III. CONSERVATION ASSESSMENT

In this section we provide the most current background information on Colorado GrSG biology, distribution, abundance, and genetics. We identify and describe pertinent mapping efforts, and for each local population, we estimate current population size, degree of genetic isolation, and amount and status of habitat. We also catalogue recent conservation efforts for GrSG and their habitats in each population area.

A. Biology and Life History

Species Description

Sage-grouse, the largest grouse species in North America, were first described by Lewis and Clark in 1805 (Schroeder et al. 1999). They are known for their strong association with sagebrush habitat, using sagebrush for both food and cover at all times of year. The species was originally given the scientific name *Tetrao urophasianus* (Bonaparte 1827), but was later renamed *Centrocerus urophasianus* (Swainson and Richardson 1831). Aldrich (1946) described eastern (*C. u.urophasianus*) and western (*C. u. phaios*) subspecies, but Benedict et al. (2003) found no genetic support for this distinction. All sage-grouse were considered a single species until Gunnison sage-grouse (*C. minimus*) were recognized as a separate species (Young et al. 2000), with all other sage-grouse now termed "greater sage-grouse". The 2 species are differentiated morphologically, by size (Hupp and Braun 1991, Young et al. 2000) and plumage (Young et al. 2000), genetically (Kahn et al. 1999, Oyler-McCance et al. 1999), and behaviorally by differences in strutting behavior (Barber 1991, Young 1994, Young et al. 2000). The current ranges of the 2 species are not overlapping or adjacent (Schroeder et al. 2004).

Greater sage-grouse are sexually dimorphic in size and plumage. Adult males weigh 5.5 - 7.0 pounds, adult females are 2.9 - 3.8 pounds, yearling males range from 4.9 - 6.2 pounds, and yearling females weigh 2.6 - 3.5 pounds (Schroeder et al. 1999). All GrSG are brownish-grey, and have black bellies, dark brown primary feathers, long tails, and yellow-green eye combs, but other features vary. Males sport a contrasting white upper breast and black bib at the throat, long black filoplumes at the base of the neck, and 2 yellowish air sacs on the chest, which are most conspicuous when inflated during courtship displays.

The life history characteristics of GrSG and Gunnison's sage-grouse (GuSG) are very similar. In this section, if data are specific to GuSG, it is so noted. Otherwise, all references are for GrSG.

Food Habits

Unlike many other game birds, sage-grouse do not possess a muscular gizzard (Patterson 1952) and therefore lack the ability to grind and digest seeds. They only occasionally, by accident, consume grit (Rasmussen and Griner 1938, Leach and Hensley 1954). With the exception of some insects in the summer, the year-round diet of adult sage-grouse consists of leafy vegetation.

Sagebrush leaves are the primary food source during the early spring (Patterson 1952, Rogers 1964, Wallestad et al. 1975). In the pre-egg-laying period, females may select forbs that are generally higher in calcium and crude protein than sagebrush (Barnett and Crawford 1994). During the first 3 weeks after hatching, GrSG chicks focus on insects (beetles, ants, grasshoppers) as their primary food (Patterson 1952, Trueblood 1954, Klebenow and Gray 1968, Savage 1968, Peterson 1970, Johnson and Boyce 1990, Johnson and Boyce 1991, Drut et al. 1994*b*, Pyle and Crawford 1996, Fischer et al. 1996*b*). Johnson and Boyce (1990) demonstrated in laboratory studies in Wyoming that GrSG chick growth and survival rates increase with the quantity of invertebrates in the diet. They also found that invertebrate forage is required to sustain GrSG chicks until they are at least 21 days old.

Diets of 4 to 8-week-old chicks were found to have more plant material (approximately 70% of the diet) than those of younger chicks, 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. 1996*b*, Huwer 2004). In Moffat and Grand Counties in Colorado, Huwer (2004) used human-imprinted GrSG chicks to experimentally test the hypothesis that chick growth rates increase with forb abundance. She found that in known brood-rearing areas with <10% to >20% forb composition, chick growth rates increased with forb abundance.

Although insects are consumed by adult grouse (Patterson 1952, Rogers 1964, Wallestad et al. 1975), forbs and sagebrush leaves comprise a majority of the summer diet (Rasmussen and Griner 1938, Moos 1941, Knowlton and Thornely 1942, Patterson 1952, Leach and Hensley 1954). 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). The quantity and make-up of forbs in adult GrSG summer diets varies with location.

From late-autumn through early spring the diet of GrSG 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 may be consumed, including big, low, silver, and fringed sagebrush (Remington and Braun 1985; Welch et al. 1988, 1991; Myers 1992; Connelly et al. 2000*c*). GrSG 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). Sage-grouse can gain weight over the winter (Beck and Braun 1978, Hupp 1987, Remington and Braun 1988, Hupp and Braun 1989a), but in exceptionally harsh winters, fat reserves can decrease (Hupp and Braun 1989a). During particularly severe winters sage-grouse are dependent on tall sagebrush that remains exposed above the snow.

Life History and Movements

Breeding

Sage-grouse are charismatic birds known for their elaborate spring mating ritual, where males congregate and “dance” to attract mates on traditional “strutting grounds”, more generally referred to as "leks" (Patterson 1952, Gill 1965). During the display, males step forward with their tail feathers and filoplumes held upright, inflate their air sacs, and produce distinctive “plop” sounds (Schroeder et al. 1999). Lek sites are open areas that have good visibility (allowing sage-grouse a greater opportunity to avoid predation) and acoustical qualities so the sounds of display activity can be heard by other sage-grouse.

The sage-grouse mating system is polygamous (a male mates with several females). Adult males defend territories within the lek arena, sometimes exclusively (Dalke et al. 1963, Wiley 1973*a*, Gibson and Bradbury 1987, Hartzler and Jenni 1988), and sometimes with overlap among territories (Simon 1940, Scott 1942, Patterson 1952, Wiley 1973*a*, Gibson and Bradbury 1986, Gibson and Bradbury 1987). Males may maintain the same territory in successive years (Dalke et al. 1963, Hartzler and Jenni 1988, Gibson 1992). Defense of a territory may include chases and wing fights with other males (Simon 1940, Scott 1942, Wiley 1973*a*), and can result in injury (Patterson 1952). Subadult males do not establish territories or mate, though they may attend the lek (Patterson 1952, Eng 1963, Wiley 1973*a*).

In Colorado, strutting occurs from mid-March through late May, depending on elevation (Rogers 1964). Males establish territories on leks in early March, but the timing varies annually by 1 - 2 weeks, depending on weather condition, snow melt, and day-length. Males assemble on the leks approximately 1 hour before dawn, and display until approximately 1 hour after sunrise each day for about 6 weeks (Scott 1942, Eng 1963, Lumsden 1968, Wiley 1970, Hartzler 1972, Gibson and Bradbury 1985, Gibson et al. 1991).

In Jackson County, Colorado, a seasonal peak of male attendance at leks occurred approximately 30 days following the peak of female attendance (Emmons 1980, Emmons and Braun 1984). Adult male sage-grouse seemed to show more fidelity to lek sites within a season than did yearling males. Emmons (1980) reported that yearling males visited 2 - 4 leks within a breeding season, while a majority of adult males visited only 1 lek. Emmons and Braun (1984) reported that inter-lek movements were more common than previously reported (Dalke et al. 1960, Wallestad and Schladweiler 1974). Emmons and Braun (1984) further reported that the adult and yearling seasonal lek attendance rates increased to 95 - 100% and then decreased later in the season.

Walsh (2002) reported much lower lek attendance rates in Grand County, Colorado, although he reported daily attendance rates rather than seasonal rates, and the research was conducted in only 1 breeding season. Lek attendance rate for adult males was 42.0% and ranged from 7.1 - 85.7%. Yearling male attendance rates were even lower at 19.3%, ranging from 0 - 38.5%. Yearling male attendance steadily increased through the season and there was a peak of male and female attendance in mid-April. Walsh (2002) also did not observe any inter-lek movements.

Females generally arrive on leks each morning after the males do, and depart while the males are still displaying. Both males and female juvenile GrSG in Colorado show some degree of natal lek site fidelity (Dunn and Braun 1985). Most females visiting the lek are bred by a few males occupying the most advantageous sites near the center of the lek (Scott 1942, Lumsden 1968, Wiley 1973*a*, Hartzler and Jenni 1988). When a female is ready to mate she invites copulation by spreading her wings and crouching (Scott 1942, Hartzler 1972, Wiley 1978, Boyce 1990). Males provide no parental care or resources and females generally leave the lek and begin their nesting effort immediately after mating.

Nesting

GrSG nests are not uniformly distributed within nesting habitat (Bradbury et al. 1989, Wakkinen et al. 1992). Research in Idaho has shown movements that range from 2.1 - 3.0 miles (Wakkinen 1990, Fischer 1994, Apa 1998). Radio telemetry research on GrSG in Colorado from 1978 - 2005 has illustrated that female movements are extensive, with 52% (n = 271/518) of the radio-marked females nesting within 2 miles of the lek of capture, and 80% (n = 417/518) within 4 miles of the lek of capture (Peterson 1980, Hausleitner 2003, A. D. Apa, CDOW, unpublished data, K. Giesen, retired CDOW, unpublished data). In addition, female grouse have been documented moving as far as 15 - 20 miles from the lek where they were captured (assumed to be the lek upon which they bred; Connelly et al. 2000*c*). More specifically, movements of females from the lek of capture to nest were a little less extensive in some populations within Colorado. Sixty-five percent (n = 64/99) nested within 2 miles and 89% (n = 88/99) nested with 4 miles from the lek of capture (Peterson 1980, K. Giesen, retired CDOW, unpublished data) in North Park. In southern Routt County and northern Eagle County, 48% (n = 15/31) and 97% (n = 30/31) of females moved 2 and 4 miles from the lek of capture, respectively (L. Rossi, CDOW, unpublished data). In northwest Colorado, 49% (n = 192/388) and 77% (n = 299/388) of females moved 2 and 4 miles from the lek of capture, respectively (Hausleitner 2003, A.D. Apa, CDOW, unpublished data).

Nests are typically shallow bowls lined with leaves, feathers and small twigs placed on the ground at the base of a live sagebrush bush (Schroeder et al. 1999). GrSG clutch size ranges from 6 - 10 eggs, with 7 - 9 being the most common (Griner 1939, Wallestad and Pyrah 1974, Connelly et al. 1993, Gregg et al. 1994, Schroeder 1997). In Moffat County, Colorado, GrSG clutch size averaged 5.7 eggs for yearling females and 7.0 eggs for adult females (overall average was 6.7 eggs; Hausleitner 2003). In addition, Peterson (1980) reported that the clutch of adult females was 7.0 eggs (range 6 - 9) and yearling clutches averaged 6.7 eggs (range 5 - 9). Incubation does not start until the last egg is laid and eggs are incubated 27 to 28 days (Patterson 1952, Peterson 1980).

GrSG have one of the lowest nest success rates of all the upland game bird species (Schroeder 1997), ranging from 63% in Montana to 10% in Oregon (Drut 1994, Connelly et al. 2000*c*). In Moffat County, nest success in 2001-2002 ranged from 45 - 60% (Hausleitner 2003). GrSG 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). Peterson (1980) reported a 33.3% re-nesting rate (females that lost their first nest and attempted to re-nest), while

Hausleitner (2003) reported lower re-nesting rates of 8 and 15% in 2001 and 2002, respectively. Clutch size of re-nesting attempts varies from 4 - 7 eggs (Schroeder 1997).

Although clutch initiation dates (date of first egg laid) can vary among years and locations, Hausleitner (2003) reported the mean clutch initiation date in Moffat County, Colorado as 26 April in 2001, and 21 April for 2002. Hatching begins around mid-May and usually ends by July. Most eggs hatch in June, with a peak between June 10 and June 20.

Survival

The survival rate of GrSG varies by year, sex, and age (Zablan 1993). Adult GrSG survival rates have been estimated from banding or radio telemetry studies (Table 4). There is evidence to suggest that adult female sage-grouse have higher survival rates than do adult males (Swenson 1986). This higher survival rate may be due to sexual dimorphism. Females have cryptic plumage and a more secretive nature, versus the more elaborate plumage and display activities of males (Schroeder et al. 1999). Seasonal female survival in Colorado was highest in winter (Hausleitner 2003). Predation, both on eggs and birds, appears to be a primary cause of mortality (Schroeder et al. 1999); human predation through sport harvest is also a cause of mortality. The availability of food and cover are key factors related to chick and juvenile survival. In Wyoming, survival of juveniles from hatch to fall was estimated to be 38% (June 1963).

Table 4. Annual survival rates of GrSG.

GrSG Sample	Survival Rate	Location	Study
Adult females	55%	Colorado	Zablan 1993
Females	75%	Idaho	Connelly et al. 1994
Males	60%	Idaho	Connelly et al. 1994
Females	67%	Wyoming	June 1963
Males	59%	Wyoming	June 1963
Adult Females (2001-2002)	65%	Colorado	Hausleitner 2003
Yearling Females (2001-2002)	71%	Colorado	Hausleitner 2003
Adult females (2002-2003)	48%	Colorado	Hausleitner 2003
Yearling Females (2002-2003)	78%	Colorado	Hausleitner 2003

Movements

Sage-grouse move seasonally among habitat types (Connelly et al. 2000*c*; see "Habitat Requirements" in this section). Depending on the dispersion of habitat across the landscape, this may result in the birds using broad landscapes throughout the year, moving great distances in some seasons, and exhibiting annual migratory patterns (Beck 1975, Wallestad 1975, Schoenberg 1982, Hulet 1983, Berry and Eng 1985, Connelly et al. 1988, Wakkinen 1990, Fischer 1994). If seasonal habitats are contiguous, the population may not show movement that could be considered migratory (Schroeder et al. 1999). The extent of movement in a given population varies with dispersion of cover types, topography, and severity of winter weather.

Connelly et al. (2000*c*) outline 4 different seasonal movement patterns, 3 that are migratory and 1 that is nonmigratory. Nonmigratory populations do not move greater than 6 miles between or among seasonal ranges. Migratory populations may be "2-stage" if they migrate among distinct winter, breeding, and summer ranges, or "1-stage" if they migrate only between 2 different seasonal habitat ranges (Connelly et al. 2000*c*).

Chicks are precocial and leave the nest with the hen shortly after hatching. Females with chicks move to areas containing succulent forbs and insects, often in wet meadow habitat, where cover is sufficiently tall to conceal broods and provide shade. Groups of unsuccessful females and flocks of males follow similar habitat use patterns during late spring and early summer, but are less dependent on wet meadow areas than are females with broods.

As fall approaches, intermixing of broods and flocks of adults is common, and the birds move from riparian areas to sagebrush-dominated landscapes that continue to provide green forbs. As late fall approaches, weather events trigger movements to winter areas. The timing of this movement varies, influenced by yearly weather conditions. Very little is known about dispersal of GrSG juveniles following brood breakup. Dunn and Braun (1985) found that females moved farther than males between their natal area lek and the lek attended in the following spring.

GrSG winter range in Colorado varies according to snowfall, wind conditions, and suitable habitat (Rogers 1964). Sage-grouse may travel short distances or many miles between seasonal ranges. Movements in fall and early winter (September-December) can be extensive, sometimes exceeding 20 miles. In North Park, Colorado, Schoenberg (1982) documented female GrSG moving more than 18 miles from winter to nesting areas. Hausleitner (2003) found that in Moffat County, Colorado, female GrSG moved an average of 6 miles from nesting areas to winter sites. The range of movements was extensive, and ranged from < 0.5 - 19 miles.

Flock size in winter is variable (15 - 100+), with GrSG flocks frequently comprised of a single sex (Beck 1977). Many, but not all, flocks of GrSG males can over-winter in the vicinity of their leks, and by March they are usually within 2 - 3 miles of breeding areas used the previous year. These movements depend on whether the population is non-migratory or moves between 2 or more seasonal ranges (Connelly et al. 2000*c*).

Habitat Requirements

Sage-grouse habitat requirements may differ by season (Connelly et al. 2000*c*). Connelly et al. (2000*c*) segregated habitat requirement into 4 seasons: (1) breeding habitat; (2) summer-late brood-rearing habitat; (3) fall habitat; and (4) winter habitat. In some situations, fall and summer-late brood-rearing habitats are indistinguishable, but this depends on the movement patterns of the population and habitat availability. The breeding habitat category includes lekking, pre-laying female, nesting, and early brood-rearing habitat. Summer-late brood-rearing habitat includes habitat used during this period by males, non-brooding females, and females with broods. Fall habitat consists of "transition" range from late summer to winter, and can include a variety of 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 sage-grouse habitats should include all habitat types necessary for fulfillment of life history needs.

For the purpose of this plan, we have combined the summer-late brood-rearing and fall habitat into a single habitat category, "summer-fall", resulting in 3 overall seasonal habitats, rather than 4. Summer-late brood-rearing habitat in Colorado is typically characterized by high elevation mesic areas, cropland, wet meadows, and riparian areas adjacent to sagebrush communities. Grouse continue to use these locales as fall approaches and there is a slow conversion of the diet from forbs to sagebrush. As mentioned earlier, in many cases these 2 seasonal habitats are indistinguishable, but in the future, local information may provide additional insight as to when and where late-summer and fall habitats can be clearly separated.

All the seasonal habitats described here include habitat used by brooding females, unsuccessful females, and male flocks.

Breeding Habitat: Leks (March – mid-May)

Lek sites can be very traditional, with grouse displaying in the very same location from year to year. Some GrSG leks in Colorado are known to have been in use since the 1950s (Rogers 1964). Leks are usually located in small, open areas, adjacent to stands of sagebrush with 20% or greater canopy cover (Klott and Lindzey 1989). Openings are usually natural, including alkali flats and meadows within sagebrush, but they may also be created by humans, including (but not limited to) small burns, irrigated pasture, and roads within sagebrush habitat (Connelly et al. 1981, Gates 1985).

Lek sites do not appear limiting (Schroeder et al. 1999), but they may vary in amount of escape cover and quality of sagebrush (Patterson 1952, Gill 1965, Connelly et al. 1988, Connelly et al. 2000*c*). The size of area needed for males to strut can vary greatly. 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 1975, 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), and acoustical qualities that allow sounds of breeding displays to carry (Patterson 1952, Hjorth 1970, Hartzler 1972, Wiley 1973*b*, 1974, Bergerud 1988*a*, Phillips 1990). The absence of tall shrubs, trees, or other obstructions appears to be critical for continued use of these sites by displaying males.

Sites chosen for display are typically close to sagebrush that is > 6 inches tall and has a canopy cover ≥ 20% (Wallestad and Schladweiler 1974). Usually leks are located in the vicinity of nesting habitat (Wakkinen et al. 1992), and are in areas intersected by high female GrSG traffic (Bradbury and Gibson 1983, Bradbury et al. 1986, Gibson et al. 1990, Gibson 1992, 1996). These sagebrush areas are used for feeding, roosting, and escape from inclement weather and predators. Males are usually found roosting in sagebrush stands with canopy cover of 20 - 30% (Wallestad and Schladweiler 1974).

Daytime movements of adult male GrSG during the breeding season do not vary greatly. Wallestad and Schladweiler (1974) found daily movements ranged between 0.2 and 0.8 miles from leks, with a maximum cruising radius of 0.9 - 1.2 miles. Ellis et al. (1987) reported that dispersal flights of male GrSG (to day-use areas) ranged from 0.3 - 0.5 miles, with the longest flights ranging from 1.2 - 1.3 miles. Carr (1967) recorded a cruising radius for male GrSG that ranged from 0.9 - 1.1 miles. Rothenmaier (1979) found that 60 - 80% of male GrSG locations were within 0.6 - 0.7 miles of a lek. Emmons (1980) reported that male dispersal distances to day-use areas of 0.1 miles were common and that 67% of all use areas were greater than 0.3 miles from the lek. In addition, Schoenberg (1982) found that male daily movements averaged 0.6 miles, but ranged from 0.02 - 1.5 miles.

Breeding Habitat: Pre-laying (late-March – April)

Connelly et al. (2000*c*) recommend that breeding habitat should be defined to include pre-laying habitat, but little is known or understood about pre-laying habitat. It has been suggested that pre-laying sagebrush habitat should provide a diversity of understory vegetation to meet the nutritional needs of females during the egg development period. For pre-laying females in Oregon, Barnett and Crawford (1994) suggested that the habitat should contain a diversity of forbs that are rich in calcium, phosphorous, and protein.

Breeding Habitat: Nesting (April – June)

GrSG prefer to nest under tall (11 - 31 inches) sagebrush (Connelly et al. 2000*c*). Peterson (1980) found in North Park, Colorado that nest shrubs averaged approximately 20 inches. In Moffat County, 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 northwestern 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 1967, Wallestad and Pyrah 1974, Keister and Willis 1986, Wakkinen 1990, Connelly et al. 1991, Apa 1998, Connelly et al. 2000*c*). Sagebrush canopy cover around nests in northwestern Colorado had a similar range of values, and averaged 27% (Hausleitner 2003).

Good quality nesting habitat consists of live sagebrush with sufficient canopy cover, and substantial grasses and forbs in the understory (Connelly et al. 2000*c*, Hausleitner et al. 2005). Few herbaceous plants are growing in April when nesting begins, so residual herbaceous cover from the previous growing season is critical for nest concealment in most areas, although the level of herbaceous cover depends largely on the potential of the sagebrush community (Connelly et al. 2000*c*).

