is essential for survival throughout the year, but especially during the winter. Greater sage-grouse begin using sagebrush in the fall after the first killing frost eliminates most forbs. During late-autumn through early spring, the diet of greater sage-grouse is almost exclusively sagebrush (Girard 1937, Rasmussen and Griner 1938, Bean 1941, Batterson and Morse 1948, Patterson 1952, Leach and Hensley 1954, Barber 1968, Wallestad et al. 1975). Many species of sagebrush can be consumed and include big, low, silver, and fringed sage (Remington and Braun 1985, Welch et al. 1988, Welch et al. 1991, Myers 1992). Greater sage-grouse have been shown to select differing subspecies of sagebrush for their higher protein levels and lower concentrations of monoterpenes (Remington and Braun 1985, Myers 1992). In fact, individual grouse have been shown to gain weight over the winter (Beck and Braun 1978, Remington and Braun 1988). In exceptionally harsh winters, fat reserves have been shown to decrease (Hupp and Braun 1989).

Survivorship and Life Span
The survival rate of greater sage-grouse varies by year, sex, and age (Zablan 1993). It is generally believed, and there is reasonable evidence to suggest, that female greater sage-grouse have higher survival rates than males (Swenson 1986). It is believed that this differing survival rate may be due to sexual dimorphism and the cryptic plumage of females and their more

secretive nature versus more elaborate plumage and display activities of males (Schroeder et al. 1999).

Research estimates survival through banding or radio-telemetry studies. The annual survival rate for banded females in Colorado has been estimated at 55%. The survival rate for yearling males was 52% and 38% for adult males (Zablan 1993). Survival rates for radio-marked females and males in Idaho have been estimated at 75% and 60%, respectively (Connelly et al. 1994). Wyoming estimated survival rate of banded females at 67% and 59% for males (June 1963). From April 2001 – 2002, Hausleitner (2003) found that the annual survival rate for adult females was 65% and 71% for yearling females. From April 2002 – 2003, adult survival rate for adult females was 48% (including females from the previous year) and 78% for yearling females (Hausleitner 2003). The survival rate of juveniles (between hatching and fall) is relatively unknown, although information is becoming available due to improved radio-telemetry technology. Survival of juveniles from hatch to fall has been estimated to be 38% in Wyoming (June 1963). An ongoing greater sage-grouse study (to run through 2007) in Northwest Colorado is evaluating juvenile survival in Axial Basin and on Cold Spring Mountain.

Factors Affecting Survivorship and Life Span

Climatic Factors

Northwest Colorado can experience extreme climatic conditions during all seasons. Long periods of below average precipitation, above average summer temperatures, above average snowfall or below average winter temperatures can have adverse effects on greater sage-grouse reproductive success and survival. In fact, prolonged drought during the 1930s and in the later part of the 20th century coincided with declines with grouse populations throughout their range (Patterson 1952, Fischer 1994, Hanf et al. 1994). Extreme climatic conditions that occur during important life cycle sequences have the potential to adversely affect food quality and/or abundance and hiding cover (Hanf et al. 1994, Fischer et al. 1996a).

Greater sage-grouse can be very sensitive to fluctuations in annual moisture (Patterson 1952, Fischer 1994, Hanf et al. 1994). Greater sage-grouse summer diet, particularly that of chicks, is heavily dependent on insects and succulent plant growth (see earlier sections on diet and habitat use). Greater sage-grouse populations decline in years of low precipitation, most likely due to low nest success and/or poor chick survival (Hanf et al. 1994, Fischer et al. 1996a).

Northwest Colorado has experienced severe drought conditions during the early years of the 21st century, beginning in 1999 in the most arid portions of the region. Conditions have been equated to those occurring in the area during the "Dust Bowl" era of the 1930s. Eastern portions of the population area have seen more normal moisture in 2005 and 2006, but western portions of the area continue to experience precipitation well below normal, with the summer of 2006 being among the driest yet. Significant areas of big sagebrush within Northwest Colorado sage grouse habitat have experienced defoliation and perhaps mortality of big sagebrush from 2002 to present, although well timed precipitation in 2005 allowed many areas to show some recovery. The extent and severity of this dieback/dieoff continues to fluctuate and needs to be evaluated.

No significant population response resulting from ongoing drought conditions has yet been detected in Northwest Colorado.

Severe winter conditions can be a prominent factor in reducing grouse survival but there is no conclusive evidence to support this claim (Wallestad 1975, Beck 1977, Robertson 1991). Winter snow accumulations force birds to move to areas blown free of snow or areas with sagebrush which extends above the snow (Eng and Schladweiler 1972, Wallestad 1975, Beck 1977, Hupp and Braun 1989, Robertson 1991). Losses of birds can be significant in especially harsh winters. The winter of 1983-1984 was particularly severe, bringing extreme cold and heavy snow to northwestern Colorado (and many parts of the western United States) for an extended period. It is believed that Northwest Colorado greater sage-grouse populations declined dramatically during this winter. Some believe that populations have never recovered to pre-1984 levels. A far less severe, but still harsh, winter occurred in 1992-93. The population effects of these winters on greater sage-grouse in Northwest Colorado are not well documented.

Poor weather conditions in the spring are also suspected in reducing sage grouse production (Connelly et al. 2000). Good winters followed by relatively wet springs can increase production (Wallestad 1975, Autenrieth 1981) by promoting good insect and forb production. In contrast, severe spring weather (cold temperature combined with rain and wind) that coincides with hatching can decrease production (Wallestad 1975).

Predation (nonhuman)

Documented Predators

Greater sage-grouse occupy an important place in the food chain in sagebrush environments and are preyed upon by a wide variety of terrestrial and avian predators. Numerous predators have been documented preying upon differing ages of sage grouse and/or their nests. Documented nest predators include ground squirrel, weasel, badger, elk, coyote, common raven, American crow, red fox, striped skunk, black-billed magpie and various species of snakes (Batterson and Morse 1948, Patterson 1952, Nelson 1955, Autenrieth 1981, Hanf et al. 1994, Young 1994, DeLong et al. 1995, Sveum 1995). Numerous species have also been documented killing and/or consuming adult sage grouse and include Cooper's, ferruginous, red-tailed and Swainson's hawks, Northern goshawks, coyote, red fox, and bobcat (Girard 1937, Rasmussen and Griner 1938, Batterson and Morse 1948, Nelson 1955, Rogers 1964, Beck 1977, Dunkle 1977, Autenrieth 1981). A number of predator species have been documented killing juvenile greater sage-grouse. Because of the small size of juvenile grouse, additional predators have been documented and include American kestrels, merlin, northern harrier, common raven, and weasel (Girard 1937, Patterson 1952, Nelson 1955, Rogers 1964, Autenrieth 1981). Predators of sage grouse, by life stage, are listed in Table 4.

Predation Defense Mechanisms

Greater sage-grouse have adapted to live, and have evolved, with many of these predators. Sage grouse and other ground nesting birds have developed effective strategies for hiding from ibe

Table 4 . Greater sage-grouse predators by life stage

Documented and Suspected Predators of Greater Sage-Grouse (data adapted from Schroeder and Baydack 2001)		
Nests	**Juveniles**	**Adult Males and Females**
Ground Squirrels	Weasels	Cooper's Hawk
Weasels	Badger	Ferruginous Hawk
Badger	Coyote	Red-tailed Hawk
Elk	Common Raven	Northern Goshawk
Coyote	American Crow	Coyote
Common Raven	Red Fox	Red Fox
American Crow	Striped Skunk	Bobcat
Red Fox	Black-billed Magpie	Badger
Striped Skunk	Snakes	Western Rattlesnake
Black-billed Magpie	American Kestrel	Golden Eagle
Snakes	Merlin	Great Horned Owl
Domestic Dogs and Cats	Northern Harrier	Swainson's Hawk
Raccoon	Eagles	Domestic Dogs
	Other Species of Hawks	Human
	Great Horned Owl	
	Domestic Dogs and Cats	

predators when they occupy habitat of sufficient quality. Schroeder et al. (1999) briefly descrsome of those adaptations. The actual timing of the strutting display and/or the formation of leks may have evolved due to predation selective pressures (Patterson 1952, Hjorth 1970, Hartzler 1972, Wiley 1973b, Wiley 1974, Bergerud 1988, Phillips 1990). Sage grouse also respond to predation by either crouching in dense vegetation or flying away from an attacking predator (Hartzler 1972, Ellis 1984). Greater sage-grouse females have also been documented defending their nests from ground squirrels (Schroeder 1997). Girard (1937) observed females attacking predators in the defense of their brood. In an attempt to lead potential predators away from nests and/or young chicks, females have been documented performing distraction displays. The distraction display includes dragging wings on the ground while moving erratically (Peterson 1980). In addition, a female will occasionally re-nest if her first nest is destroyed by predators early in the incubation period (Patterson 1952, Eng 1963, Hulet 1983, Connelly et al. 1993, Schroeder 1997), although re-nesting rates for sage grouse are relatively low (Connelly et al. 1993).

Predator Impacts to Grouse Life Cycle

Predation is the end result for the vast majority of greater sage-grouse throughout their range, both historically and presently (Bergerud 1988). What is not clearly understood is the difference between predation and scavenging and at what level the predation rate is detrimental to population recovery and/or growth. Schroeder and Baydack (2001:26) suggest that predation has the potential to affect the annual life cycle of sage grouse in 3 primary ways: "1) success of nests, 2) survival of juveniles during the first few weeks after hatch, and 3) annual survival of breeding-age birds." Peterson and Silvy (1996) conclude that the relative importance of predation on the viability of grouse populations is relatively unknown and needs further study.

Nest success varies by year, area, population density, and/or management strategy (Connelly et al. 1998, Schroeder et al. 1999). Connelly et al. (2000) suggested that several studies on nest success have illustrated success >40% and that nest predation does not appear to be a problem across the range of greater sage-grouse. In contrast, Gregg (1991) and Gregg et al. (1994) suggested that nest predation may be limiting sage grouse numbers in Oregon. More specifically, Connelly et al. (2000) suggest that increased fragmentation of habitat, the addition of nonnative predators (red fox, domestic dogs and cats) and the increased abundance of native predators (i.e. common ravens) can result in decreased nest success (Batterson and Morse 1948, Autenrieth 1981).

Red fox have been implicated in reducing nest success and the annual survival of breeding age sage grouse. Researchers in Utah's Strawberry Valley area suggest that the advancing population of red fox, considered a non-native predator by the investigators, is responsible for preying upon a large portion of the population in that area (Flinders 1999). Red fox have been implicated in other areas, but rigorous field studies are needed to support or refute these hypotheses (Connelly et al. 2000).

Predator and Alternative Prey Relationships

The nature of differing predator populations is usually determined by the abundance of their primary prey species, which typically include rodents and lagomorphs instead of grouse (Bump et al. 1947, Angelstam 1986, Marcstrom et al. 1988, Myrberget 1988). Typically, the primary prey species populations fluctuate and the numbers of sage grouse can be influenced by the densities of predators and the changes in predator foraging behaviors (Schroeder and Baydack 2001). Angelstam (1983) suggested that when predators need to search for relatively scarce prey (in the low years), they would more regularly encounter sage grouse and sage grouse nests. GSGWG members believe that lagomorph populations (especially cottontail rabbit and white-tailed jackrabbit) in Northwest Colorado peaked in the early 1990s and remained considerably depressed through the remainder of the 1990s and early 2000s. Both cottontail rabbits and white-tailed jackrabbits are showing significant signs of recovery since 2003.

Hunting Harvest

Rogers (1964) described the early hunting of sage grouse in Colorado. The first regulated hunting season for sage grouse in Colorado was established in 1877 with regular biennial season setting by the Colorado legislature between 1905 and 1937. Hunting seasons during these early years ranged from 15 to 60 days in length and featured daily bag and season possession limits of 25 and 50 respectively. With the establishment of the Colorado Wildlife Commission in 1937, the greater sage-grouse season was closed until 1944 for reasons Rogers does not state. A two-day season was held in 1944 followed by a one-day season in 1945. The greater sage-grouse season was then closed again in 1946 and remained closed until 1953. Greater sage-grouse have been hunted annually in some parts of Colorado since 1953 with variable season dates and bag limits (Rogers 1964). From 1980 to 1994 in north-central Moffat County, greater sage-grouse season lengths varied from 23 to 34 days with bag and possession limits of 3 birds per day and a maximum of 9 in possession (CDOW Small Game Brochures). There was a movement in many western states, including Colorado, from the early 1980s through the mid-1990s to expand sage grouse hunting seasons to provide additional recreational opportunity for hunters (e.g. Harju 1986). Check station data indicated most harvest occurred on the opening weekend with some additional harvest on subsequent weekends, especially those that overlapped another season such as antelope (CDOW unpublished data). Concern that sage grouse numbers were declining caused a reduction in season length and bag limit in Colorado beginning in 1995. Permits were also issued for several years to better estimate hunting pressure on greater sage-grouse. The development of greater sage-grouse hunting seasons in Northwest Colorado from 1970 on is presented in Table 5.

Biologists expanded seasons based on evidence that additional days of season did not necessarily indicate a significant increase in harvest (Hoffman and Braun 1979, Braun 1981) and the belief that sage grouse reproduction was on par with other more resilient upland game birds such as pheasant. Connelly et al. (2000) maintain that most greater sage-grouse populations can sustain controlled hunting seasons, but caution that sage grouse have the lowest reproductive potential of the upland game birds, that small populations (<100 male sage grouse counted during spring lek

Table 5. Greater sage-grouse hunting season structure in Northwest Colorado

Year	Season Dates		No. of Days	Bag Limit	Possession Limit	Notes
	Open	Close				
1970	09/12	09/14	3	2	4	
1971	09/11	09/13	3	2	4	
1972	09/09	09/11	3	2	4	
1973	09/08	09/10	3	2	4	
1974	09/14	09/16	3	2	2	
1975	09/13	09/15	3	2	2	
1976	09/11	09/13	3	2	4	
1977	09/10	09/16	7	3	6	
1978	09/09	09/17	9	3	6	Permit Req.
1979	09/08	09/23	16	3	6	Zone 4 open 9/8-16
1980	09/13	10/07	25	3	6	Permit Req.
1981	Unknown	Unknown	16	3	6	
1982	Unknown	Unknown	16	3	6	Zone 1 7 Day Season
1983	09/10	09/25	16	3	6	
1984	09/08	09/23	16	2	4	Zone 1 Limit 1/2
1985	09/14	09/29	16	3	6	
1986	09/13	10/05	23	3	6	Zone 1 Limit 1/2
1987	09/12	10/04	23	3	6	Zone 1 Limit 1/2
1988	09/10	10/02	23	3	6	Zone 1 Limit 1/2

1989	09/09	10/08	30	3	6	
1990	09/08	10/07	30	3	6	
1991	09/07	10/06	30	3	6	
1992	09/01	10/04	34	3	9	
1993	09/01	10/03	33	3	9	
1994	09/01	10/02	32	3	9	
1995	09/01	09/17	17	1	2	Zones 4,5 Close, Permit Req.
1996	09/01	09/22	22	1	2	
1997	09/13	09/28	16	1	2	
1998	09/12	09/18	7	2	4	HIP Begins
1999	09/11	09/17	7	2	4	First HIP Report
2000	09/09	09/15	7	2	4	Zone 5 reopens, Zones 2, 3c Close
2001	09/08	09/14	7	2	4	
2002	09/14	09/20	7	2	4	
2003	09/13	09/19	7	2	4	
2004	09/11	09/17	7	2	4	
2005	09/10	09/16	7	2	4	
2006	09/09	09/15	7	2	4	

counts) can be at risk of over-hunting, and that harvest rates should not exceed 10% of the fall population. Connelly et al. (2003) found that unhunted populations recovered faster than populations receiving light to moderate hunting pressure. They recommend that sage grouse hunting seasons be conservative and account for population trend and habitat quality (Connelly et al 2003). The GSGWG and CDOW developed a formula for recommending hunting seasons, described in **Part III** of this Plan, that was implemented in 1998 and has been the measure used since for regulating greater sage-grouse season length, timing, and open/closed unit recommendations in Northwest Colorado. Figure 16 shows the Game Management Units that are currently open for greater sage-grouse hunting in Northwest Colorado.

Total harvest of greater sage-grouse in Colorado has been approximately 3,000 to 7,000 birds each year, with the bulk of the harvest occurring in Moffat, Jackson, Gunnison, and Grand counties (Braun et al 1994). Total greater sage-grouse harvest in Moffat County west of Colorado Highway 13 from 1968 to 1977 as measured by questionnaire surveys averaged 4,367 birds/year (Hoffman 1979). Harvest in north-central Moffat County from 1978 to 1995 averaged 394 birds/year (CDOW unpublished data).

Sage grouse hunting pressure and harvest estimates are obtained by two principal methods. The first method is to collect data from hunter questionnaires or telephone surveys. Survey-collected harvest information is generally reported by county rather than population. The CDOW began using an enhanced system (HIP-Hunter Information Program) in 1999 to collect more reliable data. HIP data and older questionnaire data are presented in Table 6.

Harvest is also measured through the collection and analysis of sage grouse wings taken by hunters (Eng 1955, Beck et al. 1975). Sage grouse wings are collected in barrels placed at major road intersections in sage grouse hunting areas (Hoffman and Braun 1975). In Northwest Colorado, wing collection sites are generally located in Moffat County along Highway 13, Highway 40 and Moffat County Road 10N. Additional sites in Routt County were used in past years when Routt County areas were open to greater sage-grouse hunting. Recent wing barrel/collection locations are mapped in Figure 16.

This information is collected and reported on the population or subpopulation level. In Northwest Colorado, wing collection data (and many lek count summaries) were broken into 5 data summary areas, precursors to this Plan's Management Zones. Historic data were summarized by Cold Springs (Zone 1), Blue Mountain (Zone 6), Moffat County South (Zone 5), Moffat County East (Zones 4a and 4b), and Moffat County North Central (Zones 3a, 3b, 3c and parts of Zone 2, though harvest has generally been light from Zone 2). In addition to harvest information, wing data also provide important information on other population parameters, including an estimate of chick production (Eng 1955, Beck et al. 1975). Recent wing data (2002-2005) are reported in Table 7. Appendix B shows some of the additional information estimated from wing barrels.

