

# THE HISTORY AND CURRENT CONDITIONS OF THE GREATER SAGE-GROUSE IN REGIONS WITH ENERGY DEVELOPMENT





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# The History and Current Conditions of the Greater Sage-Grouse in Regions with Energy Development

## Section 1: Background and Natural History

### Introduction

Currently, the energy needs of the United States are greater than domestic sources are currently supplying, a situation which is expected to continue at an increasing rate as the energy needs of the United States rise in the future (NEPDG, 2001). The domestic supply of crude oil is approximately 5.5 million barrels per day, while consumption of crude oil is exceeding 20 million barrels per day; a domestic production shortfall of 14.5 million barrels per day (EIA, 2005). Consumption of crude oil is expected to steadily increase to over 27.5 million barrels per day by 2030, which would result in a domestic production shortfall of more than 20 million barrels per day (EIA, 2005). Natural gas shortfalls are also expected, but not as large as shortfalls for crude oil. The difference between domestic production of natural gas and consumption was approximately four trillion cubic feet (TCF) per day in 2003. While production of natural gas is expected to grow over the next 15- 20 years at a project increase of 1.5 percent annually, consumption is expected to grow at faster rate which is predicted to result in a domestic production shortfall of approximately seven TCF/day by 2030 (EIA 2005).

The Energy Policy Act of 2005 was signed into law by President George W. Bush in August of 2005, and represents the first major energy legislation passed by Congress since the original Energy Policy Act of 1992. One of the primary focuses of the new law is to increase production of domestic fossil fuels (natural gas, oil and coal). The National Energy Policy Development Group, which provided the basis for Bush's Energy Policy, suggested that one of the ways to increase domestic on-shore production is to increase production on federal lands through increased access to oil and natural gas resources on federal lands. The federal government owns approximately 30 percent

of the land in the United States, with much of the nation's public lands estimated to have substantial undiscovered energy resources (NEPDG, 2001). In the west, more than four of every 10 acres of land is owned and managed by the federal government (Western Governors' Association, 2006). Therefore, access to federal lands for the leasing and development of oil and natural gas resources is pivotal to meeting the nation's energy demands.

In terms of natural gas production, much of the onshore development within the Continental United States is occurring in the Uinta-Piceance Basin of Colorado and Utah, the Green River Basin of southwestern Wyoming, the San Juan Basin of New Mexico and Colorado, the Montana Thrust Belt, and the Powder River Basin of Wyoming and Montana (Connelly et al., 2004). Most of these Intermountain West reserves are under Bureau of Land Management (BLM) jurisdiction (Connelly et al., 2004) and in sagebrush steppe dominated landscapes (Knick et al., 2003). Growing concern about the degradation and/or loss of sagebrush steppe due to urbanization, agriculture, livestock grazing, management tactics (e.g., prescribed fires, herbicides, mechanical treatments, etc.) and energy development has resulted in an ever increasing awareness of population trend declines being observed by a sagebrush obligate species, the greater sage-grouse.

No single factor can be identified as the cause of declines in sage-grouse populations (BLM, 2004). Historically, population dynamics of sage-grouse have been defined by strong cyclic behavior;

While production of natural gas is expected to grow over the next 15- 20 years at a projected increase of 1.5% annually, consumption is expected to grow at faster rate which is predicted to result in a domestic production shortfall of approximately seven TCF/day by 2030 (ALL Consulting, 2006).

however available data and reports suggest this grouse species has observed long term population declines because of habitat loss, with range-wide decline rates estimated from 17 – 47 percent (Connelly and Braun, 1997). In 2005 the U.S. Fish and Wildlife Service (USFWS) completed a “status review” of the greater sage-grouse for listing and special protection as afforded under the Endangered Species Act. From this review process however, the USFWS determined under considerable controversy the greater sage-grouse did not warrant special protection under the Act because the overall natural distribution and population of the birds was not considered to be in significant jeopardy. As reported by the USFWS (2005), greater sage-grouse are currently estimated to number from approximately 100,000 to 500,000 individuals. Although, the USFWS estimates sage-grouse populations have declined an average of 3.5 percent per year from 1965 to 1985, they have also reported certain sage grouse populations from several states have increased or stabilized (2005). In addition, the USFWS has reported the population rate of decline from 1985 to 2003 slowed to 0.37 percent annually for the species across its entire range (U.S. Fish and Wildlife Service, 2005); an estimate which is contrary in some cases to other reported decline rates.

In terms of oil and gas development, the industry has had a historical presence in the grouse’s range; although not until recently

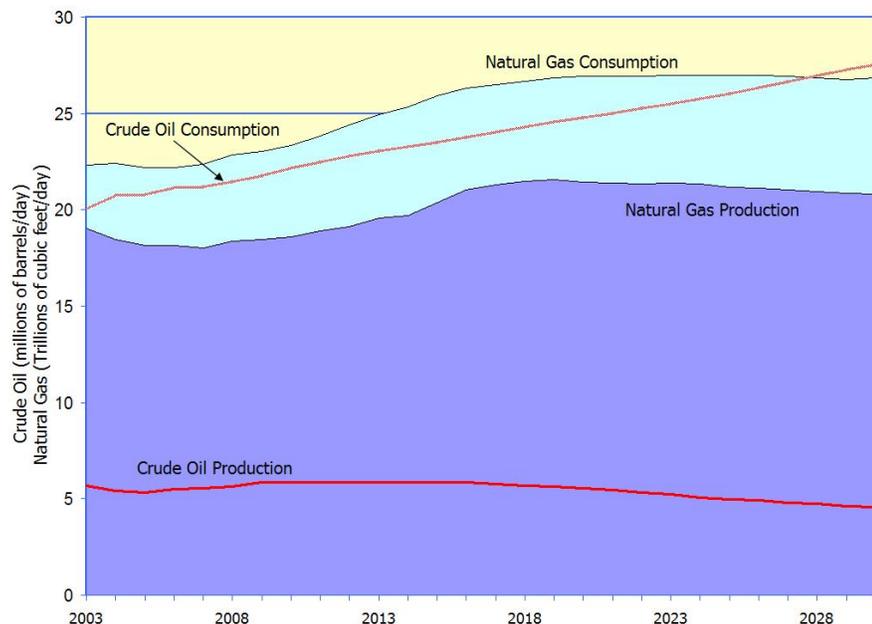
(mid-1990’s) has the area observed proportional increases in energy expansion and concentration. In any case, the greater sage-grouse is native to the Rocky Mountain region and has had a long and important history with hunters, ranchers, land managers and perhaps local communities that may not be fully understood. As such, a further discussion on this species is warranted.

**Purpose**

The surging concern and awareness for the greater sage-grouse has placed considerable strain on BLM, land managers and energy stakeholders to develop measures and conservation plans to protect critical resources for the grouse, while insuring domestic energy production remains fruitful. Federal lands make up about 72 percent of the total range of the species (Connelly et al., 2004), as well as a large portion of remaining grouse habitat. It’s this large percentage of land ownership that makes federal land management agencies primarily responsible for habitat management. BLM has the management responsibility for much of this land, which in recent years has led them to initiate a priority effort. This effort has involved funding of scientific study by the academia community, sponsorship of meetings and workgroups and development of potentially new protective management approaches.

**Figure 1: United States Domestic Oil and Natural Gas Production and Consumption**

*Graph depicts estimated domestic oil and natural gas production and consumption through 2030 (EIA, 2005)*



Considering the national importance of federal land access for energy development and supply, it is also critical to understand and address the greater sage-grouse since current conservation plans and strategies to protect this species may significantly impact the energy industry. As such, the purpose of this report is to provide a historical overview of the bird to help clarify its regional significance, which in turn may provide possible rationale for the contentious political climate being generated within much of the bird's natural range because of ongoing energy development. This paper will also address and highlight current conservation plans from important stakeholders; discuss current and historical management approaches; and synthesize current energy related scientific evaluations that address sage-grouse population declines.

## **Description, Natural History and Ecology**

### **Taxonomy and Description**

Greater sage-grouse were first identified by Lewis and Clark in 1831 as *Centrocercus urophasianus*. These "spiny-tailed pheasants" have inhabited Western North America for over 11,000 years. Currently, sage-grouse occupy approximately 258,000 square miles in 11 states and two Canadian provinces with a total population estimate exceeding well over 250,000 adult birds (Crawforth, 2004). The greater sage-grouse (*Centrocercus urophasianus*) is the largest grouse found in North America.

This avian species is considered a native upland game species that nests on the ground under sagebrush and feed on sagebrush, forbs and insects. This grouse exhibits substantial sexual dimorphism in size and appearance. For instance, the average mass of adult males is 2.5 – 3.2 kg whereas, adult females are considerably smaller with an average mass of 1.3 – 1.7 kg, with observed variation in both sexes by region and season (Dalke et al., 1963; Eng, 1963; Beck and Braun, 1978; Hupp and Braun, 1991; Schroeder et al., 1999).

Both sexes have a long pointed tail and prominent drab gray and white plumage, which distinguishes them from all other North American grouse, except with the

Gunnison sage-grouse (*Centrocercus minimus*). Although the female tends to be cryptically colored, the breast and neck feathers of males offers more contrast (Connelly, 2004). The breast feathers of males are distinctively white and composed of short, stiff feathers (Brooks, 1930). During the breeding season, males develop discernible air sacs on the breast and specialized, ornamental contour feathers called filoplumes that arise from the dorsal base of the neck. For an upland game bird, sage-grouse have a remarkably long life



**Male Sage Grouse**

*Photograph provided courtesy of the USGS*

span. Four and five year old birds are not unusual, and research shows that 60 to 80 percent of the birds survive each year. That's roughly twice the survival rate of other upland game birds. The downside is that the reproductive rate of sage-grouse is the lowest of any North American upland game bird.

### **Range and Distribution**

Currently, greater sage-grouse inhabit suitable sagebrush habitats in central Washington through southern Idaho, much of Montana, extreme southeastern Alberta and southwestern Saskatchewan, south to the southwestern corner of North Dakota, northwestern and southwestern South Dakota, most of Wyoming, western Colorado, and portions of Utah, and west to Nevada, extreme eastern California, and

southeastern Oregon (Schroeder et al., 1999 and 2004). Figure 2 illustrates the current distribution of the greater sage-grouse as reported by Schroeder et al., 2004. Approximately 99 percent of the current population is found in the United States, while the remaining one percent is located in Canada (Stiver et al., 2006). Federal lands make up about 72 percent of the total range of the species (Connelly et al. 2004) making federal land management agencies primarily responsible for habitat management. However, privately-owned lands provide critical seasonal habitats for many populations and their importance to conservation may greatly exceed the percentage of ownership within a population's range (Stiver et al., 2006). Sage-grouse populations typically inhabit large, unbroken expanses of sagebrush and are characterized as a landscape-scale species (Patterson 1952, Wakkinen 1990); however, definitive data are unavailable on minimum patch sizes of sagebrush needed to support populations of sage-grouse (Rowland, 2004).