Nearly all nests are located beneath sagebrush plants (Patterson 1952, Gill 1965, Gray 1967, Wallestad and Pyrah 1974), and GrSG nesting under sagebrush plants have higher nest success than those that nest under plants other than sagebrush (Connelly et al. 1991). Herbaceous vegetation is also important in sage-grouse nest sites (Connelly et al. 2000*c*). Grass heights are

variable and, as measured across the West, range from 5 - 13 inches (Connelly et al. 2000*c*). In addition, horizontal grass cover measurements are also variable and range from 4 - 51% cover. These measurements are similar to data from northwestern Colorado; Hausleitner (2003) reported that grass heights at nests ranged from 5 - 6 inches, grass cover averaged approximately 4%, and forb cover averaged about 7% (Hausleitner 2003).

Although not clearly understood, it is also believed that understory herbaceous cover (horizontal and vertical) is important for GrSG nesting habitat. In multiple studies, nest sites had taller and more grass cover, and less bare ground, than did random sites (Klebenow 1969, Wakkinen 1990, Sveum et al. 1998*b*, Holloran 1999, Lyon 2000, Slater 2003). In Oregon, both forb and tall grass cover appeared related to nest initiation, re-nesting, and nest success rates (Coggins 1998).

Breeding Habitat: Early Brood-rearing (mid-May – July)

Early brood-rearing habitat requirements are very similar to those for nesting habitat. Early brood-rearing habitat is found relatively close to nest sites (Connelly et al. 2000*c*), but individual females with broods may move large distances (Connelly 1982, Gates 1983). Early brood-rearing habitat is typically characterized by sagebrush stands with canopy cover of 10 - 15% (Martin 1970, Wallestad 1971), and with understories that exceed 15% herbaceous cover (Sveum et al. 1998*a*, Lyon 2000). In Moffat County, Colorado, sagebrush stands averaged approximately 11% canopy cover, and herbaceous understories averaged about 14% horizontal cover (Hausleitner 2003). High plant species diversity (sometimes also referred to as species richness) is also typical in early brood-rearing habitat (Dunn and Braun 1986, Klott and Lindzey 1990, Drut et al. 1994*a*, Apa 1998). Sagebrush heights ranged from 6 - 18 inches in Washington and Wyoming (Sveum et al. 1998*a*, Lyon 2000), and averaged about 23 inches in Moffat County (Hausleitner 2003). Adjacent shrub areas of 20 - 25% canopy cover have been reported as preferred for escape and day roosting (Wallestad 1971, Dunn and Braun 1986), but night roosting sites in Moffat County, Colorado had only 4% sagebrush canopy cover and sagebrush height was 20 inches (Hausleitner 2003).

In early summer, the size of the area used by GrSG appears to depend on the interspersion of sagebrush types that provide an adequate amount of food and cover. Females and broods may 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. 1996*a*). Females with broods remain in sagebrush uplands as long as the vegetation remains succulent, but may move to wet meadows as vegetation desiccates (Fischer et al. 1996*b*). 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 – Fall Habitat (July – September)

As sagebrush communities continue to dry out and many forbs complete their life cycles, sage-grouse typically respond by moving to a greater variety of habitats, and generally more mesic

habitats (Patterson 1952). Sage-grouse begin movements in late June and into early July (Gill 1965, Klebenow 1969, Savage 1969, Connelly and Markham 1983, Gates 1983, Connelly et al. 1988, Fischer 1994). By late summer and into the early fall, females with broods, non-brood females, and groups of males become more social, and flocks are more concentrated (Patterson 1952). This is the period of time when GrSG can be observed in atypical habitat such as farmland and irrigated habitats (Connelly and Markham 1983, Gates 1983, Connelly et al. 1988).

From mid-September into October, GrSG 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 (Wallestad 1975, Beck 1977, Connelly et al. 1988). During periods of heavy snow cover in late fall and early winter, use of mountain and Wyoming big sagebrush stands is extensive.

Winter Habitat (October-February)

GrSG winter habitat use depends upon snow depth and availability of sagebrush, which is used almost exclusively for both food and cover. Used sites are typically characterized by canopy cover >25% and sagebrush >12 - 16 inches tall (Schoenberg 1982), and are associated with drainages, ridges, or southwest aspects with slopes < 15% (Gill 1965, Wallestad 1975, Beck 1977, Robertson 1991). In Colorado, <10% of sagebrush habitat is used by GrSG during deep snow conditions (Beck 1977) because most of the sagebrush is buried under the snow. When snow deeper than 12 inches covers over 80% of the winter range, GrSG in Idaho have been shown to rely on sagebrush greater than 16 inches in height for foraging (Robertson 1991). Doherty et al. (2008) found that females preferred landscapes with extensive sagebrush habitat and gentle to flat terrain, and avoided areas with conifers, woody riparian zones, and rough terrain.

Lower flat areas and shorter sagebrush along ridge tops provide roosting and feeding areas. During extreme winter conditions, GrSG will spend nights and portions of the day (when not foraging) burrowed into "snow roosts" (Back et al. 1987). When snow has the proper texture, snow roosts are dug by wing movements or by scratching with the feet.

Hupp and Braun (1989*b*) found that most GuSG feeding activity during the winter occurred in drainages and on slopes with south or west aspects in the Gunnison Basin. In years with severe winters resulting in heavy accumulations of snow, the amount of sagebrush exposed above the snow can be severely limited. Hupp and Braun (1989*b*) investigated GuSG feeding activity during a severe winter in the Gunnison Basin in 1984, where they estimated <10% of the sagebrush was exposed above the snow and available to sage-grouse. In these conditions, the tall and vigorous sagebrush typical in drainages were an especially important food source for GuSG.

B. Distribution and Abundance

Distribution

Historic Distribution

The historic distribution of GrSG is closely tied to and largely reflects the distribution of sagebrush, particularly big sagebrush, and to some extent, silver sagebrush (Braun 1995, Schroeder et al. 2004). Direct observations and specimens of GrSG prior to the 1900s are limited in number and may not be adequate for drawing a historical distribution map. Instead, a map of historic sagebrush distribution can provide a reasonable and more thorough approximation of GrSG distribution.

Schroeder et al. (2004) presented a "presettlement" map of sagebrush habitat, targeting a period before pioneers of European descent inhabited the area. The map is based on a vegetation map by Kuchler (1985) and 7 GrSG "core" habitat types identified by Schroeder et al. (2004). Some of these "core" habitats are considered grasslands (of various plant species), but only local portions of these habitats known to be dominated by sagebrush were included in the presettlement map (Schroeder et al. 2004). In addition, 6 "secondary" habitat types, which may be of importance to GrSG under certain conditions, were included in the map if they were in currently or previously known occupied habitat, or if they were within 6 miles of core habitat (Schroeder et al. 2004). The vegetation data layer used by Schroeder was adequate for depicting rough historic range, but many inaccuracies became apparent at a statewide level with more robust vegetation datasets available for comparison.

In Colorado, sagebrush habitat was historically distributed in a discontinuous pattern, interrupted by topography and forested habitat (Braun 1995). GrSG occupied some portion of 12 counties in Colorado (Braun 1995, Schroeder et al. 2004). We adjusted the Colorado portion of the historical map by Schroeder et al. (2004), based on finer-scale knowledge of local topography and the current distribution of habitat. Specifically, we used data from the Colorado Vegetation Classification Project (CVCP, Colorado Division of Wildlife 2004*b*), a GIS data set that uses recent satellite imagery and field verification to classify vegetation into specific categories. What appear to be minor differences in mapping at the rangewide scale have more significance at the statewide scale, so a more precise data set is valuable.

We made several small additions to the Colorado portion of the historic distribution map in Schroeder et al. (2004), where sagebrush currently occurs in the CVCP (Colorado Division of Wildlife 2004*b*), and where no evidence exists that vegetation other than sagebrush was historically present (Fig. 2). A few areas that are very small even at the state scale were added, but are not identified in the figure or table. Some areas, known to have no historical sagebrush occurrence, were also deleted from the map.

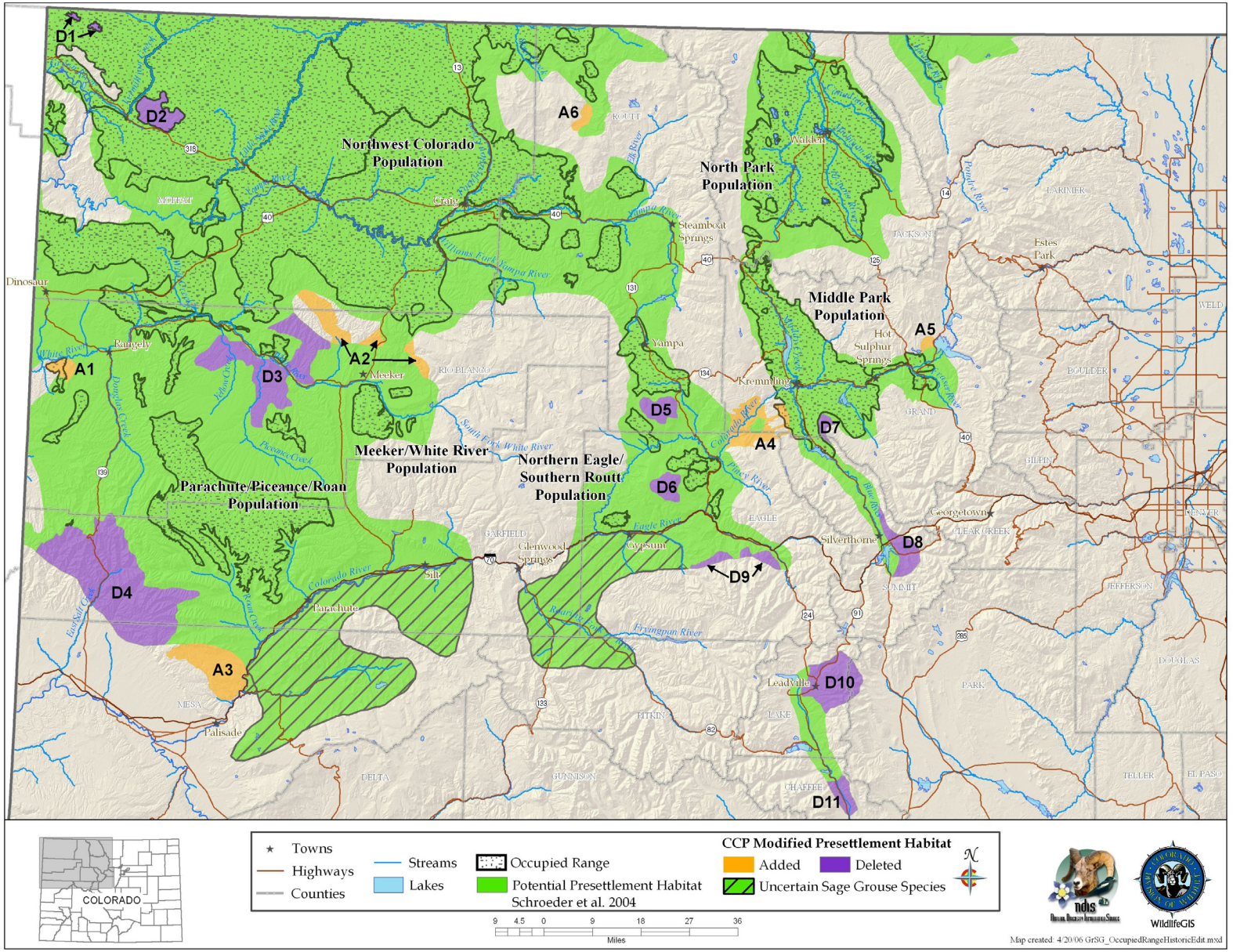

Fig. 2. The historic distribution of GrSG in Colorado most likely mirrored sagebrush distribution (based on Schroeder et al. 2004). See next page for map details.

Thus, the historic Colorado GrSG distribution map (Fig. 2) is based on Schroeder et al. (2004), but has been modified in 3 ways: (1) areas were added; (2) areas were deleted; and (3) areas were identified as range of "uncertain" sage-grouse species.

Areas Added to Historic Map

Areas added to the historic map (Fig. 2) were locales in which sagebrush occurs within the CVCP, (Colorado Division of Wildlife 2004*b*), and no evidence exists to indicate sagebrush was not in those areas historically. Areas were also added that have recently been identified as being potential habitat, based on the occurrence of sagebrush understory, that could be enhanced with restoration treatments. The CVCP project mapped vegetation classes using finer resolution data than Schroeder et al. (2004) used when broadly depicting historic habitat throughout the former range of the species. Hence, exclusions that seem minor at a rangewide scale have more significance at a statewide scale.

(A1) Shavetail Park, south of White River near the Colorado/Utah state line: area is currently occupied by sage-grouse and contains sagebrush.

(A2) Three areas around Strawberry Creek and Nine Mile Gap, north and northwest of Meeker, are mapped as potential habitat and contain sagebrush communities.

(A3) South Shale Ridge, northwest of Colorado River, is mapped as potential habitat. Large areas of sagebrush communities are in the area, as well as piñon-juniper with sagebrush understory, indicating piñon-juniper encroachment into a former sagebrush site.

(A4) Area between the NESR and MP populations is known to have had sage-grouse historically, and currently contains sagebrush and piñon-juniper/sagebrush areas that are identified and mapped as potential habitat.

(A5) Area west of Lake Granby contains sagebrush communities and irrigated agriculture areas that were most likely formerly sagebrush. Area is also identified as being potential habitat, and would be suitable habitat if some restoration is undertaken.

(A6) California Park, Routt County. Area contains sagebrush and sagebrush/mountain shrub mix and is identified as being potential habitat.

Other small areas that are difficult to see at the depicted scale were added to the historic map. The pre-settlement map was adjusted in these areas to include currently occupied or potential sage-grouse habitats.

Areas Deleted from Historic Map

Areas were deleted from the historic map (Fig. 2) due to them having non-GrSG habitat (according to CVCP vegetation classes), elevation constraints, and topography that led to conclusions of no occupation of sagebrush communities either presently or historically. For instance, some of the areas are in spruce-fir forests, in the alpine, or on steep, south-facing shale cliffs. The scale differences between the Schroeder et al. (2004) historic range mapping effort and the CVCP explain these discrepancies.

(D1) NWCO: these 2 areas are on Cold Springs Mountain and are the location of Middle Mountain and Diamond Peak, both of which are covered primarily with lodgepole pine, spruce-fir, and some aspen.

(D2) NWCO population: this area identifies the Little Bears Ears, a higher elevation area dominated by piñon-juniper woodlands.

(D3) NWCO population and Piceance portion of PPR: this area includes Black Mountain and North Ridge, near the White River, where elevation and vegetation types, predominantly thick piñon-juniper, exclude present or historic sage-grouse use.

(D4) PPR: this area includes a portion of the Bookcliffs, north of the Grand Valley, which is a steeply rising mountain range made up of shale cliff faces on the south side and piñon-juniper, spruce-fir, and aspen on top.

(D5) NESR population: King Mountain, which is dominated by lodgepole pine and spruce-fir mix.

(D6) Castle Peak: 11,275 feet and dominated by lodgepole pine and spruce-fir.

(D7) Williams Fork Mountains: dominated by lodgepole pine, spruce-fir, and aspen.

(D8) Keystone Area: dominated by Engelmann spruce, spruce-fir, and lodgepole pine.

(D9) South of Avon and Vail: slight boundary adjustment to take into account the higher elevations in this area within the White River National Forest, primarily dominated by lodgepole pine and spruce-fir forests.

(D10) Leadville and Mosquito Range on Continental Divide: high alpine area more suited for ptarmigan than for sage-grouse. Cover includes alpine, rock/talus slopes, and spruce-fir.

(D11) Along the Arkansas River in the Riverside to Berrian Park Area: ponderosa pine, Douglas fir, lodgepole pine, Engelmann spruce.

Uncertain Sage-grouse Species - Added

Schroeder et al. (2004) identified the 2 polygons shown as "Uncertain Sage-grouse Species" (Fig. 2) as being pre-settlement habitat for Gunnison sage-grouse, based upon 12 museum specimens (Table 5). The SC questioned the accuracy of the inclusion of these areas as GuSG pre-settlement habitat instead of GrSG habitat because the museum specimens were not actually reviewed by Schroeder et al. (2004). The CDOW requested and received photographs of the museum specimens that were from Garfield County (Table 5), but the photos were not conclusive in identifying the specimens (A. D. Apa, CDOW, personal communication). Morphological measurements or ancient DNA (deoxyribonucleic acid) analysis of the specimens are needed to accurately determine species. Until this is accomplished, the SC has agreed to refer to these areas as pre-settlement habitat for "Uncertain Sage-grouse Species". The SC does not intend for any historical GrSG habitat in these 2 areas to be managed as potential GrSG habitat until or unless it is proven that the museum specimens in question are GrSG.

A small area in the Colorado River/Plateau Creek triangle was added to the Uncertain Sage-grouse Species western-most polygon (Fig. 2) to account for existence of sagebrush communities and the area being mapped as potentially suitable habitat.

Table 5. Museum specimens collected for area identified in Fig. 2 as "Uncertain Sage-grouse Species".

SEX	AGE	NUMBER	DATE	SPECIFIC LOCATION	COLLECTION	COLLECTOR
Female	Adult	DMNH-27087	7/12/1905	Between Colter and Spitzer's Neck near Grand River	Denver Museum of Natural History	A. H. Felger
Female	Adult	DMNH-27088	7/12/1905	Between Colter and Spitzer's Neck near Grand River	Denver Museum of Natural History	A. H. Felger
Male	Unknown	AM-315107	3/7/1906	Garfield County	Agassiz Museum, Harvard University	J. E. Thayer
Male	Unknown	AM-315106	3/22/1906	Garfield County	Agassiz Museum, Harvard University	J. E. Thayer
Female	Unknown	FMNH-131312	10/27/1902	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9295)
Female	Unknown	FMNH-131313	10/27/1902	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9296)
Male	Unknown	FMNH-131315	9/14/1903	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9792)
Female	Unknown	FMNH-131314	9/15/1903	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9791)
Female	Unknown	FMNH-131316	9/15/1903	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9793)
Unknown	Juvenile	AM-272666	7/7/1904	Newcastle, Garfield County	Agassiz Museum, Harvard University	From Peabody Museum
Male	Unknown	AMNH-353699	9/15/1903	Newcastle, Garfield County	American Museum of Natural History	Unknown
Female	Unknown	AMNH-353700	9/15/1903	Newcastle, Garfield County	American Museum of Natural History	Unknown

Current Distribution

Colorado is on the southeastern edge of the current GrSG rangewide distribution (Fig. 3). It is, nevertheless, solidly within the range of the species, unlike some areas where populations were historically very limited in distribution and have since been extirpated (e.g., Nebraska; Fig. 3). Although GrSG distribution within Colorado has diminished (Braun 1995), the loss of range has been substantially less than in a number of other states, including Idaho, Oregon, and Washington. Thus, maintaining habitat and populations in Colorado will be important to conservation of GrSG on a rangewide basis.

A closer view of the Colorado, Utah, and Wyoming region (Fig. 4) appears to indicate that some Colorado GrSG populations cross state borders. Radio telemetry research has confirmed that GrSG in NWCO are part of a tri-state population (A. D. Apa, CDOW, personal communication). Although this is not surprising, it does underscore the need for agencies to coordinate population and habitat management efforts among the 3 states. The current tri-state distribution map (Fig. 4) is based on Schroeder et al. (2004), except that current GrSG distribution in Colorado is based on a more detailed Colorado habitat mapping effort (see "GrSG Habitat Mapping Efforts", pg. 66). Differences in map scale and data resolution between Schroeder et al. (2004) and the Colorado data are likely responsible for the apparent discontinuities in distribution that occur along state borders (Fig. 4).

GrSG currently occur in 6 separate areas in the northwestern quarter of Colorado (Fig. 5). We term these areas "populations", without implying that the populations are genetically distinct, or that they are completely isolated from each other. Rather, these "populations" are identified separately because they are, in most cases, physically separated to some degree, and individual local work groups have grown up around these separate GrSG areas to manage the "local" GrSG. Although many of the challenges facing GrSG are similar throughout the state, both biological and sociological issues may differ in importance among the different populations and local work groups. There is a small group of birds that occur in the Larimer River Valley, but this area is minimally addressed in this plan.

The identified GrSG populations occur in portions of 8 Colorado counties: Eagle, Garfield, Grand, Jackson, Moffat, Rio Blanco, Routt, and Summit. The most abundant and widely distributed population is the NWCO population, centered in Moffat County (Fig. 5). In some populations, we have identified "zones", or smaller areas within the population that are described separately and may be managed differently. In NWCO, the zones are based on GrSG management units used by the local work group. In the NESR population area, 2 zones are described, based on the path of the Colorado River. The "Routt" zone lies north of the Colorado River and the "Eagle" zone lies south of the Colorado River. Note that this line of demarcation is close to, but not identical to the line between Eagle and Routt counties.