Figure 16 . Open greater sage-grouse hunting units in Northwest Colorado

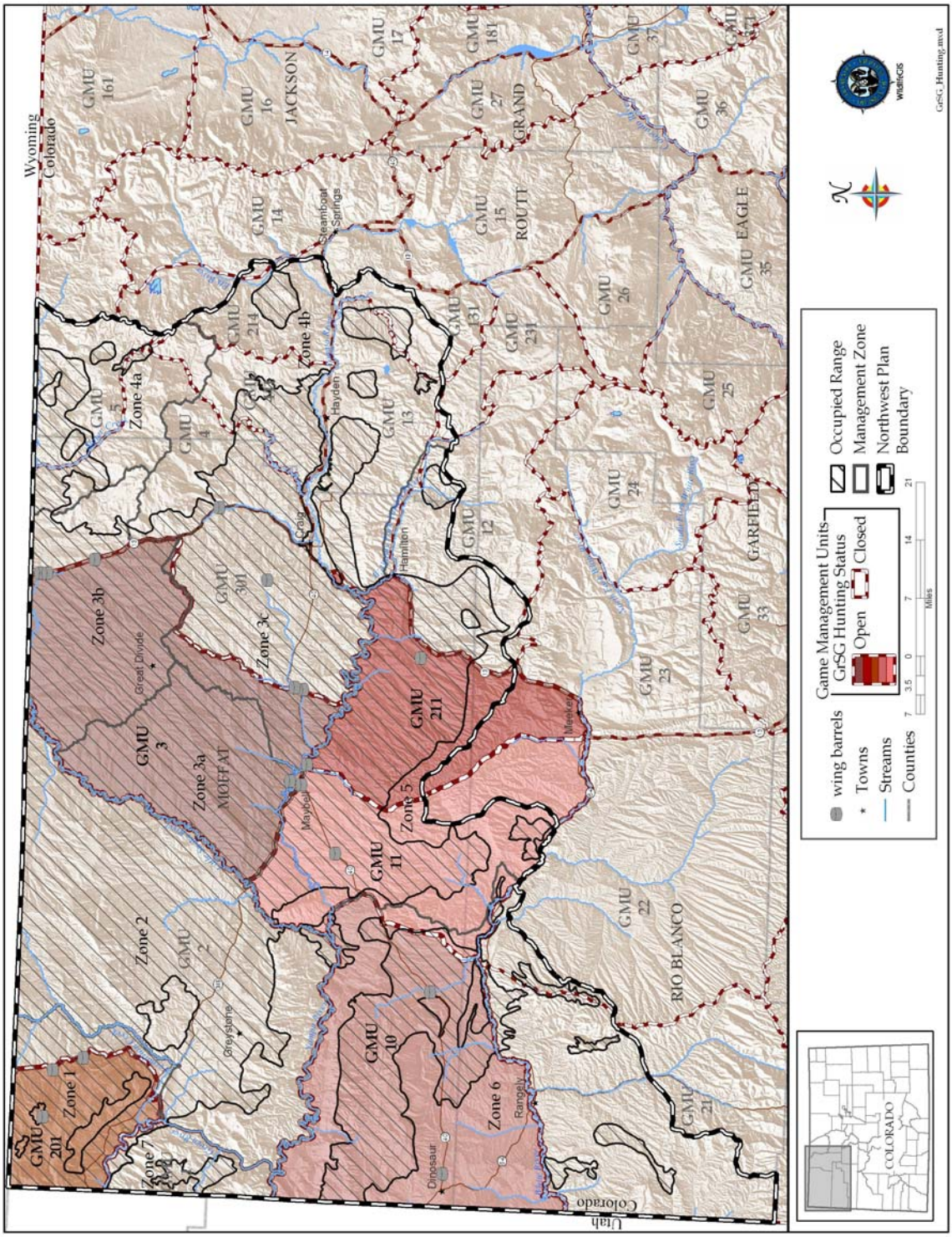


Table 6. Greater sage-grouse harvest estimates for Northwest Colorado—survey data by County

Year	Moffat Harvest Estimate	Routt Harvest Estimate	Rio Blanco Harvest Estimate	NW Colorado Total	Statewide Harvest Estimate	% of Statewide Harvest
1968	2,175	1,493	92	3,760	8,100	46
1969	7,300	2,719	22	10,041	16,617	60
1970	4,939	2,506		7,445	11,876	63
1971	5,050	1,339	13	6,402	10,592	60
1972	7,822	2,339		10,161	15,962	64
1973	2,481	1,387		3,868	7,991	48
1974	3,379	1,678	158	5,215	10,483	50
1975	3,081	1,832	460	5,373	8,444	64
1976	3,569	1,102	336	5,007	8,423	59
1977	2,645	1,974	171	4,790	7,590	63
1978	4,337	1,324	1,456	7,117	10,168	70
1979	6,882	1,433	61	8,376	14,088	59
1980	9,083	1,413	308	10,804	18,709	58
1981	7,624	1,920	1,182	10,726	14,973	72
1982	4,489	1,185	572	6,246	10,567	59
1983	4,579	1,975	1,586	8,140	17,153	47
1984					3,614	0%
1985					1,657	0%
1986	3,627	825	429	4,881	8,443	58
1987	7,612	360	691	8,663	14,343	60
1988	11,222	827	1,374	13,423	18,594	72
1989	9,104	1,992	711	11,807	16,836	70
1990	10,176	1,068	668	11,912	17,027	70
1991	7,472	618	208	8,298	11,622	71
1992	4,034	586	1,784	6,404	12,253	52
1993	3,743	928	91	4,762	7,101	67
1994	2,997	685	354	4,036	6,368	63
1995	721	51	76	848	1,712	50
1996	1,125	488	1,090	2,703	4,465	61
1997	1,466	71	119	1,656	3,392	49
1998	533	9	116	658	1,054	62
1999	278	39	67	384	702	55
2000	325	7	107	439	668	66
2001	391	29	29	449	784	57

2002	158	3	2	163	307	53
2003	140	2	2	144	427	34
2004	471	77	75	623	1,731	36
2005						
2006						

Data Source: CDOW harvest survey (questionnaire and/or telephone), HIP Program information from 1999 on.

Note: Table 6 assumes that all harvest from these three counties is of Northwest Colorado greater sage-grouse. Moffat County is entirely within the Conservation Plan area, but the other two counties have greater sage-grouse populations outside of the Northwest Colorado area. However, both Eagle-South Routt and Piceance-Parachute-Roan are small populations and both are closed to sage grouse hunting at present.

Table 7. Greater sage-grouse wing collection data for Northwest Colorado

Table 7. Number of greater sage-grouse wings collected during the fall hunting season by wing barrel location, Moffat County, 2002-2005

Location	2002	2003	2004	2005
Dinosaur	22	84	29	52
MCR 16 @ US 40		4	10	
Limestone Gap	6	3	26	7
MCR 318 @ US 40*	3		9	
MCR 72 @ MCR 10N	40	48		100
MCR 7 @ MCR 3	41	64	10	71
MCR 19 @ US 40*	14			5
MCR 17N @ US 40		25	8	23
MCR 17S @ US 40	2			
MCR 16S @ stateline		29		
Cedar Mountain	20			
MCR 3 @ Hwy 13		9	8	21
MCR 4 @ Hwy 13		20		4
MCR 17S @ MCR 51		2		3
MCR 57 @ US 40		1		12
MCR 27 @ Hwy 13 (closed)		4		
Unknown				6
TOTAL	148	293	100	304

* MCR 318 @ US 40 and MCR 19 at US 40 are believed to be the same barrel at Maybell.
Note: See Appendix B from Rick Hoffman for more wing barrel data.

Other Human Induced Mortality

Greater sage-grouse are also subject to mortality from anthropogenic structures and vehicles, though the rate of mortality from these accidents is poorly understood. Bird strikes of power lines and fences while flying can kill birds outright or injure them to the point that they can not effectively avoid predators. Collisions with motor vehicles, either while flying or while walking on or across roadways are also potential causes of direct mortality or severe injury.

B. GREATER SAGE-GROUSE POPULATIONS

Population Trends and Current Status

Greater sage-grouse are believed to have existed as a species in North America for approximately 350,000 years. Early records of sage grouse in Colorado are sketchy. Rogers (1964) interviewed numerous homesteaders present in Northwest Colorado in the early years of the 20th century and reported that the most common response was that sage grouse numbered in the "thousands." He also relates accounts of wagon loads of harvested birds taken near Hayden and thousands of birds shot for the annual Sage Hen Days held in Craig in the early 1900s (Rogers 1964). The highest densities of sage grouse in Colorado occurred in the counties of Moffat, Routt, Rio Blanco, Garfield, Jackson and Grand. Rogers (1964) further stated that populations of sage grouse in the early years of the 20th century were greater in number and extent than he observed in the 1960s. Populations appear to have declined substantially across Colorado in the 1920s and 1930s. The hunting season was first closed in 1937. Greater sage-grouse populations recovered during the 1950s, with public hunting re-instituted in 1953 and populations of sage grouse appear to have continued to increase into the 1960s. Rigorous population estimates do not exist for much of this period, but anecdotal evidence suggests that greater sage-grouse populations during this period were higher than present populations.

Rogers (1964) described sage grouse populations in Northwest Colorado as follows:

> Moffat: *This county probably has the largest population and the highest density of sage grouse of any county in the state. The highest density of sage grouse, although very localized, is in the Beaver Basin area of Cold Springs Mountain—the extreme northwest part of the county.*
>
> *Other areas in this county with a good population density are: the western portion of Blue Mountain north of Artesia near the Utah line, the 2 Bar Ranch on the Snake River, Lay Creek, Bluegravel Gulch, upper Timberlake drainage, Big Gulch drainage, upper Bighole Gulch, the head of Spring Creek, and the area around the town of Great Divide. All of these areas are northwest of the town of Craig between the Snake River, Wyoming line, Colorado Highway 13, and U.S. Highway 40. All of the rest of the area within these boundaries has a fair sage grouse population density.*
>
> *West of the Snake River—besides the Cold Springs Mountain area—a few sage grouse are found in the Powderwash drainage, the Sandwash drainage, Browns Park, Zenobia Mountain, and from the town of Greystone to the lower Snake River.*

While the principal sage grouse population in the southwest part of the country [sic] is on top of Blue Mountain within ten miles of the Utah line, a light population of birds is found in the Wolf Creek drainage of Blue Mountain, on the sagebrush flats and cultivated areas on the south slope of Blue Mountain from the Utah line through Artesia near Skull Creek, and from Massadona to Elk Springs. These birds are close to and probably range between Moffat and Rio Blanco counties through most of this area. Due to inaccessibility, very little is known about sage grouse numbers on the north slopes of Blue Mountain along the canyon of the Yampa River.

South of the Yampa River and east of Elk Springs, a fair sage grouse population is present in the Deception Creek drainage south of the town of Maybell with some of the birds ranging as far south as the town of Price Creek. A light sage grouse population is also present in the Cedar Springs drainage south of Cross Mountain and on the sagebrush flats between U.S. Highway 40 and the Yampa River from Cross Mountain to Maybell. This area quite often has a high concentration of wintering birds, but receives only light summer use.

East of the Deception Creek drainage and south of the Yampa River, a few birds are found near Juniper Springs and along the road from Juniper Springs to Axial. A light sage grouse population is present in the Axial Basin area from Hamilton to just above Axial. The High Mesa area, just south of Craig between the Williams Fork and the Yampa, used to be one of the better sage grouse areas, but most of the sagebrush has been torn up in the past ten years and the ground planted to wheat.

East on [sic-should be of] Colorado Highway 13, a few sage grouse are found within elevational limits from the highway to the Routt County line. A light sage grouse population is present in the Slater Creek, Willow Creek, Fortification Creek, Elkhead Creek, and Yampa River drainages of this area.

Rio Blanco: *As mentioned in the Moffat County write-up, a few birds range between Moffat and Rio Blanco counties in the area south of Artesia and Massadona and north of the White River. A light population is also present along both sides of the White River near the Mobley Ranch east of the town of Rangely. A little farther east and north of the White River, a few sage grouse are present in the Scenery Gulch-Coyote Basin area.* (Note: Other population areas described for Rio Blanco County are beyond the scope of this Conservation Plan).

Routt: *Four distinct sage grouse groups—two with about equal numbers and range, one with less grouse but equal range, and the fourth small in both range and numbers—are present in this county. One area with a fair population density centers around the town of Toponas in the southern part of the county. Drainage [sic] occupied in the southern part of the country [sic] are: Egeria Creek, Toponas Creek, Finger Rock Creek, Watson*

Creek, Hunt Creek, and the Yampa River near Toponas and Yampa, and the Sunnyside and Derby Creek areas to the south of Toponas. (Note: This population is not included within the scope of the Northwest Colorado Greater Sage-Grouse Conservation Plan, but is handled separately in the Eagle-South Routt Greater Sage-Grouse Conservation Plan. The remaining Routt county populations are included within the Northwest Colorado Conservation Plan area.)

The second area containing both fair and light population density of sage grouse is in the west central part of the county centering around the town of Hayden. The highest concentration of sage grouse in the county is in the Twentymile area southeast of Hayden on the upper Sage and Fish Creek drainages. A light population is present in the Twin Mesa area southwest of Hayden and in the Elkhead Creek area north of Hayden. The Breeze Basin-Yampa River area west of Hayden near the Moffat County line was, in 1947 a good sage grouse area, but no sage grouse were observed in this area in 1959 and 1960.

The upper Slater Creek and Snake River areas in the extreme northern part of Routt County have a light population of sage grouse in the summer months. Birds winter near the Wyoming line, but inaccessibility of this area in the winter and spring made it impossible to fully determine distribution.

The fourth area is north of Steamboat Springs and west of Clark on Deep Creek. This small area was not checked during the study. It furnishes some local hunting and probably falls within the light density classification.

Many of Rogers' findings above are similar to relative population densities among areas today.

In Colorado, greater sage-grouse historically occurred in at least 13 counties (Braun 1995). Currently, greater sage-grouse are found in 9 Colorado counties and are considered secure in 4 counties. Braun (1995) considered populations with greater than 500 breeding greater sage-grouse (totals of males and females in the spring) as secure. Braun (1995) concluded that secure populations were found in Jackson, Moffat, Rio Blanco, and Routt counties. Although Braun (1995) considered the populations secure, he did not cite any original reference to clarify or justify the 500 breeding individual theory. Later, Connelly and Braun (1997:230) suggested that greater sage-grouse populations in Colorado were "at risk", although Braun (1995) had concluded earlier that the major populations in Colorado were secure. Connelly and Braun (1997) do not provide any definition of the term "at risk."

Greater sage-grouse are counted in the spring while attending leks to breed. Only males can be reliably counted as the cryptic coloration and irregular attendance patterns of female grouse make consistent counts of females exceedingly difficult. Spring male counts are only an index of sage grouse population trends as there are many factors that affect male attendance on leks, but they provide the most effective trend index currently available for sage grouse (Beck and Braun

1980). Biologists are discussing other methods for counting sage grouse and for improving the predictive ability of lek counts for total population size, but no adjusted technique is yet available (Walsh et al. 2004). It is generally assumed that there are two hens in the population for each male counted in the spring (Connelly et al. 2000). Total male counts, number of active leks, and average number of males/lek are useful indices of greater sage-grouse population trends.

Greater sage-grouse lek counts have been conducted in Northwest Colorado since at least 1953, but have been sporadic and inconsistent during some periods. Intensive lek counts were replaced for large portions of Northwest Colorado with lek status checks (activity checks) between approximately 1980 and 1995. This approach is still supported by the Sage Grouse Management Guidelines (Connelly et al. 2000), but leaves a wide gap in the numerical trend data and makes analysis over this period difficult.

Widespread belief among CDOW field personnel that greater sage-grouse lek attendance was declining in the mid-1990s caused the re-establishment of intensive lek counts in 1996. Trends of greater sage-grouse counted on leks by Rogers (1964), Hoffman (1979), and Wildlife Conservation Officers/District Wildlife Managers (CDOW, unpublished data) between 1958 and 1980 suggest that Northwest Colorado greater sage-grouse populations have fluctuated over roughly ten-year intervals. No research has been implemented to verify the activity of regular cycles in greater sage-grouse population numbers.

Periodic population peaks appear in the data during the periods 1968-70 and 1978-80. However, each high point in this pattern appears to be lower than the previous high, indicating a long-term downward trend during that period. The most recent population peak occurred in the years between 1978 and 1980. Greater sage-grouse populations declined substantially from 1980 into the mid-1990s before again climbing during the late 1990s and early years of the 21st Century. Counts have continued to rise to the present. The high male count in 2005 reached 3100 males. The 1979 peak count was 3567 males. While male counts have rebounded to levels the GRSGWG did not expect to see a few years ago, lek counts are currently conducted with a much higher level of effort than occurred historically.

Lek count data show a record low in the average number of males counted during the period from 1996 to 1998. The period between 1999 and 2002 demonstrated significant increases in several population areas, approaching levels last seen in the 1978-1980 period. Lek counting effort increased dramatically from 1995 through 2006 in an effort to fully document the status of greater sage-grouse in Northwest Colorado. This additional effort has resulted in the location of many new leks that were not counted previously. Many of these "new" leks discovered in recent years are believed to have existed in 1979 but were not counted and are not represented in data from earlier years, resulting in the potential for artificially low historic counts when compared to currently known leks.

Additional 3-year averages have been calculated for the years 2000-02, and 2003-05. Lek counts conducted in the same areas, using 1978-80 as the "benchmark," indicate that decreases of greater sage-grouse in Moffat County equal: a 47% decrease in the number of strutting males, a 43% increase in the number of active leks, and a 54% decrease in the number of males/lek from 1978-80 to 2000-02. Comparison of the 1978-80 benchmark to the three year average for 2003-05 shows that strutting males declined by 25%, active leks increased by 20%, and the number of males/lek declined by 38%.

Overall, Colorado greater sage-grouse populations have been increasing for the past 17 years and there is no evidence of a dramatic overall decline for the last 39 years (Connelly et al. 2004).

Lek count data for Northwest Colorado greater sage-grouse are presented below. Figure 17 presents annual high male counts for the entire Northwest Colorado greater sage-grouse population. Figure 18 shows an annually updated three-year running average of total male counts for the years 1997 through 2005. This three-year running average dampens some of the annual variability in the raw annual lek data and allows a clearer estimation of population trend than the raw data. Figure 19 presents the annual number of active leks and average number of males per lek for the Northwest Colorado population. Greater sage-grouse lek attendance has increased between 1998 and 2006 in many Management Zones in the Northwest Colorado population. This increase has not been distributed equally across all areas of Northwest Colorado. Several fold increases in lek attendance have been seen in some parts of the population while other greater sage-grouse areas have shown little or no increase. The years from 1997 to 1999 were characterized by moist springs and mild winters, conditions believed to be favorable to increases in greater sage-grouse populations, while the 2002-2004 time period (1999-2006 in more arid regions) was one of historic drought conditions. The current trend of greater sage-grouse populations in Northwest Colorado appears to be increasing and is probably sustainable in the near future, even in light of severe drought conditions. Significant management effort may be required to maintain these numbers over the long-term.

The development of appropriate population objectives is an important part of this Conservation Plan. Following further review of the literature (in an attempt to support or refute the validity of the 500 breeding bird benchmark proposed by Braun 1995), this Plan assumes that Braun's 500 breeding individual benchmark was derived from Franklin (1980) and Soulé (1980). Those authors propose that a 500 breeding individual population (actually the effective population size) is sufficient for long-term maintenance of genetic variability in a population. Lande (1988) suggests that this number was quickly adopted as the basis of management plans for many captive and wild populations. Additionally, Lande (1995) suggested that in experiments with fruitflies, *Drosophila melanogaster*, that a population size of 5,000 is necessary rather than the Franklin-Soulé number of 500. Lande (1995) cautioned using the value of 5,000 because of

Figure 17. High male counts—Northwest Colorado greater sage-grouse population

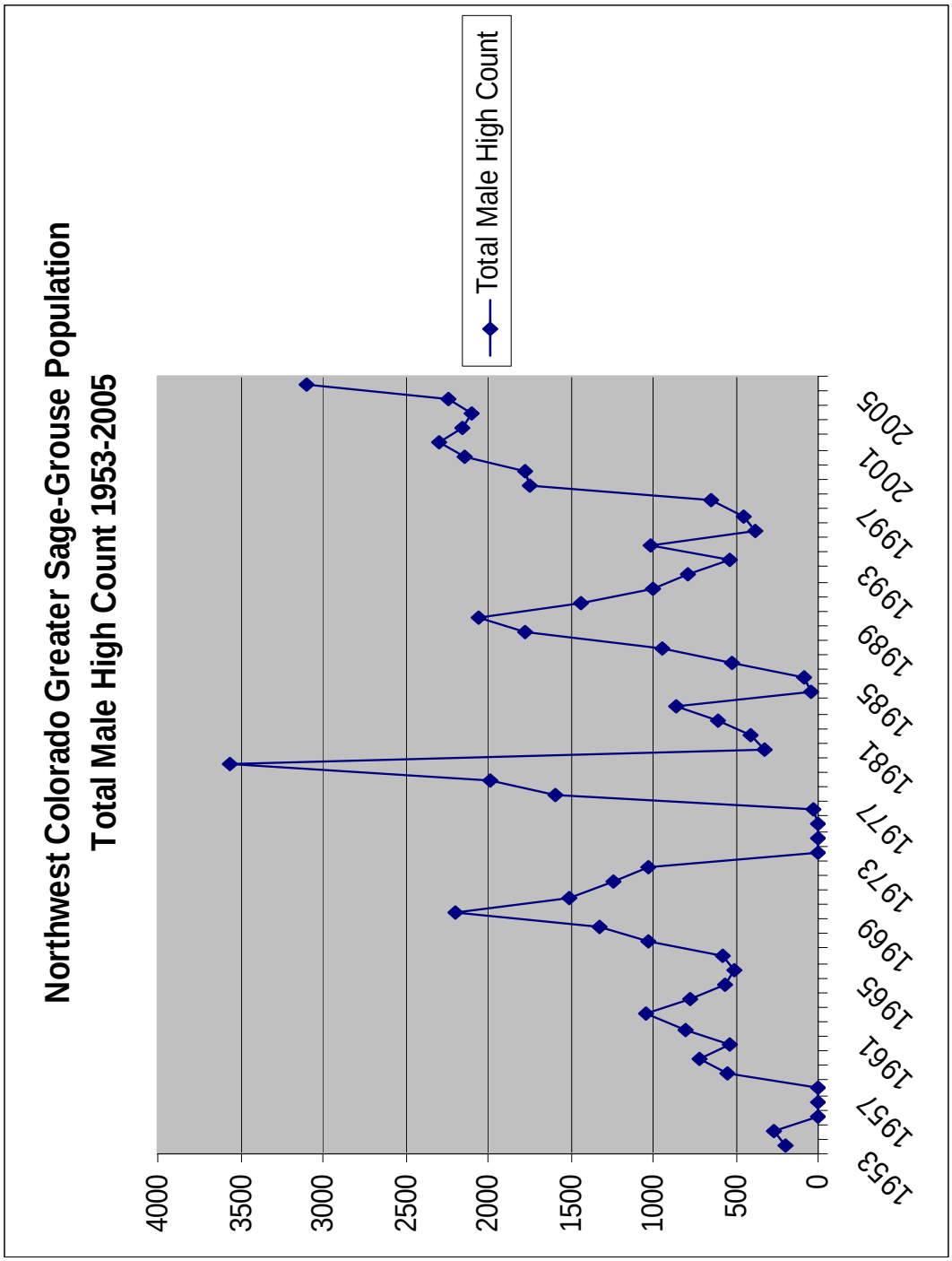


Figure 18. High male counts (three year running average)—Northwest Colorado greater sage-grouse population