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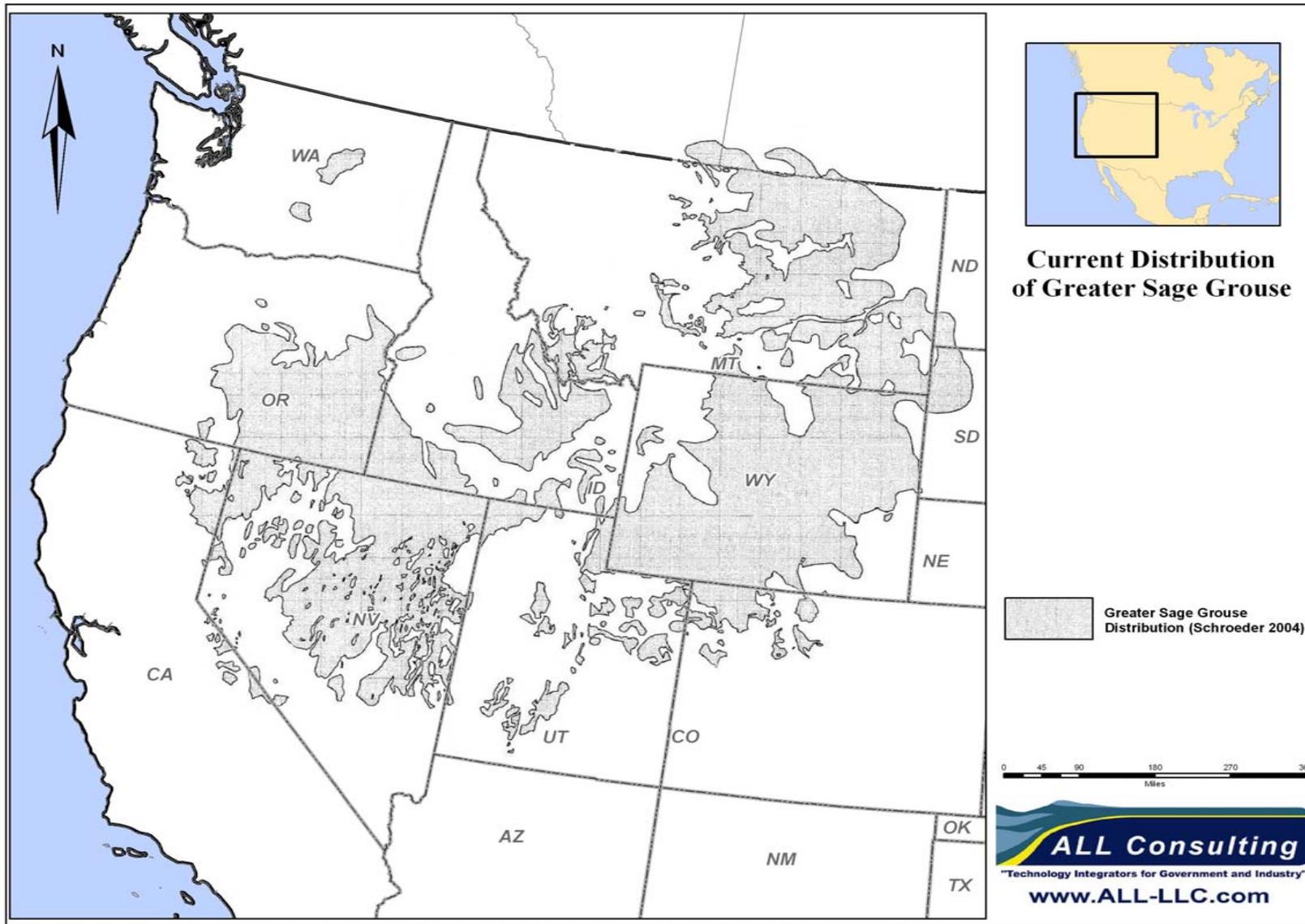
### **Habitat Requirements**

Sage-grouse are native to the sagebrush steppe of western North America, and their distribution closely follows that of sagebrush, primarily big sagebrush (*A. tridentata*). The greater sage-grouse is a sagebrush obligate species because of the bird's year-round dependence on sagebrush habitat (Patterson, 1952; Braun et al., 1976; Braun and Beck, 1996; Paige and Ritter, 1999; Schroeder et al., 1999). However, the greater sage-grouse can also use a variety of other native habitats, especially during on-breeding times, including low sagebrush types such as, little sagebrush (*A. arbuscula*, black sagebrush (*A. nova*), antelope bitterbrush (*Purshia tridentata*), as well as riparian and upland meadows and sagebrush grasslands (Patterson 1952, Dalke et al., 1963; Wallestad, 1971; Nisbet

et al., 1983; Klebenow, 1985; Connelly et al., 1991; Gregg et al., 1993; Musil et al., 1994; Braun, 1995; Apa, 1998; Schroeder et al., 1999; Aldridge and Brigham, 2002; Crawford and Davis, 2002; Danvir, 2002). In addition, greater sage-grouse have also been shown to use human-modified habitats, such as croplands (alfalfa), when such habitats are adjacent to sagebrush sites (Schroeder et al., 1999).

Sage-grouse are polygamous and exhibit similar breeding behaviors each year on ancestral strutting grounds or leks (Patterson, 1952; Wiley, 1978). Breeding habitats are sagebrush-dominated rangelands, typically consisting of large, relatively contiguous sagebrush stands (Connelly et al., 2000; Leonard et al., 2000). Males display on leks that are characterized by low, sparse vegetation or bare ground (Patterson, 1952; Gill, 1965; Klebenow, 1985). Leks can be occupied for years, with reported use exceeding 25 years (Dalke et al., 1963 and Wiley, 1978). Nesting habitat is often a broad area within or adjacent to leks, winter range or between winter and summer ranges (Klebenow, 1969; Wakkinen, 1990; Fischer, 1994). Productive nesting habitat includes sagebrush with horizontal and vertical structural diversity (Wakkinen, 1990; Gregg 1991; Schroeder et al., 1999; Connelly et al., 2000). Nesting habitats include moderate sagebrush cover, typically ranging from 15 to 25 percent (Connelly et al., 2000). During winter, sage-grouse rely on exposed sagebrush for foraging and shelter (Batterson and Morse, 1948; Patterson, 1952; Schroeder et al., 1999; Rassmussen and Griner, 1938; Patterson, 1952; Remington and Braun, 1985; Robertson, 1991). Sage-grouse have also shown a preference for large intact expanses of sagebrush and habitat avoidance of conifer and rugged terrains conditions (Naugle et al., 2006a).

Figure 2: Habitat Distribution Map



### **Seasonal Movement and Water Use**

Sage-grouse have shown the ability to display numerous annual migratory patterns (Beck, 1975; Wallestad, 1975; Hulet, 1983; Berry and Eng, 1985; Connelly et al., 1988; Wakkinen 1990). In fact, according to Connelly et al. (2000), four distinct migratory behaviors can be observed, which include:

- Distinct winter, breeding, and summer areas
- Distinct summer areas and integrated winter and breeding areas
- Distinct winter areas and integrated breeding and summer areas
- Well-integrated seasonal habitats (non-migratory populations)

In addition, seasonal movements between distinct seasonal ranges may exceed 75 km (Dalke et al. 1963; Connelly et al., 1988), which can make it difficult to estimate population sizes (Connelly et al., 2000). As such, to better define populations Connelly et al. (2000) identified three distinct sage-grouse populations based on seasonal movements, which include:

- Non-migratory, grouse do not make long-distance movements between or among seasonal ranges.
- Single stage migratory, grouse move between two distinct seasonal ranges
- 2-stage migratory, grouse move among three distinct seasonal ranges.

Migratory patterns do not appear to be dependent on free-flowing water, although sage-grouse reliance on water can vary (Schroeder et al., 1999). Although, there are no apparent and consistent benefits of developed water sources to greater sage-grouse (Rowland, 2004), in Nevada for instance, a study by Nisbet et al. (1983) showed few leks were far from water. Additionally, during a seven year study in eastern Idaho, sage-grouse gathered in large flocks near water during the fall migration (Dalke et al., 1963) and in Colorado, the Division of Wildlife (2006) indicates grouse are likely to drink twice or more each day if water is available. Furthermore, sage-grouse may remain in irrigated fields during much of the summer (Connelly and Markham; 1983; Gates, 1983; Wakkinen, 1990).

## Section 2: Historical Significance and Habitat Disturbance

### Introduction

The significance of the greater sage-grouse for those who live in the Rocky Mountain region likely varies from person to person. For some, the bird may represent recreational opportunity (e.g. hunting) or even food, while for others it may simply symbolize the region. In any case, to state the greater sage-grouse is an important cultural component for the region is likely an overstatement, even though the observed decline within the population seems to be the basis for large scale public concern. From a historical perspective, which can be inferred to have begun with the Homestead Act of 1862, sage-grouse habitat has been disturbed or removed for more than 100 years. Subsequently, grouse populations and associated habitats have been a concern to sportsmen and biologists for the past 80 years (Hornaday, 1916; Patterson, 1952; Autenrieth, 1981). Despite management and research efforts that date to the 1930s (Girard, 1937), breeding populations of this species are declining. The aim of the Section is to discuss the significance of the greater sage-grouse from a historical perspective (some anecdotal), as well as address some historical management practices or issues that may help explain or further define the birds current population trend.

### Historic Sage-Grouse Population Trends

The original distribution of the sage-grouse was not contiguous, as habitats were physically fragmented by other habitat types such as forests and deserts, which were further divided by river valleys and mountain ranges (Patterson, 1952; Rogers, 1964). Historically, greater sage-grouse could be found in portions of 12 states within the western United States and three Canadian provinces (Schroeder et al., 2004). Sage-grouse currently occupy 670,000 km<sup>2</sup>, or 56 percent, of their potential pre-settlement range, which once covered approximately 1,200,000 km<sup>2</sup> (Schroeder et al., 2004). Population estimates from the Fish and Wildlife Service indicate at least two million

birds occupied their natural range in the mid-19<sup>th</sup> century, significantly more than the 100,000 to 500,000 which is estimated by the USFWS to be present today. In addition, research suggests *breeding populations* have declined by 45 percent to 80 percent from numbers estimated during the 1950s (Braun, 1998) and in more recent data from 1985 to 1995, declines have averaged 33 percent (Connelly and Braun, 1997); the slowing rate of decline likely attributable to the cessation of broad use chemical applications to remove sagebrush and the ending of certain predator control programs.