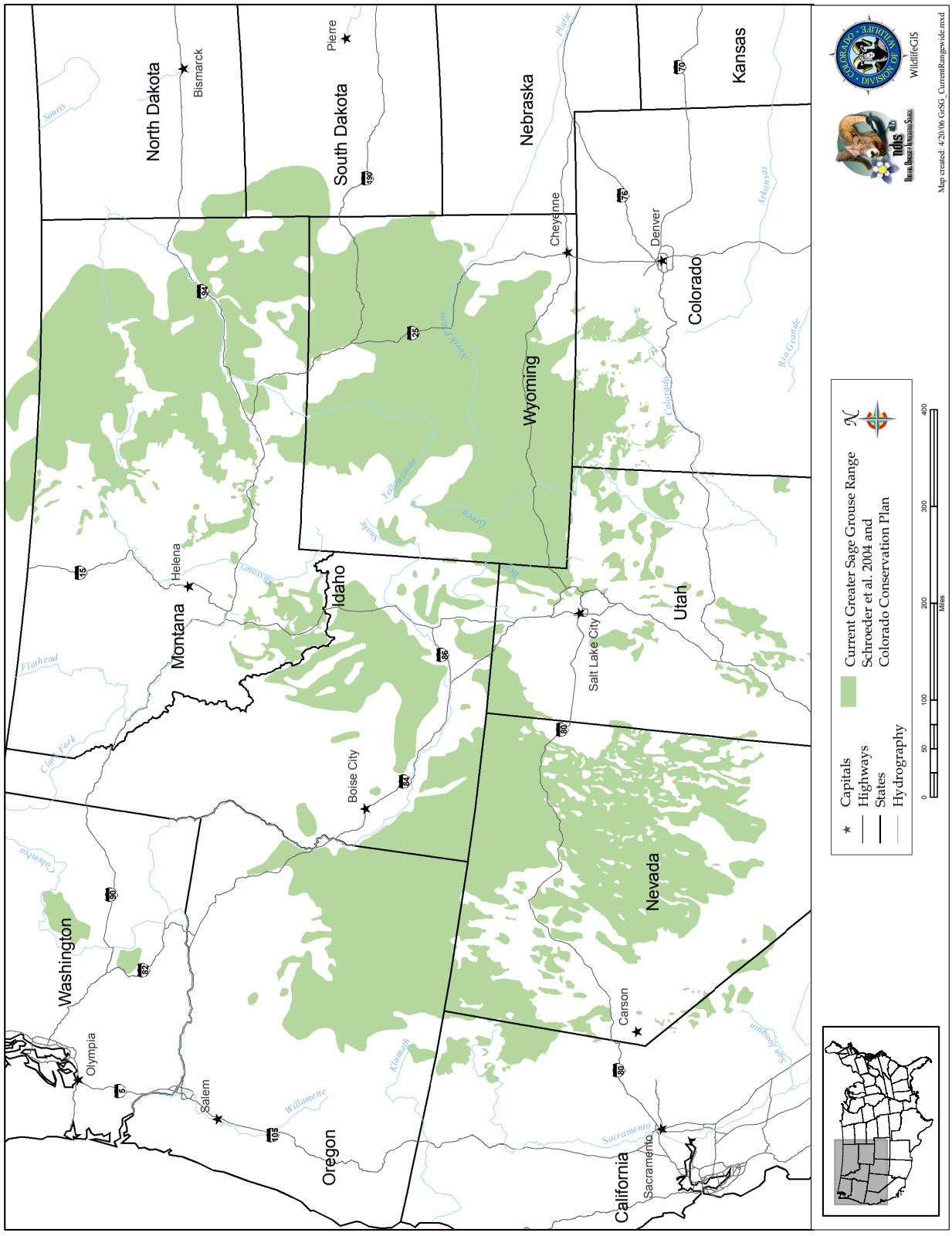

Fig. 3. Current rangewide distribution of GrSG (based on Schroeder et al. 2004).

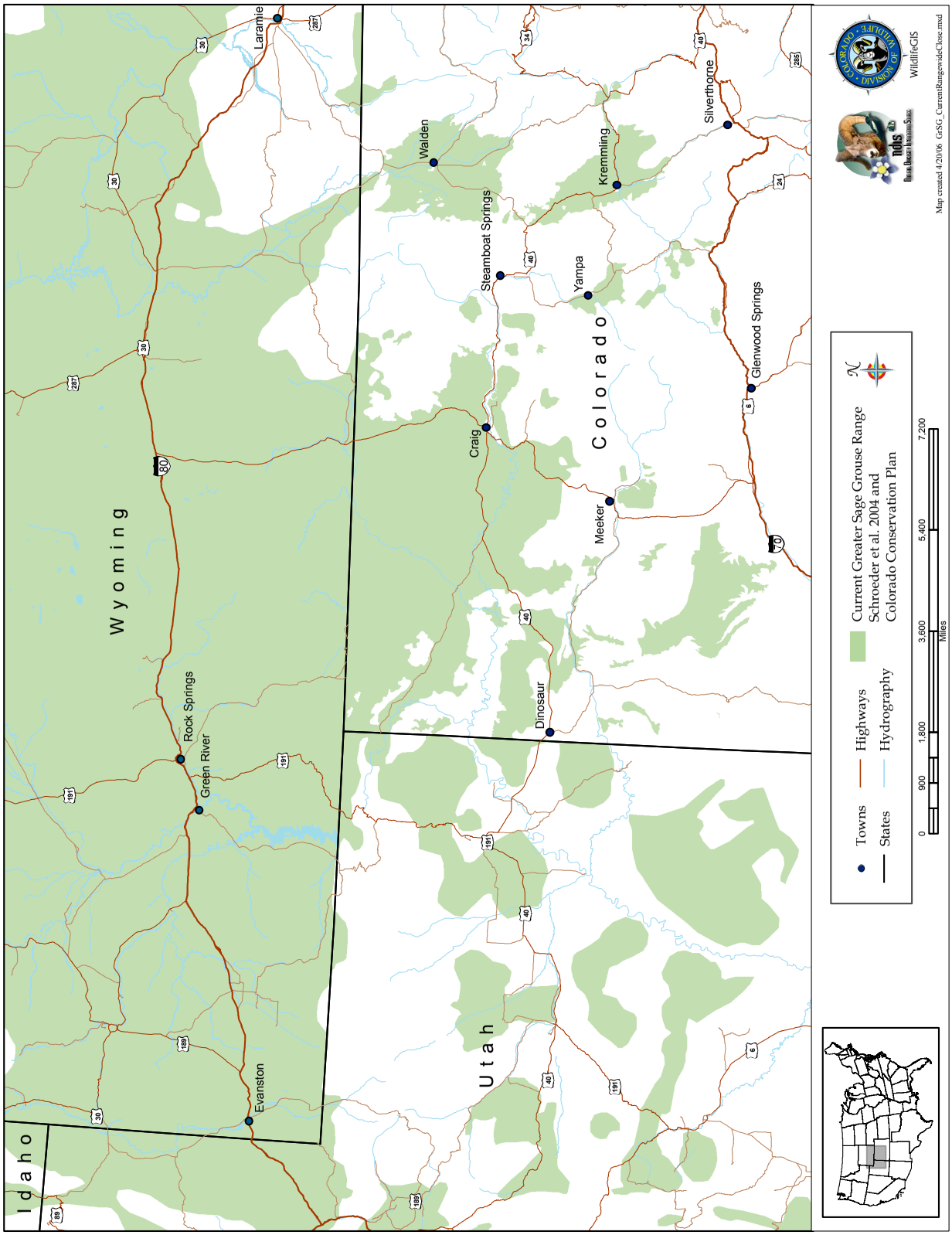

Fig. 4. Current distribution of GrSG in Colorado, Utah, and Wyoming (based on Schroeder et al. 2004).

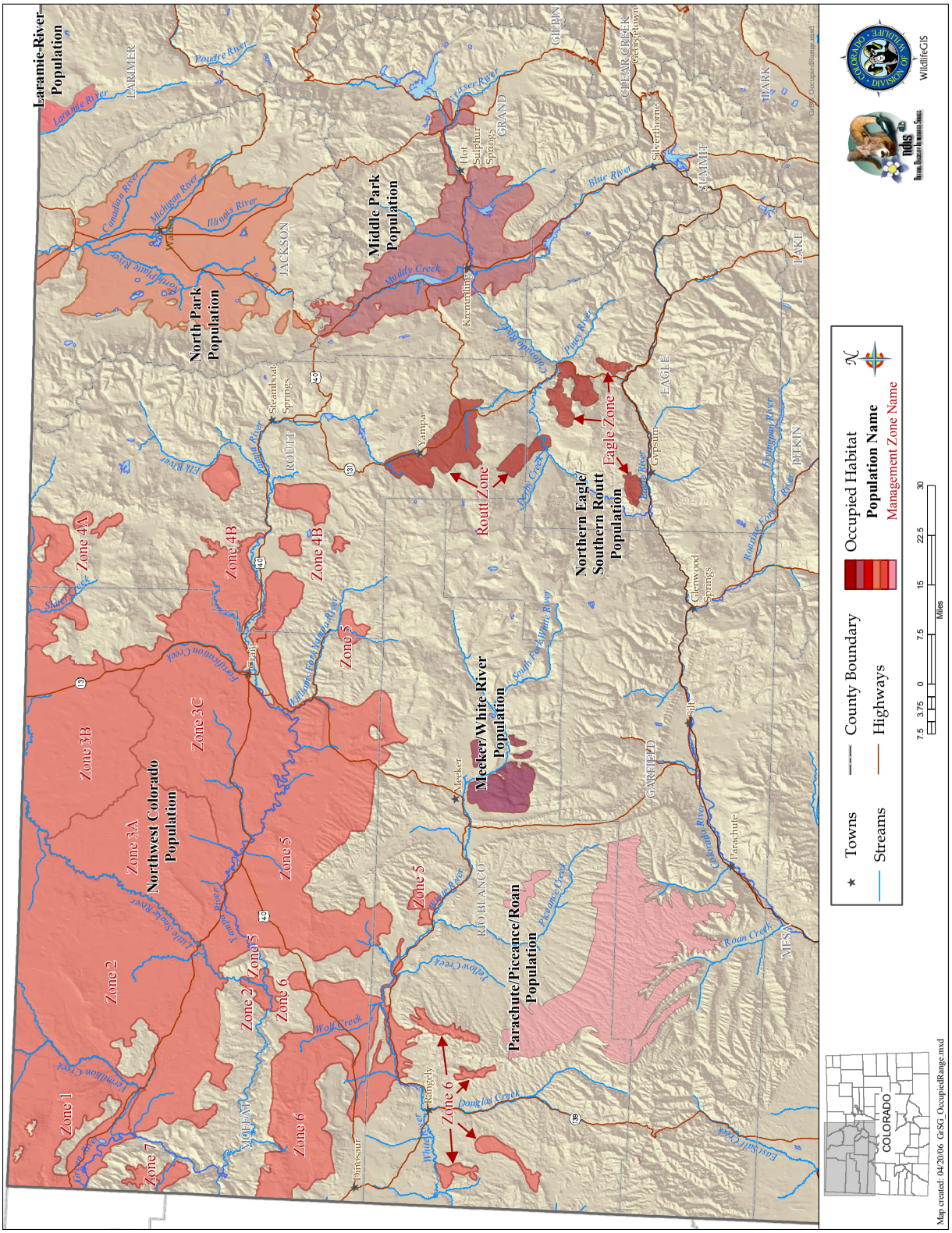

Fig. 5. Current distribution of GrSG in Colorado, illustrating locations of 6 populations.

Abundance

Lek Counts and Population Estimation

Inventory and monitoring of wildlife populations is an obvious prerequisite to conserving them, and is especially important when quantitative goals for species conservation have been developed. What is not obvious is how to accomplish inventory, and what level of resources is appropriate to commit to this task, since resources devoted to inventory and monitoring will not be available for other critical conservation tasks. Having accurate and precise estimates of GrSG numbers does not in and of itself improve the species' status.

Population trends of sage-grouse have been monitored across the western U.S. using variations on a lek count methodology first described by Patterson (1952), who studied sage-grouse in Wyoming. Patterson speculated that the maximum number of males counted over 3 or 4 counts spread throughout the display period might be a useful index to sage-grouse population trends. Wildlife managers have monitored populations of many species through the use of indices, where a count or measurement is made of some characteristic of a population that is both convenient to measure and is thought to be related to abundance. With birds, indices are often based on vocalizations made during the breeding season, such as pheasant "crow" call counts, dove coo-count indices, and bobwhite whistling counts (Lancia et al. 1994). Anderson (2001) noted the weaknesses of this type of sampling, which may be convenient for wildlife managers, but does not lead to defensible estimates of population size or status. The index, whether it is pheasant crows or the number of male sage-grouse counted on a lek, has an unknown relationship to the larger population of interest.

As a result of the publication of Patterson (1952), the lek count became the standard for sage-grouse population monitoring. Patterson (1952) based the census on the belief that all males regularly attend leks. His suggested maximum of 3 or 4 counts made sense under this assumption, because given normal environmental variables associated with lek counts (e.g., cold temperatures, snow, predator harassment), it might take 3 or 4 trips to get a "good" count of all the males present.

The lek count protocol proposed by Patterson (1952) has weaknesses. Dalke et al. (1963:833) thought lek counts provided a reasonably accurate method of determining breeding population trends, but noted the high degree of variability in daily counts and suggested a "…need for more refined census methods as sage-grouse management becomes more intensive in the future." Jenni and Hartzler (1978:51) used and supported the technique but speculated that high variance in counts was because "…some unestablished birds wandered about visiting different leks on different mornings."

Beck and Braun (1980) presented a critical review of the practice of using lek counts to assess population trends or size. They pointed out that without information on the total number of leks in an area, attendance patterns of adult and yearling males, inter-lek movements, and the relationship between the maximum count and the population size, nothing could be concluded

about population size or trends from lek counts. Despite these criticisms, the Western States Sage Grouse Committee essentially codified lek counts as a means to assess population trends 2 years later when it published its "Sage Grouse Management Practices" (Autenrieth et al. 1982). The publication advises caution in the interpretation of counts because of the high level of variance in the data, but no additional aid in interpretation of lek count data is given. The committee's most recent guidelines (Connelly et al. 2000*c*) also suggest viewing lek data with caution, but state that lek counts (per Autenreith et al. 1982) provide the best index to breeding population levels. In an extension of that assumption, Connelly et al. (2000*c*) reaffirm specific statements from Connelly and Braun (1997) that suggest there has been a 17 - 47% decline in breeding populations across their range.

Applegate (2000) and Anderson (2001) pointed out that index data cannot be extrapolated to estimates of animal density or abundance unless the proportion of the total population that is counted in the index method is known. For sage-grouse populations, this depends on (1) the proportion of leks that are known and counted; (2) the number and timing of counts conducted; (3) time of day in which counts are conducted; (4) lek attendance rates by yearling and adult males; and (5) the sex ratio of the population. All of these parameters are likely to vary significantly, both spatially and over time, yet when population estimates are derived from lek count data these parameters are assumed to be fixed constants.

Lek count data have been used to make inferences about sage-grouse population trends for at least 50 years, without any credible scientific investigation into the relationship between lek counts and population size. Because of the interest in having population estimates for sage-grouse (and because of the lack of other efficient methods for population estimation of sage-grouse), it is now a common practice to use lek data to estimate the size of various populations of sage-grouse. Multiple untested assumptions are often made in using lek count data to estimate sage-grouse population size (Table 6). These usually include assumptions regarding population sex ratio, an estimate of the percentage of leks that are counted, and the percent of males in the population that are counted at leks. The Washington State Recovery Plan for Greater Sage-grouse (Stinson et al. 2004) also mentions that males could make inter-lek movements, but does not address this in its estimates (Stinson et al. 2004).

Table 6. Untested assumptions made in using lek count data to estimate sage-grouse population size. In some cases the population estimate made was used to bracket one end of range of estimated population sizes.

Region/Source	Assumptions		
	Sex Ratio M:F	**Percentage of all leks that were located and counted**	**% of males (associated with the lek) that are actually counted**
Middle Park, CO / local plan (MPCP 2001)	1:2	90 %	75%
North Park, CO / local plan (NPCP 2001)	1:2	90 %	75%
Northern Eagle – Southern Routt Counties, CO/ local conservation plan (NESRCP 2004)	1:2.2	Not described	53%
Gunnison Basin, CO / local conservation plan (GBCP 1997)	1:2	80 %	(50 - 100 %) used 75 %
Nevada / statewide conservation plan (Neel 2001)	1:1.5 - 2.3	80 %	75 %
Washington / statewide conservation plan (Stinson et al. 2004)	1:1.6	100 %	100 %

Assumptions Made in Sage-grouse Population Estimation from Lek Counts

Here we examine 4 assumptions made in estimating population from lek counts.

(1) *Percent of Leks Counted.* We recognize that lek counts may be useful as a trend indicator. Under this assumption it is believed that a constant percentage of leks are detected. It is not necessary to know what the percentage of leks detected is, but to estimate population size, either all leks must be counted, or the proportion of the total that is counted must be estimated (lek detection probability).

Numerous studies have documented that lek densities can vary considerably over time. Bradbury et al. (1989) found a persistent excess of large and small lek sizes. Within an area, lek numbers seem to increase roughly in proportion to population size (Cannon and Knopf 1981). Core or "traditional" leks increase in size, while satellite leks appear and disappear as populations increase and decrease. Thus, it is probably not reasonable to assume that the proportion of leks detected is constant over time unless search effort increases proportionally as populations increase. Managers and researchers are also far more likely to detect and count a higher proportion of leks at low population densities than at high densities. It is probably also

not reasonable to assume unknown leks are of "average" size, because unknown leks are more likely to be satellite leks, and thus smaller. Lastly, because detectability may be a function of number of males, larger leks may be more noticeable.

(2) Inter-lek Movements. Attendance by males at more than 1 lek is problematic, because birds may be counted multiple times at different leks, thus inflating population estimates, or they may not be counted at all if they are attending a different lek when counts occur. The ability of lek counts to serve as an index to population trends will not be affected by inter-lek movements if the movements are relatively constant from year to year. Unfortunately, inter-lek movements are both significant and variable. Dalke et al. (1963) reported inter-lek movements by individual (banded) adult males varied by year from 22 - 47%. Dunn and Braun (1985) recorded no marked birds moving between leks in 1982, but 14 of 91 (15%) were observed at 2 or more leks in 1983. Emmons and Braun (1984) reported all (11) juvenile males attended from 2 - 4 leks during the breeding season, while inter-lek movements of adults were infrequent (3 of 11; 27%).

(3) Lek Attendance. Population estimates from lek count data assume that a constant proportion of males, often 75%, are detected by the maximum of 3 - 4 counts (e.g., Table 6). There is considerable evidence that lek attendance is highly variable due to age, social status, weather, body condition, and parasite load or disease. Patterson (1952:152) suggested that all males regularly attended leks, although the only data he presented to support this assertion was: "All these marked birds were identified morning after morning occupying the same territory on the strutting ground." He was examining marked birds with respect to territoriality in this reference, and the marking referred to birds he captured on leks and dyed, or birds he identified by tail feather patterns. Dalke et al. (1963:820) didn't calculate attendance rate for banded birds, but indicated that "…banded males were ordinarily absent from the strutting grounds from 1 to 3 days at a time…", and "The less dominant males were irregular in their visitations. The dominant males were present almost daily under all conditions." Dalke et al. (1963:822) also noted, "Banded males were often seen in the sagebrush adjacent to the strutting grounds," although this was attributed to trapping disturbance. Hartzler (1972) documented males with almost daily lek attendance and others that only sporadically attended leks in Montana. Wiley (1973*a*) stated that there was an abundance of males that didn't attend leks, and he further speculated (Wiley 1974) that attendance patterns of males were likely to be a function of density (lek size). Dunn and Braun (1985) reported daily attendance rate of marked adult males was only 43%, ranging from 3 - 96% for individual males. Daily attendance by yearling males was only 33% (Dunn and Braun 1985).

One bias in assessing attendance based on observations of banded birds is that apparent low attendance may be caused by mortality of banded birds. Emmons and Braun (1984:1023) studied male sage-grouse lek attendance with the objective "…to examine the daily attendance patterns on leks of male sage-grouse during the breeding season," but lumped attendance across 5-day, 15-day, or season-long averages. Although their data indicated significant within-year and across-year variation even when lumped into 5-day intervals, they did not report what fraction of radio-marked males would be detected by normal counting protocols. Since 93% of the birds on which attendance rates were based were trapped while night-roosting on leks, it is probable the birds caught were highly territorial, dominant males who regularly attend leks, and thus it is likely the estimate of lek attendance may be biased high.

The physical condition of sage-grouse can also affect their attendance at leks. Hupp and Braun (1989a) found that sage-grouse had depleted lipid and protein reserves following a severe winter in Colorado. This, and snow cover, caused the birds to largely delay initiating display activities until late April. There was substantial variation in lipid reserves across 3 years, which could impact lek attendance and display rates. The authors noted substantially higher variation in lek counts within a season for GuSG than for GrSG in North Park.

Boyce (1990) reported that males with avian malaria were significantly less likely to attend leks than males without malaria, and that malaria varied spatially and temporally across 11 leks in southeast Wyoming. Thus, disease prevalence has the potential to impact attendance rates and lek counts, and variability in disease prevalence may increase variability in attendance rates.

Walsh et al. (2004) studied attendance rates of radio-marked and color-banded male and female sage-grouse captured during winter in Middle Park, Colorado during 1 mating season. They found male daily attendance rates were highly variable (7 - 86% for adults, and 0 - 42% for yearlings), and influenced by age, date, and time of day. They documented that counts conducted between half an hour after sunrise and 1.5 hours after sunrise (typical when managers count more than 1 lek in a morning) detected only 74% and 44% of the actual high count of adults and yearlings for that day, respectively.

(4) Sex Ratio. Most population estimates derived from lek counts assume 2 females/male in the breeding population (e.g., Table 6). This assumption is based on long-term wing data obtained by determining sex and age of wings obtained at wing barrels or check stations (CDOW, unpublished report). It is apparent both from wing data and from population modeling that sex ratios vary markedly from year to year. This is because males encounter higher mortality rates as they mature and enter the breeding population (Zablan et al. 2003). Therefore, the sex ratio will be a function of the age structure of the population; older age-structured populations will have high female-to-male sex ratios because this differential mortality will have had longer to operate. Following years of above-average recruitment, populations will have female-to-male sex ratios closer to 1:1, since yearling and first-year adults will dominate the population and will have experienced little differential mortality.