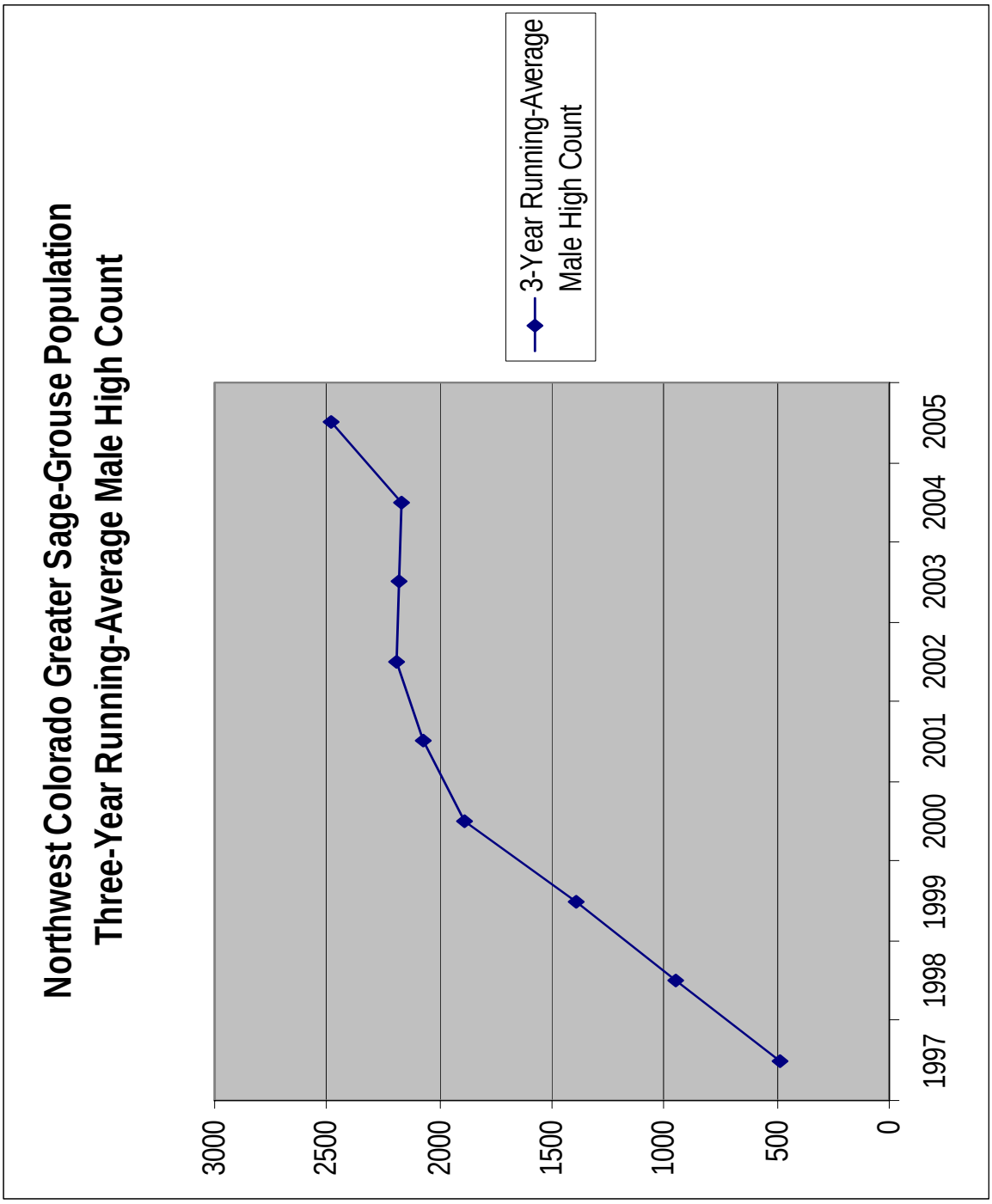
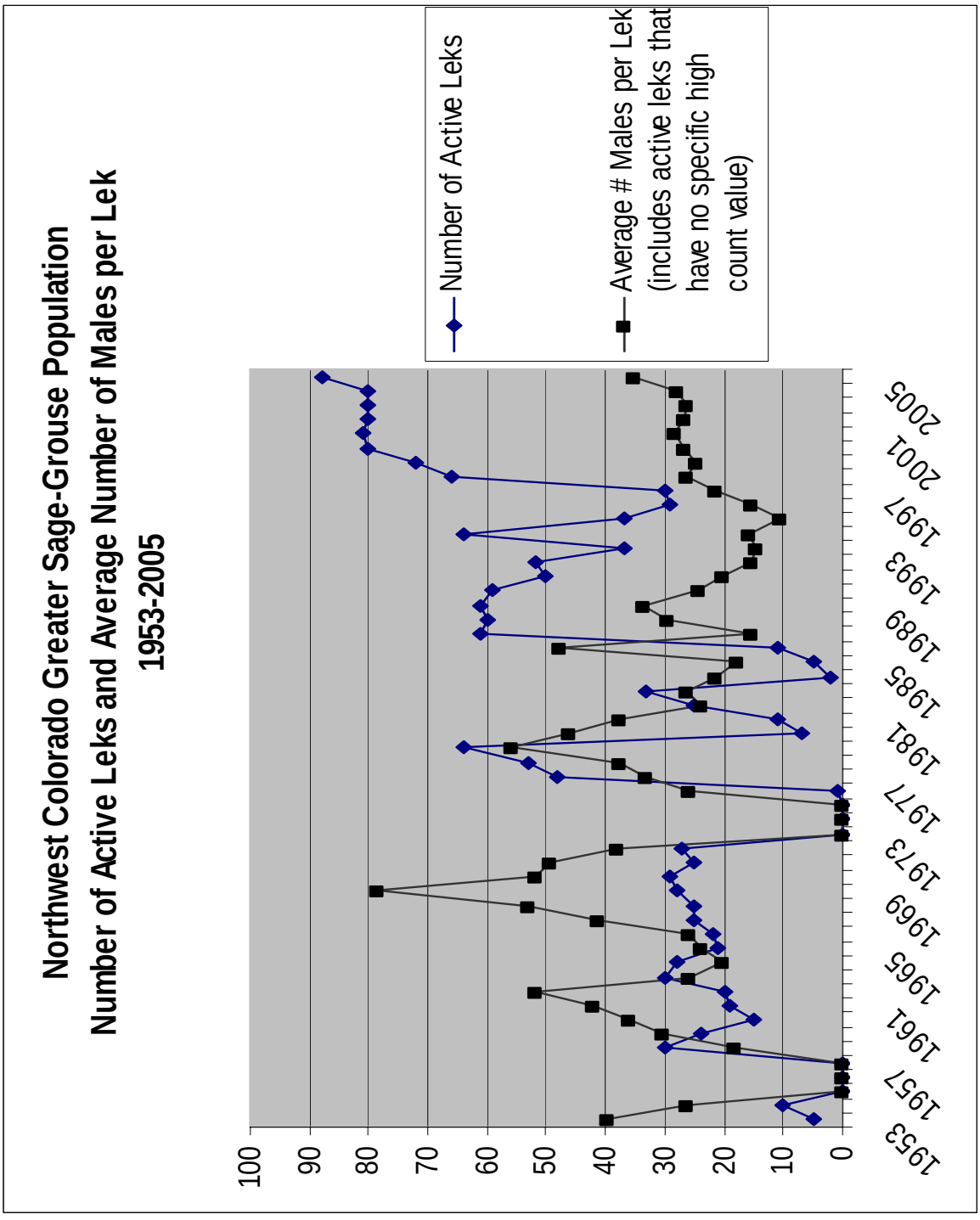


Figure 19. Number of active leks and average number of males per lek—Northwest Colorado greater sage-grouse population


Northwest Colorado Greater Sage-Grouse Population
Number of Active Leks and Average Number of Males per Lek
1953-2005
Number of Active Leks
Average # Males per Lek (includes active leks that have no specific high count value)
100
90
80
70
60
50
40
30
20
10
0
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005

differences among characters and species in genetic mutations and environmental fluctuations. Due to these vastly different numbers, and the fact that they were derived on species other than sage grouse, additional information is needed to adequately estimate genetic minimum viable populations for greater sage-grouse.

Rather than estimating the percent of annual increase or decrease of any of the aforementioned variables, the Northwest Colorado Greater Sage-Grouse Work Group believes it is more useful to evaluate long-term trends and 3-year running averages (adjusted annually) of lek counts to measure progress in sustaining the Northwest Colorado population of greater sage-grouse. The GSGWG has opted to use the three year running average of high male counts, supported by number of active leks and average males/lek, as its primary measure of greater sage-grouse population trend and progress toward conservation goals. Management Zone specific population trends and future population objectives are described in **Part IV: Implementation and Monitoring**.

C. POPULATIONS OF SAGEBRUSH OBLIGATES OTHER THAN GREATER SAGE-GROUSE

While greater sage-grouse populations in Northwest Colorado have been extensively counted and studied, little or nothing is known about the local status of other sagebrush obligate species. It is assumed that their numbers and geographic extent are tied to the condition and extent of big sagebrush communities. This Plan operates with the intent that maintenance of substantial areas of high quality sagebrush steppe, measured by healthy populations of sage grouse, will provide sufficient habitat for these other sagebrush obligate species to thrive in Northwest Colorado.

At least 73 species of wildlife are associated with sagebrush communities (Boyle and Reeder 2005). Several species of birds, small mammals, and herptiles are found only in sagebrush environments. Neotropical passerine birds obligated to use sagebrush environments include Brewer's sparrow, sage sparrow, and sage thrasher. Additionally, though not obligated to use only sagebrush environments, vesper sparrow and loggerhead shrike are also commonly found in sagebrush communities in Northwest Colorado. Other obligate species include the sagebrush vole and the sagebrush lizard. In addition to these obligates, a large number of other birds, small mammals and reptiles commonly make use of sagebrush environments within Northwest Colorado. Paige and Ritter (1999) address bird species found in sagebrush areas and Yanishevsky and Petring-Rupp (1998) provide habitat management guidelines for several species of sagebrush nesting birds. Welch and Criddle (2003) describe many of the vertebrate and invertebrate species using big sagebrush for food or shelter.

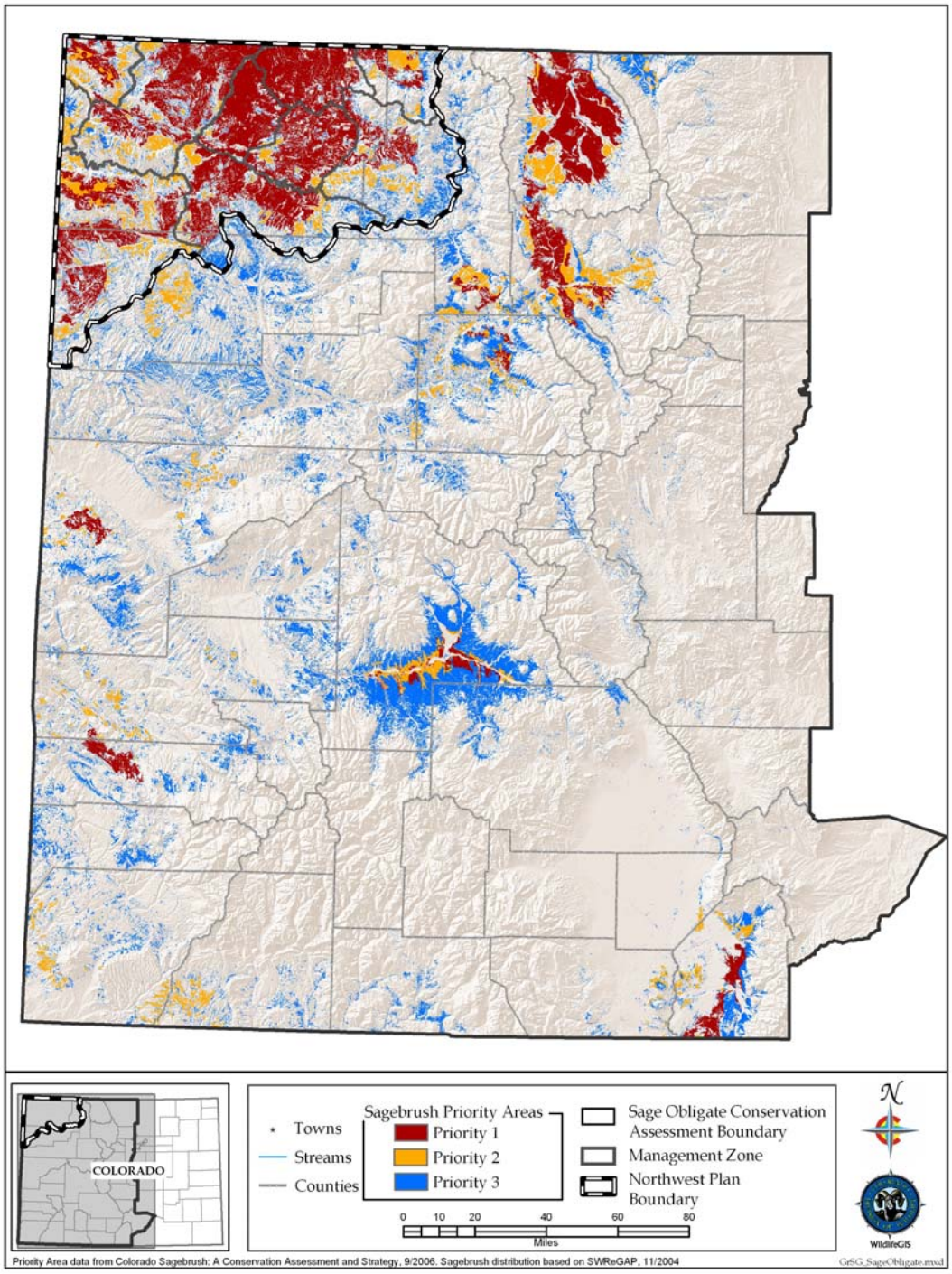
Boyle and Reeder (2005) assessed habitat quantity and risks for 11 species that have significant ties to sagebrush communities and that are not covered under other conservation planning efforts. Species were divided into three groups:

- Group 1: sagebrush obligates generally requiring relatively large patches of sagebrush habitat (Brewer's sparrow, sage sparrow, sage thrasher, sagebrush vole)

- Group 2: species not as closely associated with sagebrush as Group 1, but significant components of sagebrush fauna, generally more tolerant of smaller patches of sagebrush and higher interspersion of other vegetative types (black-throated sparrow, kit fox, northern harrier, vesper sparrow)
- Group 3: species moderately associated with sagebrush communities, including edges (green-tailed towhee, lark sparrow, Merriam's shrew)

Habitats were evaluated across the west slope of Colorado for suitability for these various assemblages of species. Patch size and likely presence of threats to continued existence of habitats were important variables measured. Significant habitat areas for conservation of the three groups individually and collectively were evaluated. Sagebrush habitats within the Northwest Colorado Greater Sage-Grouse Conservation Plan boundary were determined to be highly important in future conservation of these species in Colorado. Figure 20 shows areas of particular importance for sagebrush obligate conservation within Northwest Colorado and the high importance of Northwest Colorado sagebrush habitats to statewide conservation of these species.

Figure 20. High priority sagebrush obligate conservation areas in Colorado



D. TRENDS IN NUMBERS AND DISTRIBUTION OF WILDLIFE POPULATIONS

Big Game

Greater sage-grouse share habitat in Northwest Colorado with large herds of mule deer, pronghorn antelope, and elk. Sagebrush ecosystems provide critical habitat for mule deer, elk, and pronghorn antelope. These ungulates have a significant influence on the sagebrush ecosystems. All three species of big game wildlife have experienced significant changes in population number and seasonal patterns during the 20th Century. Mule deer and pronghorn antelope habitats show strong similarities to greater sage-grouse habitat. Elk also use large areas of greater sage-grouse habitat in addition to other habitat types.

Big game populations are managed in Colorado by Data Analysis Units (DAUs). These DAUs represent big game herd units. They are based on the assumption that interchange across DAU boundaries is minimal. DAUs range greatly in size based on the amount of suitable big game habitat and number of big game animals in each DAU. For instance, DAU E-2 includes all elk habitat from the Continental Divide east of Steamboat Springs, CO to the Little Snake River in central Moffat County, an area of 2,813 square miles. In contrast, DAU E-1 covers an area less than half the size in northwestern Moffat County because elk emigration and immigration across the Little Snake River is slight. DAUs are further broken down into smaller Game Management Units (GMUs) where harvest management can be more specifically targeted. GMU boundaries are frequently drawn on topographic or political borders. In Northwest Colorado, GMUs are roughly analogous with the greater sage-grouse Management Zones described later in this document. Mule deer and elk DAUs are largely identical in Northwest Colorado. Pronghorn antelope DAUs differ somewhat from deer and elk. GMUs do not differ between species. Figures 21, 23 and 25 show the locations of DAUs for elk, mule deer and pronghorn antelope respectively. Figures 22, 24 and 26 show population trends for elk, mule deer and pronghorn antelope respectively in the various DAUs. Tables 8, 9 and 10 describe current population sizes and current management objectives for elk, mule deer and pronghorn antelope by DAU. Table 11 describes the size of the various DAUs and their overlap with greater sage-grouse habitat.

Big game populations are managed in accordance with DAU plans for each species in each DAU. DAU plans are revised periodically through a public process. These plans stipulate herd size and age/sex ratios for the herd units. Northwest Colorado greater sage-grouse habitat includes all or portions of four CDOW DAUs each for mule deer and elk and five DAUs for pronghorn antelope. All three species of big game wildlife show significant differences in population size and density between the DAUs west of the Little Snake River, and those to the east of the Little Snake.