In 1845 and 1874, Colonel John Fremont and Elliot Coues respectively, reported that sage-grouse were abundant throughout much of Wyoming in the early to mid-1800s



**Powder River Basin,  
Northern Wyoming  
Photograph taken by ALL  
Consulting**

(Wambolt et al., 2002). However, In a review of historic information by Robert McQuivey, retired Nevada Division of Wildlife biologist, Mr. McQuivey found few references of abundant sage-grouse during exploration

and emigration in the 1840s and 1850s or early settlement following 1860 (Northwest Nevada Sage Grouse Working Group, 2002). Thus, based on historical reviews, as well as the bird's historic distribution, much of the overall decline in sage-grouse abundance appears to have begun in the late 1800's (Hornaday, 1916; Crawford, 1982; Drut, 1994; Washington Department of Fish and Wildlife, 1995; Braun, 1998; Schroeder et al. 1999). In the following years, anecdotal accounts also indicate greater sage-grouse populations were declining throughout their range by the 1920s and 1930s (Braun, 1998; Bent, 1932; Gabrielson and Jewett, 1940; Rush, 1942; Patterson, 1952; Rogers, 1964). In any case, state wildlife agencies in the early 1900's responded to the perceived low population numbers by reducing bird bag limits and harvesting lengths, as well as mandating season closures (Patterson, 1952).

In most cases, population counts that were attempted in the early to mid-1900's were typically inconsistent or unreliable and did not improve until more scientifically sound count protocols were established (Jenni and Hartzler, 1978; Emmons and Braun, 1984). Formal surveys of the abundance of sage-grouse started in the early 1950's (Dalke et al. 1963, Eng, 1963; Rogers, 1964) and were in general, affected by inadequate access to privately owned lands and equipment, as well as a general lack of understanding of sage grouse life history characteristics (Braun, 1998).

In more recent times, analysis of sage-grouse populations by Connelly et al. (2004) have indicated negative population trends from the 1960's to the mid-1980s with some stabilization afterwards. In the past 15-20 years, most areas have exhibited relatively stable or minor population declines, although between 1989 and 1994 Connelly et al. showed some areas observed population increases (2004). Recent data for 2005 also indicates potential population increases within some areas of the birds range, such as the Powder River Basin in Montana.

In general however, it is evident the overall greater sage-grouse population has been declining at various rates for some time; the estimated rate of decline often being

dependent on the analyzed time frame. For example, the rate of decline from 1965 to 2003 has been estimated an overall annual rate of 2.0 percent; 3.5 percent from 1965 to 1985; and at a lower rate in 1986 to 2003 of 0.4 percent, a level that was estimated to be five percent lower than the 2003 population (Connelly et al., 2004).

From a state perspective, sage grouse populations have been declining at various rates as well. Populations in Colorado have declined from 45 to 82 percent since 1980 (Wambolt et al., 2002) whereas; populations in Wyoming and Washington have declined 17 and 47 percent, respectively, from pre-1985 to post-1985 (Braun, 1998). Sage-grouse numbers in South Dakota declined from approximately 25,000 birds in the 1950's to 5,000 in 1992 (Drut, 1994). In Utah, the decline is estimated at 50 percent since settlement (Drut, 1994) and in Nevada, populations have been declining since 1970 (Neel, 2001).

## **Historic Significance**

### **Hunting and Food**

The harvest (commercial and sport hunting) of the greater sage-grouse throughout much of the species sagebrush rangeland has been a popular activity which has transpired for some time (Patterson, 1952; Autenreith, 1981). As far back as the 1800s, hunting has negatively impacted many populations of this species (Patterson, 1952). In a 1964 interview, which was collected from Forest Service Historical Records, Sid Tremewan, First Forest Supervisor of the Humboldt National Forest, described sage-grouse hunting conditions in the 1800's as such:

"Sage chickens were so plentiful in the 1890's ...they clouded the sky. I can remember killing them with a stick on many occasions...parties used to come out in wagons from Elko. They would camp for weeks at a time just hunting and fishing. When they were ready to go home, they usually had one last shoot. A dead-axe wagon wouldn't hold the birds they killed. They would just leave on the ground in big piles to rot. It was a contest to see who kill the most.

The decrease in sage-grouse numbers resulted in the end of harvest activities, as implemented by some state programs, until perceived population increases were observed (Patterson, 1952). In Nevada, hunting laws began around 1890 with liberal seasons and bags but, as time passed and bird populations decreased, reductions in the length of the hunting seasons and bag limits was enforced until around 1900 and continued until the late 1920s (Northwest Nevada Sage Grouse Working Group, 2002). Due to concerns about sage-grouse populations (Hornaday, 1916; Girard 1937) as a result of long term evidence of hunting impacts, most other states prohibited harvest by the 1930's (Patterson, 1952; Autenrieth, 1981). By the 1950s, populations had recovered to the extent that limited hunting seasons were re-established within large portions of the grouse's range (Patterson, 1952; Autenrieth, 1981). During the 1960's in Montana, for instance, the peak years for hunting were 1963-1966, with an average of 65,000 birds per year; the lowest recorded harvest year was in 1993 with 6,000 birds.

Historically, as well as in more modern times, greater sage-grouse hunting has

Early settlers dubbed them "sage chickens" and ate them like domestic fowl and over the next half century, the birds were an important food source for pioneers.

been a recreational, economic and culturally important tradition in many

areas. Their dramatic and unique breeding rituals have meant the arrival of spring in the Rocky Mountain region for millennia. For the Native American's the sage-grouse was a staple of their diets and for some tribes, dances, costumes and celebrations honored the bird's contribution to their society and in some cases, revered sage-grouse more than the eagle (Idaho Department of Fish & Game, 1998). Early settlers dubbed them "sage chickens" and ate them like domestic fowl and over the next half century, the birds were an important food source for pioneers (Idaho Department of Fish & Game, 1998).

Western settlers reported seeing the skies darkened by large flocks of sage-grouse (Wambolt et al., 2002). Pioneers described filling wagons with sage-grouse to provide food for their communities as well as for miners and other working groups (Rogers, 1964). In Colorado, Rogers (1964) indicated that thousands of sage-grouse were killed each year to feed participants in the annual "Sagehen Days" in the town of Craig.

In addition to the direct harvesting of sage-grouse, fur trapping of predators for financial gain may have had or is having an indirect effect on the birds' population. Fur trapping is what drove the exploration of the North American continent but; in the last five hundred years, there are fewer fur bearers now being taken than at any previous time. Within approximately the last thirty to forty years, the price of fur has dropped to the point that laying traps is no longer economically feasible. In addition, the social and/or political attitude toward trapping has certainly deteriorated. As a consequence, current increases to populations of predators has occurred, which when coupled with other factors (e.g., loss of habitat), may have a certain role in the current region-wide negative population trends being observed by the bird.

Historic hunting practices may have also had some role in the bird's current population trend. In sagebrush habitats, sage-grouse often were (and are) the only upland bird available for harvest, providing a specific recreational and economically opportunity that would otherwise be unavailable. In Idaho for example, the Idaho Department of Fish and Game estimated that in the early 1990s about 17,000 hunters pursued the bird each year, with a value of more than \$2 million to Idaho's economy. To date however, Braun (1998) reported he believed hunting and the subsequent affects on the birds population was minimal since hunting is thought to help with population replacement and be compensatory. However, Connelly et al. (2003) reported areas closed to hunting showed increases to breeding populations and that moderate levels of harvesting slowed population recovery.

## **Historical Wildlife and Land Use Management Tactics**

### **Predator Control**

The historic implementation of government funded predator control programs typically coincided with the development of ranches, livestock grazing on public lands, hunting (Northwest Nevada Sage Grouse Working Group, 2002) or even fur trapping. When implemented these control programs were not aimed at reducing predators for sage-grouse but were instead used to eliminate predators of domestic cattle and sheep using shooting, trapping and poisoned baits; the poisoning of cattle and sheep carcasses was a common practice up until a few years ago (approximately 1972-1980). However, the result of this program included the direct reduction of important sage-grouse predators such as the coyotes and golden eagles, as well as skunks, badgers, dogs, feral cats, etc. In addition, poisoned baits increased the vulnerability of scavengers like ravens, a sage-grouse egg predator. Federally supported predator control programs that used poisons decreased when banned by government edict in 1972 (Northwest Nevada Sage Grouse Working Group, 2002).

The use predator control programs to manage predator population sizes have been a historic concern for landowners and wildlife managers since predation can directly affect sage-grouse survival rates and/or nest success (Northwest Nevada Sage Grouse Working Group, 2002). Some theorize the absence of current control programs are the primary factor limiting sage-grouse populations and possibly explain why some historic sage-grouse populations had more success. To examine certain affects predation has on grouse, Batterson and Morse (1948) removed many common ravens in Oregon within the range of sage-grouse. Results of the study indicated a short-term increase in nest success. However, the overall effects of predator control on historic and current sage-grouse populations to include behavior, genetics and breeding population size, has not been researched by the scientific community (Schroeder and Baydack, 2001).

Although some data indicates sage-grouse predator populations are increasing (as sage-grouse populations decline), to date implementing predator control to help North American populations of grouse species is seldom used for several reasons (Schroeder and Baydack, 2001). (1) Nesting often is dispersed over large areas, greatly increasing the cost effectiveness of the control programs; (2) the long-term biological consequences of predator control are poorly understood and may actually be counterproductive under some circumstances and (3); many potential predators of sage-grouse are now legally protected; certain control methods such as poisons have been prohibited; and public attitudes towards predator control have changed (Messmer et al., 1999).

To a certain extent intensive predator control programs can influence predator numbers at the local level, e.g. coyote control for livestock production and red fox and skunk trapping to protect upland nesting ducks (Montana Sage-Grouse Work Group, 2005). If land use changes continue to degrade sagebrush habitats and the impacts of predators are shown to negatively impact sage-grouse populations, direct predator control actions may assume greater management importance (Nelson, 2001).