Sex ratios for all age classes (immature, yearling, and adult) of GrSG from wing data (CDOW, unpublished report) yielded varying sex ratios. In Middle Park from 1976-1993, wing data yielded 1.5 ± 0.5 females/male. In Northwest Colorado wing data yielded 1.6 ± 0.4 females/male from 1976-1998. In North Park, from 1974-1998 wing data yielded a sex ratio of 1.7 ± 0.3 females/male. More specifically, in northwestern Colorado, wing data from Cold Springs, Blue Mountain, and Central Moffat County yielded sex ratios of 1.8 ± 0.5, 1.4 ± 0.4, and 1.6 ± 0.3 females/male, respectively. We assume that a constant sex ratio is not defensible since it masks annual variability in nature. The long-term (1974-1998) average sex ratio for all GrSG age classes in Colorado was 1.6 ± 0.4 females/male, which is significantly lower than the 2.0 females/male that is typically used in population estimation equations.

Alternative Methods of Population Estimation

Given the unreliability of the assumptions used, how do estimates derived from them compare to other, more rigorous estimates? Using mark-recapture statistical techniques, Walsh (2002) estimated the size of adult and yearling male and female GrSG populations in Middle Park during 1 breeding season. He compared them to population estimates derived from lek counts using standard assumptions (90% of leks are known and counted, 75% of males are counted, and there are 2 females/male in the population). He found that adjusted lek count estimates underestimated population size from mark-recapture estimates by 28%, because attendance rates were much lower than assumed and there were more females (2.3/male) than assumed.

Stiver, using mark-recapture techniques, estimated there were 53 male and 115 female GuSG in San Miguel County in Colorado in the spring of 2003 (J. Stiver, University of Nebraska, personal communication). Extrapolation from the maximum of 4 lek counts using standard assumptions listed above yielded estimates of 41 males and 82 females, underestimating the mark-resight estimates by 23 and 29 %, respectively. The maximum of 4 counts of males represented only 53% of the male population (as estimated by mark-resight), well below the assumed 75%. Thus, estimates of population size extrapolated from lek count data using standard assumptions appear to significantly underestimate population sizes.

Mark-recapture methods have shown promise in developing population estimates with confidence intervals, but the difficulty in capturing and marking the proportion of the population necessary (Walsh 2002) suggest it will be practical only for small populations. Recent research (Wilson et al. 2003) has explored using individual DNA as a marker, eliminating the need to handle and mark individual birds. The CDOW is exploring the utility of using DNA assayed from fecal droppings (collected on leks) as a mark-recapture technique. CDOW will also explore the practicality of using other methods to estimate lek and/or population density such as line-transects (Burnham et al. 1980). CDOW will continue to test the assumptions about male attendance and sex ratios implicit in estimating population size from traditional lek counts.

Conclusions

It is not defensible to generate breeding population estimates for sage-grouse from lek counts by assuming that (1) all (or some fraction of) leks are known; (2) unknown leks are of average size; (3) the maximum of 3 or 4 counts represents 75% of the males in the population; (4) there are exactly 2 (or any fixed ratio) females per male in the population; and (5) there is no variability in the assumptions across time, space, or population size. Unfortunately, that does not diminish the need for population estimates. It is difficult to evaluate past population trends, or to assess where we are relative to population targets or population viability without estimates of current population size. Either new methods need to be developed, or assumptions used to extrapolate from lek counts need to be evaluated and refined.

Estimating population size of GrSG by whatever means will be expensive and potentially disruptive to individual sage-grouse at varying levels. In the long-term, annual estimates of population size are probably unnecessary and may be counter-productive from the standpoint of

diverting resources and impacting birds. Currently annual lek counts represent the only method for monitoring trends in GrSG populations, and should be continued until better, more precise estimates can be obtained. Therefore, even though we recognize the lack of statistical reliability, we estimate population sizes from lek counts. However, for the purposes of this plan, to eliminate at least one parameter with unknown variability (sex ratio), we estimate breeding males only. In our estimates we make the following assumptions:

1) All leks are known and counted (the estimate is thus conservative, if some leks are unknown).
2) The maximum of 3 - 4 counts represents 53% of males in each population (Stiver, University of Nebraska, unpublished data).

The formula that incorporates these assumptions follows:

C = maximum male count on lek

$$\text{Estimate of males in population} = \frac{C}{0.53}$$

Estimated Number of Males in Colorado GrSG Populations

Using 2007 lek count data and the assumptions listed for this plan, we generated estimates of the current number of males in each GrSG population (Table 7).

Table 7. Colorado GrSG 2007 lek counts and population estimates.

Population	**Male High Count (Total for all leks)**	**Estimated Number of Males in Population**	**% of Total Estimated Males in Colorado**
Middle Park	214	404	4.6
Meeker – White River	8	15	0.2
Northern Eagle – Southern Routt Counties	86	162	1.9
North Park	912	1,721	19.8
Northwest Colorado	3,218	6,072	69.7
Parachute – Piceance – Roan	178	336	3.9
TOTAL	**4,616**	**8,710**	**100.0**

Decline of Greater Sage-grouse

In Colorado, GrSG historically occurred in at least 13 counties (Braun 1995). GrSG have been extirpated in Lake and Chaffee counties, and for 2 other counties sage-grouse have also been lost, although whether they were GrSG or GuSG is not certain (see Fig. 2, pg. 41). Braun (1995) suggested that greater sage-grouse are currently found in 9 Colorado counties. He considered populations with more than 500 breeding GrSG (totals of males and females in the spring) as persistent, and concluded that persistent populations were found in Jackson, Moffat, Rio Blanco, and Routt counties. Populations that Braun (1995:6) considered "at risk" of extirpation include Larimer, Grand, Summit, Eagle, and Garfield counties.

Although Braun (1995) considered the populations in 4 counties secure, he did not cite any original reference to clarify or justify the basis for "500 breeding individuals" constituting a secure population. Following further review of the literature (in an attempt to support or refute the validity of the 500 breeding male benchmark) this plan will assume that the 500 breeding individual estimate was derived from Franklin (1980) and Soulé (1980). Those authors proposed that a population (or "effective" population) of 500 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 captive and wild populations. Additionally, Lande (1995*a*) suggested that in experiments with fruit flies, a population size of 5,000 is necessary rather than the Franklin-Soulé number of 500. Lande (1995*a*) cautioned using the value of 5,000 because of differences among characters and species in genetic mutations and environmental fluctuations.

Later, Connelly and Braun (1997:230) suggested that grouse populations in Colorado were "at risk", although earlier Braun (1995:6) concluded that the major populations in Colorado were "persistent." Connelly and Braun (1997:230) did not provide any definition of the term "at risk". Connelly and Braun (1997) also argued that breeding populations (males/lek) of sage-grouse decreased by 33% across GrSG range, and males/lek declined by 31% and chicks/hen declined by 10% in Colorado since 1984.

Braun (1998) further emphasized the population decline in Colorado and reported an 82% decline in lower Moffat County (all of Moffat County excluding the Cold Springs and Blue Mountain areas), in the 3-year average of the number of strutting males counted on leks between 1978-80 and 1996-98. Braun (1998) concluded that there had been a 57% decrease in the number of active leks during the same time period. More recent and updated calculations (Fig. 6) suggest that the declines are not as severe as suggested by Braun (1998). Counts of strutting have been conducted in the same areas. If the 1978-80 timeframe is used as the "benchmark," the current lek counts illustrate a 25% decrease in the number of strutting males, a 20% increase in the number of active leks, and a 38% decrease in the number of males/lek in the latest 3-year running average (Figs. 6 and 7).

Although there has been a decline in the number of males counted from the 1978-1980 period, the decline in Moffat County has not been as severe as Braun (1998) concluded. These dramatic shifts in numbers of strutting males may be a result of the hypothesized cyclic nature of greater sage-grouse populations (Rich 1985, Braun 1998). Braun (1998) suggested that the strutting

male counts (males/lek) in Jackson County support the hypothesis of cyclic highs on 10-year intervals. Essentially no research has been conducted on this subject.

Simple calculations of the percent of change are instructive, but the lack of severity of the decline is also supported by Connelly et al. (2004). Connelly et al. (2004) reported that Colorado sage-grouse populations increased at an average rate of 4.3% from 1986-2003. In addition, although the number of grouse counted on strutting grounds is lower (0.7 - 1.6 times) than counted in the late 1960s and early 1970s, Colorado GrSG populations have been increasing in the last 17 years and there is no suggestion of a dramatic overall decline the last 39 years (Connelly et al. 2004).

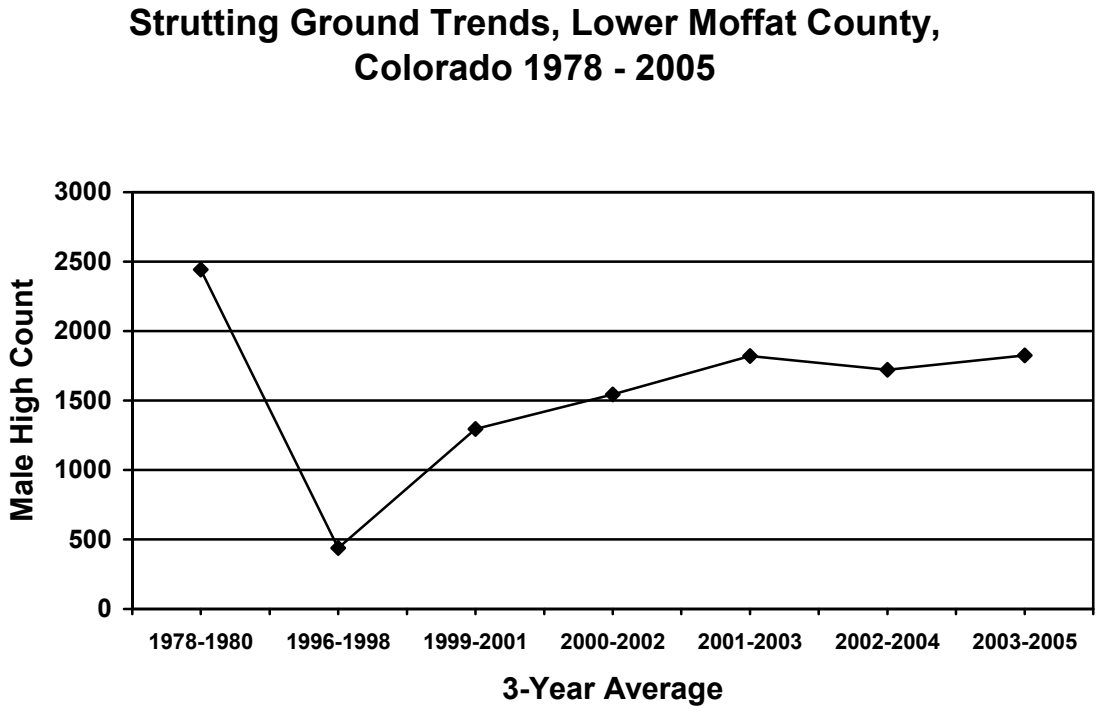

Fig. 6. Trends in the annual total high count of males, Lower Moffat County, Colorado, 1978-2005.

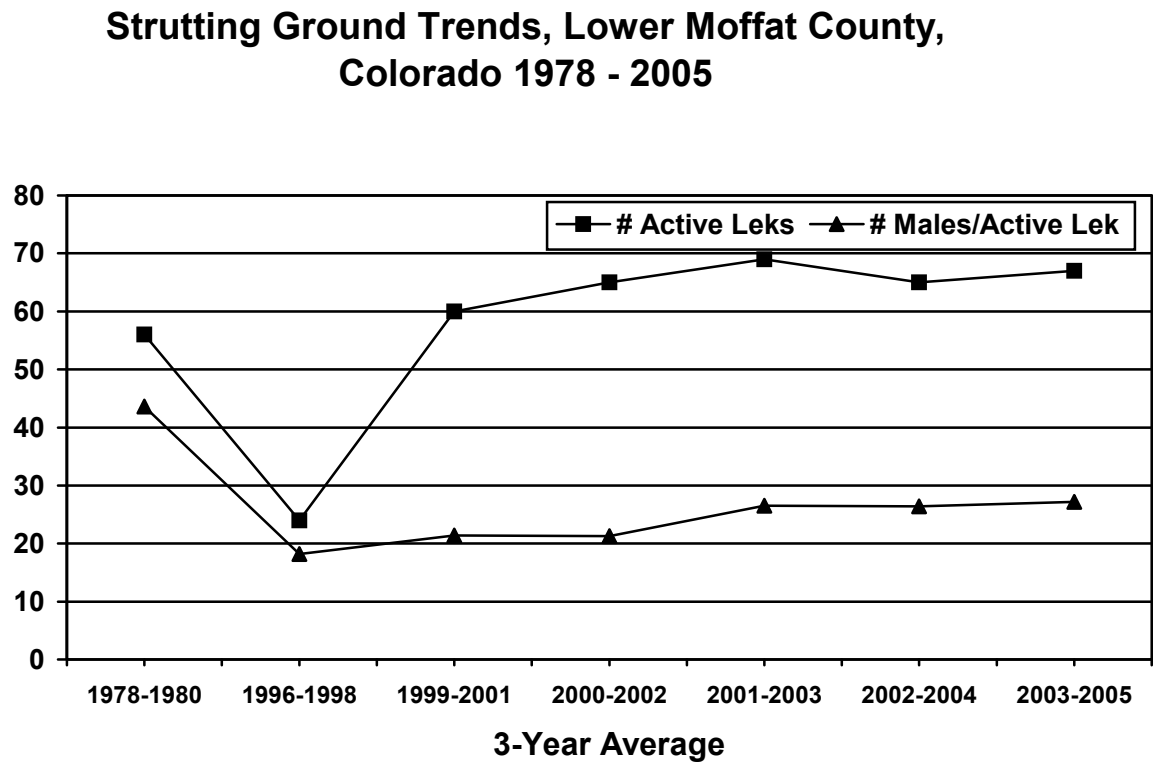

Fig. 7. Known active leks and males/active lek, Lower Moffat County, Colorado, 1978-2005.

C. Genetics

The distribution of genetic variation among populations across the entire range of GrSG has been unknown, despite increasing pressure on managers to make difficult decisions about which populations may be, from a species conservation perspective, more "important" than others. The identification of any genetically discrete groups of GrSG is paramount in the development of GrSG management plans. If conservation plans include strategies to augment populations by translocating birds from outside populations, it is imperative to understand if and how the populations vary genetically. In addition, because GrSG distribution continues to become more fragmented (resulting in smaller and more isolated populations), it is important to determine the relative amount of genetic diversity contained in each population. Populations with relatively low levels of genetic diversity can suffer from inbreeding effects and can be more susceptible to parasitic agents and disease.

Genetic data can provide information relevant to an understanding of gene flow, isolation, genetic diversity, and the evolutionary history of a species. Further, it can facilitate a cohesive management strategy that takes genetic distinctiveness into account, based in part on a clear picture of the entire "genetic landscape" of a species. This increases the efficiency of management decisions and adds to their scientific foundation.

Previous population genetic studies of sage-grouse have focused on assessing taxonomic status (Kahn et al. 1999, Oyler-McCance et al. 1999, Benedict et al. 2003). These studies provided useful taxonomic information and knowledge of the distribution of genetic variation locally, yet they lacked the range-wide perspective necessary to make management decisions regarding GrSG at the species level.

Oyler-McCance et al. (2005) provided a comprehensive examination of the distribution of genetic variation across the entire range of GrSG, greatly extending the sampling range and density of previous studies. They collected data from 46 populations in all 11 U.S. states with populations of GrSG, and 1 Canadian province (Alberta). They collected approximately 20 tissue samples per population, and used both mitochondrial DNA (mtDNA) sequence data and data from nuclear microsatellites.

Overall, the distribution of genetic variation (in both mitochondrial and nuclear data sets) showed a gradual shift across GrSG geographic range (Oyler-McCance et al. 2005). This pattern suggests localized gene flow with isolation by distance (i.e., movement among neighboring populations but not across the range; Oyler-McCance et al. 2005). In the mitochondrial data, this can be seen upon examination of the most common mtDNA haplotypes (Fig. 8). Haplotype A is the most widespread, occurring in all but North Dakota, South Dakota, and Washington. Haplotype X is found primarily in the western part of the range, while haplotypes B and C are found in the central and eastern part of the range. Haplotype EJ is found only in the northeastern part of the range in Alberta, Montana, North and South Dakota, and Wyoming.

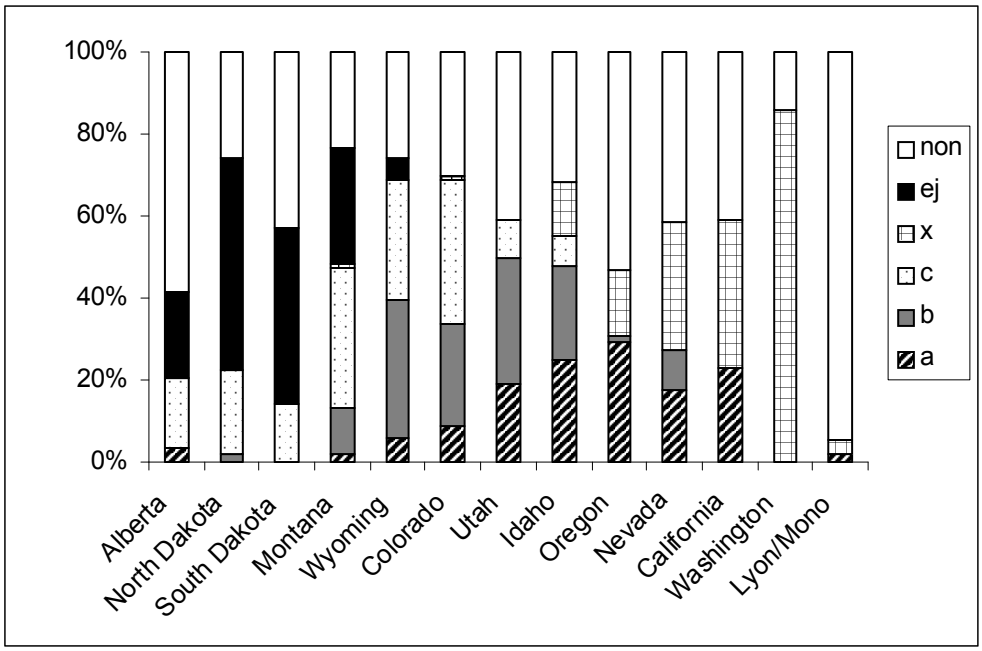

Fig. 8. Proportion of individuals in each state with common haplotypes (non represents haplotypes that are not common) reported by Oyler-McCance et al. (2005). The haplotypes ej, x, c, b, and a were the most common haplotypes found in the study. Each bar represents the proportion of each of these common haplotypes for every state.

Analysis of the nuclear microsatellite data showed a similar pattern. There was a positive correlation between genetic distance and geographic distance (Mantel test), suggesting an isolation by distance phenomena. Results of a STRUCTURE analysis (a software program that delineates how many genetically discrete "clusters" are best described by the data), showed that clusters were made up of geographically adjacent populations (Fig. 9), again suggesting localized gene flow and isolation by geographic distance. The smaller, more fragmented populations on the periphery of the range (North Park, Middle Park, and Eagle in Colorado, Strawberry Valley and Wayne in Utah, Lyon/Mono in Nevada/California, and Douglass/Grant and Yakima in Washington) made up their own clusters, suggesting lower amounts of gene flow in these areas. In Colorado, samples from North Park, Middle Park, and Eagle are in one cluster, while samples from sites in northwestern Colorado are in another cluster (Fig. 9).

These data are consistent with previous dispersal studies that suggest gene flow is most likely dependent on the movement of individuals between neighboring populations, and not on the long-distance movements of individuals across large portions of the range (Oyler-McCance et al. 2005). Oyler-McCance et al. (2005) suggest that this information is especially pertinent to conservation efforts that consider translocations and augmentation of existing populations using sage-grouse from outside populations. Their data suggest there are linkages among neighboring populations, and genetic differences among distant populations. This raises the possibility that individual populations may be genetically adapted to local conditions, and that translocations should involve neighboring populations rather than geographically distant populations (Oyler-McCance et al. 2005).