Figure 21. Northwest Colorado elk winter range and data analysis unit map

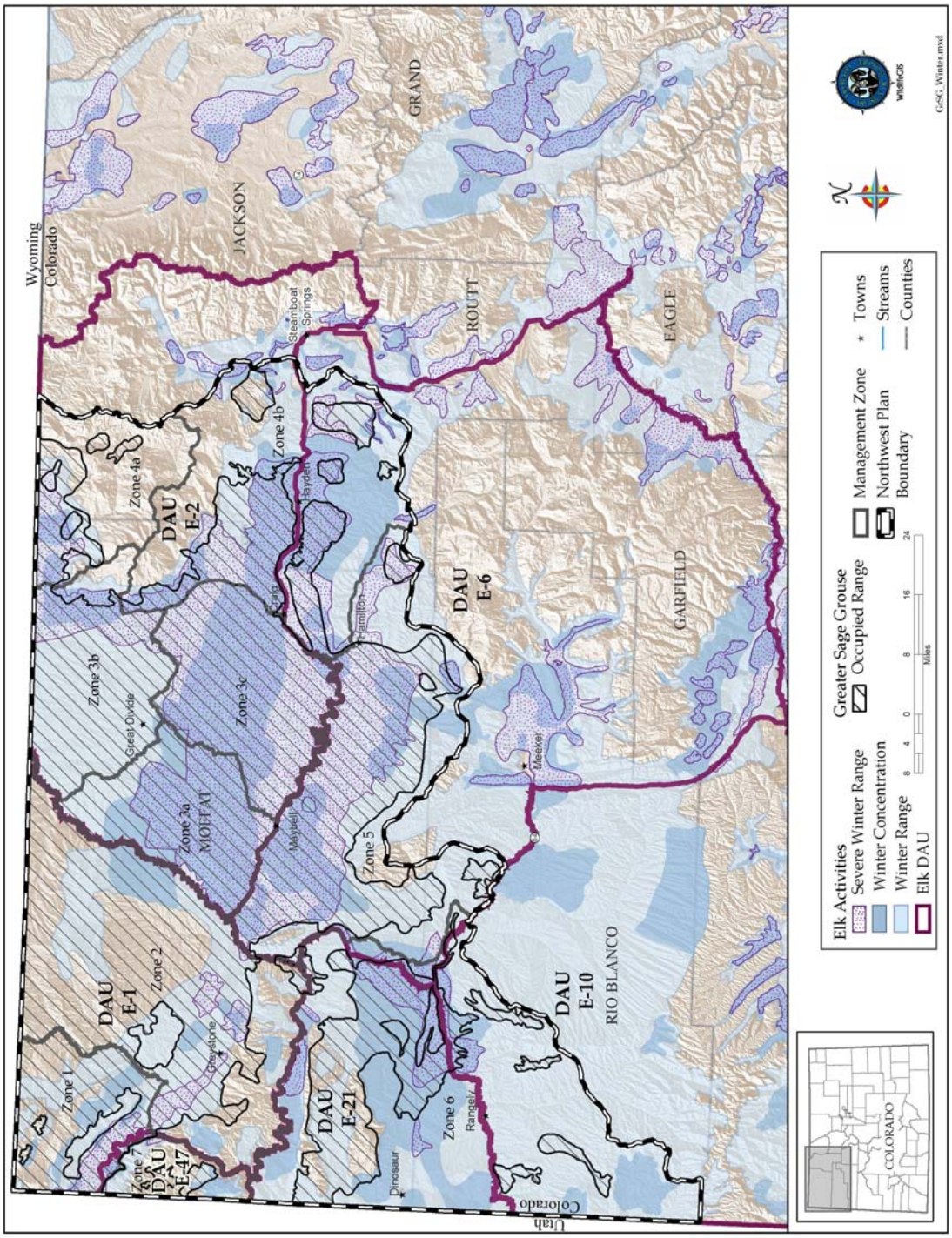
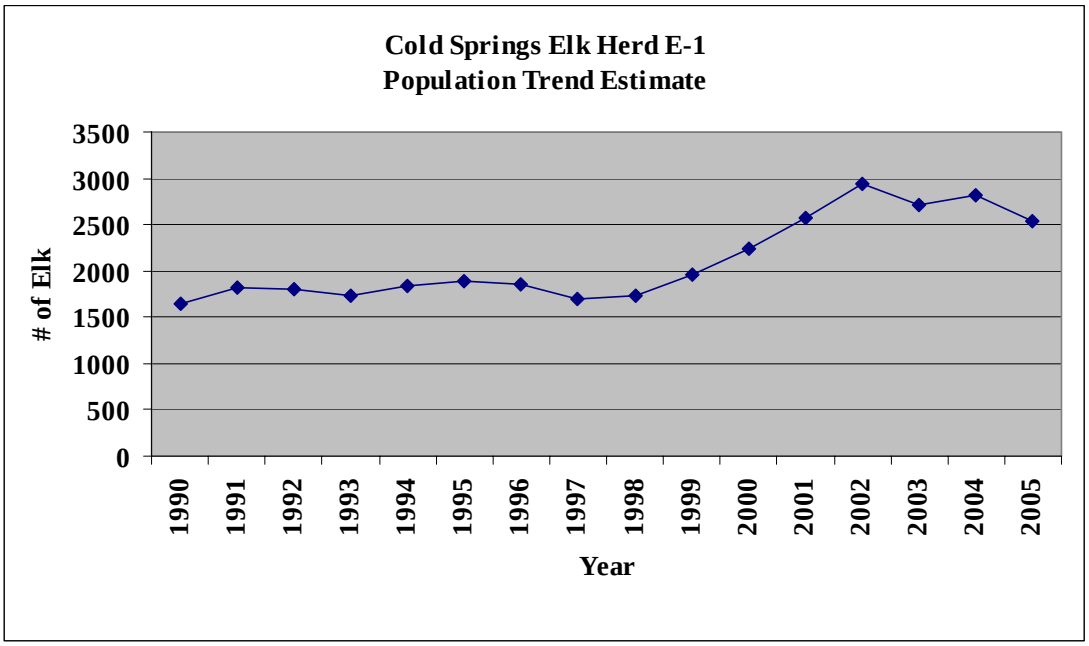


Figure 22. Northwest Colorado elk population trends by DAU



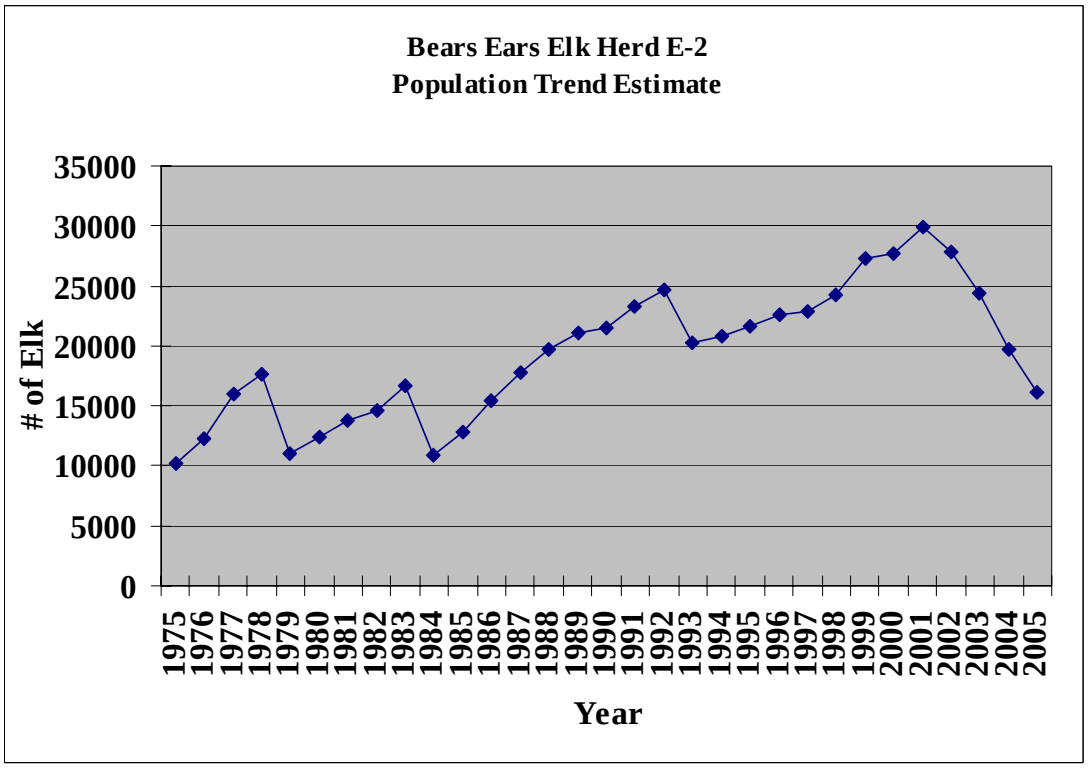
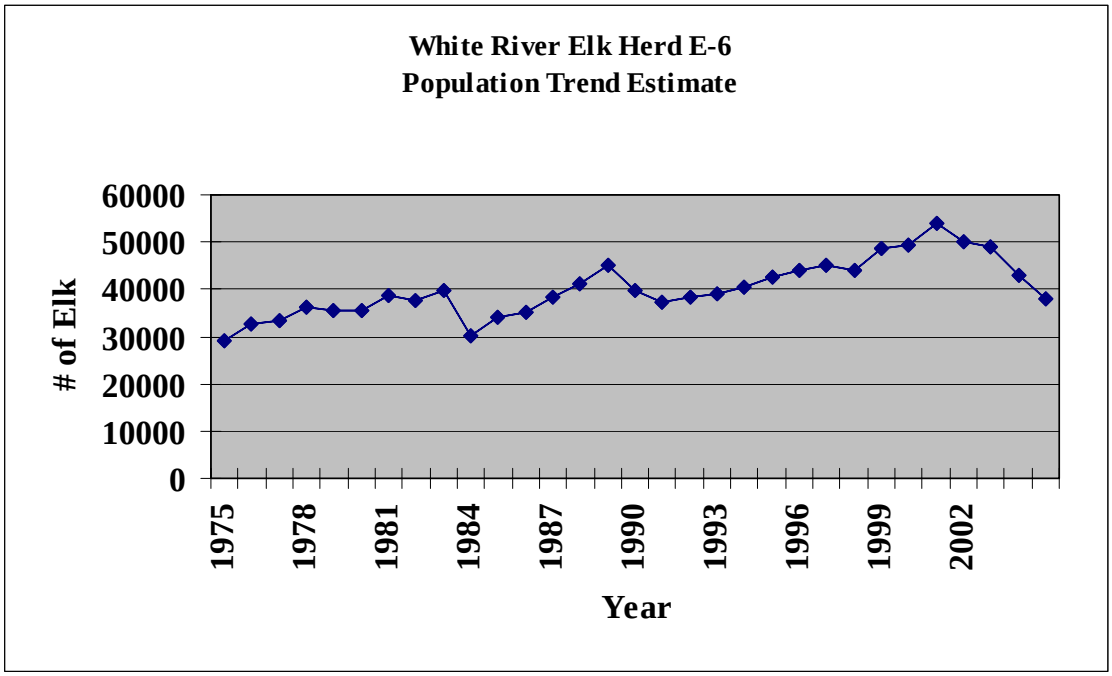


Figure 22. Northwest Colorado elk population trends by DAU continued



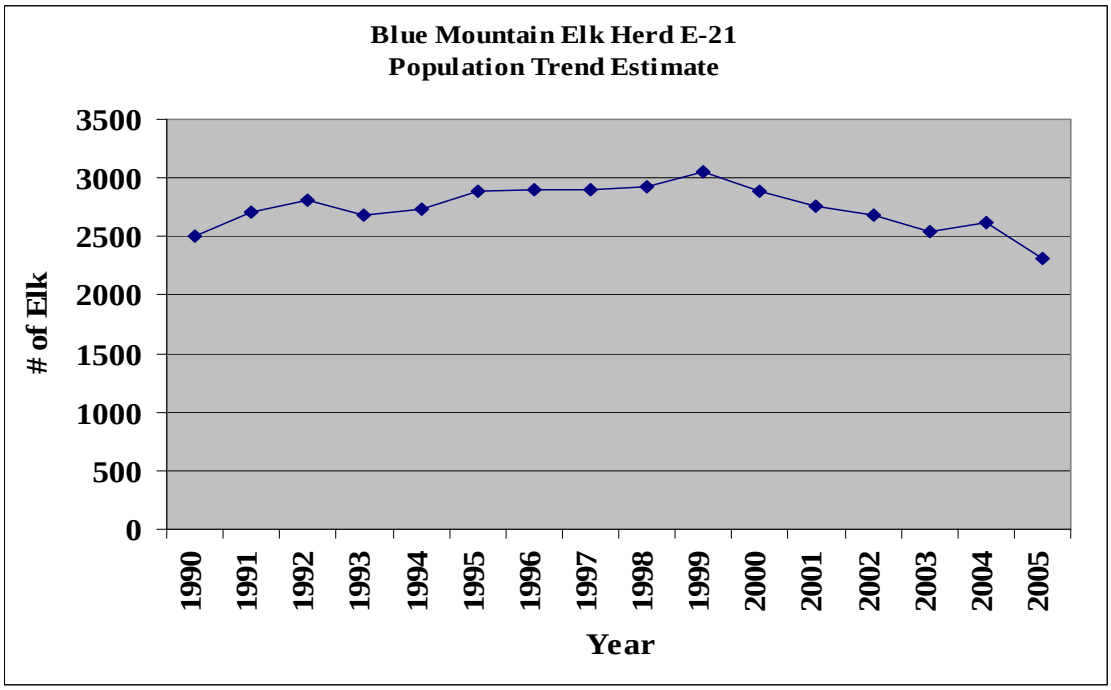


Figure 23. Northwest Colorado mule deer winter range and data analysis unit map

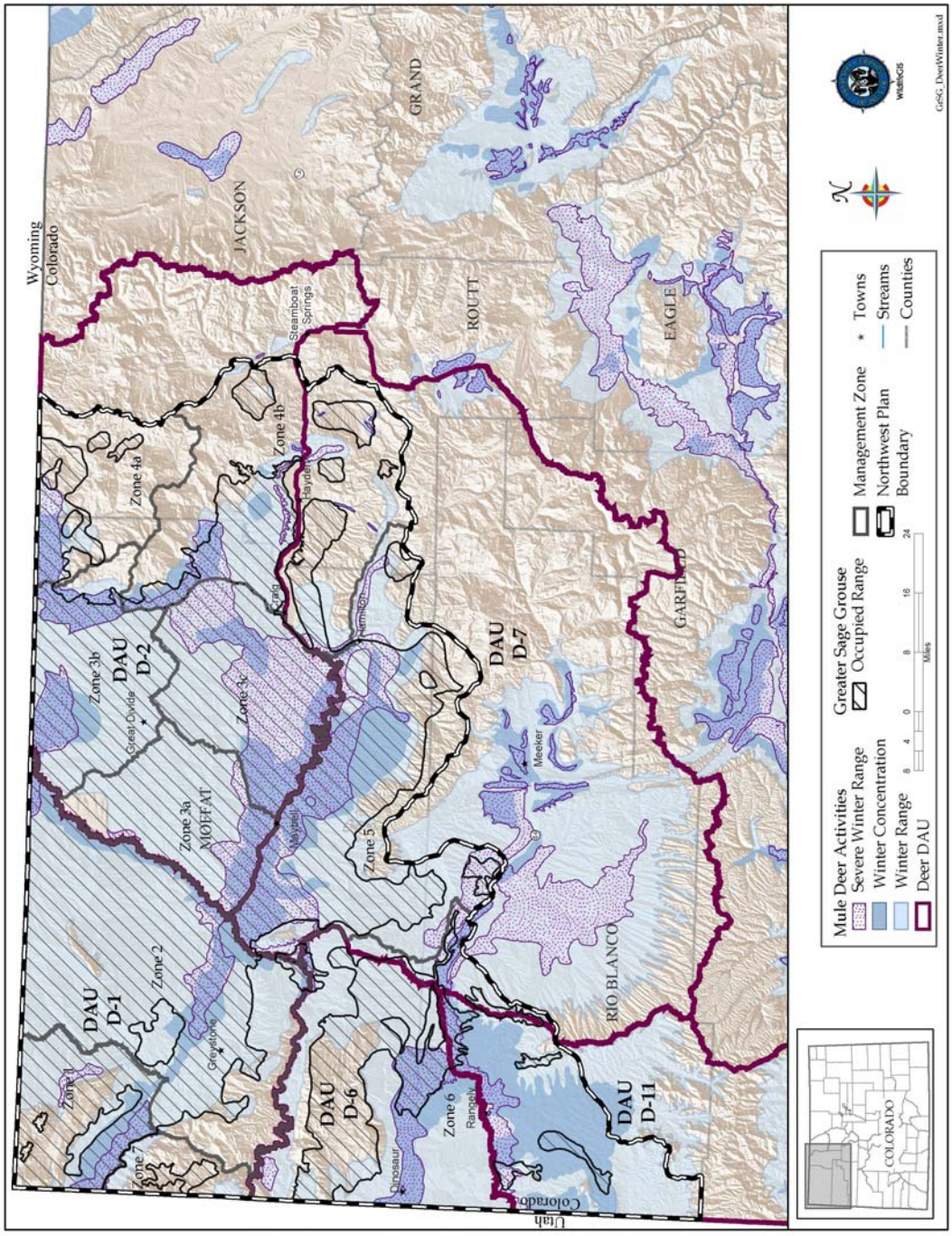
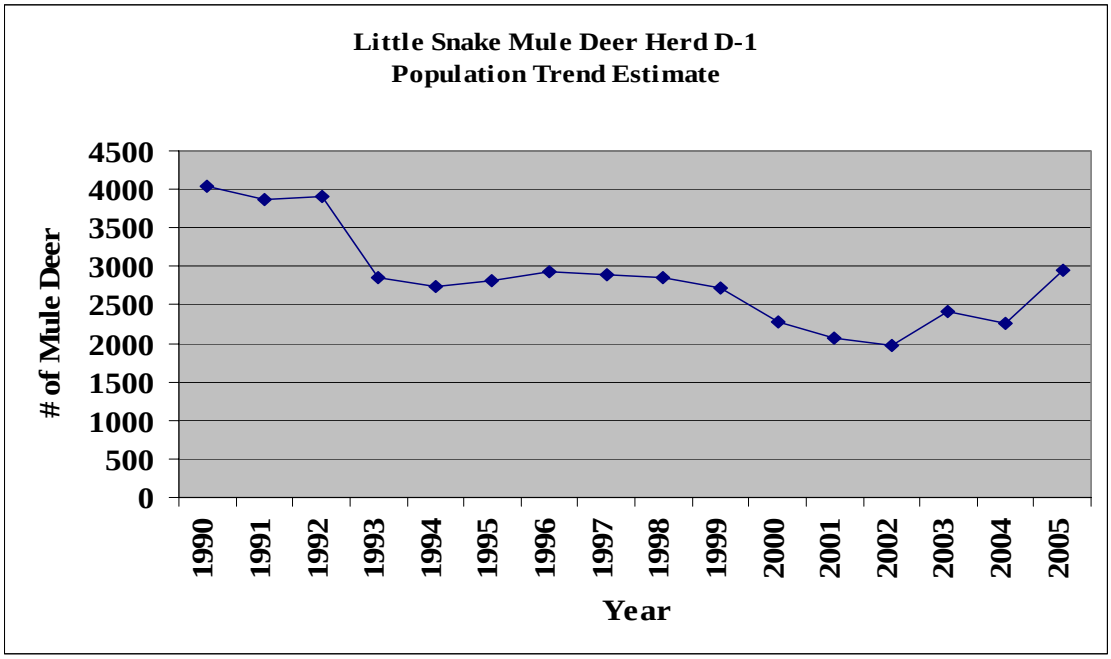


Figure 24. Northwest Colorado mule deer population trends by DAU



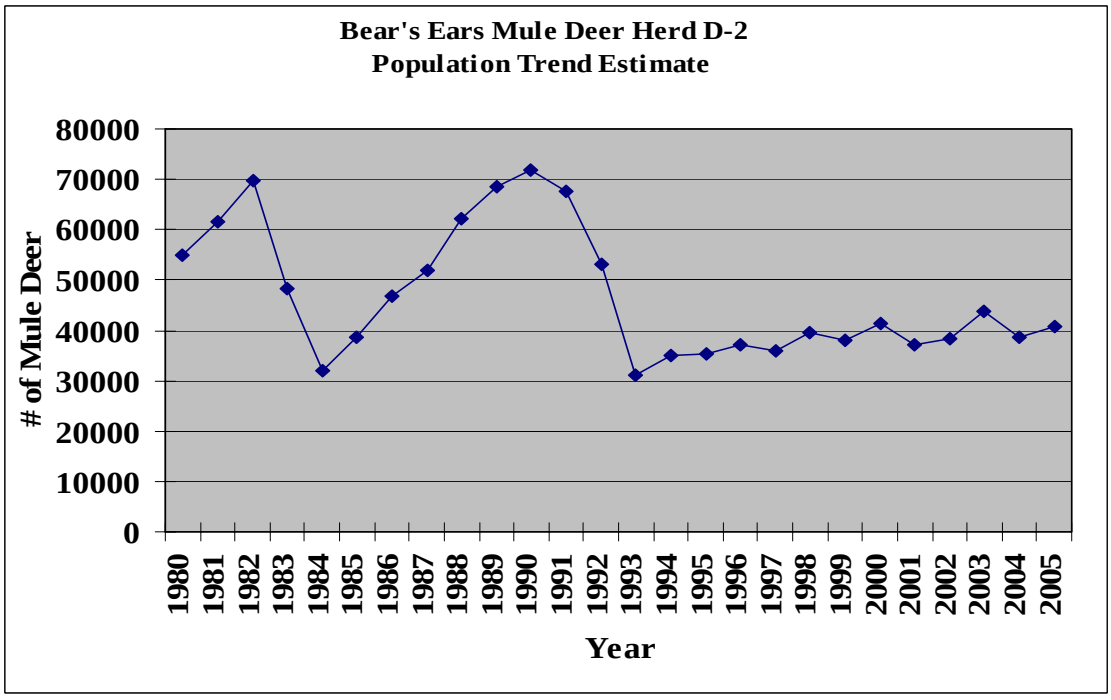
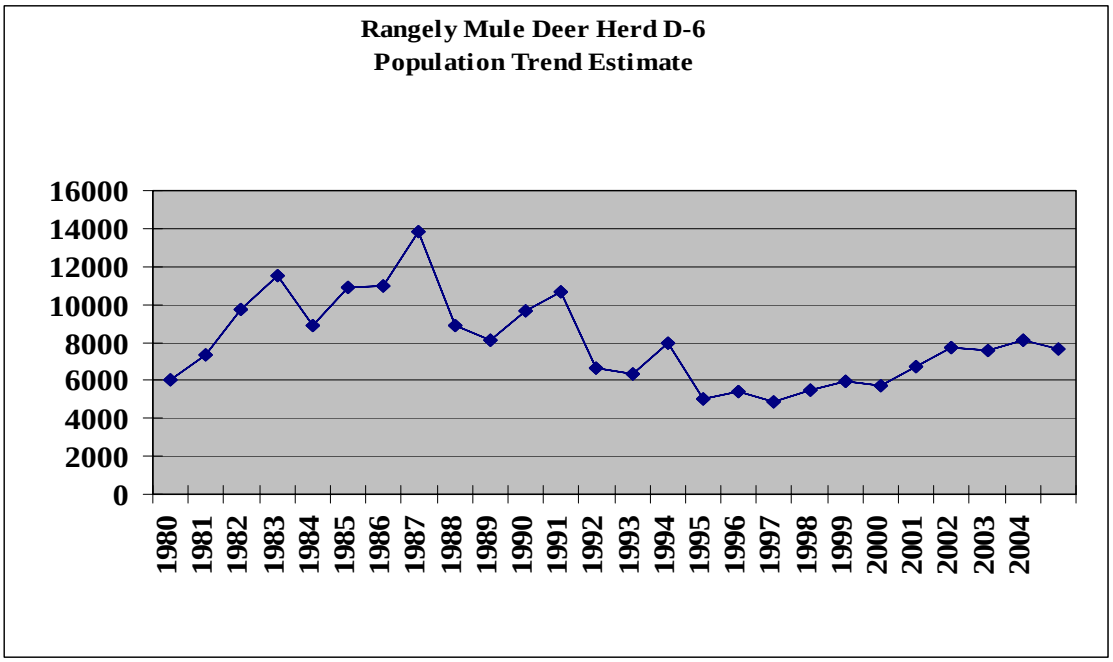