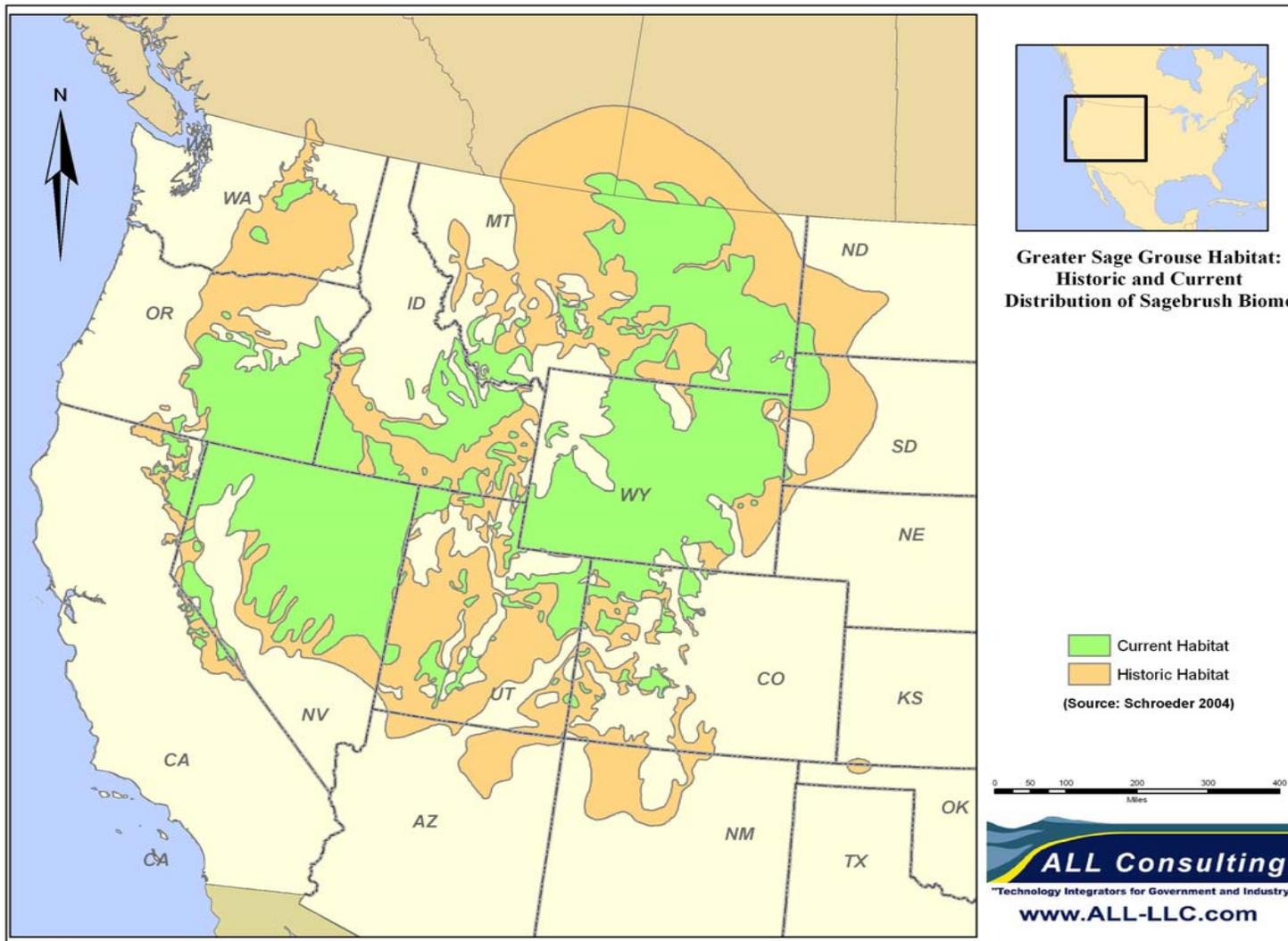
### **Historical Loss of Sagebrush Habitat**

Land managers have used prescribed fires, mechanical treatments (including shredding, roller chopping, hand slashing, bulldozing, beating, chaining, root plowing, and disk plowing), biological agents, and herbicides to remove sagebrush from vast areas on federal and private lands for reseeding with non-native grasses, primarily to provide forage for livestock (Pechanec et al., 1965; Vale, 1974; Bureau of Land Management, 1991). Although no single historic or current land use is likely the cause for the observed declines in sage-grouse populations, the alteration and range-wide quality reduction of the sagebrush biome is generally recognized (Connelly et al., 2000; West and Young, 2000). Figure 3 compares the current and estimated historical sagebrush biome as reported in Schroeder et al., 2004.

Since the settlement of the West, land use activities in some manner have adversely affected the population of the sage-grouse, their distribution and range, and quality of sagebrush habitats. Historically, the sagebrush biome was one of the most widely distributed habitats in the United States. During the known history of this vegetative community, sagebrush vegetation types and sage-grouse distributions have varied significantly as climatic patterns shifted (Montana Sage-Grouse Work Group, 2005). It is estimated that about the time Western lands were being occupied by settlers, approximately 220 million acres of

sagebrush existed in North America. However, a portion of this sagebrush habitat would have been occupied by successional plant communities due to fires, effects of prolonged drought, localized flooding, disease outbreaks and other cyclic disturbances (Northwest Nevada Sage-Grouse Working Group, 2002). From this, an unknown portion of the estimated 220 million acres would not have provided ideal sage-grouse habitat (Northwest Nevada Sage Grouse Working Group, 2002), thus decreasing the size of predicted historic sagebrush distributions.

**Figure 3: Current and Historical Distribution of the Sagebrush Biome**



### **BLM Lease Grazing and Agriculture**

The first significant loss of sagebrush habitat likely occurred in the 1880's with the advent of irrigation projects, which expanded and intensified croplands areas formerly thought to be marginal for crop production (Todd and Elmore, 1997). Starting in 1862, settlement of western rangelands within the sagebrush biome was encouraged by a series of Homestead Acts (Todd and Elmore, 1997). Most land with agricultural potential was homesteaded and in private ownership by 1930 (Braun, 1998) and include the conversion of approximately 1.2 million km<sup>2</sup> (296 million acres) of public lands. During the same period, a series of legislative acts were passed to regulate grazing on public lands and delegated responsibility to the U.S. Forest Service in the Department of Agriculture and the Grazing Service in the Department of Interior for administrating public land grazing (Connelly et al., 2004). Furthermore, the Taylor Grazing Act, which was passed in 1934, authorized the Secretary of Interior to establish grazing districts of "vacant, unappropriated and unreserved land from any parts of the public domain" (Connelly et al., 2004). The Secretary of Interior also was authorized to issue permits to graze livestock upon annual payment of fees, of which a portion was returned to the individual states (Connelly et al., 2004).

As the region was homesteaded, sage grouse habitat deteriorated rapidly under intensive agriculture, as land was heavily grazed or converted to crops (Montana Sage Grouse Work Group, 2005). In some cases, areas could not support annual or biennial crop production and thus were reverted to pastures or rangeland (Braun, 1998). By the 1930's, Sage grouse habitat had been fragmented or severely reduced in many areas (Braun, 1998) and by the early 1960s, elimination or reduction of sagebrush to increase grass production became a common practice on public as well as private rangeland (Martin 1970). It was during this time frame that greater sage-grouse experienced two major population declines.

Later, the federal farm program encouraged conversion of private rangeland to cropland,

which affected an untold amount of sagebrush steppe during the 1970s and 1980s (Montana Sage Grouse Work Group, 2005).

Currently, more than 70 percent of the sagebrush dominated rangeland that provided suitable grouse habitat has been converted to cropland in

Currently, more than 70 percent of the sagebrush-dominated rangeland that provides habitat has been converted to cropland in some states (Braun, 1998) and domestic livestock alone have grazed over most, if not all, areas used by sage grouse.

some states (Braun, 1998) and domestic livestock alone have grazed over most, if not all, areas used by sage grouse (RangeNet Project, 1964). In some cases, plowing of private lands to convert rangeland to cropland continues, although at low rates (Braun, 1998). Swenson et al. (1987) documented decreases of sage grouse in Montana following plowing of sagebrush steppe. Currently, the BLM manages grazing on more than 160 million acres of public land in the West and administers over 18,000 grazing permits and leases.

### **Herbicide Use**

Treatments to remove the herbaceous understory, maximize forage production and reduce plant toxicity for livestock, stabilize soils, and reduce shrub cover were implemented following unrestricted grazing in the late 1800s and early 1900s (RangeNet Project, 1964). It is conservatively estimated that at least 50 percent of all western rangelands have been treated with herbicides at least once (Braun, 1998). Estimates of treated sagebrush habitat vary and range from 10-12 percent, covering 400,000 km<sup>2</sup> (400,000 to 480,000 km<sup>2</sup>) by the 1970s (Vale, 1974; Pechanec et al., 1965), and 200,000- 240,000 km<sup>2</sup> treated over a 30-year period (Schneegas, 1967). Other estimates indicate that since the early 1960's treated areas probably exceed 20-25 percent of the total remaining sagebrush-dominated rangelands and by some accounts, no areas used by sage-grouse are known to have escaped treatment.

Spraying of herbicides primarily degrades habitat for sage-grouse by increasing fragmentation and removing shrubs used as nesting cover. Historically, treatments were designed to decrease unpalatable plants, such as sagebrush, to livestock even though those plants may be palatable to elk (*Cervus elaphus*) or sage-grouse and other species (Connelly et al., 2004). Until the early 1980s, herbicide treatment (primarily with 2,4-D) was the most common method to reduce sagebrush on large tracts of rangeland (Braun, 1987). Chemical control of sagebrush has been accomplished with 2,4-D, 2,4,5-T, and Tebuthiuron with 2,4-D being most commonly used from the early 1960's until the late 1970's (Braun, 1998). Treatments vary from short-duration livestock grazing to chemical and mechanical control of sagebrush. Depending upon type of treatment, sage-grouse may alter their use or completely avoid treated areas (Braun et al., 1976 and 1987). Thus, treatments have altered sage-grouse use of habitats throughout western North America.

"No amount of royalties will ever give me the enjoyment of sitting on a ditch bank in the morning and watching the deer, the ducks and the grouse. On the other hand, I wouldn't be sitting here at all if it weren't for those royalties." (Cilfford, 2000).

### Oil & Gas Development

In Wyoming, Pinedale resident Paul Hagenstein, who has depended on gas leases on his own ranch thru the years, summed up the quandary which confronts many in the State:

"No amount of royalties will ever give me the enjoyment of sitting on a ditch bank in the morning and watching the deer, the ducks and the grouse. On the other hand, I wouldn't be sitting here at all if it weren't for those royalties." (Cilfford, 2000).

Although the oil and gas industry is and has been held responsible to a large extent for the negative trend being observed by greater sage-grouse populations, the historic effect of this industry on the birds overall population size and habitat is poorly understood (Braun, 1998) because of the lack of replicated, well designed studies. However, the discovery and subsequent development of gas and oil fields throughout the western United States has been

identified as one potential causative agent (Braun, 1987; Connelly et al., 2004) since direct impacts are probable. Potential impacts of gas and oil development to sage-grouse include habitat loss and fragmentation from well, road, and pipeline construction, and increased human activity causing the displacement of individuals through avoidance behavior (Holloran, 2005).

Development of mines and energy resources in western North America was initiated prior to 1900 (Robbins and Wolf, 1994) and oil and gas development in the sagebrush biome began in the late 1800's with the discovery of oil in the Interior West (Connelly et al., 2004). In Wyoming, which is dominated by sagebrush habitat, the first coal mine was opened in 1868 while the first oil well

began producing in 1884. In Colorado, oil and gas development began at least in the early 1920's. Since the 1960's, development of natural gas resources has dominated the region. In many cases, energy development preceded formalized counts of sage-grouse and in Colorado for instance, counts of sage-grouse were initiated on a sporadic basis and were typically incomplete and primarily focused on larger, more accessible leks (Braun et al., 2002). As such, sage-grouse related data gathered between the 1940's and the 1970's throughout much of the birds range are not directly comparable to those collected in the last 25-30 years. Therefore, accurately assessing actual impacts from oil and gas development on sage-grouse populations, as well as other surface disturbing practices, is not feasible (Braun et al., 2002).