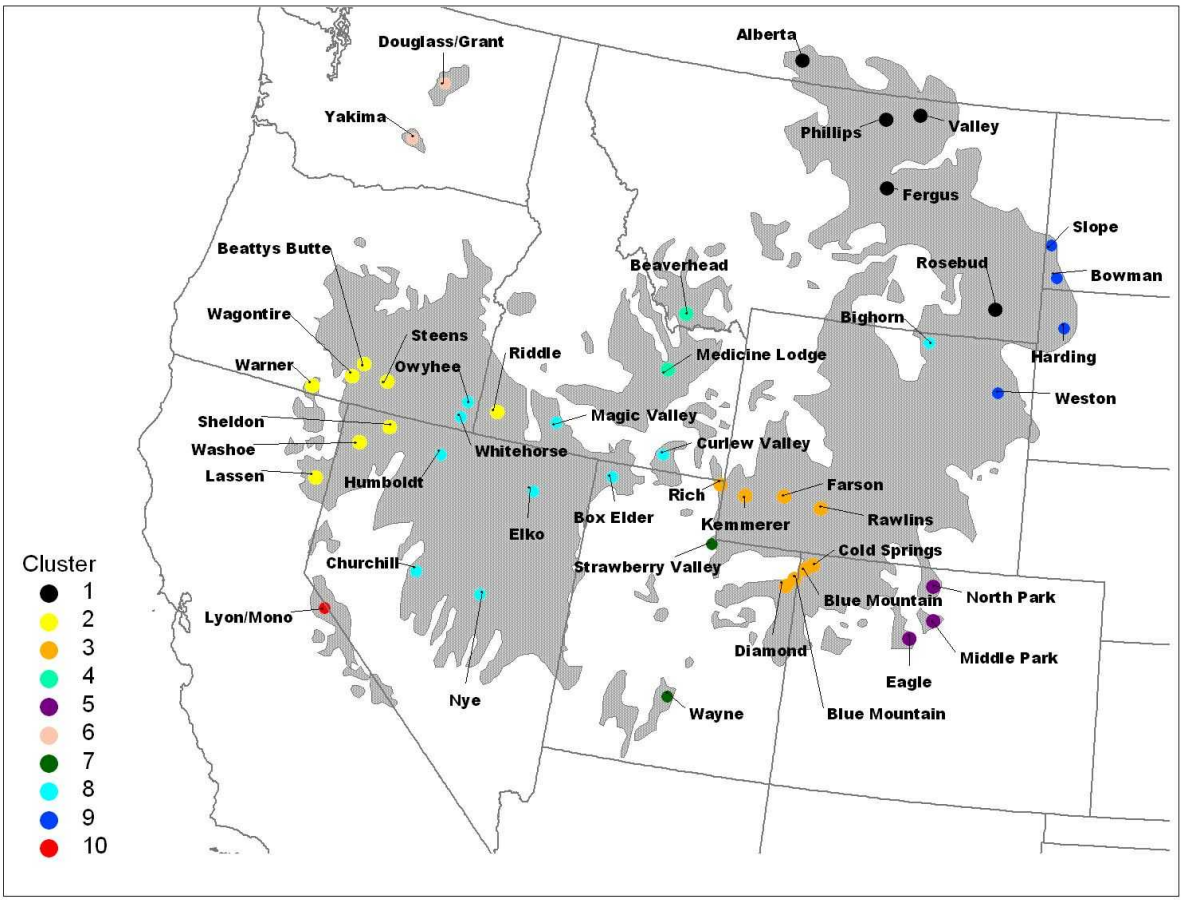

Fig. 9. Map of sampling sites for the microsatellite analysis conducted by Oyler-McCance et al. (2005), color coded by the cluster each population has been assigned to using STRUCTURE analysis.

Oyler-McCance et al. (2005) also found that levels of genetic variation differed among populations (Tables 8 and 9). They found the highest level of genetic variation in Magic Valley, Idaho, in the mtDNA data set (13 haplotypes/population, Table 8), and in Alberta in the microsatellite data set (an average of 7.14 alleles, Table 9). In both mtDNA and micrsosatellite data sets the least amount of genetic diversity was found in the 2 Washington populations, Yakima and Douglass/Grant (1 and 3 mtDNA haplotypes/population, respectively, Table 8; and an average of 3.29 and 3.14 microsatellite alleles per population, respectively, Table 9; Oyler-McCance et al. 2005).

Oyler-McCance et al. (2005) also point out that the 2 Washington populations did not show signs of a recent population bottleneck as was found in Strawberry Valley, Utah, which had been documented to have had a severe population decline due to predation problems within the last 10 years. Their test for population bottlenecks, however, only detects recent bottlenecks on the order of 0.2 - 4.0 generations (Luikart and Cornuet 1998). Population declines in Washington have been estimated to be at least 77% between 1960 and 1999 (Schroeder et al. 2000) suggesting that declines have been ongoing and significant for 40 years. Oyler-McCance et al. (2005) indicate that the lack of genetic diversity in the Washington populations is not surprising

given their small population size and isolation and the fact that they currently occupy only 8% of their historic range (Schroeder et al. 2000). They suggest that any translocations or augmentations of the Washington populations should involve populations that are geographically close.

Summary

The study by Oyler-McCance et al. (2005) documented the distribution of genetic variation across the entire range of GrSG. They found that isolation by distance has left an imprint on GrSG gene pools, and that local adaptation is a realistic possibility for the species that should be considered in decisions involving translocations. They argue that this genetic data, used in conjunction with large scale demographic and habitat data, will provide an integrated approach to conservation efforts for GrSG. For Colorado, there appears to be a genetic line of demarcation (north to south) between Colorado GrSG populations, suggesting that if translocations are undertaken, birds should be moved north-south, and not east-west.

Table 8. Haplotype frequencies for all populations included in the study by Oyler-McCance et al. (2005).

Population	N	Proportion in clade I	Proportion in clade II	Number of haplotypes
Blue Mt., Colorado	21	0.36	0.64	11
Cold Springs, Colorado	25	0.57	0.43	7
Eagle, Colorado	26	0.40	0.60	5
Middle Park, Colorado	21	0.33	0.67	6
North Park, Colorado	23	0.38	0.63	8
Box Elder, Utah	28	0.71	0.29	7
Wayne, Utah	25	0.50	0.50	8
Rich, Utah	26	0.64	0.36	9
Diamond, Utah	26	0.56	0.44	9
Blue Mt. Utah	18	0.60	0.40	5
Strawberry Valley, Utah	23	0.25	0.75	4
Kemmerer, Wyoming	18	0.43	0.57	7
Farson, Wyoming	25	0.40	0.60	5
Rawlins, Wyoming	20	0.40	0.60	5
Bighorn, Wyoming	20	0.00	1.00	4
Weston, Wyoming	20	0.10	0.90	10
Converse, Wyoming	13	0.08	0.92	6
Rosebud, Montana	23	0.00	1.00	4
Beaverhead, Montana	22	0.29	0.71	7
Valley, Montana	26	0.17	0.83	6
Phillips, Montana	18	0.22	0.78	9
Fergus, Montana	23	0.00	1.00	4
Harding, South Dakota	21	0.17	0.83	6
Slope, North Dakota	36	0.20	0.80	5
Bowman, North Dakota	22	0.17	0.83	6
Alberta	29	0.25	0.75	8
Riddle, Idaho	44	0.36	0.64	11
Curlew Valley, Idaho	19	0.50	0.50	8
Medicine Lodge, Idaho	20	0.20	0.80	5
Magic Valley, Idaho	49	0.54	0.46	13
Whitehorse, Oregon	33	0.14	0.86	7
Steens, Oregon	21	0.29	0.71	7
Warner, Oregon	19	0.38	0.63	8
Wagontire, Oregon	19	0.38	0.63	8
Beattys Butte, Oregon	21	0.25	0.75	8
Churchill, Nevada	18	0.17	0.83	6
Washoe, Nevada	20	0.38	0.63	8
Elko, Nevada	20	0.63	0.38	8
Humboldt, Nevada	21	0.33	0.67	6
Sheldon, Nevada	19	0.29	0.71	7
Nye, Nevada	20	0.50	0.50	6
Lassen, California	22	0.14	0.86	7
Lyon/Mono, NV/CA	54	0.40	0.60	10
Yakima, Washington	25	0.00	1.00	1
Douglass, Washington	18	0.33	0.67	3

Table 9. Sample population names, locations, sample size, mean number of alleles and assigned cluster (identified by STRUCTURE analysis) for each population included in the study by Oyler-McCance et al. (2005).

Population	State/ Province	N	Mean # of alleles	Assigned cluster
Blue Mountain-CO	Colorado	25	5.71	3
Cold Springs	Colorado	30	6.14	3
Eagle	Colorado	26	5.71	5
Middle Park	Colorado	21	5.71	5
North Park	Colorado	22	6.43	5
Box Elder	Utah	31	6.86	8
Wayne	Utah	27	5	7
Rich	Utah	31	6.71	3
Diamond	Utah	27	6	3
Blue Mountain-UT	Utah	18	4.86	3
Strawberry Valley	Utah	23	3.86	7
Kemmerer	Wyoming	21	5.71	3
Farson	Wyoming	25	6	3
Rawlins	Wyoming	20	6.71	3
Bighorn	Wyoming	20	5.14	8
Weston	Wyoming	20	6.29	9
Rosebud	Montana	25	6.71	1
Beaverhead	Montana	19	6	4
Valley	Montana	29	6.86	1
Phillips	Montana	19	6.14	1
Fergus	Montana	30	6.29	1
Harding	South Dakota	26	5.57	9
Slope	North Dakota	36	4.86	9
Bowman	North Dakota	24	5.43	9
Alberta	Alberta	36	7.14	1
Riddle	Idaho	25	5.43	2
Curlew Valley	Idaho	19	6.29	8
Medicine Lodge	Idaho	36	8	4
Magic Valley	Idaho	31	7	8
Whitehorse	Oregon	18	6	8
Steens	Oregon	22	6	2
Warner	Oregon	22	5.29	2
Wagontire	Oregon	22	5.57	2
Beattys Butte	Oregon	24	5.71	2
Owyhee	Oregon	25	6.43	8
Churchill	Nevada	19	5.57	8
Washoe	Nevada	22	5.71	2
Elko	Nevada	22	7	8
Humboldt	Nevada	24	6.43	8
Sheldon	Nevada	23	5.29	2
Nye	Nevada	23	6.29	8
Lyon/Mono	Nevada/ California	68	5.71	10
Lassen	California	55	6.43	2
Yakima	Washington	29	3.29	6
Douglass/ Grant	Washington	21	3.14	6

D. GrSG Habitat Mapping Efforts

CCP Habitat Mapping

CDOW is using the Wildlife Resource Information System (WRIS) and GrSG habitat-use data to map GrSG habitat. The following habitat definitions were used during the initial mapping portion of this project, and appear in maps in the CCP. Future mapping should also focus on distinguishing between areas that are "Suitable and Vacant", versus those that are "Suitable but Unknown" (see Habitat Monitoring strategy 9.1.1.1, pg. 355). In addition, initial mapping of these habitats was done at a fairly coarse level and may not be suitable for project-level planning. More detailed mapping may need to occur for specific projects.

Occupied Habitat: Areas of suitable habitat known to be used by GrSG 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. This category can be delineated 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: Suitable habitat for sage-grouse that is separated (not contiguous) from occupied habitats that either (1) has not been adequately inventoried, or (2) has not had documentation of grouse presence in the past 10 years.

Potentially Suitable Habitat: Unoccupied habitats that could be suitable for occupation of sage-grouse if practical restoration were applied. Soils or other historic information (photos, maps, reports, etc.) indicate sagebrush communities occupied these areas. As examples, these sites could include areas overtaken by piñon-juniper or converted to rangeland.

BLM Habitat Mapping

A mapping effort was also initiated by the Colorado BLM in 2002, through a contract with the Colorado Natural Heritage Program (CNHP), as part of a national agency mapping effort. With the help of other agency biologists, the Colorado BLM completed a statewide habitat risk map. BLM and CDOW biologists (primarily) hand-edited spatial information about sagebrush and sage-grouse habitats on 1:100,000 topographic maps based on Basin-wide vegetation inventory data and local knowledge of the area. They identified existing sage-grouse habitat in Colorado that appears to be in good condition, as well as habitat that is "at risk." For those habitats considered to be at risk, biologists identified the specific issue(s) potentially affecting the habitat (e.g., weeds, fire, lack of fire), and whether the "risk" threatened habitat quality or might result in habitat loss and/or fragmentation. In identifying habitat quality ("good" or "at risk"), biologists also considered whether the habitat quality in a habitat polygon was likely to significantly degrade within 5 years if no management actions were taken. CNHP organized, compiled,

facilitated and produced the results of this mapping effort. These maps were not included in this plan due to their large size; currently, one can access the maps at local BLM field offices.

Four habitat quality risk factors were identified: (1) weed invasion; (2) piñon-juniper encroachment; (3) old and even-aged sagebrush overstory; and (4) poor herbaceous understory condition. Six factors causing habitat loss or fragmentation were noted: (1) weed domination; (2) piñon-juniper replacement; (3) oil and gas development; (4) powerline infrastructure development; (5) subdivisions (housing development); and (6) existing or proposed land-uses (ranging from land exchange to agricultural conversion).

For each polygon, any occurrence of sage-grouse was noted, and site-specific comments (e.g., wildfire, gravel pit, weed infestation associated with oil field) were recorded. The BLM habitat map will be updated every 5 years to reflect changes in habitat due to management, new information, or a consequence of nature (e.g., drought, fire, disease). These maps are expected to help identify and prioritize BLM budget, conservation actions, and management for sage-grouse on public lands. The maps will also be made available to other agencies and local work groups to use as a tool in sage-grouse management proposals and decisions.

In addition, BLM has developed a national sage-grouse mapping effort designed to provide range-wide information about the location, status, and trend of GrSG habitats, and the influence of a variety of land-uses/disturbances on those habitats. This modeling effort is not intended to portray quality of existing habitat, but rather to depict relative connectivity of existing sagebrush ecosystems across the West. Colorado GrSG habitats fall within 2 regions covered by this project, the Wyoming Basins Region in the northwest portion of the state, and the Colorado Plateau Region. This project was spearheaded by the National Science and Technology Center in Denver. BLM, CDOW, and other biologists had an opportunity to review and validate some of the modeling assumptions that were used in this GIS mapping exercise. These maps may be useful in prioritizing proposed GrSG projects in the state, and identifying those areas with habitat fragmentation issues. These data sets may be updated in the future as new activities or habitat modifications occur across the landscape.

E. Individual Populations: Status and Distribution

Meeker – White River Population

General Description

The Meeker – White River population in Rio Blanco County extends south and east of the town of Meeker, with most of the population located south of the White River (Fig. 10). The currently occupied habitat totals 41,160 acres. Most of the land is privately owned (90%), with BLM managing 8%, USFS 1%, and CDOW 1% (see Appendix J, "GrSG GIS Data").

Population Information

There is limited information on the MWR population. There is 1 currently known active lek, and 6 leks that have not shown activity in years (considered "historic" leks). The population has probably been in decline since the 1950s. The current lek was discovered in 2004, and strutting male counts have been 30 (2004), 25 (2005), 15 (2006), and 8 (2007). Portions of the MWR area are difficult to access, due both to topography and the large amount of privately-owned habitat. It is possible there are other active leks that remain undiscovered, despite periodic flights by CDOW to search for leks.

Historic Information

Rogers (1964) considered the GrSG populations in the area to be light: "Areas around the town of Meeker, Josephine Basin to the west, Rio Blanco to the southwest, the Mesa to the south, and Beaver Creek to the east had a fair population of sage-grouse up till ten years ago. No birds were reported in these areas or on three previously used strutting grounds until August 1960 when one sage hen was found killed by a car five miles north of Rio Blanco and in March of 1961 when 41 sage-grouse were observed by Dwight Owens on the Mesa."

Local Conservation Plan

No local conservation plan currently exists for the MWR population area and no local work group has been formed to date. The CCP will serve as a conservation plan for this population until a local conservation plan is completed at some point in the future.

Completed Conservation and Habitat Actions

Although a local work group has not yet formed for this area, interest in GrSG conservation is good, and some actions specific to GrSG have already been undertaken. From 2000-2002, the

CDOW and Yampa-White Habitat Partnership Program (HPP) Committee purchased a seed drill for landowners to use for GrSG and sharp-tailed grouse habitat enhancement work. In addition, approximately 800 acres of CRP and other grasslands (dispersed in many small parcels and among several landowners) were reseeded with bunchgrasses and palatable forbs to enhance GrSG habitat. In 2003, field collections were made of Moffat County native forbs, for description of germination and development of native seed stock.

Easements

In 2005, the Yampa Valley Land Trust secured 2 conservation easements in GrSG habitat. Total acreage of conservation easements in the MWR area is 2,129 acres in occupied habitat and 1,596 acres in potentially suitable habitat (Fig. 10 and Appendix J, "GrSG GIS Data").

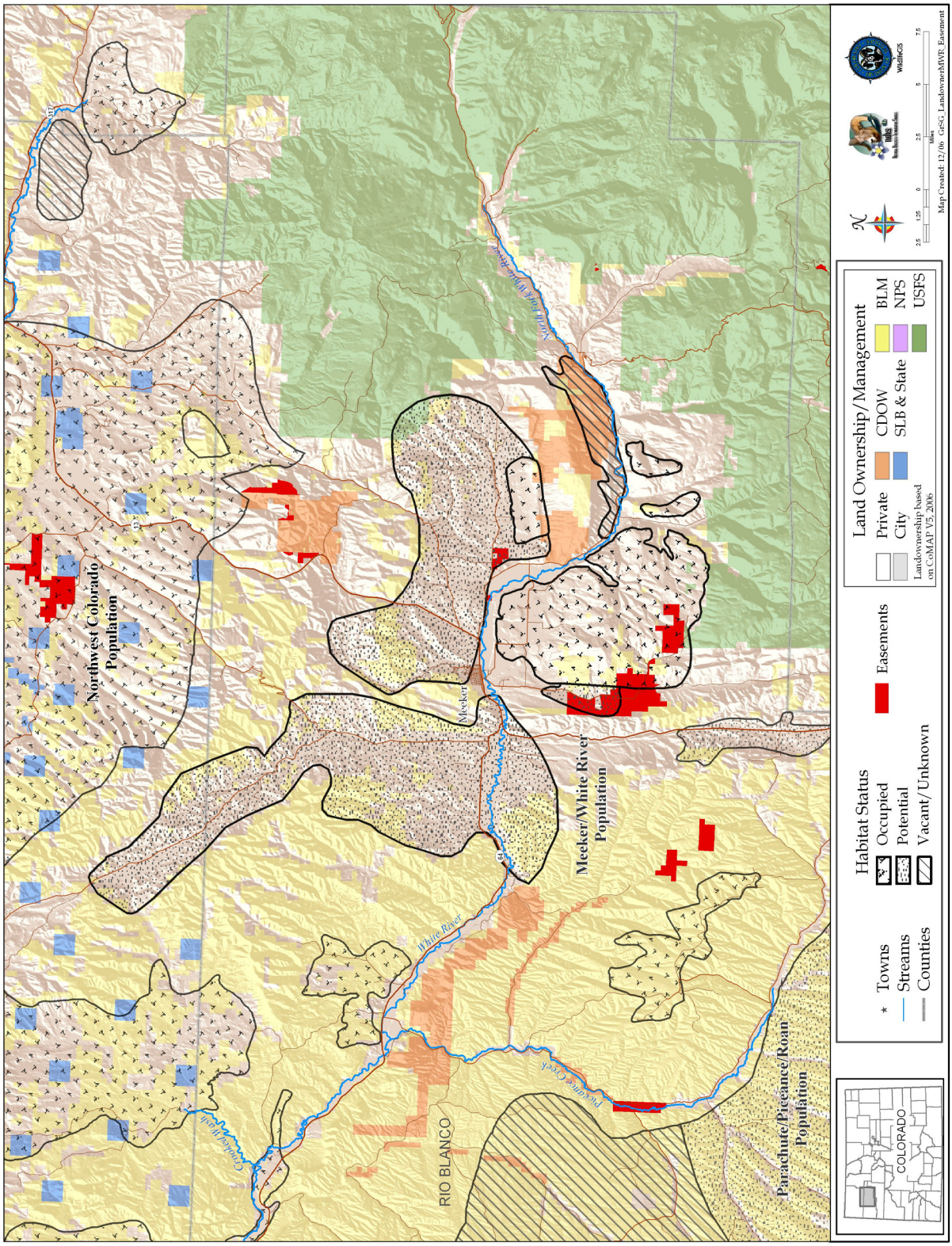

Fig. 10. Habitat status, landownership, and conservation easements in the MWR GrSG population area.

Middle Park Population

General Description

The Middle Park GrSG population area is located primarily in Grand County, but also in portions of Eagle and Summit Counties, and is bounded on the west by the Gore Range (Fig. 11). It surrounds the towns of Kremmling, Hot Sulphur Springs, and Granby (Fig. 11). The total area of occupied habitat for MP is 259,019 acres. Most of the area is in a high elevation intermountain basin that has varied terrain. Annual precipitation at Kremmling, in the middle of the population area, is 11 inches.

Sagebrush rangelands are the primary cover type in this area, although they are somewhat fragmented within Middle Park due to the geology and river corridors in the area. Landownership in the MP area is mostly private (57%), followed by BLM (29%), SLB (8%), CDOW (2%), NGOs (non-governmental organizations, 2%) and USFS (2%) (see Appendix J, "GrSG GIS Data").

The primary land-use in MP is a combination of cattle and hay production. A good portion of the area is used for year-round recreational activities. Other land-uses in MP include single and multi-family homes, commercial development, and industrial development such as gravel pits.