Figure 24. Northwest Colorado mule deer population trends by DAU continued



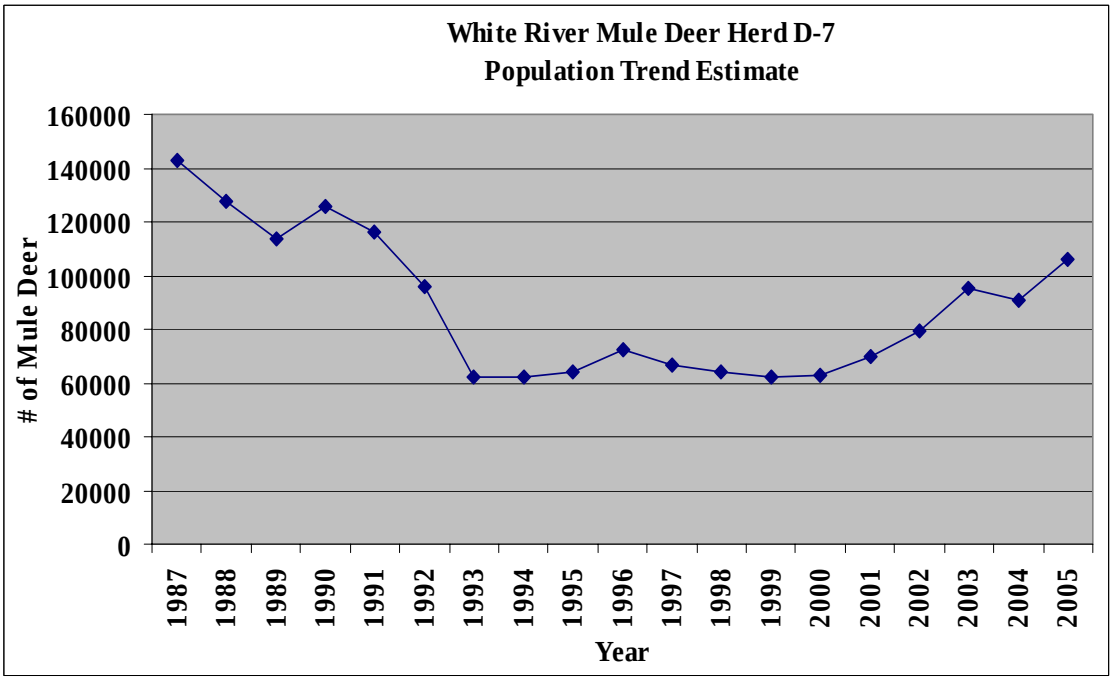


Figure 25. Northwest Colorado pronghorn antelope winter range and data analysis unit map

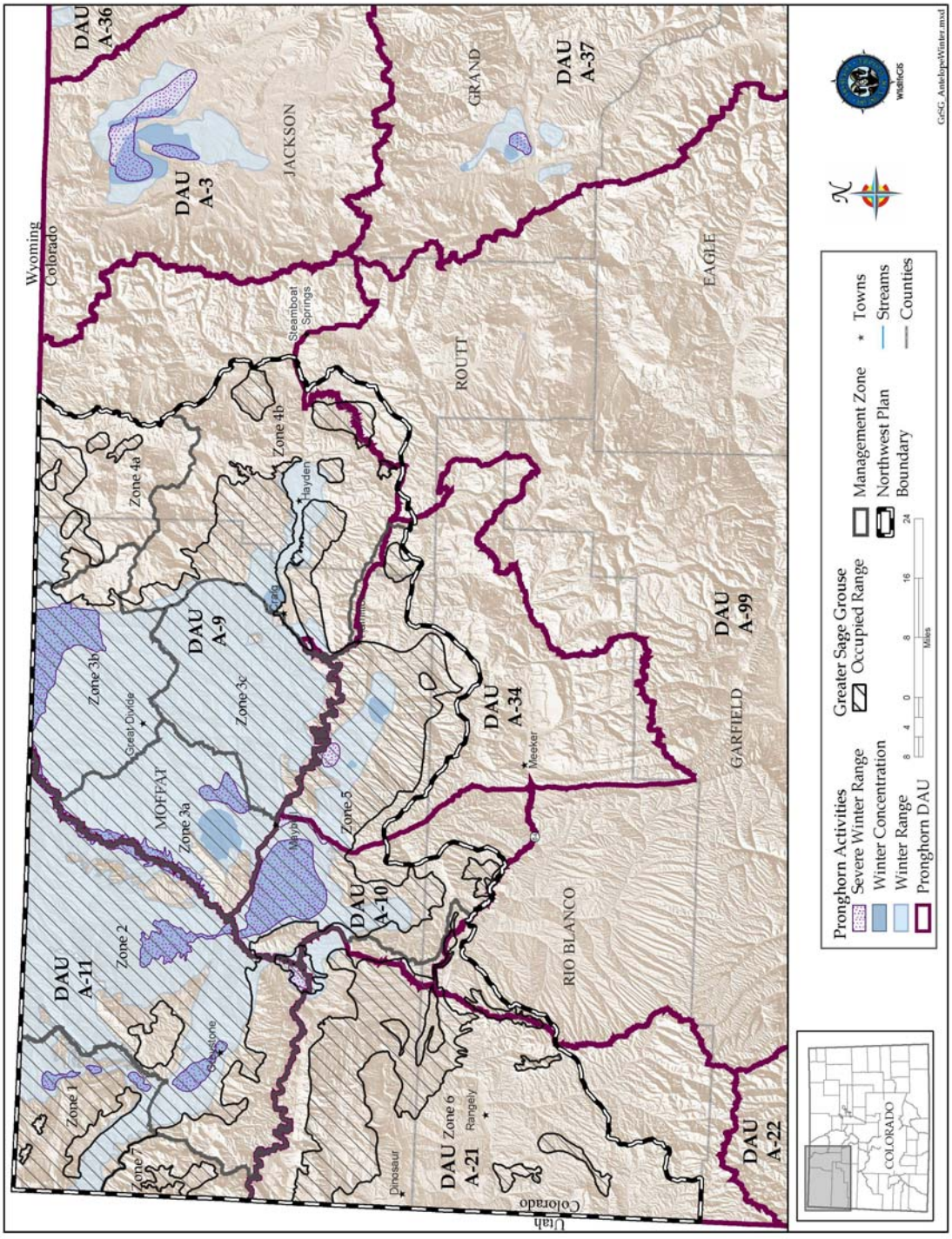
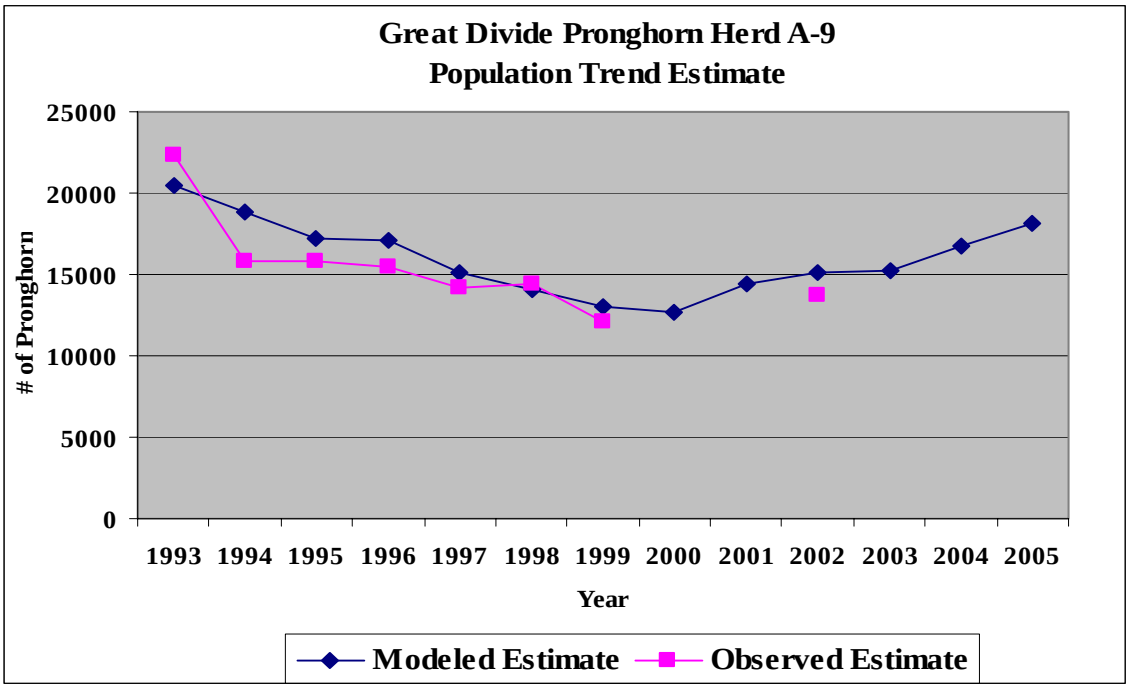


Figure 26. Northwest Colorado pronghorn antelope population trends by DAU



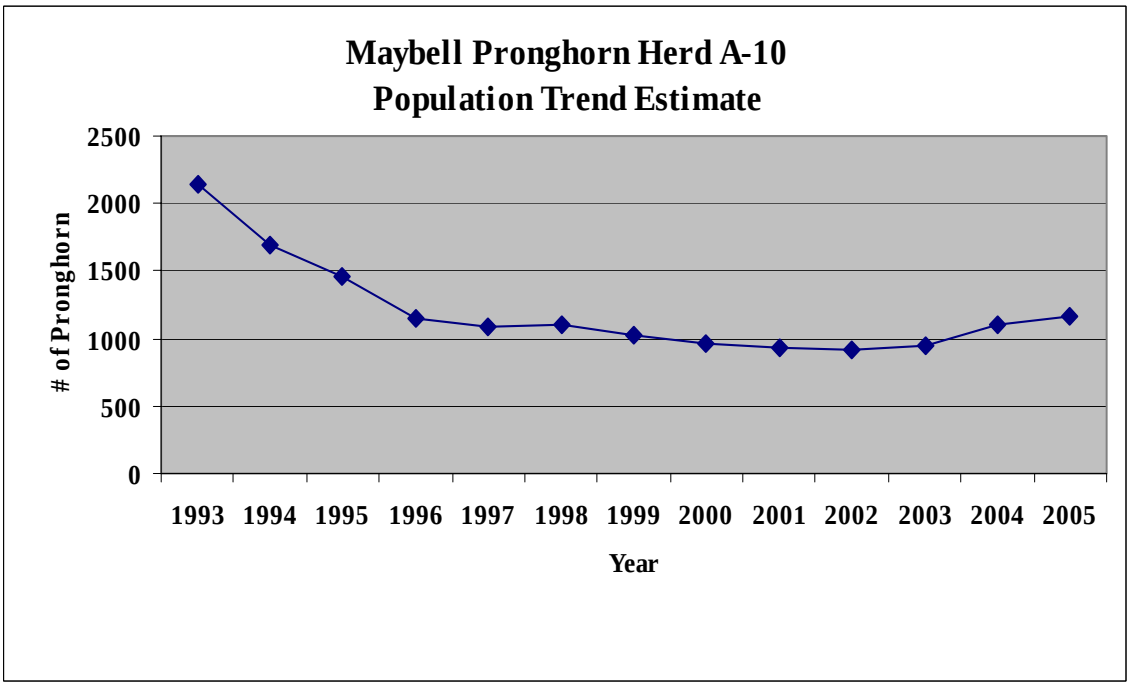
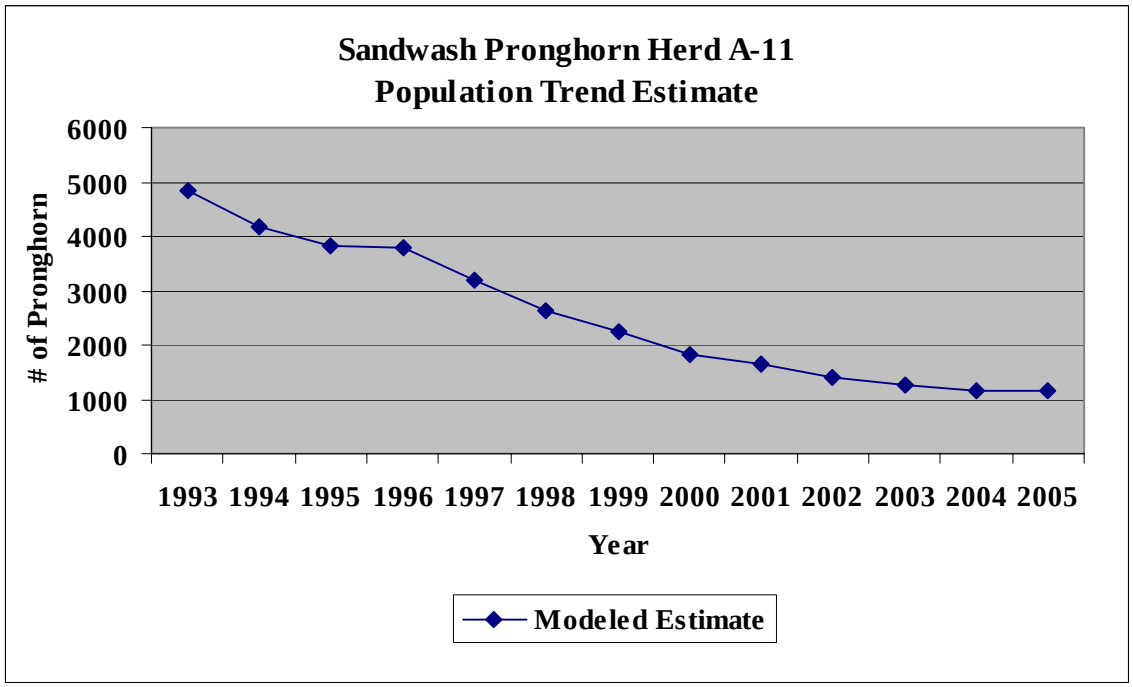


Figure 26. Northwest Colorado pronghorn antelope population trends by DAU continued



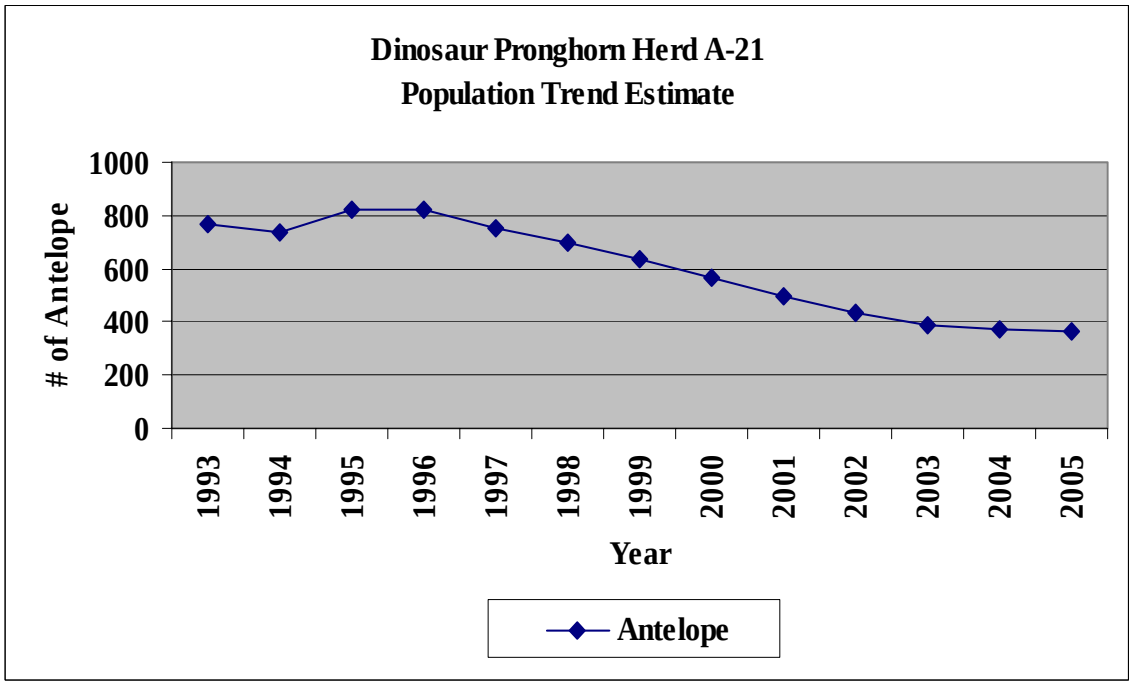


Figure 26. Northwest Colorado pronghorn antelope population trends by DAU continued

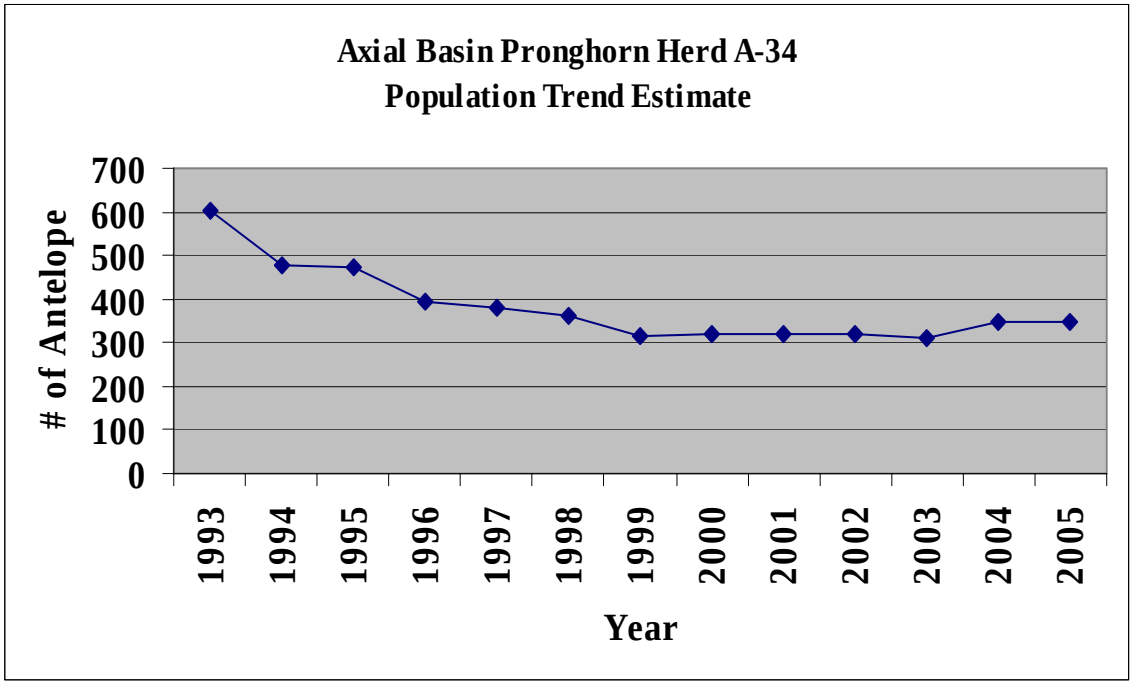


Table 8. Northwest Colorado current elk population estimates and objectives by DAU

DAU Number	DAU Name	Long-Term Objective	Current Estimate (Post-Hunt 2005)
E-1	Cold Springs	950	2,530
E-2	Bears Ears	11,000-15,000	16,000
E-6	White River	32,000-39,000	38,000
E-21	Rangely/Blue Mountain	1,200	3,200

Table 9. Northwest Colorado current mule deer population estimates and objectives by DAU

DAU Number	DAU Name	Long-Term Objective	Current Estimate (Post-Hunt 2005)
D-1	Little Snake	13,500	3,000
D-2	Bears Ears	37,800	41,000
D-6	Rangely	7,000	8,000
D-7	White River	67,500	106,000

Table 10. Northwest Colorado current pronghorn antelope population estimates and objectives by DAU

DAU Number	DAU Name	Long-Term Objective	Current Estimate (Post-Hunt 2005)
A-9	Great Divide	15,800	18,000
A-10	Maybell	1,400	1,200
A-11	Sandwash	1,300	1,150
A-21	Dinosaur	300	350
A-34	Axial Basin	300	350

Table 11. Big game data analysis units—acreage and overlap with greater sage-grouse habitat

DAU Number	DAU Name	DAU Acreage	DAU Acreage in NW Colorado Plan Area	Percent Overlap with NW Colorado Plan Area
E-1	Cold Springs	918,547	918,547	100
E-2	Bears Ears	1,800,578	1,419,338	79
E-6	White River	2,694,776	945,252	35
E-21	Rangely/Blue Mountain	532,600	532,600	100
D-1	Little Snake	999,934	999,934	100
D-2	Bears Ears	1,800,578	1,419,338	79
D-6	Rangely	532,600	532,600	100
D-7	White River	2,635,538	987,114	37
A-9	Great Divide	2,032,660	1,651,085	81
A-10	Maybell	390,416	305,946	78
A-11	Sandwash	999,934	999,934	100
A-21	Dinosaur	1,101,683	870,963	79
A-34	Axial Basin	890,774	358,764	40

Table 12. Northwest Colorado habitat assessment model forage allocation (data from Wockner et al. 2005)

Mean Precipitation, Whole Study Area, 16000 Pronghorn, Livestock 10-yr Ave.							
% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	203,717	412,647	621,577	100
10	16,518	33,458	50,398	148,662	301,122	453,582	90
20	27,780	56,270	84,761	111,120	225,080	339,044	80
30	35,952	72,824	109,697	83,876	169,898	255,923	70
40	42,148	85,375	128,602	63,222	128,063	192,903	60
50	47,012	95,226	143,441	47,012	95,226	143,441	50
60	50,938	103,179	155,420	33,925	68,717	103,510	40
70	54,146	109,679	165,211	23,229	47,052	70,876	30
80	56,851	115,157	173,463	14,213	28,789	43,366	20
90	59,146	119,805	180,464	6,565	13,298	20,032	10
100	61,115	123,794	186,473	0	0	0	0

Note: The elk and deer midpoints in the highlighted line approximate the current situation for the four combined elk and deer DAUs modeled.