## Section 3: Current Sage-Grouse Management Plans and Conservation Issues

### Introduction

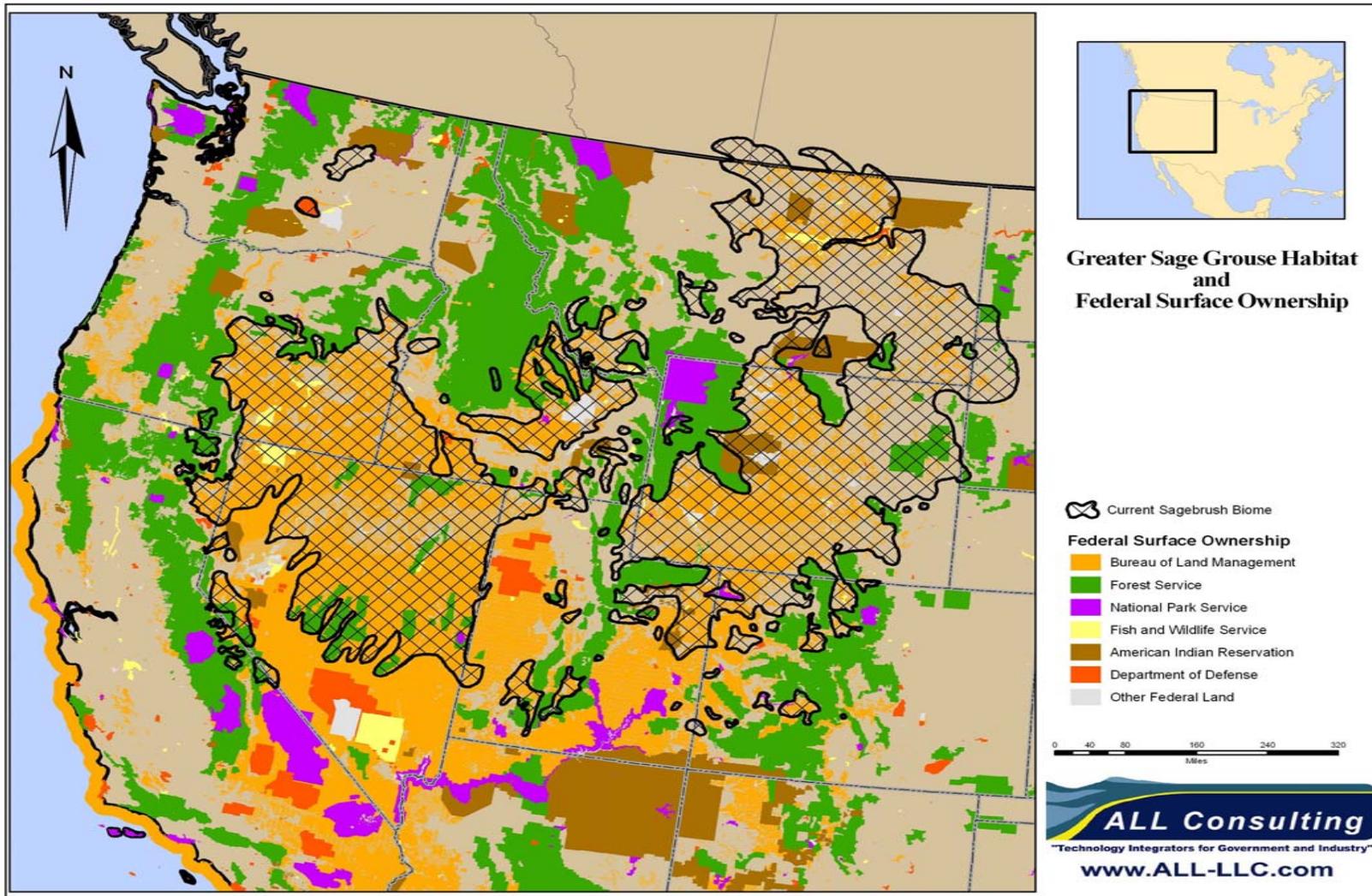
As noted in Section 1, greater sage-grouse are native to the sagebrush steppe of western North America and their distribution and range closely parallels that of sagebrush, especially big sagebrush (*A. tridentata*). Due to their dependence on sagebrush, a critical component of current sage-grouse management policy involves protecting and conserving sagebrush landscapes and habitat. Sagebrush habitat has experienced extensive alteration and loss (Connelly, 2004) and is likely a primary reason for the long term decline being observed in many sage-grouse populations. Many sage-grouse and sage-grouse habitat conservation strategies exist today which help to further illustrate the need for conservation, as well as address management approaches that may afford the species long term protection if implemented in a reasonable manner by involved stakeholders.

As of 2000, three federal agencies, the BLM, U.S. Fish and Wildlife Service, and the U.S. Forest Service were engaged in range-wide sage-grouse conservation planning efforts. Figure 4 provides for an overview of sage-grouse distribution versus federal land ownership. Of these groups, the BLM is the only federal agency that has prepared a formal strategy to address sage-grouse conservation for lands and programs it administers (Stiver et al.2006). The objective of this Section is to highlight certain federal conservation plans and/or management

approaches which are currently being implemented on federal lands. Special emphasis is being placed on federal plans since these lands constitute approximately 72 percent of the sage-grouse's total range (Connelly et al. 2004). This Section will also identify and discuss those conservation issues that are typical to many of these plans.

It should be noted that the 11 states which fall within the range of the greater sage-grouse signed a Memorandum of Understanding (MOU) to work cooperatively to develop conservation plans for the greater sage-grouse. In many cases, bi-state or individual state conservation plans were developed, such as *Management Plan and Conservation Plan Strategies for Sage Grouse in Montana*, or are being developed. The development of these plans are important to the overall conservation strategy since they address potential policies and approaches which are not limited to federal administered lands (e.g. state and private lands). Review of greater sage-grouse conservation plans in this Section will be limited to available federal publications, including the Western Association of Fish and Wildlife Agencies (WAFWA), since federally related plans will likely have the most influence in the near future. However, a summary of state plans developed as part of the current cooperative MOU, as well as other sage-grouse related programs, will be provided under a separate subsection as well.

Figure 4: Sage-Grouse Distribution and Federal Land Ownership



## Conservation Plans

### Bureau of Land Management

#### *National Sage-Grouse Habitat Conservation Strategy*

The BLM characterizes the sage-grouse as a sensitive species and provides specific guidance and policy for this species within BLM's Manual 6840, Special Status Species Management. BLM administers over half of the remaining sagebrush landscapes in the United States and slightly less than half of all remaining sage-grouse habitat (Stiver et al., 2006). From a geographically perspective, sage-grouse habitats administered by the BLM encompass the 11 states where the bird can be naturally found. As such, BLM is affectively responsible for administering the largest portion of sage-grouse habitat. For this reason BLM developed the National Sage-Grouse Habitat Conservation Strategy "to guide future actions for conserving sage-grouse and associated sagebrush habitats and to enhance BLM's ongoing conservation efforts." (BLM, 2004).

Fundamental to BLM's habitat strategy are guidance documents or land use plans that mandate or recommend certain sage-grouse conservation measures be incorporated into all ongoing BLM programs and activities, including oil and gas development. For example, BLM's Buffalo Field Office in Wyoming requires the performance of three sage-grouse surveys per year between April 7th and May 7th to identify lek or breeding sites as part of Coal Bed Natural Gas (CBNG) Plans of Development (POD). In such situations when lek sites are found, lands within ½-mile of the breeding site are placed under a specific stipulation category or Controlled Surface Use (CSU), which can prohibit or restrict occupancy or surface disturbance practices.

BLM designed their habitat strategy to revolve around four primary goals, which include:

- Increase understanding of resource conditions in order to prioritize habitat maintenance and restoration;
- Expand partnerships, available research and information that support effective management of sage-grouse habitat and;
- Ensure leadership and resources are adequate to continue ongoing conservation efforts and implement national and state-level sage-grouse habitat conservation strategies and/or plans.

The direction of the Strategy revolves around identifying "Guiding Principals", such as cooperative integrated approaches, land use plans, use of scientific study, etc., and serves as the umbrella for BLM state-level strategies. Furthermore the strategy identifies efforts or "action items", delineates responsibility, establishes timeframes for completion, and stresses the importance of local and State coordination. Information specific to sage-grouse and sage-grouse protection and conservation is not present in this Strategy.

### Western Association of Fish and Wildlife Agencies (WAFWA)

#### *Greater Sage-grouse Comprehensive Conservation Strategy*

The Western Association of Fish and Wildlife Agencies (WAFWA), founded in 1922, is a quasi-governmental organization which represents public agencies from 23 states who charged with the protection and management of fish and wildlife resources in the western part of the United States and Canada. In 2002, WAFWA entered into a contract with the U.S. Fish and Wildlife Service to produce a complete conservation assessment of the greater sage-grouse and their associated habitat. The assessment was conducted in two phases: The first phase of the assessment was completed by J.W. Connelly in 2004 (produced by WAFWA) and the second phase, the *Draft Greater Sage-Grouse Comprehensive Conservation Strategy*, was completed in December 2006.

The WAFWA conservation strategy encompasses the pre-settlement distribution of potential habitat for greater sage-grouse, an area defined by Schroeder et al. (2004) as 463,500 square miles. WAFWA defines the overall strategy for the management and conservation of greater sage-grouse by developing “associations among local, state, provincial, tribal, and federal agencies, nongovernmental organizations, and individual citizens necessary to design and implement cooperative actions to support viable populations of sage-grouse and the landscapes and habitats upon which they depend.” (Stiver et al., 2006). The Strategy proposes establishment of seven biologically based sage-grouse and sagebrush management zones which typically cross jurisdictional boundaries and require continued collaboration and coordination (Stiver et al., 2006), as well as seven guiding principles that includes:

- Inclusion and Mutual Respect,
- Local, State, Agency and Group Initiative and Leadership,
- Commitment to Monitoring and Adaptive Management,
- Commitment to Continued Cooperation and Coordination,
- Functional and Productive Landscapes,
- Best Science and Scientific Integrity, and
- The Range-wide Issues Forum.

In addition, the Strategy stresses the need for monitoring to provide the information needed for adaptive management and the development of reliable methods for estimating populations, so that the effectiveness of conservation plans are appropriately evaluated. Most importantly, the conservation strategy identifies five primary issues or research needs that require additional assessment. Who, when and why questions as they pertain to these issues or research needs are addressed as well. Additional discussion on this subject is addressed further in Section 4.

These five issues include:

- Consistent methodology for describing sage-grouse habitat.
- Standardized and statistically rigorous method to monitor the status and trend of sage-grouse populations.
- Implement new population monitoring techniques.
- Develop metrics to evaluate effectiveness of conservation actions.
- Need for infrastructure/resources to complete, implement, and evaluate new population monitoring techniques.