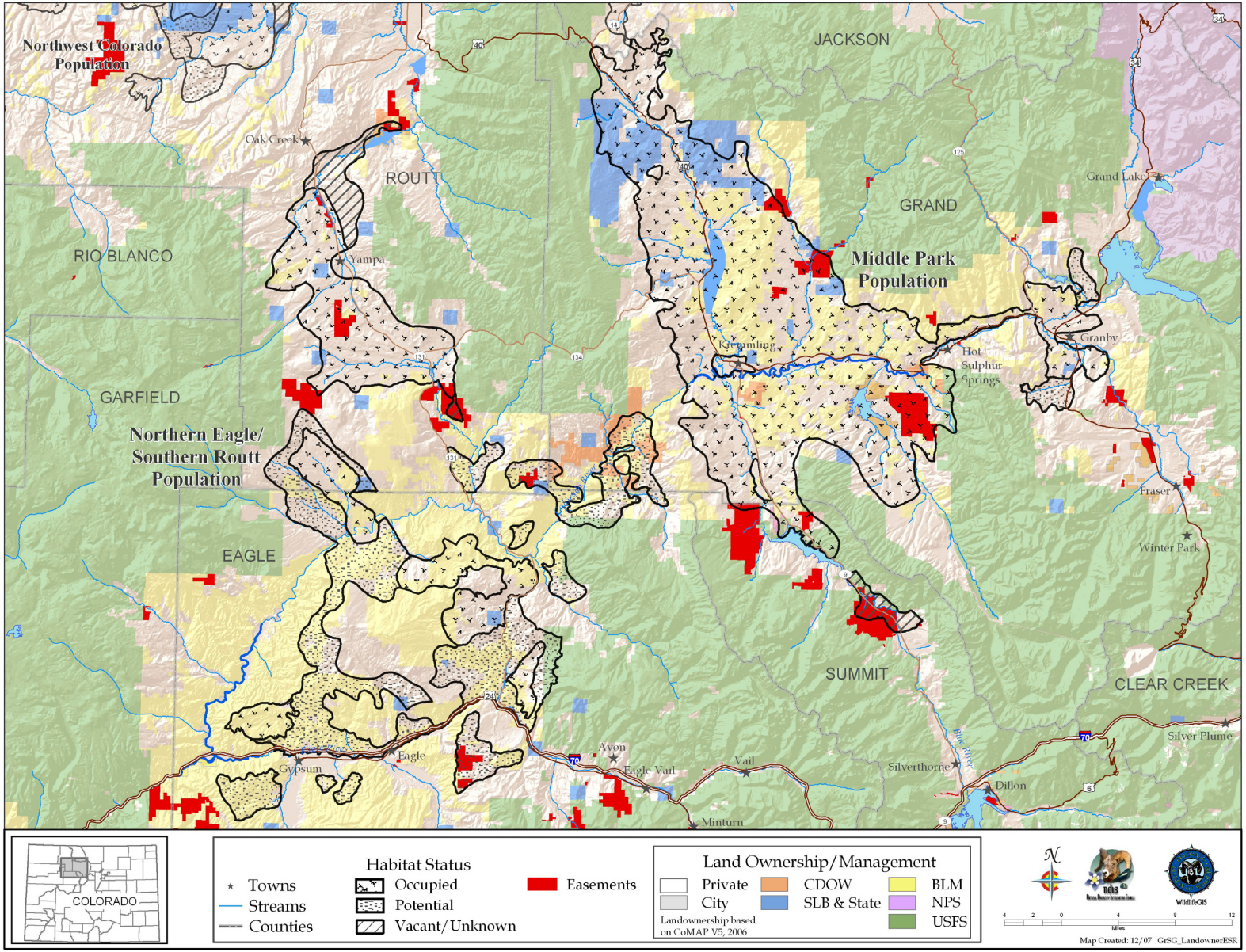

Fig. 11. Habitat status, landownership, and conservation easements in the MP and NESR GrSG population areas.

Population Information

The Middle Park Conservation Plan (MPCP 2001) did not make an estimate of GrSG population size, noting the many difficulties and assumptions that occur in such estimates. The MPCP (2001) does recommend, if estimating population size from lek counts, to follow 3 assumptions: (1) 90% of leks are counted; (2) 75% of all males are counted; and (3) the ratio of females to males is 2:1. Note that, for the purposes of this plan, we estimate only the number of breeding GrSG males in each local population, not the total population size (see Table 7 [pg. 56] and summary of population estimation in "Conclusions" [pg. 55]).

Lek counts have been conducted in Middle Park regularly, although not necessarily consistently, since 1959 (Fig. 12). Over this period, some new leks have been discovered, and some existing leks have been abandoned, with no clear trend in number of active leks. It is believed that there are still active leks that have not yet been located, due to difficult terrain and weather, and complicated by landownership patterns.

According to the MPCP (2001), the highest concentration of GrSG is currently in sagebrush north of Kremmling in the Muddy and Troublesome drainages. There is another concentration of birds south of the Colorado River near Parshall in the Williams Fork drainage, and fewer GrSG along the Blue River south of Kremmling. The lowest density of GrSG is in sagebrush rangelands near Granby.

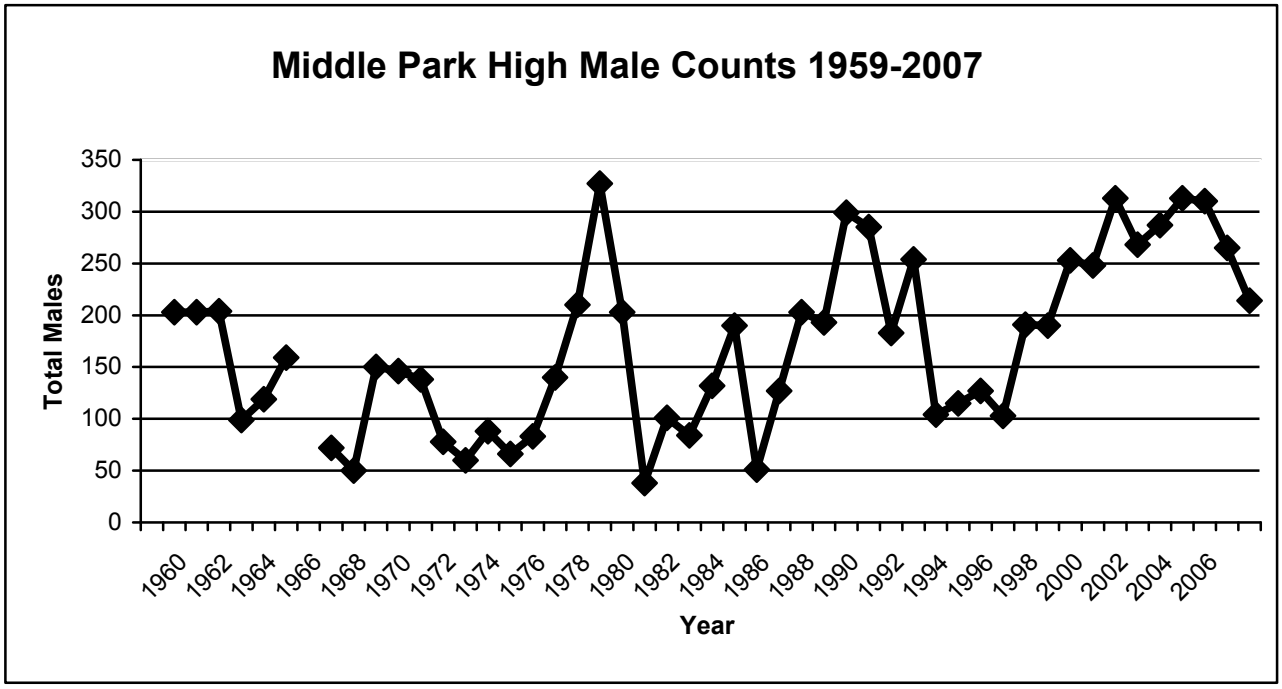

Fig. 12. Lek count data for Middle Park GrSG population, 1959-2007.

Historic Information

According to Rogers (1964), the explorer John Fremont reported sage-grouse along what is now the Colorado River in Middle Park in 1842. In 1964, sage-grouse populations were present along the Colorado River from Parshall to Granby, and extending both north and south of Kremmling for 10 - 15 miles (Rogers 1964).

Local Conservation Plan

In 1999, a group of concerned citizens and agencies formed the Middle Park Sage-grouse Committee (MPSGC). This group developed and completed the Middle Park Sage-grouse Conservation Plan (MPCP 2001) in January, 2001, and is now involved in undertaking actions to conserve sage-grouse in Middle Park. Each year, representative members of the MPSGC formulate a Work Plan in the spring, and review completion of the Work Plan the following December.

Area boundaries in the MPCP (2001) were designated using known historic range, sage-grouse observations, and elevation. Population goals were: (1) "at an optimum level…to maintain a spring population of at least 1,100 birds"; (2) to maintain a minimum spring population of 550 sage-grouse; (3) to maintain spring male breeding activity in at least 4 of 5 defined geographic areas; and (4) to reevaluate the preceding goals in 2004, and every 5 years thereafter (MPCP 2001:10).

Issues potentially affecting GrSG were identified and categorized into the following groups: (1) habitat-related management; (2) wildlife-related management; (3) human demographics and growth-related issues; and (4) planning and outreach issues. Conservation actions were designed to address these issues (MPCP 2001).

Completed Conservation and Habitat Actions

Table 10. GrSG habitat projects reported in Middle Park GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
Pinto Valley, near lek	Fence modified to decrease raptor perching and GrSG collisions	N/A	Landowner	2000-2002
Gravel Pit lek	Two-track road closed	N/A	BLM	2000-2002
BLM and CDOW	Dixie harrow; sagebrush thinned and interseeded	135	BLM	2000-2002

Table 10. GrSG habitat projects reported in Middle Park GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
Dunning Creek	Dixie harrow, brush beat and Lawson aerator; treated sagebrush and broadcast seeding	240	BLM	2003
Inspiration Point	Prescribed burn; reduce piñon-juniper encroachment in historic GrSG habitat	175	BLM	2003 and 2004
Blue Valley Ranch	Prescribed burn to create habitat mosaic as breeding habitat enhancement project	240	Private	2004
BLM	Fertilization; improve winter habitat	200	BLM	2004
Hartman Divide	Lawson aerator; reduce piñon juniper encroachment in historic GrSG habitat	227	BLM	2004
Hartman Divide	Hot saw; reduce piñon juniper encroachment in historic GrSG habitat	50	CDOW	2004
Sulphur Gulch, Sudan Property, Skyline Drive	Fertilization; improve winter habitat	120 (40 each)	BLM and CDOW	2005
Junction Butte, McQuery Gulch, Barger Gulch Moore Reservoir, Mitchell Reservoir	Brush beat and Lawson aerator; early brood-habitat improvement	1,200	BLM	2005
Private	Brush beat	35	Private	2005
Private	2,000 pounds of clover and ladak alfalfa interseeded around meadow edges	500 – 1,000	Private	2005
Wolford Mountain Management Area	Reclaimed (drilled/seeded) seven miles of closed routes	10	BLM	2006

Table 10. GrSG habitat projects reported in Middle Park GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
Hartman Divide	Thinning of encroaching piñon-juniper in the GrSG historic range	30	BLM	2006
Sulphur Gulch and between Corral and Rock Creek	Fertilization; improve winter habitat	500	BLM	2006
South of Pinto Creek	Brush beating	100	BLM	2006
Antelope Creek	Fencing of riparian area	40	BLM	2006
Private	Planting of alfalfa	120	NRCS	2006
Private	6,000 pounds of clover applied via aerial application to the periphery of irrigated fields and ditches adjacent to sagebrush habitat	1,600	NRCS /CDOW / USFS	2007

Easements

Conservation easements that benefit GrSG total 8,883 acres of occupied habitat and 2,267 acres of vacant/unknown habitat in the MP population area (Fig. 11, Appendix J, "GrSG GIS Data").

North Park Population

General Description

The North Park GrSG population area encompasses most of Jackson County (Fig. 13). The total area of occupied habitat is 413,915 acres. North Park itself is a high elevation intermountain basin, surrounded on 3 sides by mountains. It is bordered on the west by the Park Range (Sierra Madres), on the east by the Medicine Bow Mountains, and on the south by the Rabbit Ears Range. The North Platte flows north from its headwaters in North Park into Wyoming. The county seat, Walden, lies roughly in the center of North Park. Elevation in this area ranges from 7,900 to 9,500 feet. Annual precipitation is 10 inches at Walden, and up to 25 inches in the higher elevations. Half of this precipitation comes in the form of snow.

The primary cover type in NP is sagebrush rangelands on rolling hills, arranged in a mosaic with irrigated meadows and pastureland along riparian areas. Aspen and coniferous forests dominate the higher elevations in the surrounding mountains. Landownership in NP is approximately 52% private and 48% public (primarily BLM, but also SLB, USFWS, USFS, and CDOW; see Appendix J, "GrSG GIS Data"). The 23,240-acre Arapaho National Wildlife Refuge is located in the center of North Park. The Refuge includes wetland, riparian, and upland habitats that support a multitude of avian species, including sage-grouse. NP continues to be an agricultural area, with the vast majority of land being used for cattle grazing. The human population has changed very little in the past 100 years, with approximately 1 person/mi^2. There has been little housing subdivision outside of the towns of Walden, Gould, and Rand. Recently, subdivision into 35-acre parcels has begun in some areas in sage-grouse habitat, but most of the private land remains in large working ranches.

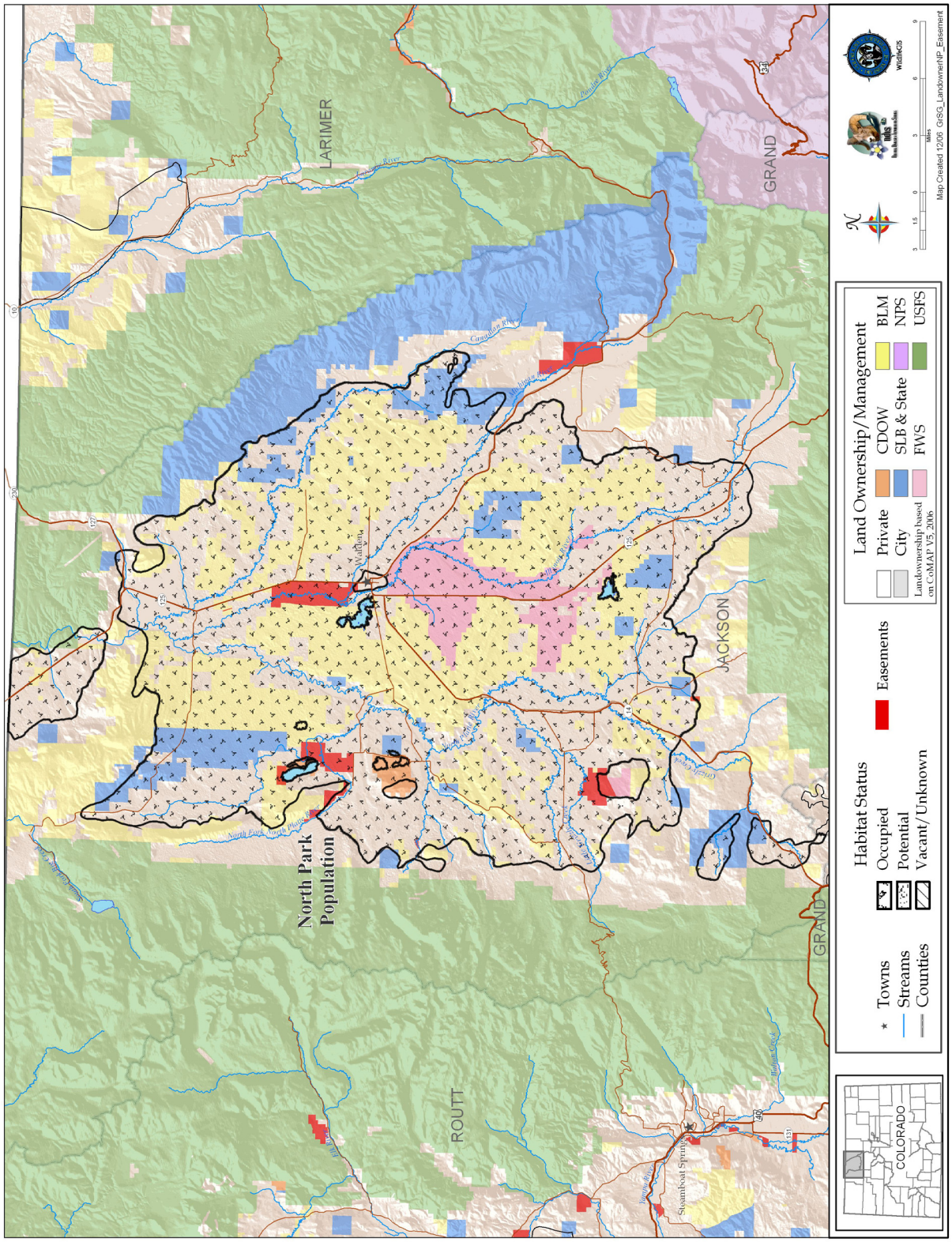

Fig. 13. Habitat status, landownership, and conservation easements in the NP GrSG population area.

Population Information

The North Park Conservation Plan (NPCP 2001) estimated the population in 2001 was between 4,254 and 6,315 birds. Both estimates are based on a high count of 1,418 males in 2001 (note; lek count data have since been refined, see Fig. 14), and on the assumption that there are 2 females per males in the spring population. The higher estimate (6,315) has 2 additional assumptions: (1) 90% of leks are known and counted; and (2) 75% of males are counted on a given day. Note that, for the purposes of this plan, we estimate only the number of breeding GrSG males in each local population, not the total population size (see Table 7 [pg. 56] and summary of population estimation in "Conclusions" [pg. 55]).

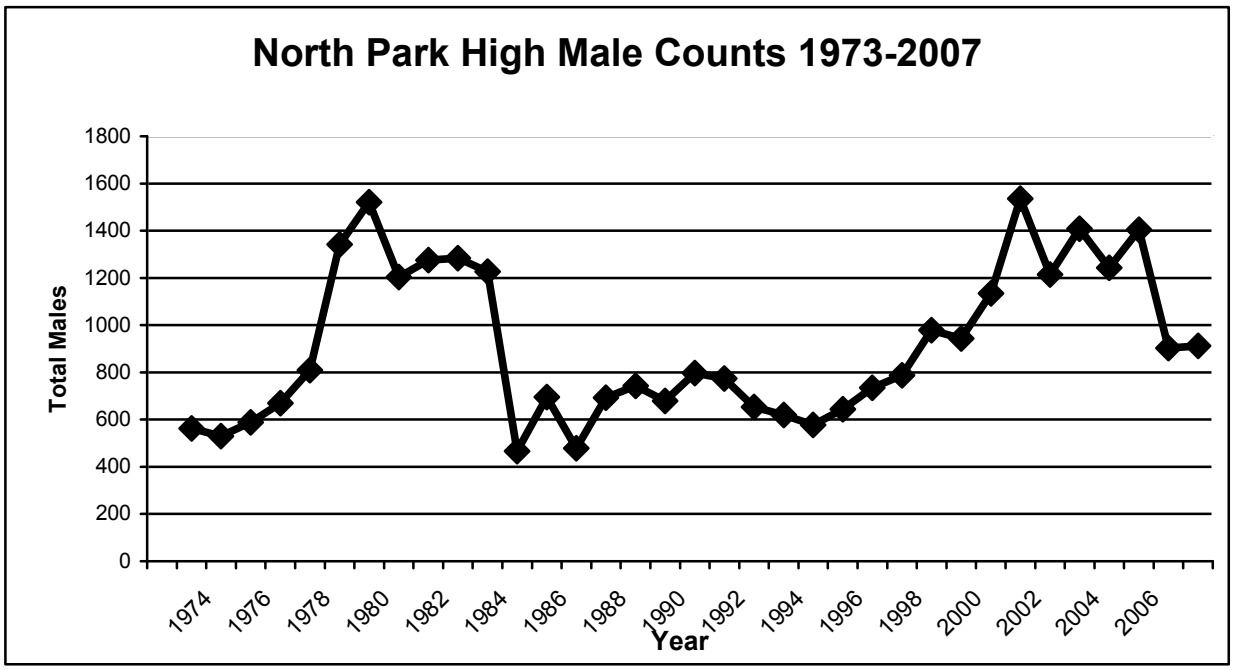

Fig. 14. Lek count data for North Park GrSG population, 1973-2007.

Historic Information

Rogers (1964) reported sage-grouse throughout Jackson County, except at higher elevations. Historical writings indicate that sage-grouse were present when European people arrived in North Park. Notes from George Bird Grinnell's 1879 visit to North Park specifically mention "sage and dusky grouse." Efforts to identify population trends began in the 1950s when wildlife personnel were asked to identify areas of sage-grouse use and to report the general number of birds observed. In the early 1970s CDOW developed organized lek counts and attempted to locate and map all active display grounds. Annual reports have been compiled since the early census efforts began and comparisons of those results have shown the variations in population estimates over time.

Local Conservation Plan

A group of citizens and agencies (including ranchers, county commissioners, county administrator, interested citizens, and state and federal biologists) formed the North Park Sage Grouse Working Group (NPSGWG) in 1998 to address concerns about the status of sage-grouse in the North Park area. The North Park Greater Sage-grouse Conservation Plan (NPCP 2001) was completed and signed in December, 2001. The work group remains active and holds quarterly meetings. The group has been cooperating with the North Park Habitat Partnership Committee (NPHPP) and the Owl Mountain Partnership (OMP) to implement habitat improvement projects on both public and private lands.

The boundaries of the NPCP (2001) were drawn based on known sage-grouse use sites, observations of sage-grouse, and potential sage-grouse habitat. The population goal stated in the NPCP (2001) is for a spring count of 850 males (or more) on 25 leks (based on a 3-year running average), with a minimum goal of 500 males on 20 leks. A list of conservation actions is given within the NPCP (2001) for each of 4 estimated population levels (0 - 499, 500 - 675, 676 - 850, and >850).

Completed Conservation and Habitat Actions

Most of the projects undertaken by the NPSGWG have been mechanical sagebrush treatments aimed at increasing sagebrush age-class diversity and the abundance of grasses and forbs. All sagebrush treatment projects were followed by at least one year of livestock grazing deferment. Most projects reported have been funded by the NPHPP and the OMP (Table 11).

Table 11. GrSG habitat projects reported in North Park (CDOW, unpublished reports). All projects were designed to increase sagebrush age-class diversity and the abundance and/or diversity of grasses and forbs, unless otherwise noted.