Numbers and density of elk, mule deer and pronghorn antelope are substantially higher in DAUs east of the river. Furthermore, these herds east of the Little Snake tend to be highly migratory, while populations west of the river tend to be substantially smaller and more sedentary.

Elk are common in most areas of Northwest Colorado. Elk populations were lowest shortly after the turn of the century but rebounded by the 1920s. Many elk summered in high elevation pastures in Routt and eastern Moffat counties and migrated west to Maybell and Elk Springs in central and western Northwest Colorado to winter. These migrating bands of elk were eliminated during the 1920s by hunting. From the 1930s to the 1980s, elk were rare in central and western Moffat County, with most elk remaining year round at higher elevations east of Colorado Highway 13. Elk began to re-establish westward migrations during the winter of 1978-1979. Movement increased following the 1983-1984 winter. Northwest Colorado elk populations peaked in the late 1990s and early 2000s. Elk populations in most areas of Northwest Colorado have stopped growing, but many are still above objective. Most greater sage-grouse habitats in Northwest Colorado are used by elk during the winter months.

Elk populations in Northwest Colorado are divided into the White River, Bears Ears, Cold Springs, and Rangely/Blue Mountain herd units (DAUs E-6, E-2, E-1, and E-21 respectively). A fifth DAU, E-47, is limited to only the small sliver of land west of the Green River along the Utah border. This relatively small elk herd is heavily influenced by Utah management and is not modeled by CDOW. The White River elk herd is the largest in Colorado by a substantial margin. The Bears Ears herd is the second largest in the state. Both herds are highly migratory, utilizing high elevation summer ranges in eastern portions of the DAUs and migrating west to low elevation winter ranges in significant numbers. Much of the winter range for each herd occurs within greater sage-grouse habitat. Particular areas of overlap occur in the Axial Basin, in Bald Mountain Basin and in the sandhills south of Maybell, CO. Elk winter range is shown in Figure 21. Both herds grew steadily, to remain substantially above objective from the early 1980s until recently. CDOW has been actively attempting to reduce the size of both herds, with some evidence in recent years that both are trending downward.

Elk populations in the Browns Park and Blue Mountain herd units are much smaller. Both herds are managed for production of high quality bull elk and are hunted under tight license limitations. Both herds are quite sedentary and exhibit only localized movements between seasonal ranges. Some winter overlap exists in eastern portions of both DAUs between these herds and migrants from the White River and Bears Ears herds.

Mule deer are widely distributed across Northwest Colorado. Mule deer numbers in northwestern Colorado peaked in the 1960's and 1970's and currently occur at much lower numbers in some areas. Population lows have generally followed severe winters such as those occurring in 1973-74, 1978-79 and 1983-84. As much as a third of the mule deer population in D-2 was lost during the winter of 1983-84. These population declines have generally been made up within 2 years of the severe winter event. Mule deer in this area spend the summer in small

bands scattered across suitable habitat. They are attracted to wet meadows and hayfields in the spring and fall and concentrate in sagebrush habitats in larger herds through the winter.

Mule deer populations in Northwest Colorado are likewise divided into four principal Data Analysis Units: White River, Bears Ears, Little Snake, and Rangely (DAUs D-7, D-2, D-1 and D-6 respectively). As with elk, the principal mule deer herds are located east of the Little Snake River. The White River mule deer herd is the largest in the state, and the Bears Ears herd is also one of the largest. Both herds exhibit substantial migratory behavior, though to a lesser extent than elk at present. The Browns Park and Rangely herds are smaller and more sedentary, generally staying within single or adjacent Game Management Units. These western herds are managed for trophy buck production under license limitations. Mule deer winter range is portrayed in Figure 23.

Pronghorn antelope occur in most habitats occupied by greater sage-grouse in Northwest Colorado. Long-time residents describe antelope as being rare in the early years of this century with populations establishing in many areas following the winter of 1948-1949. Antelope populations peaked in the early 1990s and have since declined as a result of increased hunting pressure and effects of drought. Traditionally found in lower elevation sagebrush habitats in western and central Moffat County, antelope have expanded their range east toward Black Mountain and California Park and southeast toward Hayden over the past two decades. This range extension has been particularly prominent during the past few years of drought. Many antelope have left drier traditional ranges in search of more nutritious forage. The effect has been particularly pronounced in the western end of the Great Divide DAU and in the Sand Wash DAU.

Pronghorn antelope populations are divided into five Data Analysis Units. These are the Great Divide, Sandwash, Maybell, Axial Basin, and Dinosaur herd units (DAUs A-9, A-11, A-10, A-34, and A-21 respectively). The Great Divide DAU includes the largest antelope population in Northwest Colorado and one of the largest in the state. Estimated antelope populations in the Great Divide DAU have grown from a low point of approximately 9,000 animals following the severe winter of 1983-84 to a high point of approximately 22,000 in 1993. Northern Moffat County occasionally receives an influx of antelope from Wyoming as antelope flee harsh winter conditions north of the state line. These population “bubbles” can last for several years as antelope slowly return north. Winters from 1993 through 2006 have been unexpectedly mild and have not produced these migrations. Antelope winter range is shown in Figure 25.

The Habitat Partnership Program and CDOW developed a habitat assessment model in 2005 (Wockner et al. 2005). This spatially based computer model is designed to evaluate the appropriateness of big game population levels on a landscape scale forage availability basis. The model was completed for all four of the deer and elk DAUs present in Northwest Colorado. It allows managers to evaluate the effects of varying populations of mule deer, elk and pronghorn antelope on vegetation, while taking into account precipitation, site potential and condition, vegetation production and livestock grazing. The model figures a very conservative allocation of

annual vegetative production to be left on the ground for ecological health (i.e. a lot of residual forage left behind), including (though not specifically) residual herbaceous growth for nesting sage grouse. The model also allows CDOW managers to look at potential implications of herd management decisions for one big game species on the other species. The model indicated that big game numbers at the time were sustainable on the basis of landscape scale forage availability, given average conditions, but that big game numbers were likely on the upper end of what could be sustained over the long term. A portion of the model output is reproduced in Table 12.

Lagomorph Populations

Species of lagomorphs (rabbits and hares) are often heavily represented in the diet of sagebrush steppe predators. Cottontail rabbits and white-tailed jackrabbits occupy most areas of Northwest Colorado, with black-tailed jackrabbits replacing white-tailed jackrabbits at lower elevations in Browns Park and the Dinosaur/Massadona vicinity. When lagomorph populations are high, they may take significant predation pressure off other animals in the environment, including sage grouse. When numbers of lagomorphs fall, predators may increase effort on peripheral species. This may have the effect of increasing predation rates on sage grouse.

Population levels of cottontails generally fluctuate over a five to seven year cycle across North America while jackrabbits fluctuate over approximately ten year periods. CDOW does not collect systematic data on lagomorph populations, however, field observations indicate that cottontail populations last peaked in north-central Moffat County in 1991, falling off soon thereafter. While portions of Moffat County began to see rebounding cottontail populations starting in approximately 2000, cottontail recovery in north-central Moffat County did not occur until 2004-05. Cottontail populations are quite high in many areas of Moffat County in 2006. Jackrabbit populations peaked around 1992 and also have not completely returned to prior levels in most areas of Moffat County, although there are signs of recovery in some areas in 2006.

Predator Populations

Populations of small mammalian carnivores and avian predators are difficult and expensive to census. Development and analysis of data on these species have not been traditional priorities of state wildlife management agencies, including the CDOW. Population indices derived from commercial fur harvest or livestock protection may be available for some species but should be used with caution as many factors other than population size have affected the harvest of furbearers through the years in Colorado. As a result, no good data are available on past and present populations of many of these predators. Some indicators of trend can be derived, however. These suspected trends are described below.

Beaver and Roth (1997) conducted a winter survey of raptors in northwestern Colorado and found an increase in winter raptor use. Anecdotal observations by GSGWG members and local biologists appear to confirm these findings. Populations of rough-legged hawks in the winter and red-tailed hawks in the summer appear to be increasing. Winter bald eagle census conducted annually by CDOW along the Yampa River has also shown a steady increase (CDOW

unpublished data). Wintering populations of golden eagles have not been counted by CDOW biologists, but most believe that the number of wintering golden eagles in Northwest Colorado is increasing. Population trends of summering golden eagles are unknown, but there is growing concern among biologists that summer golden eagle numbers are declining. The U.S. Fish and Wildlife Service initiated baseline golden eagle surveys in areas of the west in 2004 to evaluate golden eagle population trends (Good et al. 2004).

Anecdotal evidence supplied by both landowners and biologists suggests that raccoon and red fox populations have expanded in range and size in Northwest Colorado since the 1950's. Fitzgerald et al. (1994) state that the ecological role and current range of the raccoon is poorly understood in western drainages and imply that range expansion has occurred. Finley (1995) reports that raccoons have rapidly expanded into northwestern Colorado from the northern Great Plains and that populations of raccoon in the West are not confined to riparian areas and woodlands as they are on the Great Plains. He attributes the expansion of raccoon to the removal of wolves from western ranges, leaving room for expanded populations of smaller predators. Several GSGWG members have stated that raccoons were intentionally introduced to areas of Northwest Colorado by Colorado Division of Wildlife employees during the 1950s. Crowe (1986) states that raccoon were historically reported only in eastern counties in Wyoming but are now found statewide.

Crowe (1986) also suggests that the range of red fox has expanded in the sagebrush steppe ecosystem either through range expansion of native red fox following anthropogenic habitat alteration or colonization of new areas by red fox of hybrid native and introduced European bloodlines. Kamler and Ballard (unpublished manuscript) surveyed predator control records in western Utah and eastern Nevada and found that red fox had expanded from traditional high country ranges into low elevation shrublands during the 1980s and 1990s and predict significant increases in red fox predation of ground level bird nests, including those of sage grouse. Andelt (2003) reported more scent station visitations by red fox in areas of fragmented habitat in Northwest Colorado associated with agricultural land conversion than in areas with greater proportions of sagebrush vegetation.

The release and subsequent expansion of mid and small size predators with the removal of large predators has been repeatedly suggested (Finley 1995, Palomares et al. 1995, Henke and Bryant 1999) in recent years. Palomares found that a rabbit predation increased by a factor of 4.8 to 9.5 times with the removal of the top predator in the area (Iberian lynx). Henke and Bryant found that rodent diversity declined after coyote control was initiated in an area in Texas. While there is much work yet to be done to validate the meso-predator release hypothesis, it raises the question of unintended consequences of various predator control levels.

Population control of small carnivores has occurred in several ways in Northwest Colorado. The predominant control of these species in the 20th Century has been human caused. Trapping, shooting and poisoning of these mammalian and avian carnivores has accounted for much of the mortality of these animals in the past. Most of this human caused mortality has been associated

with ranching operations, particularly sheep ranches because of the greater vulnerability of young lambs to predation. Commercial harvest of some mammalian species for fur and recreational harvest has accounted for smaller proportions of the mortality. Human pressure on these small predators was probably greatest from the 1950's to the 1970's. The number of sheep operations in Northwest Colorado was at its peak during those years (Moffat County Assessor-Predator Control Tax Records). Poisons were widely available and extensively used over wide areas of public and private land. Fur markets were variable but fairly strong, and incidental or recreational harvest of these animals was largely unregulated.

Regulation of predator control began to increase in the early 1970's, reaching a peak in the 1990's. Sheep operations have since declined in number with resulting reduction of predator control efforts. Poisons are illegal for the control of most predators and have generated considerable public opposition, though some poison use still occurs. Enforcement of poisoning prohibitions, particularly with regard to raptors has been emphasized. Take and possession restrictions by the CDOW have increased, with the closure of some furbearer recreational seasons and substantial limitation of others. Public concern about the ethical implications of fur use and trapping has resulted in a near elimination of the commercial and recreational fur market, and a citizen-sponsored Constitutional amendment in 1996 eliminated the use of traps in Colorado for commercial, recreational, and agricultural harvest and damage control except under stringent limitations. These trends, singly and together, could tend to increase the size of predator populations if ecological "room" existed for the addition of predators in sagebrush ecosystems in Northwest Colorado. While there are no data to prove that predator populations have increased, GSGWG members speculate that populations of red fox, raccoon and golden eagles have increased in Northwest Colorado since the 1970's.

E. LAND USE TRENDS

Trends in Land Use and Management

Changes in land use in Northwest Colorado were initiated in the period between 1870 and 1880 with the advent of domestic livestock grazing and initial settlement (Athearn 1982). These changes have continued to the present with increased settlement and human population growth, larger and more efficient agricultural equipment and practices, and increased Federal programs affecting land management. Little, if any, of Northwest Colorado is in an undisturbed pre-settlement condition. Consequently, there have been significant and often permanent changes in vegetation types as well as extensive fragmentation (roads, trails, fences, power lines, encroachment of unsuitable habitat types, etc.) of the remaining vegetation that may be useful to greater sage-grouse.

Trends in Land Development

Northwest Colorado has experienced considerable development in the past several decades. Much of this development has occurred since energy booms in the 1970's expanded the population of Northwest Colorado.

Surface and underground coal mining is prevalent in areas of Moffat and adjacent Routt counties south and east of Craig, CO. Several of these mines occur in greater sage-grouse habitat. Ground and vegetation disturbance during mining can involve large acreages. Acreage permitted for coal mining in Northwest Colorado has been relatively static in recent years, but improvements in the economic value of coal increases the chance of existing mine expansion or new mine development. Several potential mine expansions in or adjacent to greater sage-grouse habitat have been proposed since 2000. Coal potential and mine locations are mapped in Figure 27. Subsequent reclamation and re-vegetation is generally successful and is often attractive to wildlife although reclamation in more arid environments can be difficult. Mined land reclamation in Routt County has been highly attractive to Columbian sharp-tailed grouse, due in large part to highly diverse seed mixtures planted on reclaimed lands (Boisvert 2002). Use of mine reclamation by greater sage-grouse has developed much more slowly due to the greater reliance on slow growing big sagebrush. Establishment of big sagebrush and other shrubs can often be difficult as a result of competition from other plants and wildlife use.

Oil and gas drilling also occurs across large areas of greater sage-grouse habitat, primarily in the northwestern, north-central, and east central portions Moffat County. Most greater sage-grouse habitat in Northwest Colorado occurs over high potential natural gas formations. Oil and gas development in greater sage-grouse habitat is also extensive in western portions of Rio Blanco County. Several oil and gas fields have been in long-term production in Northwest Colorado. The Rangely oil field has been in production since the 1920s. The Hiawatha and Powderwash natural gas fields have also been in production for decades but activity has proceeded at a relatively slow pace and with considerable spacing between wells. The Great Divide and Bighole Gulch fields were approved for downspacing to one well per 80 acres in 2003. The pace and density of natural gas development is increasing dramatically in recent years, particularly in the Great Divide area and in the area between Great Divide and the Little Snake River to the north. A substantial increase in deep coal bed natural gas is also occurring in central Moffat County between Craig and Maybell. Leasing interest in federal, state, and private oil and gas leases is widespread throughout Northwest Colorado. Expectations of 4000 new natural gas wells in the next 20 years are not unreasonable (BLM unpublished data). Oil and gas potential and current development areas are portrayed in Figure 28.

Oil facilities generally have a small footprint, usually a few acres or less, but each pad often contains tanks and other equipment for a period of years. Facilities may suppress greater sage-grouse use of habitat for a considerable distance beyond the actual footprint of the facility (Pitman et al. 2005, Robel et al. 2004) and can result in lek abandonment and increased mortality (Holloran 2005, Naugle 2006a). Compressor stations, active wells and drilling rigs produce loud and sustained noise that can interfere with greater sage-grouse, particularly during the breeding season. Effective reclamation of oil and gas pads and other facilities, including the re-establishment of big sagebrush in some instances, is important for maintenance of greater sage-grouse habitat in these development areas. This can be challenging in drier portions of Northwest Colorado. Reclaimed pad sites have been used as leks sites in some areas.