### **U.S. Geological Survey (USGS)**

#### *Effects of management practices on grassland birds: Greater Sage-Grouse*

The U.S. Geological Survey's (USGS), *Effects of management practices on grassland birds: Greater Sage-Grouse*, is a literature review of sage-grouse behaviors, habitat requirements and management issues. This report was sponsored by the Grasslands Ecosystem Initiative, Northern Prairie Wildlife Research Center, and USGS, to stabilize or increase populations of declining grassland birds (sage-grouse) by focusing on proper management of breeding habitat. The report concludes with numerous management recommendations and includes the following:

- Restoration of sage-grouse habitat;
- Maintain, conserve, and restore large blocks of intact sagebrush;
- Protect lek sites and adjacent habitat;
- Control encroachment of pinyon/juniper woodlands into sagebrush habitats;
- Identify and attempt to eliminate or control invasive, non-native plants in sagebrush steppe;
- Manage livestock grazing through stocking rates and season of use on all seasonal ranges of sage-grouse to avoid habitat degradation;

- Avoid development of livestock-watering structures in sage-grouse habitat; and
- Avoid construction of power lines in sage-grouse habitat.

### **U.S. Forest Service and National Resource Conservation Service (NRCS)**

The U.S. Forest Service (Forest Service) and the National Resource Conservation Service (NRCS) currently have not published formal conservation plans or strategies for the greater sage-grouse, although the Forest Service, Region 1, designated the sage-grouse as a “sensitive” species in 1995. However, both agencies are involved with the conservation process through sponsorship of collaboration workgroups and symposiums and research funding. For instance, the Forest Service Rocky Mountain Research Station hosted the Sage-grouse habitat restoration symposium in 2005. The symposium consisted of 14 presentations or papers, which summarized knowledge and research gaps in sagebrush taxonomy and ecology, seasonal sage-grouse habitat requirements, approaches to community and landscape restoration, and re-vegetation technology. The NRCS, along with the Western Governors’ Association, have published, *“Conserving the Greater Sage-grouse: Examples of Partnerships and Strategies at Work Across the West”*. The aim of this report is to illustrate the depth of commitment and cooperation that is taking place across the entirety of the West to conserve the greater sage-grouse. This particular publication is focused on the various conservation workgroups which constitute the 11 western states that signed the MOU for the conservation of greater sage-grouse populations.

### **Highlight of Non-Federal Research Group Efforts and Conservation Programs**

#### **State and Sage-Grouse Workgroups**

In 1996, the WAFWA developed their first sage-grouse MOU, which impart suggested that individual states initiate local area conservation planning groups to address sage-grouse conservation issues. Currently, range wide sage-grouse state conversation

plans are under full implementation or are under development or at a minimum, have designed conservation strategies, such as the State of North Dakota. In most cases sage-grouse workgroups and responsible agencies are the principle entities for establishing and administering statewide sage-grouse conservation plans. Statewide plans typically provides a schedule for group formation, identifies population objectives, fire suppression strategies, and hunting season conformance (Connelly et al., 2004) In many situations the involvement and coordination among local work groups is imperative for sage-grouse conservation since the bird’s population is often distributed among multiple jurisdictional boundaries. For this reason, effective management in these types of situations requires coordination between the various landowners, wildlife managers and the public.

#### **Cooperative Sagebrush Initiative (CSI)**

The Cooperative Sagebrush Initiative (CSI) was established for the purpose of recovering the western sagebrush steppe biome principally thru funded partnerships between public and private stakeholders. In general, the primary objective of CSI is the eventual restoration of sagebrush steppe ecosystems through the removal of invasive western juniper and application of adaptive management techniques. According to CSI, “Landowners, communities, and conservation groups have the proven ability to deliver conservation on private and public lands. Government agencies have the scientific knowledge and technical capacity to help make that happen. Industry has the leadership and resources to energize the former and leverage the latter.” If the collaboration between these three groups comes to fruition, CSI could then have an important role in future sage-grouse conservation efforts. As of March 2007, CSI has not collaborated on or funded any projects.

#### **Industry**

The involvement of the oil and gas industry is a vital component for the successful conservation of the sage-grouse. To date, this particular industry has had active members within sage-grouse workgroups

and is involved in surveying and monitoring efforts within important sage-grouse habitat, such as the Cedar Creek Anticline or Powder River Basin. In certain areas, the oil and gas industry has been responsible for generating sage-grouse distribution density data, as well as other wildlife species, in localities that previously lacked data. In addition, the Industry is beginning to take a more active role in the conservation and protection of the bird by funding study based projects. Other environmental consultants and the Argonne National Laboratory are also involved in current research. Currently, studies relating to vegetation and habitat analysis of critical wintering areas for sage-grouse, as well as studies to determine how to best maintain the sagebrush vegetation complex and associated sagebrush obligate wildlife species while allowing energy development to proceed, are ongoing or have recently been completed. Although more research and stakeholder collaboration is needed (refer to Section 4), participation and financial support from many oil and gas industrial leaders within important sage-grouse habitat is continuing.

### **Land Use, Habitat Alteration and Conservation Issues**

Important sage-grouse habitat considerations and issues that resource managers are currently contending with include maintaining expansive stands of sagebrush (*Artemisia* spp.), especially varieties of big sagebrush (*A. tridentata*), with abundant forbs in the understory, particularly during spring; undisturbed and relatively open sites for leks; and healthy perennial grass and forb stands intermixed with sagebrush for brood rearing (Connelly, 2004). These considerations are significant because over the past century, the

sagebrush biome has encountered a variety of land uses (West and Young, 2000; Crawford et al. 2004) and subsequently, only a small portion remains in a similar condition to that encountered by settlers (West, 1999).

Although there are many potential reasons for the alteration of sagebrush, the fact that there have been long-term changes is little in doubt (Braun et al., 1976; Knick et al., 2003; Connelly et al. 2004). Interactions among land use, disturbance and vegetation response, and climate have altered patterns and processes within sagebrush habitats that in some cases, have caused extensive loss of sagebrush habitats from some regions (Connelly et al., 2004). However, despite these changes, sagebrush communities still occupy approximately 500,000 km<sup>2</sup> among 13 states and three provinces (Connelly et al., 2004). The focus of this subsection is to discuss current land uses that are facilitating the decline of sagebrush habitat.

### **Livestock Grazing**

The effect livestock grazing is having on the sagebrush biome is a contentious management issue for many (Brussard et al., 1994; Noss, 1994; Wambolt et al., 2002; Crawford et al., 2004). Virtually all sagebrush lands are managed principally for livestock grazing (Knick et al., 2003; Klebenow, 1982; Call and Maser, 1985; Beck and Mitchell, 2000; Connelly et al., 2004; Crawford et al., 2004). In 2001, 15,000 permits were issued for 10.2 million animal unit months of forage consumption on lands managed by the BLM (Bureau of Land Management, 2002). Grazing by livestock has occurred over a large portion of greater sage-grouse range (Braun, 1998). The effects livestock grazing has on the vegetative composition



**CBNG Development near Gillette, Wyoming**  
*Photograph taken by ALL*

and structure in sagebrush communities has been well documented (Vale, 1974; Owens and Norton, 1992; Fleischner, 1994; West, 1999; Belsky and Gelbard, 2000; Jones, 2000). However, the implication of grazing pressure on sage-grouse populations is poorly understood. One reason for this is a lack of experimental research (Braun, 1987; Beck and Mitchell, 2000; Connelly et al., 2000). Instead, many studies infer negative effects on sage-grouse habitat by noting that grazing systems require appropriate design to adequately address nesting and brood rearing habitat needs (Gregg et al., 1994; DeLong et al., 1995; Sveum et al., 1998). Additionally, grazing may effect stages of life history (e.g. during nesting, brood rearing and wintering) differently which may add to a certain lack of understanding (Stiver et al., 2006).

The complexity of livestock grazing issues is also due in part to the indirect nature of potential effects grazing has on soils, vegetation, and animal communities (Jones, 2000). For example, livestock consume or alter vegetation, trample soils and sagebrush plants and redistribute nutrients (Miller et al., 1994; West, 1996; Belnap and Lange, 2001). In addition, these effects can include encroachment by noxious weeds and alteration in fire risk (Stiver et al., 2006). Furthermore, the extent to which these grazing issues influence habitats depends on the relationship between the level of grazing disturbance and the ability of the habitat to overcome this disturbance (Stiver et al., 2006). The assessment of habitat alteration by grazing is typically site specific or small-scale, and does not include analysis of regional or large scale effects (Mitchell, 2000). This type of habitat assessment is contrary to typical conservation plan approaches, such as BLM's, since the aims of these plans are to establish large-scale or regional objectives.

### **Noxious Weeds/Invasive Species**

Noxious weeds and the spread of non-native plant species have become widespread across the range of sage-grouse over the last 50 years. Noxious weeds and other invasive plant species, such as annual grasses (e.g., cheat grass), displace more desirable native plant species and cause significant adverse biological effects to

habitat used by sage-grouse by reducing the productivity of healthy rangeland (Montana Sage-Grouse Work Group, 2005; Connelly et al., 2004). For example, plant community structure can be altered when invasive species are able to replace other plant species within a community or secondly; wildlife communities may change when invasive plant infestation alters the vegetative community structure. Although, noxious weeds can impact many classes of wildlife, no scientific reports, models or maps currently exist to provide a list of the susceptibility of habitats (Connelly et al., 2004). Some estimate that greater than 50 percent of the sagebrush ecosystem in western North America has been invaded to some extent by cheatgrass (West, 1999), with losses projected to accelerate in the future (Hemstrom et al., 2002). However, Connelly et al. (2004) reports that estimates of the size of infestations for any listed invasive species are subjective because of the lack of a definition of what constitutes an infestation (Connelly et al., 2004). As such, evaluating a reasonable estimate for infestation within any given area is difficult to accomplish.

The introduction and subsequent spread of weeds can occur through several means, but the primary concern for resource managers is the spread of noxious weeds by vehicles (Montana Sage Grouse Work Group, 2005). Throughout the range of the greater sage-grouse, herbicide treatment is the most widely employed active method to control noxious weeds. Other preventative measures or Best Management Practices (BMPs) exist as well and may include vehicular washing or re-vegetation plans. In any case, herbicide use may pose some toxicological risk to sage-grouse (and other wildlife) as exposure through absorption from treated plants, inhalation of chemical particles suspended in the atmosphere, and direct ingestion of treated plants can occur (Montana Fish, Wildlife and Parks, 1994). However, it is important to understand that the short-term, transient impacts that may result from proper herbicide application are typically less than not treating areas, since noxious weeds are ultimately more effective at competitively displacing desirable plant components (Montana Sage-Grouse Work Group, 2005).