General Location or Ownership	Project Description	Acres Treated (if applicable)	Project Completed By	Year Completed
BLM Land	Brush beat	70	OMP	2000
Owl Mountain State Wildlife Area (SWA)	Dixie harrow	175	NPHPP	2000
Delaney Butte SWA	Dixie harrow	123	NPHPP	2000
Colorado State Trust Land	Dixie harrow	118	NPHPP	2000
Arapahoe National Wildlife Refuge (NWR)	Dixie harrow	114	NPHPP	2000
Private land	Dixie harrow	139	NPHPP	2000

Table 11. GrSG habitat projects reported in North Park (CDOW, unpublished reports). All projects were designed to increase sagebrush age-class diversity and the abundance and/or diversity of grasses and forbs, unless otherwise noted.

General Location or Ownership	Project Description	Acres Treated (if applicable)	Project Completed By	Year Completed
Private land	Dixie harrow & seeding	200	NPHPP	2000
Private and BLM land	Spike treatment (to improve livestock distribution in riparian bottoms)	90	OMP	2001
Private land	Dixie harrow	82	NPHPP	2001
Private	Dixie harrow	120	NPHPP	2001
Private	Dixie harrow	33	NPHPP	2001
Private	Dixie harrow	60	NPHPP	2001
Private	Dixie harrow	309	NPHPP / NRCS	2001
BLM	Dixie harrow	232	NPHPP	2001
BLM	Brush beat	160	OMP	2002
Private	Dixie harrow	410	NPHPP	2002
Private	Dixie harrow	550	NPHPP	2002
BLM	Lawson aerator	230	NPHPP	2002
Private	Lawson aerator and seeding (to improve lek attendance by enhancing early brood-rearing habitat around some leks)	150	North Park Sage Grouse Work Group and NPHPP	2002
Private	Dixie harrow (brood-rearing habitat)	260	NPHPP	2003
BLM	Brush beat	310	BLM and NPHPP	2005
BLM	Lawson Aerator	200	BLM and NPHPP	2005

Table 11. GrSG habitat projects reported in North Park (CDOW, unpublished reports). All projects were designed to increase sagebrush age-class diversity and the abundance and/or diversity of grasses and forbs, unless otherwise noted.

General Location or Ownership	Project Description	Acres Treated (if applicable)	Project Completed By	Year Completed
BLM	Seedbed preparation and seeding to restore degraded grazing allotment (in critical winter range); fence installation for grazing management	300	BLM, OMP, CDOW, Partners for Fish and Wildlife, Silver Spur Ranches	2005
Arapaho NWR	Install cross fence to allow grazing deferment and implementation of habitat restoration	1,600	CDOW, Arapaho NWR	2005
BLM and Private	Dixie harrow (20 acres); Cross fence constructed in riparian habitat (1,900 acres)	1,920	NRCS (WHIP), Partners for Fish and Wildlife, OMP	2005
Private	Brush beat to enhance brood rearing habitat	100	Partners for Fish and Wildlife, CDOW, OMP	2006
Private	Brush beat to enhance brood rearing habitat	200	CDOW, OMP	2006
BLM	Herbicide treatment to remove broom snakeweed in order to improve grass and forb component	100	BLM	2006
BLM	Brush beat	200	BLM	2006

Easements

In 2005, The Nature Conservancy (TNC) closed on a conservation easement that lists sage-grouse and sagebrush as conservation values (1,169 acres in occupied habitat; See Fig. 13 and Appendix J, "GrSG GIS Data").

Northern Eagle – Southern Routt Counties Population

General Description

The GrSG population area in northern Eagle and southern Routt Counties is located north of Interstate 70, west of the town of Edwards, and extends west to Garfield County and north to just past the town of Phippsburg (Fig. 11, pg. 72). The habitat that is currently known to be occupied by GrSG within these boundaries (95,388 acres) exists in several large patches, mostly connected by potential GrSG habitat (Fig. 11, pg 72). Landownership is approximately 71% private and 29% public (primarily BLM, but also SLB, USFS, and CDOW; see Appendix J, "GrSG GIS Data").

The topography and habitat are different between the northern and southern zones of this population. The "Routt" zone lies north of the Colorado River and the "Eagle" zone lies south of the Colorado River. Note that this line of demarcation is close to, but not identical to the line between Eagle and Routt counties (Fig. 11, pg. 72).

In the Eagle Zone, key topographic features are the valleys created by the Colorado and Eagle Rivers. Elevation ranges from 6,160 feet at the confluence of the 2 rivers to 11,275 at Castle Peak. The topography surrounding the Eagle and Colorado Rivers is mountainous, with canyons cut along the rivers and tributaries. Precipitation varies primarily with altitude and ranges from 12 - 30 inches per year, although most of the sagebrush receives only 12 - 20 inches annually (NESRCP 2004).

The dominant cover types between the Eagle and Colorado Rivers in the Eagle Zone are (1) sagebrush-grassland mixed shrub rangeland (which includes sagebrush, serviceberry, mountain mahogany, chokecherry, and Gambel oak); and (2) piñon-juniper woodlands. Mixtures of the 2 types are common. Hay meadows are found in the riparian areas along the Eagle River and some of its tributaries. In the Colorado River valley, piñon-juniper dominates, although with a good representation of sagebrush grassland and other mixed-shrub rangelands. Gambel oak, aspen, and coniferous forest cover types are found at higher elevations.

Landownership in the Eagle Zone is approximately 67% BLM and 33% private (see Fig. 11, pg. 72). Historical land-use in both the Colorado and Eagle River valleys has been primarily livestock ranching. However, in recent years, subdivision and "second home" development has expanded greatly in the Eagle River valley, following construction of Interstate 70 and nearby ski resort development.

The Routt Zone of this population area includes the Upper Yampa River Valley just south of Phippsburg, as well as the Egeria Creek drainage, which flows into Rock Creek, and ultimately the Colorado River. The terrain around both these valleys is less steep than in the Eagle Zone, with rolling hills and low mesas. Elevation ranges from 7,424 feet at Phippsburg to 12,172 feet at Dome Peak. Annual precipitation ranges from 12 - 16 inches in the lowest elevation to 50 inches in the mountains in the western part of the area. Most of the sagebrush receives slightly more precipitation that that in the Eagle Zone, ranging from 16 - 25 inches/year.

Sagebrush-grass rangeland is the primary cover type in the Routt Zone area, with aspen and coniferous forests at higher elevations. There is much less piñon-juniper than in the Eagle Zone, but more irrigated grass and hay fields.

In the Routt Zone only 17% of the land is managed by the BLM, 79% is private, and 4% is SLB. The primary land-use in the area is livestock ranching. There is potential for future residential and second home development in and around the towns Phippsburg, Toponas, and Yampa, primarily because of the proximity to Steamboat Springs, a tourist destination, as well as to recreational interests in the Flat Top Mountains to the west.

Population Information

The Northern Eagle Southern Routt Counties Conservation Plan (NESRCP 2004) reported an estimated population in 2004 of 304 - 489 GrSG (note: the NESR work group is in the process of revising these estimates). This is based on lek count data, using an index derived from Walsh et al. (2004). The index makes 3 assumptions: (1) there are 2.2 females for every male; (2) all leks are counted; and (3) the number of males that are counted ranges from 53% to 100% (resulting in a range of population estimates). Using the same index, lek counts in the 1960s (Fig. 15) would have yielded population estimates from 1,100 to 1,800 sage-grouse. Note that, for the purposes of this plan, we estimate only the number of breeding GrSG males in each local population, not the total population size (see Table 7 [pg. 56] and summary of population estimation in "Conclusions" [pg. 55]).

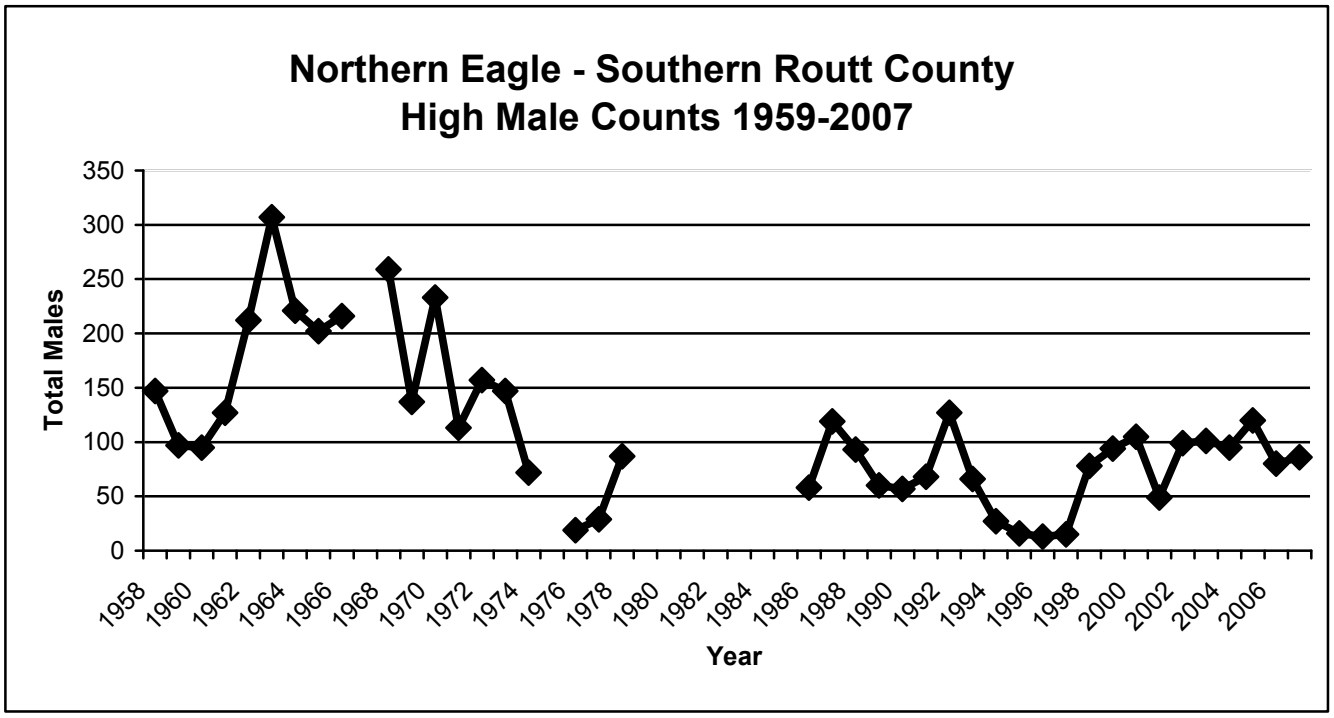

Fig. 15. Lek count data for NESR GrSG population area, 1959-2007.

Historic Information

Rogers (1964) reported that in the early 1900s, settlers observed large numbers of sage-grouse in Moffat and Routt Counties. He described a GrSG population ranging in an area from Toponas to Yampa. In Eagle County he noted sage-grouse populations east and northwest of Burns, northeast of Gypsum, and north of Wolcott (Rogers 1964).

Local Conservation Plan

The local work group in this area was formed in 1998 by local landowners, public land management agencies (e.g., BLM, USFS, NRCS, CDOW), TNC, CSU Extension, and other stakeholders. A draft plan that identified issues and a population goal was produced in 2000, but the group then discontinued work because participation declined. The work group reformed in 2003 and the conservation strategy portion of the plan was completed. The NESRCP was finalized and signed on September 1, 2004 (NESRCP 2004).

The boundaries of the GrSG population area in the NESRCP (2004) were defined by identifying areas with known historic use, sage-grouse observations, and potentially suitable sagebrush habitat. The NESRCP (2004: 24) stated its population goal was to, "Maintain the current population and increase to a population of 500 birds during the breeding season." The habitat goal (NESRCP 2004:24) to be used to achieve this population goal was to "Maintain on suitable sites across the Northern Eagle/Southern Routt landscape relatively large, contiguous stands of sagebrush with a variety of vegetative conditions interspersed throughout, in the desired arrangement with good connectivity to provide the quantity and quality of sage-grouse habitat to support the desired population of 500 birds."

Conservation actions in the NESCRCP (2004) are organized to address particular issues, including utilities, habitat change, disease and pesticides, land-use changes and residential development, reservoir development and other water-related issues, recreation/travel management, predation, grazing, and hunting.

Completed Conservation and Habitat Actions

Table 12. GrSG habitat projects reported in Northern Eagle - Southern Routt County GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
Private	Mechanical treatments to rejuvenate sagebrush; stream restoration to improve wet meadow habitat	50	NRCS (WHIP), Partners for Fish and Wildlife	2005
Private	Piñon juniper removal to enhance sage-grouse habitat near an active lek	120	CDOW, Private	2006
BLM	Piñon juniper removal to enhance sage-grouse habitat	160	CDOW, BLM	2006
Private	Cross fencing to improve grazing management	580	NRCS (WHIP), CDOW, Partners for Fish and Wildlife	2006

Easements

The Yampa Valley Land Trust holds 3 conservation easements on over 2,290 acres in sage-grouse habitat in southern Routt County. Total easement acreages for the entire NESR area are 2,430 acres in occupied habitat, 2,161 acres in potentially suitable habitat, and 953 acres in vacant/unknown habitat (see Fig. 11, pg. 72; Appendix J, "GrSG GIS Data").

In 2006, CDOW closed on a conservation easement on 2,050 acres in important GrSG habitat. The conservation easement protects 2 active leks, as well as nesting and brood-rearing habitat.

Northwest Colorado Population

General Description

The Northwest Colorado population of GrSG is located in the northwest corner of the state (Fig. 16), primarily in Moffat County, but also in portions of western Routt County and northwestern Rio Blanco County. It is the largest GrSG population in Colorado, and the area of occupied habitat is 2,563,033 acres. Landownership is approximately 41% private and 59% public (primarily BLM, but also SLB, CDOW, USFWS, NPS, and USFS; see Appendix J: "GrSG GIS Data").

The western half of NWCO is considered arid to semi-arid, and the eastern half, which begins to climb into foothills and mountains, is semi-arid. Annual precipitation ranges from 8 - 20 inches, occurring primarily as snow in winter and early spring.

Vegetation in NWCO is variable, depending on soils, climate, aspect, elevation, and topography. Sagebrush communities are widespread and diverse, and there is some hybridization of sagebrush species in the area. In some areas sagebrush dominance may reduce herbaceous understory. There are some areas of juniper encroachment, and sagebrush merges into mountain shrub communities at higher elevations, and into greasewood shrub at lower elevations.

Livestock grazing in NWCO probably began in the 1870s (Athearn 1982). In recent years there has been a slow decline in sheep and cattle grazing. However, grazing remains the dominant land-use in the area. Energy development, including oil, gas, and coal, is increasing in NWCO. Housing development is also growing in some areas of NWCO, although it is not widespread.

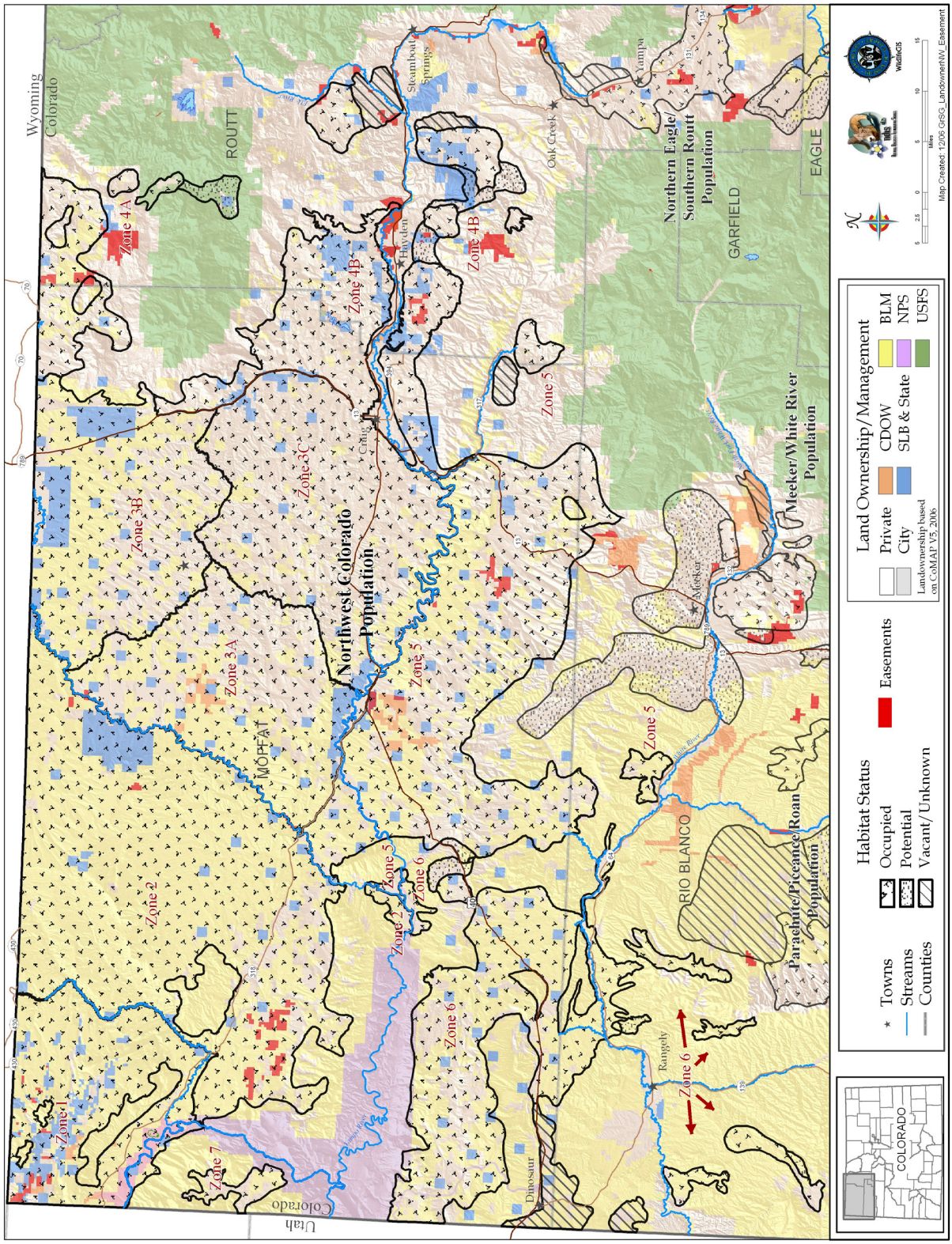

Fig. 16. Habitat status, landownership, and conservation easements in the NWCO GrSG population area.

Population Information

Lek counts have been conducted in the NWCO population since at least 1953 (Fig. 17). Efforts have been inconsistent through the years and have been hampered by many factors, including a number of years without lek counts. A greater and more consistent effort has been made since 1995 to more clearly document GrSG lek counts in the NWCO population, with the most consistent data collection occurring from 1998 to the present. According to lek count data, the long-term trend appears to be stable, but substantial population fluctuations have occurred regularly. Population peaks have occurred in 1968-70, 1978-80, and in the years since 2000. Lek counts from 2006 totaled nearly 3,500 males.

The NWCO local work group has not attempted to derive a population estimate from lek counts due to the variety and uncertainty of methods, but instead tracks 3-year running averages of high-male lek counts. The number of active leks and number of males per lek are used as secondary measures of population trend. The NWCO local working group is exploring the use of subsets of leks with the longest and most complete count records as more accurate indicators of trend for the years prior to 1998. Note that, for the purposes of this plan, we estimate only the number of breeding GrSG males in each local population, not the total population size (see Table 7 [pg. 56] and summary of population estimation in "Conclusions" [pg. 55]).

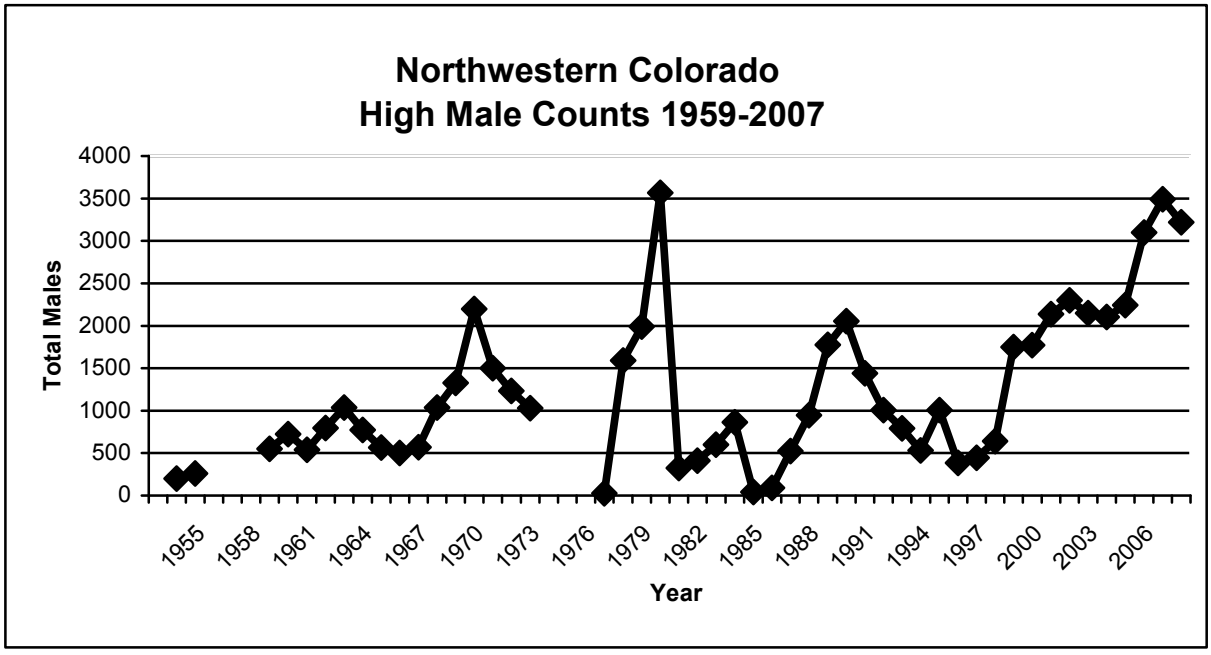

Fig. 17. Lek count data for the Northwest Colorado GrSG population, 1953-2007. No data were recorded in 1955-1957 and 1973-1975. Data for 1976, 1984, and 1985 are very low total counts and appear as nearly zero in the figure. Effort made in counting leks was low in those years, and not comparable to other years. Most consistent effort has been since 1998.