Figure 27. Coal potential and mine locations in Northwest Colorado

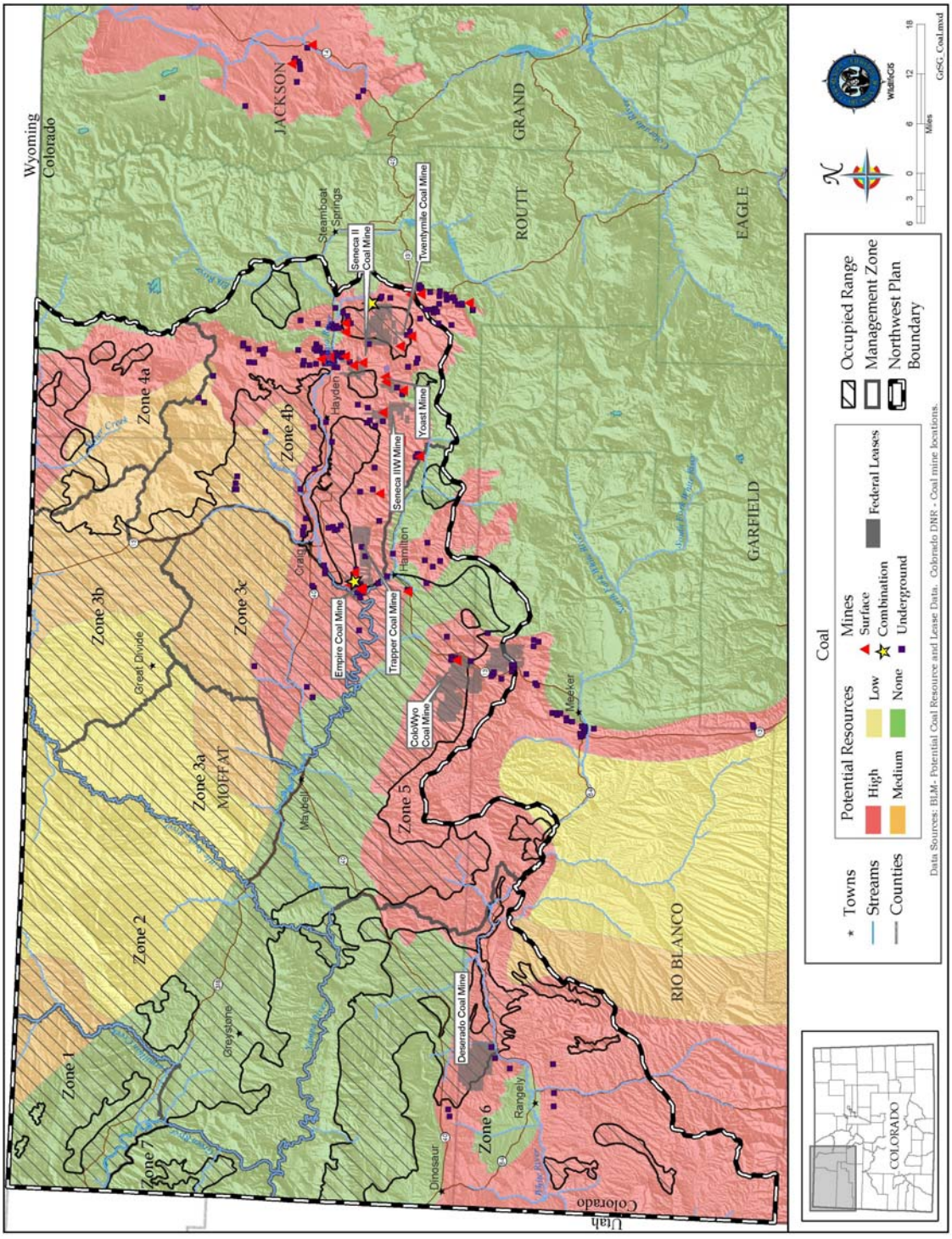
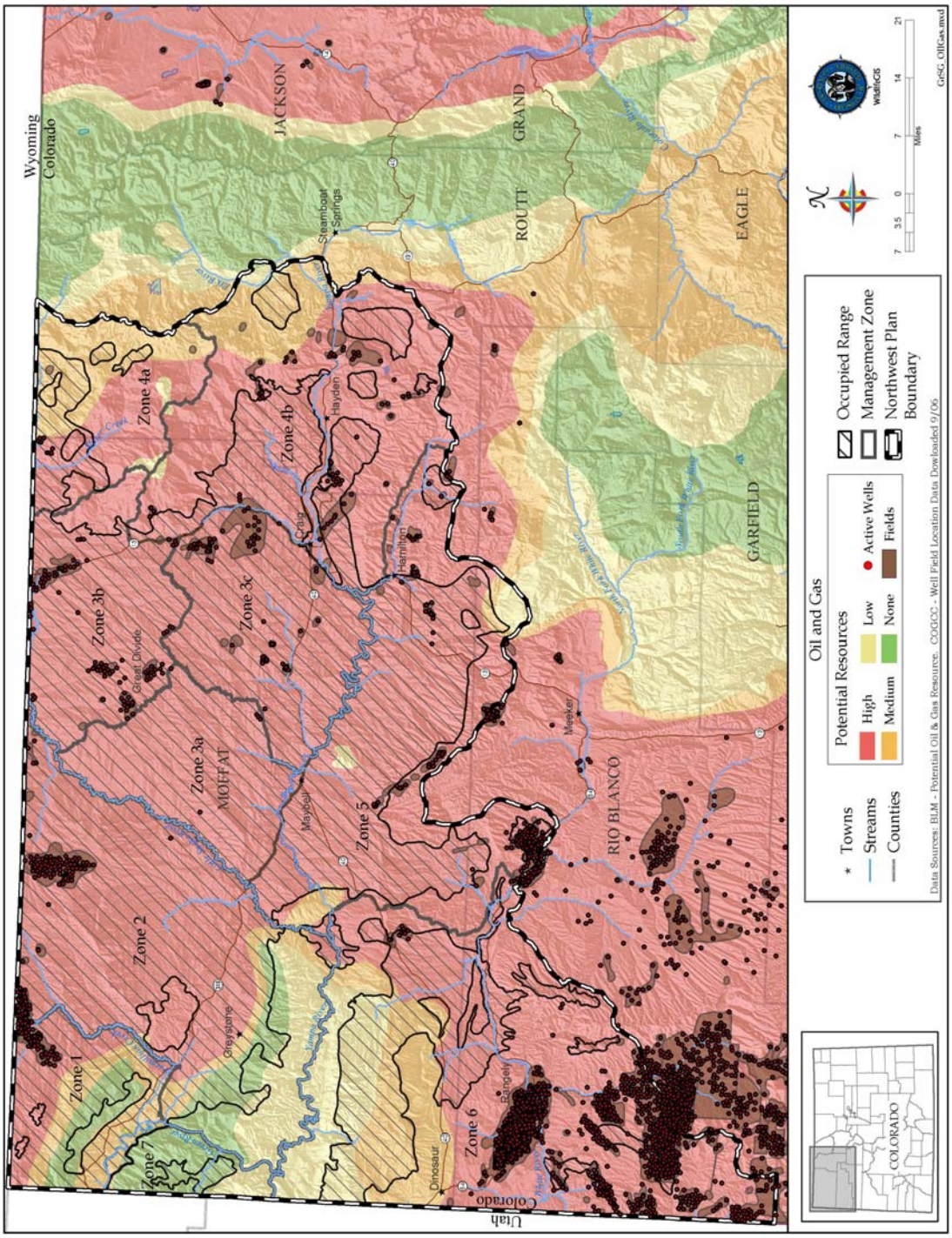


Figure 28. Oil and natural gas potential and development in Northwest Colorado



Homestead History

Large areas of Northwest Colorado were homesteaded during the 1910's and 1920's (Athearn 1982, Babcock 1990). Small homesteads were scattered across much of the county, generally located near water sources and wet meadows. These homesteads may have protected water sources from extensive livestock grazing. Many of these homesteads maintained small alfalfa fields, which provided greater sage-grouse brood habitat. Most of these homesteads, and their associated hayfields, were abandoned by the end of the 1950's.

There has been a trend of consolidating smaller homesteads/ranches into larger units for quite some time in Northwest Colorado. Perhaps the first example of this phenomenon occurred in Brown's Park (then known as Brown's Hole) about 1900. Since little demographic data was collected during this time period, personal accounts are among the few sources of information available.

The next examples of consolidating smaller homestead into larger units occurred in the Great Divide Region. In her 1980 unpublished manuscript, Liane Davis presented several Denver Post articles about a large land speculation in the 1930's. The promoters were also promising irrigation and increased settlement into the area. Most of the folks attracted to the area were not farmers and the irrigation system was not initiated, much less completed. As a result, nearly all the new farms were abandoned (Davis 1980). Other important homesteading areas include Fairview, Bord Gulch and Rabbit Gulch. Historic homestead areas are mapped in Figure 29. These areas are centered around rural school locations documented by Babcock (1990).

Little demographic data was collected during this time period. However, the 1945-1946 Colorado Year Book does offer some insight as to the reduction of farm numbers. In 1930, Moffat County reported 797 farms. In 1945, the number of farms had decreased to 360 (Anonymous 1947).

The most recent consolidation of agricultural lands began in the last 20 years. The increased efficiency and global economics of modern agriculture has reduced profit margins to a level that increases in the basic units of production are required to keep an enterprise viable. In the intermountain West, this has resulted in larger farms and ranches, development of agricultural land and many small farms and ranches that rely on non-farm income (Torell et al. 2002).

A new "homesteading" movement is underway in part of Northwest Colorado. Increasing numbers of small (35-40) acre residential developments are being created in sage grouse habitat, especially in portions of Routt County and northeast of Craig in Moffat County. Unlike the homesteads of the 1920's, these do not generally produce habitat valuable to sage grouse, but often result in the elimination of habitat.

Residential and rural housing in greater sage-grouse habitat was minor for many years after the abandonment of many homesteads in the 1930's. Small acreage lots, up to 40 acres in size, are increasingly being offered for home development. Many of these lots and the resulting homes

are in historic or occupied greater sage-grouse range. The impact of these small acreage rural sites, complete with buildings, dogs and cats, and more horses than pasture may have the greatest long term impact of any land development on sage grouse habitat. Residential development in greater sage-grouse habitat is most active in southwestern and central Routt County around the towns of Hayden and Steamboat Springs and in Moffat County west, northwest and northeast of Craig. Areas prone to residential development are mapped in Figure 29.

New and expanded highways, roads and rail sidings have cropped up to service mines, ranches, and residential properties. Fences have increased in number over the years as allotments have been split and cross-fenced, as rural properties are developed, and as new county roads cross greater sage-grouse habitat. Power lines have also increased in number and length. Several large transmission lines cross greater sage-grouse habitat to service mines and transfer electric power out of the area. Numerous service lines are also found in greater sage-grouse habitat. Major power lines are mapped in Figure 29.

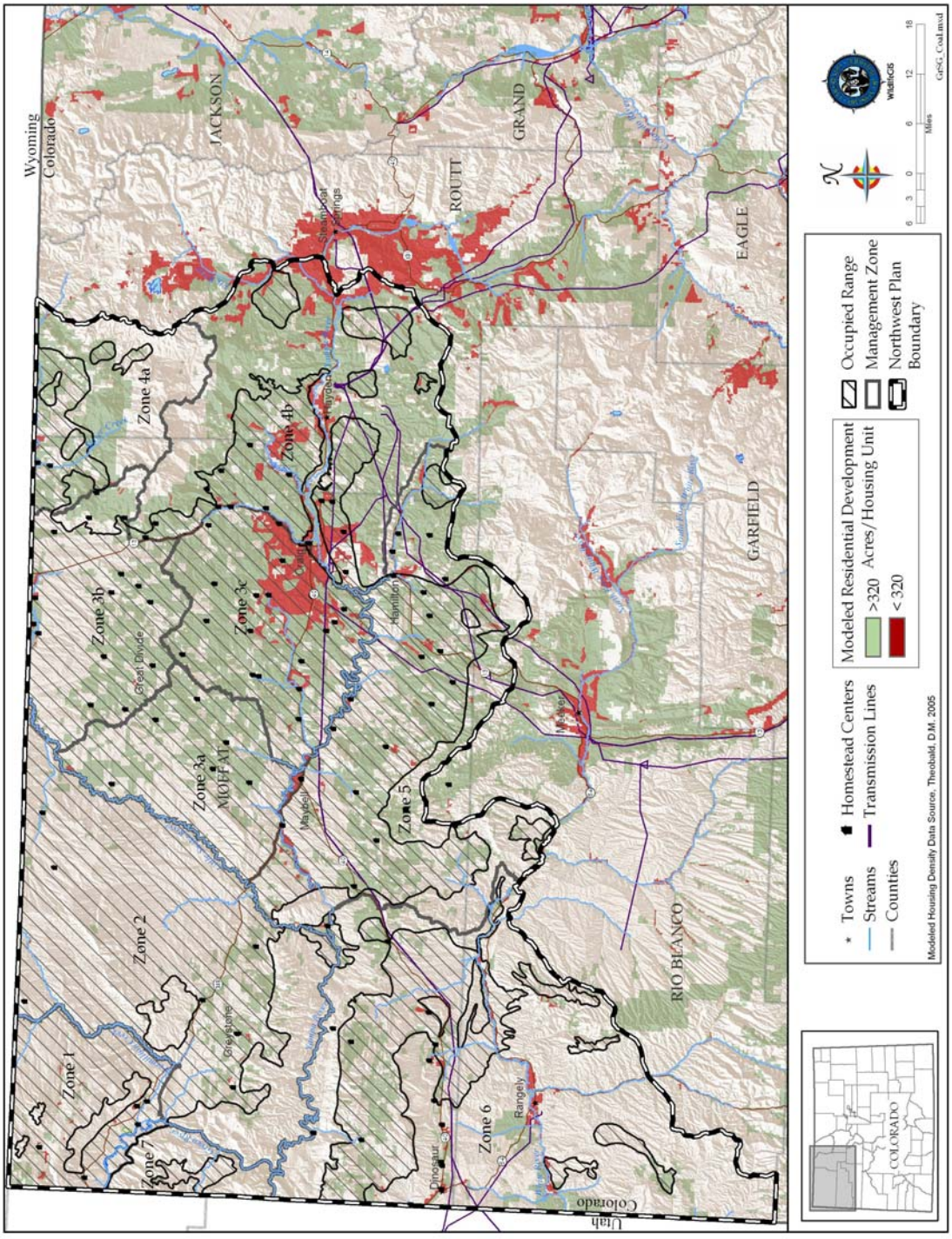
Trends in Agriculture

Livestock Grazing

In Northwest Colorado domestic livestock rely on sagebrush ecosystems and play a role maintaining sagebrush systems. The livestock industry is critical in providing open space for sage grouse habitat.

The history and place of herbivory in the Intermountain West often leads to debate about the appropriateness of domestic livestock grazing on federal lands (Vavra et al. 1994, Clifford 2002). Young (1994a), Young et al. (1976), Vale (1975b) and Daubermire (1970) have all indicated our current plant communities are different than those present "pre-European contact." All have listed numerous reasons for this difference including grazing, fire, introduced plants, agriculture and more recently, climatic change. In a somewhat different slant, Burkhardt (1996) questioned the often-held assumption that Intermountain plant communities evolved without the presence of large herbivores. In response to this assumption, land management practices (livestock grazing) were often developed with an additional assumption that livestock grazing was an unnatural impact on native plant communities. A rather large body of research was presented by Burkhardt that indicates plant communities in the Intermountain West did evolve in the presence of grazing by large herbivores, and paleontological/geological records indicate that Pleistocene era plant communities were similar to the present native flora of the Intermountain West.

Figure 29. Historic homesteads, modern residential development, and major power line map



Livestock grazing was introduced into the intermountain west in the mid to late 1800's. Records indicate livestock grazing was introduced to Northwest Colorado in the 1870's (Athearn 1982). Grazing was unregulated in Northwest Colorado until the formation of the USFS in 1903 and the formation of the Grazing Service in the 1930's. Most greater sage-grouse habitat in Northwest Colorado is grazed by domestic livestock. Current federal land grazing allotments are mapped in Figure 30. Several of the BLM allotments displayed as sheep or horse allotments also support cattle.

Historical numbers of livestock in Northwest Colorado have varied and, like other areas in the west, were affected by weather, markets, regulation, etc. There has been a general decline in sheep numbers in Northwest Colorado over the last 50 to 60 years while cattle numbers increased into the 1960s and then began to decline (Figures 31 and 32).

Wheat Farming and CRP

Wheat production began in Moffat County in the 1910's. Major expansion of acreage in grain production occurred in the 1940's as well as early in the 1970's. The amount of total acreage converted into cropland has not increased dramatically since the 1970s. The total acreage of cropland has decreased since 1977 while the acreage in the Conservation Reserve Program (CRP) has increased. Currently Moffat County has 33,284 acres in CRP and 9,651 acres in wheat. Routt County has 17,475 acres enrolled in CRP and 4,685 acres planted in wheat and other grains and oil crops in 2006. An additional 4,436 acres in Routt County is fallowed cropland. Rio Blanco County does not have significant wheat or CRP acreage in the Northwest Colorado greater sage-grouse area. Cropland areas are mapped in Figure 33. Two vegetation classes from the satellite imagery are shown: dryland agriculture and grass/forb mix. The dryland agriculture class includes most active cultivated lands as well as recent or maintained grass pastures. The grass/forb mix includes other lands where old fields have been planted back to grasses, including some CRP lands.

Many former wheat fields have been planted back to grass through the Conservation Reserve Program within the past 15 years. It may take many years, however, to return plowed ground to historic character, due to the long time required for big sagebrush to establish and become tall enough to provide nesting cover.

CRP, a program within the federal Farm Bill, was initially created to reduce soil erosion. Early CRP plantings were dominated by introduced grasses, as they provided the best short-term control of erosion. Most of these fields show little establishment of sagebrush at present. CRP land suitability as greater sage-grouse habitat was not a consideration during the early years of the program, and few forbs or shrubs were planted. Mandatory long-term rest of CRP grass stands with little management allowed grasses to reach and maintain dominance to the exclusion of sagebrush and may have provided greater benefit to generalist predators than greater sage-grouse. More recent CRP enrollments have encouraged the use of a broader mix of species including big sagebrush. Several early CRP fields have been enhanced with a broader range of native grasses, including bunchgrasses, palatable forbs, and big sagebrush. While most CRP

Figure 30. Federal land grazing allotments in Northwest Colorado

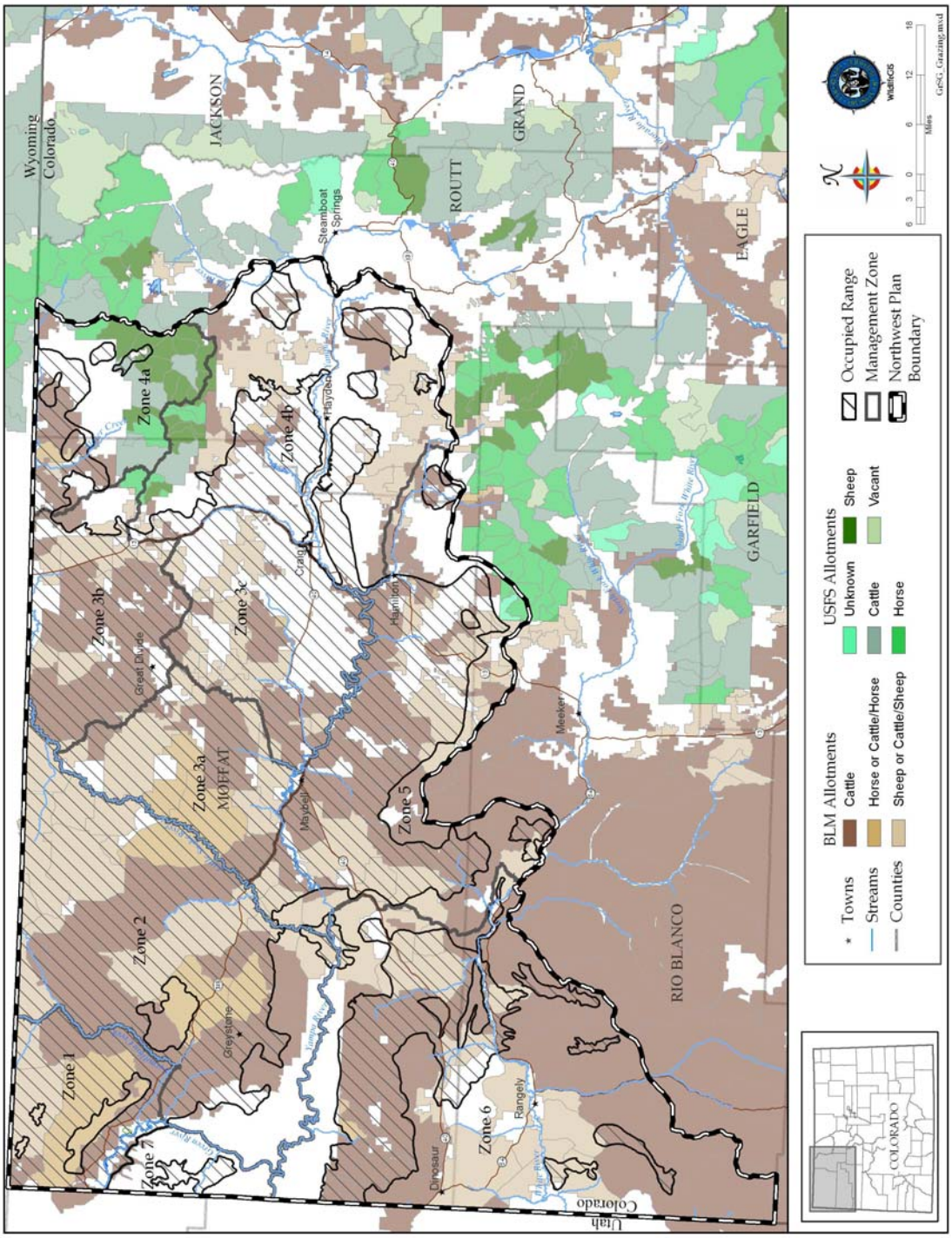
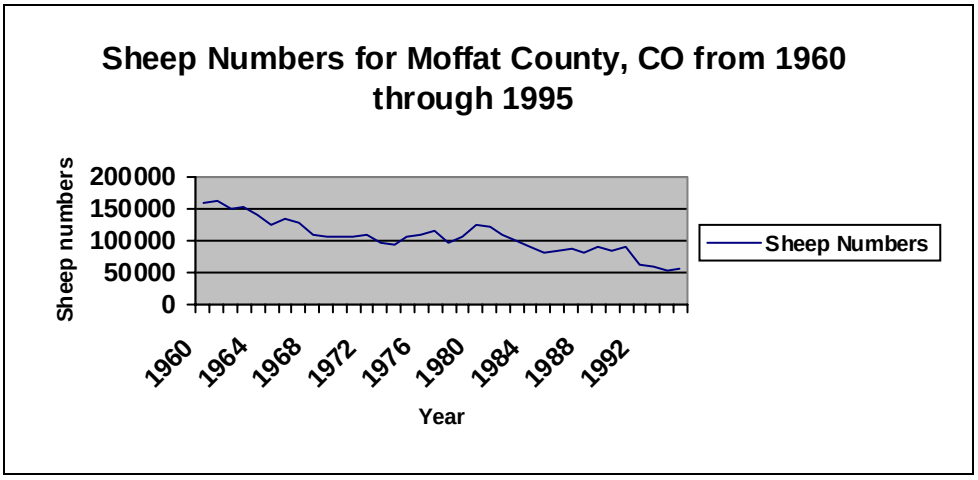
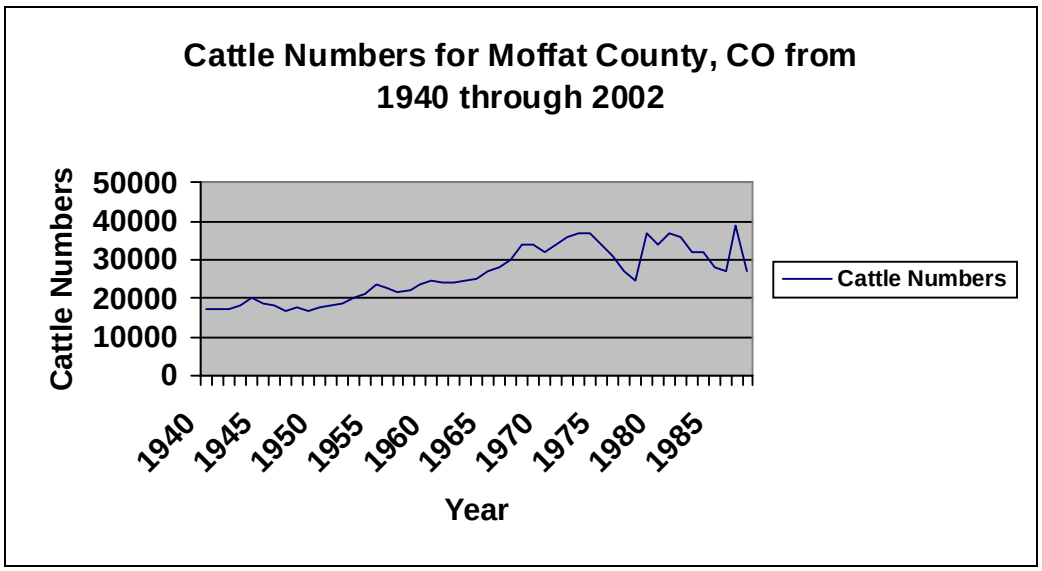