## **Energy Development**

Resource extraction for energy development has historically been widespread throughout greater sage-grouse habitats (Scott and Zimmerman, 1984; Braun, 1987 and 1998; Braun et al., 2002). Although CBNG development is fairly recent (1997), development of this resource is emerging as a growing concern for sage-grouse. To date, there are more than 15,000 active CBNG wells within the Powder River Basin of northeastern Wyoming, as well as 10,000



**Operating CBNG Wells from CX Ranch Field,  
Decker, MT**

*Photograph taken by ALL Consulting*

km of overhead power lines (Braun et al., 2002). CBNG Development is also ongoing in other portions of the range of sage-grouse, including Utah, Montana, and Colorado (Rowland, 2004). Oil production and exploration in the Rocky Mountain region is expected to remain constant or slightly decrease (National Petroleum Council, 2003) whereas; natural gas development within those basins is expected to increase for the next 15 to 20 years.

Infrastructure associated with energy development such as, roads and power lines, may fragment habitats for sage-grouse (Braun, 1998; Connelly et al., 2000; Braun et al., 2002). Direct mortality also occurs from collisions of sage-grouse with fencing (Call and Maser, 1985; Danvir, 2002), which is typically needed for livestock grazing, and vehicles on roads (Patterson, 1952). The

effects of roads and power lines on the greater sage-grouse have not been widely studied but their presence may facilitate habitat fragmentation and increase the occurrence of local avian predators due to the addition of perch sites, respectively (Braun, 1998). In general, the effects of energy development thus far indicate a negative trend on sage-grouse populations, although the overall industry affect or relative magnitude on the population range-wide is still relatively uncertain (Holloran, 2005). Additional studies are need to fully understand how and what facets of energy development affect the grouse, as well as what life history characteristics are most susceptible. For instance, do potential impacts vary by energy type (e.g., coal-bed natural gas, strip mining, oil wells, and wind turbines), or do impacts vary by the size of the development 'footprint' or by the sex, life history stage, habitat, and region of the population in question (Lyon, 2000; Braun et al., 2002; Lyon and Anderson, 2003; Holloran, 2005)?

Current research does suggest that the energy industry is having an affect on sage-grouse populations in areas where development is expanding, such as in the Powder River Basin or Pinedale Anticline of Wyoming. For example, Naugle et al. (2006) in a recent study (not peer reviewed) reported leks with coal-bed natural gas development (>40 percent developed within 3.2 km of lek) showed lower population trends than leks with minimal or no development. In addition his finding indicated leks adjacent to natural gas fields (10-40 percent developed) also showed higher population trends than leks further away from development, suggesting that sage-grouse may be avoiding developed areas by moving into adjacent undeveloped habitat (Naugle et al.,2006). In an other study, Holleran (2005) reported male lek attendance decreased with physical distance to the nearest drilling rig and the number of males also declined when the lek was located downwind from a drilling rig, indicating that noise from energy development was likely a contributing factor (Holloran, 2005). However, as stated earlier, the effects of oil and gas development on sage-grouse has not been extensively documented. Although exploration and

development may affect sage-grouse habitat and populations in the short term, as addressed in the above cited studies, long-term impacts after reclamation are not clearly understood.

### **Prescribed Fire**

Typically, prescribed fire is used to control annual grasses, facilitate growth of forbs, and control juniper and pinyon woodland expansion into sagebrush habitats (Connelly et al., 2004). In addition, prescribed fires are used to remove sagebrush and improve livestock foraging, and have been used on certain landscapes with the specific intention of enhancing conditions for sage-grouse and other wildlife species (Klebenow, 1973). The relationship between fires and leks is contrary. At the U.S. Sheep Experiment Station near Dubois, Idaho, fires (both wild and prescribed) apparently were the catalyst for the displacement of two active leks, enhanced the formation of one, and had no obvious effect on the fourth (Hulet et al., 1986). Thus, the benefits and detriments to sage-grouse habitats and relative frequency of fire often are subjects of disagreement (Montana Sage-Grouse Work Group, 2005).

Private landowners and public land managers consider the use of a prescribed fire as an effective tool to manage sagebrush stands with dense sagebrush cover. In addition, some stakeholders believe prescribed burning may minimize wildfire risks that otherwise might adversely affect the sagebrush community. However, others are concerned about both spatial and temporal effects that fire can have on wildlife that depend on the sagebrush community (Montana Sage-Grouse Work Group, 2005). Burning of sagebrush has been shown to reduce or alter both the understory and canopy cover of this community type (Connelly et al., 2000; Wambolt et al., 2002). While some short-term benefits, such as increases in annual forbs, may accrue from prescribed burning, nesting cover in particular may be reduced and thus become less suitable (Wroblewski, 1999; Nelle et al., 2000). Long-term effects are observed in xeric sagebrush ecosystems and in some cases may require substantial amounts of time to recover (Hemstrom et al., 2002). Lastly, when coupled with the outright loss of sage-grouse habitat from fire, the

subsequent altered regimes have resulted in significant habitat degradation in sagebrush steppe from invasion of cheatgrass and other non-native species vegetation following wildfires (Pellant, 1990; Billings, 1994; Knick, 1999; West 1999).

### **Additional Conservation Issues**

**Urbanization** - For sage-grouse, as well as most wildlife species, urbanization of an area often results in the removal of habitat and typically presents unnatural, anthropogenic conditions that require specie acclimation for co-existence. More recent urban expansion into rural subdivisions has resulted in direct habitat loss and conversion, as well as specie avoidance due to the presence of humans (Braun 1998; Connelly et al. 2000). In some Colorado counties, up to 50 percent of sage-grouse habitat is under rural subdivision development, and it is estimated that three to five percent of all sage-grouse historic habitat in Colorado has been developed into urban areas (Braun 1998).

Connecting roads and railways, power line and communications corridors, and use of surrounding regions for recreational use, exert a great influence on sagebrush habitats as well (Connelly et al., 2004). Power lines and communication towers provide perches for raptors (Steenhof et al., 1993; Knight and Kawashima, 1993) and road corridors facilitate predator movements and spread of invasive plant species (Gelbard and Belnap, 2003). In addition, recreational activities within the range of sage-grouse are likely having unintentional negative affects on the population.. Activities such as lek viewing, monitoring, photography or other incidental activities such as, hiking, cross-country skiing, horseback riding, etc., are likely fragmenting certain populations or lek locations or at a minimum, disturbing certain aspects of natural behavior.

**Agriculture** - Landscape conversion of native sagebrush stands to cropland or pasture through plowing or mechanical treatment is one of the more common practices that result in habitat loss or fragmentation (Knick and Rotenberry, 1997; Wisdom et al., 2002). Plowing and introduction of cultivated crops or other

nonnative species for pasture have been reported as a major factor leading to the long-term loss of sage-grouse habitat (Montana Sage-Grouse Work Group, 2005). Plowing of sagebrush steppe is detrimental to sage-grouse because it affects suitable terrain on which sage-grouse winter, and sagebrush is not likely to recover as a result of continuous cultivation (Montana Sage-Grouse Work Group, 2005). In addition, agriculture development indirectly influences wildlife in sagebrush habitats by providing access for predators, such as domestic cats and the red fox (*Vulpes vulpes*) (Connelly et al., 2004). Additional discussion of this subject is discussed in Section 2.

**Hunting** - Sage-grouse hunting is an economically and recreationally important tradition throughout much of the species natural range. Harvesting of this species occurs in 10 of the 11 western states that contain populations of sage-grouse, the State of Washington being the only exception (Connelly et al., 2004). Harvest of greater sage-grouse has occurred throughout recorded history (Patterson 1952; Autenreith, 1981), but relatively few studies address the affect this activity may be having on the overall sage-grouse population (Connelly et al., 2004). Furthermore, there is disagreement concerning its overall impact on sage-grouse populations. Some believe that hunting sage-grouse is compatible with healthy sage-grouse populations where habitat is of sufficient quality and quantity, while others think the birds should not be removed from the population since the species is considered at risk. Although assessment of this issue is incomplete, associated wildlife management agencies have begun reducing harvest opportunities or bag limits to curtail this issue, as well as minimize the possibilities that hunting may have a negative impact on populations.

**West Nile Virus** - The effects of the West Nile Virus (WNV) on the greater sage-grouse are a surging issue which until recently, was not actively studied. Although further research is still required to accurately reflect the impact of this virus on the grouse, available data suggest concerns from resource managers may be warranted. In 2003, known sage-grouse mortalities from the WNV included 19 in Wyoming, only

three in Montana and five in Alberta. However, in a study by Naugle et al. (2004), mortality associated with WNV infection decreased survival of female greater sage-grouse by 25 percent across four populations in Wyoming, Montana, Alberta, Canada, in 2003.

In addition, in one specific population mortality was as high as 75 percent due to the WNV (Naugle et al., 2004). In the same study, serum from 112 sage-grouse collected after the outbreak with confirmed WNV deaths indicated that none of the birds had produced antibodies, suggesting that they lack resistance and that greater sage-grouse rarely survive WNV infection (Naugle et al., 2004). The mosquito, *Culex tarsalis*, is believed to be the most likely vector of WNV in birds (Naugle et al., 2004). Furthermore, in a one year study by Naugle et al. (2004), results indicated a positive correlation between CBNG impoundments, wetlands and ponds, and population sizes of *C. tarsalis*. It should also be noted that the WNV has been found in at least 228 species of birds, 29 mammals, and two reptiles have been infected with WNV (Centers for Disease Control and Prevention, 2004).

**Genetics** - Research on the genetic characteristics of sage-grouse has expanded rapidly in recent years and has helped identify some important characteristics. Foremost, research has discovered the greater sage-grouse is genetically distinct from the congeneric Gunnison sage-grouse (*C. minimus*). The management and conservation implications of this discovery have yet to come to fruition. Research has also included assessments of speciation, range-wide variation, population structure and connectivity, and genetic drift (Hupp and Braun, 1991; Young et al., 2000; Benedict et al., 2003; Oyler-McCance et al., 2005). However, because these research efforts are now only beginning, many questions still exist. In particular, the relationship that may exist between genetics and behavior (dispersal) and management (population size or fragmentation) is a subject that has yet to be studied. For example, can genetics be used as a standard technique to monitor and evaluate population structure, spatial configuration, and health?

## Section 4: Synopsis of Energy Related Scientific Evaluations and Discussion of Research Needs

### Introduction

As stated throughout this document, no single factor can likely be attributed as the primary reason for sage-grouse population declines, although the development of gas and oil fields throughout the western United States has been recognized as one potential causative agent (Braun 1987, Connelly et al. 2004). Impacts from oil and gas field development on sage-grouse are both short- and long-term (Braun, 1998; Braun et al., 2002). In his study in 1987, Braun noted that initial stages of development were related to the decreased numbers of grouse near these sites. Braun also believed permanent negative impacts occur as a result of energy related infrastructure, although in some cases bird populations were reestablished over time.

To date, the effects oil and gas development is having on the overall population of greater sage-grouse has not been thoroughly researched and in most cases, been relatively limited in scope. Although funding and research is beginning to increase and expand due to the overwhelming interest in this species, data gaps still exist that prevent accurate assessment of energy related population effects. In addition, many sage-grouse conservation plans have been developed by varying stakeholders aimed at stabilizing observed range-wide population declines, as well as management and mitigation approaches to increase current population levels. However, in some cases these plans may have limited applicability from an oil and gas perspective until additional long-term monitoring and scientific evaluation are completed to develop a comprehensive understanding of the industry's cumulative impacts on the birds overall population level.