Historic Information

Rogers (1964) stated that the Moffat County GrSG population had both the highest number of birds and the highest density in the state. Rogers (1964:116) reported that in Rio Blanco County, "…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."

Historically, Moffat County likely had one of the highest sage-grouse populations, which was distributed more widely than it is currently (Rogers 1964). Rogers (1964) stated that settlers from the early 1900s remembered large numbers ("thousands") of sage-grouse in Moffat and Routt Counties. Rogers (1964) estimated that in some areas of Moffat County, sage-grouse density ranged as high as 30 - 50 birds/mi^2.

Local Conservation Plan

The Northwest Colorado Greater Sage-grouse Working Group formed in 1996, and its intent is to "enhance greater sage-grouse populations while taking into account the importance of local economies for the long-term maintenance of greater sage-grouse habitats and while maintaining all existing human uses of sage grouse habitats in Northwest Colorado" (NWCOCP 2006:i). A final conservation plan will be completed in 2008.

The boundary of the area, as defined in the Northwest Colorado Conservation Plan (NWCOCP 2006), follows topographic and other natural features. The area totals 4,277,771 acres of land, and 2,564,115 acres of occupied sage-grouse habitat. This extensive area includes a wide range of elevations, precipitation levels and range sites with implications for the capability of sites to provide GrSG habitat. To account for these differences in ecological sites and differences in issues affecting GrSG habitat, the NWCOCP (2006) divides the NWCO population into 10 management zones to aid in setting objectives, implementing conservation strategies, and tracking progress. Population targets are established for the entire population and for each management zone. The target is to maintain the number of males counted on leks each year (reported as a 3-year running average) above the level determined by 25% below the mean of 1998-2005 lek counts. Nearly all management zones exceed this level by considerable margins at present.

Completed Conservation and Habitat Actions

Table 13. GrSG habitat projects reported in Northwest Colorado GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
BLM	Mechanical treatments to rejuvenate sagebrush stands in a mosaic pattern	3,000	BLM	2001-2002
Browns Park SWA	Brush beat for brood-rearing habitat	40	CDOW	2001-2002
Little Snake SWA	Brush beat to enhance brood habitat	130	CDOW	2001-2002
Private land, NE of Craig	CRP plantings to improve nutritive quality	1,000	CDOW	2001-2002
Private	Numerous prescribed burns in upland to restore riparian function and improve brood habitat	<100 acres	Landowner	2001-2002
Little Snake SWA	Prescribed burn	170	CDOW	2003
SE of Hayden	Brush control and reseeding to enhance nutritive quality in historic/potential habitat	500	Landowner	2003
N of Maybell	5 miles water pipeline distribution system completed to alter livestock distribution; ground tanks accessible to GrSG	N/A	NRCS, Landowner	2003
BLM, around Douglas Mountain	3 prescribed burns to maintain sagebrush parks and remove juniper encroachment	1,200	BLM	2003
Fan Rock lek site (NE of Craig)	Encroaching brush cleared	5	Landowner	2003
N/A	Native forb seed collected to derive germination description and develop native seed stock	N/A	Upper Colorado Environmental Plant Center (UCEPC)	2003
BLM, Douglas Mountain	Brush beat	500	BLM	2004
BLM, Conway Draw	Brush beat and reseeded drought-related sagebrush die-off area		BLM	2004

Table 13. GrSG habitat projects reported in Northwest Colorado GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
Little Snake SWA	Red Wash burn reseeded with palatable forbs to restore degraded upland riparian area	120	CDOW	2004
Little Snake SWA	Water distribution system developed with ground-accessible tanks	N/A	CDOW	2004
Great Divide	Water distribution system ad 5-mile pipeline installed for livestock management and tanks for GrSG	N/A	NRCS, Landowner	2004?
BLM, Sevenmile Ridge	Removal of encroaching juniper	750	BLM	2005

Easements

In 2004 a conservation easement was obtained on 1,800 acres of Conservation Reserve Program (CRP) /sagebrush bottoms south of Hayden. This easement includes management strategies for both sage-grouse and sharp-tailed grouse habitat. TNC secured a 1,281-acre conservation easement NE of Hayden. This easement refers to sage-grouse and Columbian sharp-tailed grouse as protected conservation values; about 80% of the area has upland habitat for both species. Total easement acreages for the NWCO area are 18,683 acres in occupied habitat, 240 acres in potentially suitable habitat, and 922 acres in vacant/unknown habitat (see Fig. 16 and Appendix J, "GrSG GIS Data").

Parachute – Piceance – Roan Population

General Description

The Parachute – Piceance – Roan population) is located within the area bounded by the towns of Meeker, Rifle, Palisade, and Rangely (Fig. 18). Currently occupied habitat within this area lies in 2 patches: (1) the larger western Roan Plateau and Cathedral Bluffs area; and (2) the smaller Magnolia area (Fig. 18). Total occupied habitat in PPR is 304,588 acres.

The Roan Plateau lies at the headwaters of the Douglas, Parachute, Piceance, and Roan Creeks, and forms a divide between the White and Colorado Rivers. The physiography of the plateau area varies from south to north. The top of the plateau appears to be a broad, rolling plain, but to the south in the Parachute and Roan Creek drainages, the plateau drops off abruptly into the deep canyons of these creeks and their tributaries. The ridgetops between the canyons are broad (up to 2.5 miles wide) and relatively level. Similarly, the west side of the area drops off extremely abruptly at the Cathedral Bluffs into East Douglas Creek. In contrast, the terrain drops fairly gently into the tributaries of Piceance Creek Basin to the north and east; this area is dissected by numerous relatively shallow parallel canyons, with relatively narrow ridgetops in between.

Current grouse habitat in this area is primarily between 7,000 and 8,700 feet in elevation. The Magnolia portion of the PPR lies east and north of Piceance Creek, west of Colorado Highway 13, and south of the Dry Fork of Piceance Creek. The elevation in this area is somewhat lower, between 6,500 and 7,500 feet. Precipitation within occupied habitat in the PPR ranges from 16 - 25 inches per year, varying primarily with elevation.

Vegetation cover also varies from south to north. On the southern, lower ends of the ridges between Parachute and Roan Creeks and their tributaries, mountain shrub communities (a mix of serviceberry, Gambel oak, bitterbrush, and big sagebrush) dominate, interspersed with patches of big sagebrush and aspen, depending on topography. Aspen pockets are found on north- to northeast-facing slopes, and sagebrush appears along gentle slopes in the bottoms of washes. Ridgetops to the north are dominated by big sagebrush, and aspen pockets are found on the northern slopes, occasionally on the ridges. This situation holds along the highest ridges forming the White River-Colorado River divide, as well as along the Cathedral Bluffs to the north. In the Piceance Creek drainage, mountain shrub is a lesser component, found on north-facing slopes only. Big sagebrush dominates on ridgetops, but as one travels north or northeast down these ridgetops, piñon and juniper woodlands are more prevalent, and appear to be encroaching into the sagebrush as time has passed over the years. The Magnolia area is similar in this regard. In the PPR population area, sage-grouse are largely restricted to sagebrush-covered ridges and plateaus at higher elevations, whereas slopes with mountain shrubs and narrow valley bottoms (even those with some sagebrush) are not used.

Mountain shrub communities, particularly serviceberry, are more common and extensive in PPR than elsewhere in GrSG range. Serviceberry is well-established in the PPR, with dense areas of serviceberry occupying the lower and drier ridges within occupied habitat. Big sagebrush is the

dominant shrub species in the highest elevations of occupied GrSG habitat, but is interspersed with serviceberry in many locations. While PPR sage-grouse have been demonstrated to use the margins of serviceberry stands for nesting and brood-rearing habitat, higher lek counts occur where sagebrush is the dominant shrub.

Landownership in PPR is approximately 65% private and 35% public (primarily BLM; see Appendix J, "GrSG GIS Data"), and varies within the area. On the south side, in the Parachute and Roan drainages, approximately 90% is private, and a large portion of that is owned by large energy corporations. To the north in the Piceance Basin, a slight majority is in public ownership, particularly at the lower elevations, with the exception of canyon bottoms along streams, which tend to be privately-held. The traditional land-use in the area has been domestic livestock grazing. However, the potential for large-scale energy resource development has loomed on the horizon since the discovery and patenting of oil shale claims in the 1920s. The presence of oil shale and natural gas in the area accounts for the large proportion of ownership by energy companies. Currently, natural gas development is rapidly expanding in the area as pipelines tied into national supply networks have been constructed and prices have risen. Residential development is not a factor in the area at this time, although there is the possibility that worker camps will be constructed within sage-grouse habitat as gas development increases, due to the remote locations of this activity from towns and the difficult nature of travel in this rugged country.

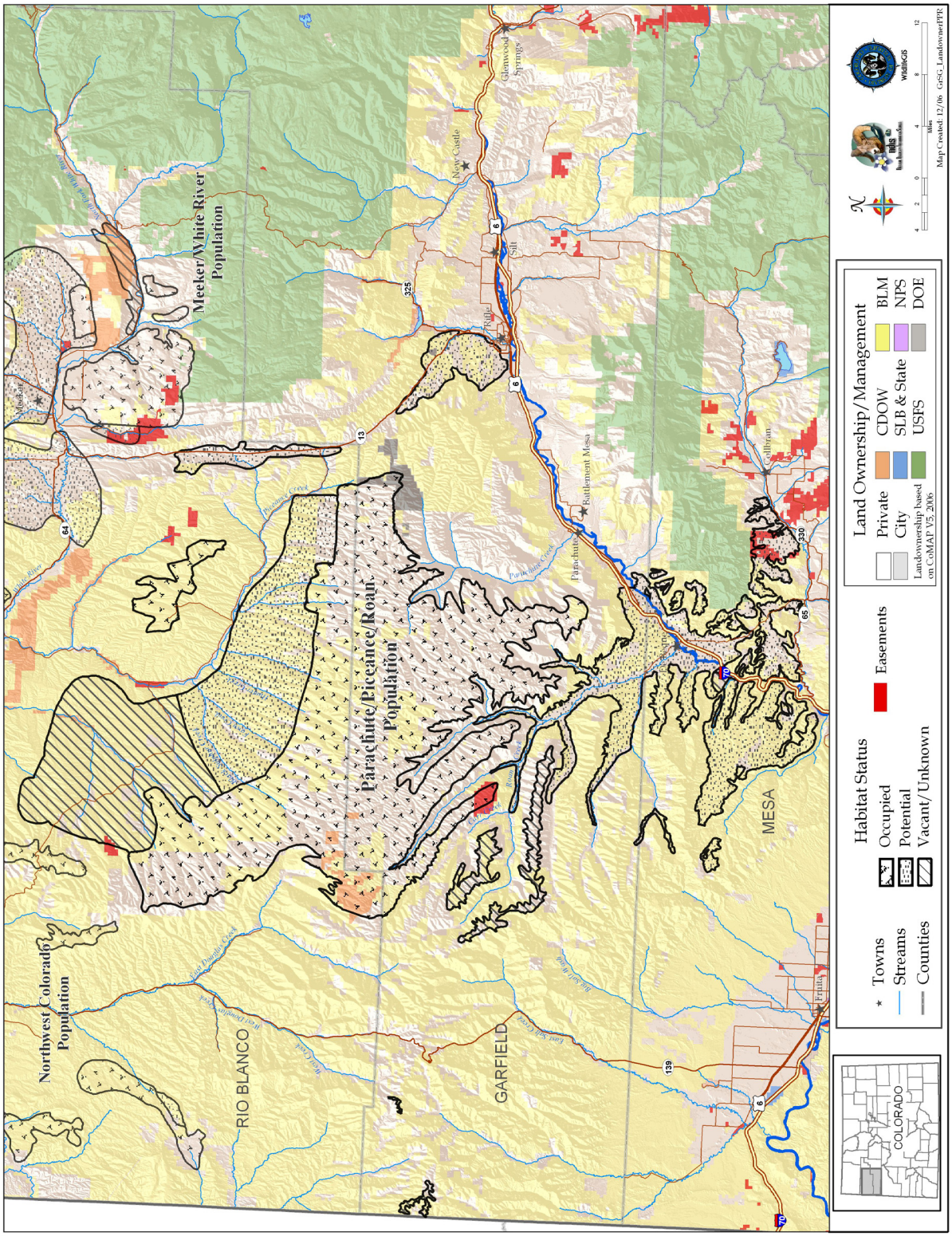

Fig. 18. Habitat status, landownership, and conservation easements in the PPR GrSG population area.

Population Information

Leks in the PPR are concentrated at high elevations and remote locations, particularly in the Parachute – Roan portion of this population. Many of these leks are inaccessible from the ground during optimal periods for lek counts due to snow and mud conditions. This makes consistent lek counts difficult to accomplish, complicating comparison of data among years. Aerial lek counts have been the only possible method for counting sage-grouse on leks for some of the PPR. These aerial counts have historically been conducted by fixed-wing aircraft, which results in reduced sightability of birds and less consistent counts from year to year. CDOW has used helicopter surveys in 2005, 2006, and 2007 to count leks in this population. These counts have resulted in substantially higher counts that appear more consistent among years.

Extensive field work in 1976 and 1977 provided the first complete look at sage-grouse distribution and numbers in the PPR (high male count = 234; Kraeger 1977). Lek counts conducted by CDOW in the spring of 2005 by CDOW, (the most exhaustive count completed since 1976), yielded a high male count of 180 birds (Fig. 19). Because of the limited amount of consistent data available, we can't describe any trend in this population. Note that, for the purposes of this plan, we estimate only the number of breeding GrSG males in each local population, not the total population size (see Table 7 [pg. 56] and summary of population estimation in "Conclusions" [pg. 55]).

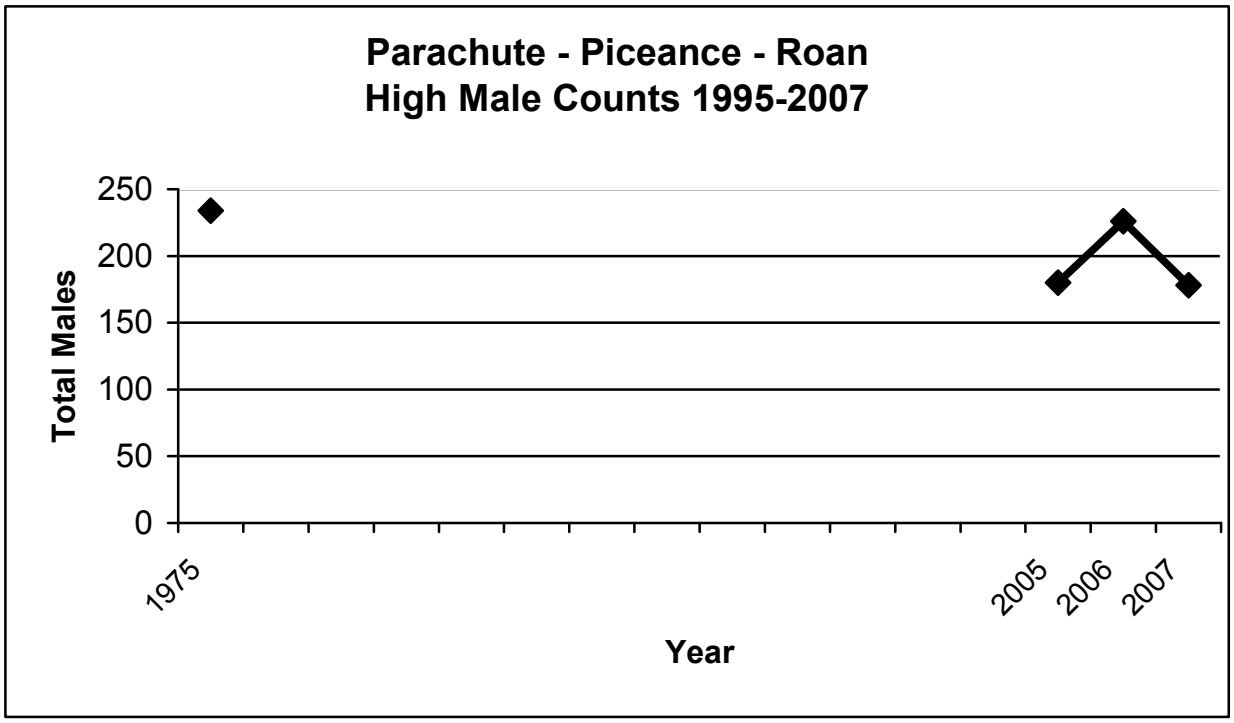

Fig. 19. Lek count data for Parachute – Piceance – Roan GrSG population, 1995-2007. The data point for 1976 was estimated from categorical data (4 categories: 1-2, 3-5, 6-15, 15+), and though the specific value is approximate, the data are considered reliable. Data collected in the interim years are not reliable because of the difficulty in obtaining lek count data in the PPR area, and varied effort in conducting lek counts during those years.

Historic Information

Rogers (1964) described a "light" population of sage-grouse on the Bookcliff (Roan) Plateau from Wagonwheel Ridge at the headwaters of Parachute Creek, west to Douglas Pass (this includes the headwaters of Douglas, Parachute, Piceance, and Roan Creeks.) He also noted sage-grouse in areas to the northwest, northeast, and south of the town of Rifle, as well as east and south of DeBeque in the Roan, Wallace, and Sunnyside drainages near the Mesa County line. Anecdotal information from local long-term residents of DeBeque, Colorado indicates that greater sage-grouse may have occupied lower areas of the Roan Creek valley during winter periods during the 1930s and 1940s. Following a severe winter storm that brought deep snow and sub-freezing temperatures in February of 1989, a small group of GrSG were observed by the CDOW in an area dominated by big sagebrush in the Castle Rock area, about 3.5 miles southwest of DeBeque in Mesa County (J. Gumber, retired CDOW, personal communication).

The Gunnison Sage-grouse Rangewide Steering Committee (2005) questioned whether sage-grouse previously found south of the Colorado River in the DeBeque-New Castle area are GrSG or GuSG. No published evidence exists to prove this one way or another, but a river as small as the Colorado would not present a barrier to travel by sage-grouse. Sage-grouse are strong fliers and have the ability to cross a river the size of the Mississippi. Regardless, sage-grouse have been extirpated south of the Colorado River in Garfield and northeastern Mesa counties, as well as north of the Colorado River and east of Parachute Creek in Eastern Garfield County.

Local Conservation Plan

Efforts to develop a local conservation plan began in the summer of 2005. Informational meetings were held in Roan Creek, Piceance Creek, and Parachute in June 2005, and a work group was formed in July, 2005. Work group meetings have been held monthly since then, and work on the plan is progressing steadily, with expected plan completion in early 2008 (Parachute – Piceance – Roan Conservation Plan; PPRCP 2008). The primary issue the work group has addressed is energy and mineral development (and associated infrastructure). Other issues include grazing, predation, habitat quality, recreation, piñon-juniper encroachment, and water development. Strategies have been developed for all issues and final preparation of the plan is in progress.

Completed Conservation and Habitat Actions

Table 14. GrSG habitat projects reported in Parachute – Piceance – Roan GrSG area (CDOW, unpublished reports).

General Location or Ownership	Project Description and Purpose	Acres Treated (if applicable)	Project Completed By	Year Completed
Habitat surrounding Magnolia Lek	Hydroaxe used to control encroaching tall shrubs	50	CDOW	2000-2002
Piceance SWA	Dixie harrow; sagebrush thinning to enhance nest cover and brood forage	1,200	CDOW	2000-2002
Near Magnolia Lek	Brush beating for understory restoration	500	BLM	2000-2002
Piceance SWA	Understory enhancement: reseeding with palatable forbs	400	CDOW	2000-2002
Barnes Ridge	Large pipeline corridor reclaimed with sagebrush and palatable forb species	87 (8 miles of corridor)	Industry	2000-2002
N/A	Field collection of native forbs for germination description and native seed stock development	N/A	UCEPC, NRCS	2003
BLM, Wolf Ridge	Prescribed burn in juniper encroachment area	280	BLM	2004
Skinner Ridge / Colorado Nature Ranch (now Kessler Canyon Ranch)	Sagebrush and serviceberry treatments (brush hog), to reduce shrub overstory for nesting and brood-rearing habitat	N/A	NRCS, ranch, CDOW	2005 and ongoing

Easements

No easements specifically for sage-grouse or sage-grouse habitat exist in the area covered by the conservation plan effort. A conservation easement, originally secured through the Rocky Mountain Elk Foundation, exists in the south portion of Brush Mountain (Roan Creek), within GrSG occupied range (Fig. 18). There are at least 2 easements in former GrSG range in the Plateau Valley in Mesa County (south of the Colorado River), in areas at the margins of what may have been historic range for whichever species of grouse used the area. Total easement acreages for the area are 1,355 acres in occupied habitat and 1,808 acres in potentially suitable habitat (see Fig. 18 and Appendix J, "GrSG GIS Data").