Figure 31. Sheep numbers for Moffat County



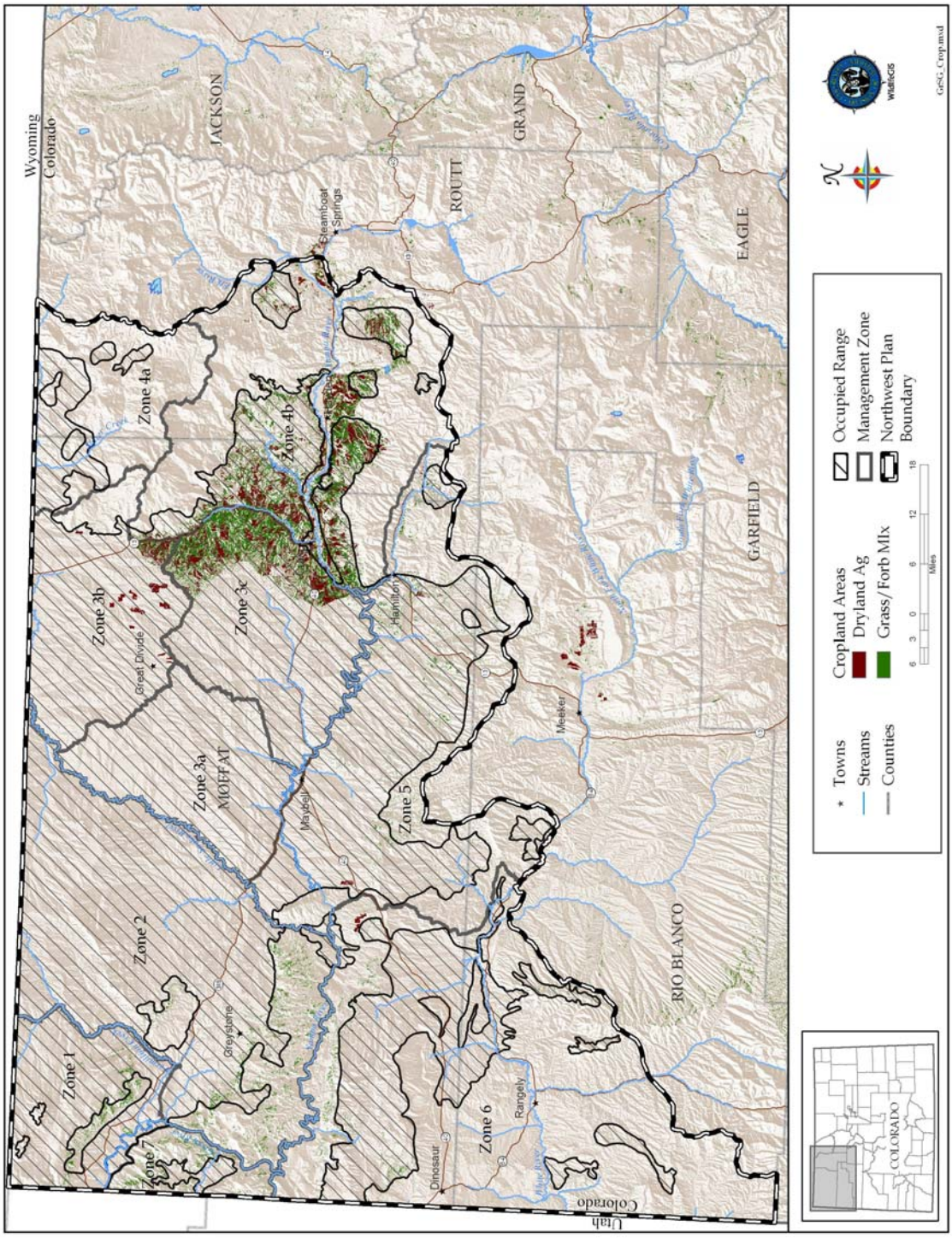
Sheep numbers for 1960 through 1987 are based on estimates of the USDA/ National Agriculture Statistics Service. Sheep Numbers for 1987 through 1995 are based on estimates of the Moffat County Assessor (Predator Control Tax).

Figure 32. Cattle numbers for Moffat County



Cattle Numbers for 1940 through 1962 are based on estimates of the USDA/ National Agriculture Statistics Service. Cattle Numbers were not reported from 1987 through 2000. Reporting resumed in 2001 and changed slightly in the data collected.

Figure 33. Cropland areas in Northwest Colorado



lands in Moffat and Routt counties do not yet provide high quality habitat for greater sage-grouse, continuation of the CRP program will allow those lands to eventually acquire the vegetative characteristics that are attractive to sage grouse.

The CRP program must be renewed periodically through the Farm Bill. CRP contracts carry a ten-year term. Most of the CRP acreage in Moffat and Rio Blanco counties expires in 2007. There will likely be a restructuring of the CRP program nationally that may affect the ability of Northwest Colorado landowners to re-enroll sage grouse habitat in the CRP program.

Socioeconomic Considerations

The economy of the communities in the Northwest Colorado greater sage-grouse planning area is inextricably linked to the non-renewable and renewable natural resources of the area. All of the top 17 county tax payers in Moffat County and 5 of the top 10 taxpayers in Routt County are energy related businesses (coal, oil and gas and power generation and distribution) in 2003-04 (Yampa Valley Partners 2005). Agriculture is also an important contributor to economic well being and quality of life in Northwest Colorado. Many portions of the area also depend heavily on hunting and other outdoor related recreation based on the environmental quality and resulting wildlife found in the northwestern corner of the state. Routt County is particularly dependent on natural amenity based recreational activities. All of these economic drivers make use of resources coming from of from under greater sage-grouse habitat. Many of them benefit from high quality, productive habitat. It is in Northwest Colorado's long-term economic interest to maintain greater sage-grouse habitat in productive condition.

Communities in the Intermountain West are reflective of diverse and complicated relationships between natural resource extraction industries (agriculture, minerals, energy development, etc.), landownership (private vs. public) and local, state and federal laws and regulations. These rural communities are also reflective of cyclic (boom/bust) economics and global economics that drive commodity prices (Torell et al. 2002).

Northwest Colorado is also reflective of these complex relationships. While livestock production is still the dominant use of the landscape, agriculture continues to change its role on the landscape. In their Community Indicators Project, the Yampa Valley Partners (2005) presented statistics to reflect this trend. In 1970, farm and ranch employment represented 22.5% of the total jobs in Moffat County. In 2000, only 7.8% of the total jobs were in the farm and ranch sector. Fewer farms and ranches over 1000 acres exist today vs. 10 years ago. Data on farms and ranches by size shows an increase in small or part-time operations. It indicates a consolidation of commercial operations, i.e. commercial agriculture must get bigger to survive as a sole source of income for a family. Since the 1970's and 80's additional water storage has been built and has allowed more acres to be irrigated today than in the 60's. Irrigated hay acres provide crucial insect populations for sage grouse chick survival.

Ranches provide large unfragmented tracts of land for greater sage-grouse habitat. It is recognized that preservation of these active ranches is crucial to the continued existence of greater sage-grouse in Northwest Colorado.

Even though the livestock industry is declining, it can still have significant impacts on other sectors of the local economy. Should greater sage-grouse be listed under the federal Endangered Species Act, the livestock industry as well as all other natural resource users in Northwest Colorado could fall under intense regulatory scrutiny (Vavra et al. 1994). Torell et al. (2002) address the economic implications of some grazing management alterations to benefit greater sage-grouse. Elimination of spring grazing on BLM ranges to enhance sage-grouse nesting habitat would have a significant impact on the viability of many ranches.

Broadly applying the take regulations within the Endangered Species Act could have significant impact locally. The local coal/energy industry could be particularly affected. Over the past thirty years, the industry has grown to become a significant portion of local economy. Listing the greater sage-grouse under the Endangered Species Act will increase bureaucratic processes in environmental permitting and compliance. A listing could result in slow growth and the elimination of new projects because of the increased cost of environmental permitting and compliance.

Listing greater sage-grouse under the provisions of the Endangered Species Act could also have a variety of other local impacts. Activities that could be affected include noxious weed control, maintenance of rights of ways, subdivisions and land development, livestock grazing management, big game wildlife management, and recreational land use.

While relationships between land use decisions and the local economy are fairly easy to conceptualize, determining an economic effect in actual dollars is often difficult. The magnitude of economic impacts is important to local decision-makers as it helps them to comment and react to land management decisions. An economic input/output (I/O) model is being developed for Northwest Colorado through the auspices of the BLM Little Snake Field Office Resource Management Plan revision currently in progress. A final model for local use will be available in the winter of 2006-07.

A major purpose of this conservation plan is to achieve long-term conservation of greater sage-grouse and sage-grouse habitat in Northwest Colorado without the need for the additional regulatory and potential economic burdens likely to result from a listing under the Endangered Species Act. The GSGWG believes that this local, non-regulatory approach to greater sage-grouse conservation will achieve more benefit for sage-grouse at less cost and with less disruption of economic and social networks than traditional regulatory mechanisms.

F. HISTORIC AND PRESENT ROLE OF FIRE IN SAGEBRUSH HABITATS

Sagebrush communities are very diverse. Winward (2004) describes the principal species of sagebrush found on the west slope of Colorado along with a description of the ecology of each. Sagebrush sites also vary considerably in species composition and richness, vegetative production and response to treatment based on a variety of conditions including soil, elevation, species or subspecies of sagebrush and other site characteristics (Miller and Eddleman 2001). Miller et al. (1994) summarized the prevailing view of the role of fire on landscapes in the sagebrush steppe ecoregion. Fire played an important role in maintaining the structure and composition of plant communities within the sagebrush steppe by allowing grasses and forbs to remain major components of sagebrush dominated rangelands. Fire suppression is also believed to play a role in allowing pinyon-juniper encroachment into sagebrush habitat. Greater sage-grouse have been shown to avoid areas with significant pinyon-juniper encroachment. Prior to settlement, fires are thought to have occurred, locally distributed across the landscape, every 50-100 years in the region. However, on some of the more productive mountain big sagebrush sites, fire frequencies have been reported to be between 17 and 25 years. Alluvial draws, often dominated by basin big sage, likely burned at greater frequency, but fires were generally confined to small areas in the bottoms and lower hillsides. Prior to settlement, fires were started by natural causes and were intentionally set by Native Americans. With settlement, both natural and human set fires were significantly reduced.

It should be noted that there is some dispute in the scientific community about the veracity of this traditional approach to sagebrush management. Welch and Criddle (2003), for example, argue that commonly stated historic fire return intervals for some sagebrush types are considerably exaggerated and further argue that the suppressive effect of sagebrush overstory on herbaceous understory is overstated. Careful monitoring of pre- and post-treatment stand conditions will need to be measured across a variety of sites to verify the accuracy of some of these principles.

Big sagebrush is generally intolerant of fire. It is frequently killed by fire and is a poor re-sprouter. While the historic pattern of sagebrush fires is difficult to determine, it is believed that many wildfires burned only small patches of sagebrush with relatively low intensity, due to a mix of sagebrush age classes in many stands, some of which were not as prone to ignite. Underlying grasses and forbs in the burn area were released, while younger "greener" sagebrush was preserved in surrounding areas. Research has shown that forage in recently burned areas is higher in nitrogen, a nutrient highly sought by wildlife and livestock.

Fire Effects On Different Species of Sagebrush
(Information from the Fire Effects Information System-www.fs.fed.us/database/feis/index.html)
Artemisia tridentata ssp. tridentata – basin big sagebrush
Basin big sagebrush is generally not preferred by sage grouse but sage grouse do feed on basin big sagebrush where mountain and Wyoming big sagebrush are absent. Basin big sagebrush is considered to provide good cover for sage grouse. Basin big sagebrush plants are killed by fires

and do not re-sprout. Seed does not survive exposure to heat but prolific seed production with high germination rates allows seedlings to establish quickly after a fire if an off site seed source is present. Recovery rates of basin big sagebrush stands depend on the size and patchiness of a burn. Interior plants that survive fires are important source of seed for recovery.

Artemisia tridentata ssp. vaseyana – mountain big sagebrush
Mountain big sagebrush provides an important source of forage and cover for sage grouse. Mountain big sagebrush is killed by even low severity fires and will not re-sprout. Regeneration of mountain big sagebrush relies on seed and rates of recovery vary widely. Seeds are short lived and probably do not form a persistent seed bank. Mountain big sagebrush requires at least 15 years to recover after a fire.

Artemisia tridentata ssp. Wyomingensis – Wyoming big sagebrush
Wyoming big sagebrush is considered a crucial food item of sage grouse and provides important habitat for the birds. Wyoming big sagebrush is generally the most palatable of the big sagebrush species. Wyoming big sagebrush is easily killed by fire and will not re-sprout. It is dependent on seed germination for recovery after a fire. Seedling growth is slower than other subspecies. Fire does not appear to affect germination rates of soil-stored seed. Burning in Wyoming big sagebrush usually does not increase forb density or diversity.

Artemisia cana – silver sagebrush
Silver sagebrush requires more moisture than most sagebrush species. In places where it is abundant, silver sagebrush is an important component of the sage grouse diet because it is one of the most palatable and nutritious sagebrush species. Nutritional content of silver sagebrush is highest in the spring and declines slowly over the winter. Silver sagebrush is used by sage grouse for thermal and hiding cover throughout its range and at lower elevations, it provides nesting cover. Fuel loads in silver sagebrush communities are generally high enough to carry fire and top-kill plants but it has a strong re-sprouting response. Fall burning may result in greater mortality than spring burns due to internal water stress. Regeneration is also possible from seed establishment after a fire but is not as strong as re-sprouting.

Artemisia frigida – fringed sage
Palatability of fringed sage for sage grouse varies across its range. It is rated as fair in Wyoming and good in Utah. Fringed sagebrush has minimal cover value for sage grouse due to its low growth form. Direct effects of fire on fringed sage vary depending on severity and season of fire. Fringed sagebrush typically reestablishes a burn site from surviving seed or off site seed dispersal but it is capable of re-sprouting. Fringed sagebrush produces an abundance of seed, which can remain viable in the soil for many years.

Artemisia arbuscula – low sagebrush
The forage value of low sagebrush is considered good for sage grouse in Colorado. Sage grouse use low sagebrush communities for nesting, roosting and resting sites as well as escape cover. Low sagebrush is usually killed by fire and is not capable of re-sprouting. Fire is not common in

low sagebrush stands and when it does occur, it is usually patchy and small in size due to low fuel loads. Regeneration after fires can occur within 2-5 years but may require more than 10 years and is dependant upon off-site seed sources.

Artemisia spinescens – budsage
Budsage is considered a desirable forage species and is important for upland game birds but has little cover value. Little information is available on fires direct effects on budsage but it is not capable of re-sprouting if killed by fire. Budsage relies on establishment from off site seed sources, which generally are not common because it flowers early and buds are often damaged by frost.

Artemisia nova – black sagebrush
Black sagebrush provides fair to good forage value for upland game birds and is used most in winter range and provides good cover for sage grouse. Sparse vegetation typically associated with black sagebrush stands reduces fire occurrence within these stands. When exposed to fire, black sagebrush plants are easily killed by fire and do not re-sprout. Regeneration occurs almost exclusively from seed, which can remain viable for up to 2 years.

Fire Suppression
Indirect fire suppression began in Northwest Colorado with the introduction of large herds of domestic livestock prior to the turn of the century. Historic grazing during this period reduced fine fuels and made existing sagebrush stands much more fire resistant. Direct fire suppression, the extinguishing of wildfires, became more common in the latter half of the 20th Century. Fire suppression from both causes is believed to have caused sagebrush stands to increase in canopy coverage and density with a resulting reduction or loss of herbaceous understory species in many areas. Sagebrush stands have become more even-aged and less productive across large areas of greater sage-grouse habitat. Fires that do start tend to burn greater acreage and at higher intensity due to the increased amount of fuel available to the fire. BLM fire data shows a rise in fire starts and acreage burned within the last 20 years of the 20th century (LSFO Fire Management Plan 2000). Recent wildfires in Northwest Colorado are mapped in Figure 34.

Fire Planning
The Little Snake Field Office of the BLM completed a Fire Management Plan in April 2000. The White River BLM Field Office completed their Fire Management Plan in 1999. These plans attempt to restore wildfire to its natural place in some sagebrush habitats in Northwest Colorado while protecting sage grouse habitats from excessive conversion of sagebrush cover due to fire. Moffat County and Rio Blanco County have also completed wild land fire planning for private and state lands that uses the same planning categories as the BLM Fire Management Plans. The Moffat County Fire and Fuel Management Plan enables resource managers to use wildfires to manage vegetation on private lands with the agreement of the landowner. Changes in legislation in 2000 allowed counties to move beyond fire suppression to managing wildfires for resource benefit and to reduce suppression costs. The choice to allow fires to burn will be initially made and regularly re-assessed according to several parameters at the time the fire starts and during the

fire, including fire fighting resources available, funding, weather, topography, firefighter safety, and potential benefits to the resource. Private landowners will be contacted immediately if fire is found on or near their property and their preferences for fire management will be determined. Numerous opportunities are outlined in the Moffat County Fire and Fuel Management Plan for partnerships among agencies and private landowners to implement fuel treatments that may enhance some sage grouse habitats and protect others.

Areas with significant infestations of annual weeds including cheatgrass and *Lepidium*, or invasive perennial weeds need to be carefully considered when applying fire to the landscape. Fire can dramatically increase the incidence of cheatgrass in burned areas, particularly those without substantial remnant stands of perennial native grasses. Repeated fires in these situations often result in type conversion of sagebrush habitats to cheatgrass or other invasive monocultures. The presence of adequate understory, presence of weeds, need for herbaceous reseeding, and status of sagebrush seed production on burn sites are all important considerations affecting plant community response when applying fire to sagebrush habitats (Monsen 2005).

Figure 34. Map of recent wildfires in Northwest Colorado greater sage-grouse habitat