The previous and ongoing research programs which have focused specifically on the direct effects the energy industry is having on sage-grouse population declines have been very limited in number (less than ten published reports) but, in general, have been well funded and scientifically sound. In

most cases, the results of these studies have indicated oil and gas development at a minimum, is partially related to the negative trend of many greater sage-grouse populations, as well as the sagebrush biome. For informative purposes, the intent of this Section is to summarize and compare several recent academic studies that have focused on oil and gas development and associated sage-grouse population effects. It is hoped this brief evaluation will provide the reader with a better sense of the types of energy related research and information that is being collected for this bird. In addition, this Section will discuss some possible research needs that may help further define the effect the energy industry is having on the bird. The following three studies were chosen to demonstrate current examples of energy related sage-grouse studies. Any inference to the validity of the study methods, results or of their importance are not intended and should not be taken as such. (Note: Additional data and method analysis intended to further evaluate the affects the oil and gas industry is having on the greater sage-grouse, which may include results from these studies, is planned under separate cover in the near future.)

- Lyon, A. G. *The potential effects of natural gas development on sage-grouse near Pinedale, Wyoming.* (Thesis)
- Matthew J. Holloran, and S. H. Anderson. *Greater Sage-grouse Population Response to Natural Gas Development in Western Wyoming*
- Naugle, D. E., B. L. Walker, and K. E. Doherty. *Sage-grouse population response to coal-bed natural gas development in the Powder River Basin: interim progress report on region-wide lek-count analyses.* (not peer reviewed)

## Recent Scientific Review

### A.G. Lyon

*The potential effects of natural gas development on sage-grouse (Centrocercus urophasianus) near Pinedale, Wyoming.*

In 1998 thru 1999, Ms. Lyon for a master's thesis at the Department of Zoology and Physiology, University of Wyoming, looked at the potential effects gas exploration and development is having on sage-grouse populations near Pinedale, Wyoming. As part of the study, 60 sage-grouse were captured on or near six lek sites. The lek sites were classified into two principle categories: disturbed and undisturbed. Lek classification was determined by the presence of development within three kilometers of the lek site and/or lek isolating topographic features (drainages). To help identify factors that may be related to sage-grouse population declines, various parameters (e.g., environmental characteristics, comparison of undisturbed vs. disturbed lek conditions, travel movements, etc.) were evaluated within life history categories that included:

- Early brood rearing;
- Nest habitat, nesting site fidelity;
- Summer movement and habitat;
- Cock lek-use.

Results from the study indicated hens in disturbed areas were approximately 30 percent less likely to initiate nest sites than those females in undisturbed areas. Additionally, travel from lek and nest locations was approximately twice as far for hens nesting in disturbed areas. During the course of the study, it was reported that for 1998 data, hen and yearling survival rate was 74 percent, while the rooster survival rate was only 52 percent. For comparative purposes, previous studies were cited, which indicated hen and yearling survival rates were 35 to 40 percent (Wallestad, 1975), respectively and rooster survival rates in Idaho ranged from 46-54 percent (Connelly et al., 2004).

### Matthew J. Holloran, and S. H. Anderson

*Greater sage-grouse population response to natural gas development in western Wyoming*

From 2000 thru 2004, Holloran and Anderson investigated the potential impacts of gas field development on greater sage-grouse populations on a study area designated by five km buffers around known leks in the upper Green River Basin near the town of Pinedale, in western Wyoming. The study area encompassed approximately 109,000 ha (1090 km<sup>2</sup>), and was dominated by big sagebrush and high-desert vegetation. The primary objective of the study was to determine if increased levels of



**Female Sage Grouse**  
*Photograph courtesy of Robert Shantz*

gas field development near known greater sage-grouse leks influenced breeding behavior. For this study, leks were categorized based on the total number of producing gas wells located within five km: leks with less than five wells were controls; leks with five to 15 wells were considered lightly impacted (n = 19 lek years); and leks with greater than 15 wells to be heavily impacted. Assessment of lek attendance was conducted as a function of the annual maximum number of males estimated through lek counts (Connelly et al., 2003).

Lek disturbance from oil and gas development was estimated by calculating either the total change in the maximum number of males attending all leks within a given impact status, or by calculating average annual change in the maximum number of males by lek impact status. Results of the study indicated distributions of sage-grouse nests in contiguous habitat that was free of gas development were spatially related to lek location, and a five-km buffer included 64 percent of nests. In addition, closely spaced nests had lower success than isolated nests, which suggested to the author that predation risk decreased the quality of otherwise suitable habitat when birds are forced to crowd nests into smaller areas to avoid energy development. The report also indicated the total maximum number of males declined 51 percent on heavily impacted leks from the year prior to impact to 2004 (control leks declined three percent during the same time period). Further, the total maximum number of males on three heavily impacted leks situated centrally within the developing field declined 89 percent, and two of the three leks were essentially inactive in 2004.

**Naugle, D. E., B. L. Walker, and K. E. Doherty**

*Sage-grouse population response to coal-bed natural gas development in the Powder River Basin: interim progress report on region-wide lek-count analyses. (not peer reviewed)*

To test whether CBNG development influences trends in the status and size of sage-grouse populations, Naugle et al. (2006) analyzed lek-count data from 516 leks in the Powder River Basin in areas with and without CBNG development. Leks were considered within CBNG development when >40 percent of an area within 3.2 km was developed or when >25 percent of the area was developed and development overlapped a lek center. In addition, a lek was considered to be on or near the periphery of development if 10-40 percent of

the area within 3.2 km was developed and development did not overlap the lek center. Leks with <10 percent development were considered outside a CBNG development area. Lastly, data for this study was provided by the by Wyoming Game and Fish Department and Montana Fish Wildlife and Parks and augmented by various other sources.

The primary objective of this study was to determine whether CBNG development influences breeding male sage-grouse attendance in the Powder River Basin. Relative to Dr.

Finally, as noted by Naugle et al., this study and subsequent analysis did not rule out the possibility that reduced population indices and apparent avoidance of developed areas by sage-grouse were being driven by habitat loss instead of oil and gas development.

Naugle's population estimates of five years ago, results of the study indicate sage-grouse population declines of 41 percent. Leks with extensive CBNG development showed substantially lower population trends than leks with minimal CBNG or no development and leks in areas adjacent to CBNG fields showed higher population trends than leks further away. Naugle explained the latter by suggesting sage-grouse may be avoiding developed areas and moving into adjacent undeveloped habitat. Male attendance at leks with minimal or no CBNG increased by approximately 25 percent from 2004 to 2005; but leks with extensive CBNG remained at historic lows. Finally, as noted by Naugle et al., this study and subsequent analysis did not rule out the possibility that reduced population indices and apparent avoidance of developed areas by sage-grouse were being driven by habitat loss instead of oil and gas development.

**Table 1: Summary of Recent Energy Specific Sage-Grouse Studies**

Study	Location	Objective	Methods	Results
Lyon	Pinedale, WY	Identify potential population effects from energy development	3 km lek study areas; captured and radio collared 60 birds	Hens 30 percent less likely to initiate nest in disturbed areas; hens travel twice as far in disturbed areas and move towards development.
Holloran and Anderson	Green River Basin, WY	Identify potential population and Breeding behavior effects from energy development	5 km lek study areas; leks categorized by number of wells; lek attendance as percent of annual maximum number of males	Closely spaced nests had lower success than isolated nests; total maximum number of males declined 51 percent on heavily impacted leks.
Naugle et al.	Powder River Basin, WY and MT	Identify potential population effects from energy development	3 km lek study areas; leks categorized by level of disturbance; data provided by State agencies	Sage-grouse population declines of 41 percent; Leks within development areas showed substantially lower population trends

**Data Gap Analysis**

At the time of the analysis, among the states in which sage-grouse research was reported, Oregon and Wyoming were underrepresented in the published literature and oil and gas development was mentioned only four percent of the time. In 1999, Schroeder et al. (1999) made comment to the relatively limited focus of sage-grouse

At the time of the analysis, among the states in which sage-grouse research was reported, Oregon and Wyoming were underrepresented in the published literature and oil and gas development was mentioned only four percent of the time.

research. Up until 1999, much of the research had focused on the behavior of the sage-grouse, yet few of these studies were applicable to management, and basic questions remain unanswered (Rowland and Wisdom, 2002).

In a non-energy related analysis of 100 sage-grouse studies by the Oregon Department of Fish and Game in 2002, numerous data gaps or data collection issues were identified. The

following is a summary of this analysis report:

In terms of project duration or study length, only 10 percent of the studies described a duration of greater than five years; the median value was substantially lower, only two years. Nearly half the research reports that mentioned “sagebrush” as occurring in the study area did not identify what sagebrush species or subspecies was present in the project area (e.g., silver or big sage). In addition, identification of population data was scarce, particularly information on population growth rates and mortality or survival rates. For these parameters, population growth rates of sage-grouse were mentioned in only one study and mortality or survival rates were given in 17 percent of the reports, and population trends or lek counts in 19 percent. At the time, important topics that were not well researched included habitat connectivity and fragmentation, genetics, habitat restoration, dispersal, and translocation. Also lacking were published studies on effects of human activities such as construction of power lines and roads, recreation, and urban development. To date, information on the aforementioned data gaps for the greater sage-grouse appears to still be prevalent.

## Research Needs

In terms of mining, and the associated roads, power lines, noise, and increased human activities, sage-grouse numbers and habitat are potentially being impacted in the short term (Braun, 1998). However, studies in Montana, Wyoming, and Colorado indicated some recovery of sage-grouse populations after initial development and subsequent reclamation of mine sites, roads, etc. (Eng et al., 1979; Tate et al., 1979; Colenso et al., 1980; Scott and Zimmerman, 1984; Braun, 1986). Remington and Braun (1991) concluded that sage-grouse were displaced by coal mining activities but returned to fluctuating predisturbance levels once mine activity ceased. Braun (1987) reported similar findings for sage-grouse in areas impacted by oil development. However, research to clarify potential areas being re-populated by sage-grouse with ongoing development, such as the Anticline in Wyoming, and positive population trends being for some populations within these types of areas still requires additional effort.

The performance of lek counts is the primary method for estimating sage-grouse population size. Although, counting sage-grouse on leks appears to be the most reliable current method for determining population trends over time (Connelly et al., 2004); the usefulness and accuracy of this method has been in question for some time (Beck and Braun, 1980) and more recently by Walsh et al. (2004). These questions suggest a need for development of alternative counting methods to improve current knowledge of sage-grouse population dynamics and methods for determining population trends (Stiver et al., 2006). However, available information that may facilitate development of new counting methods is inconsistent and in most cases based on short-term local studies (Stiver et al., 2006). For example, conflicting data have been published on lek attendance patterns. Emmons and Braun (1984) reported the mean lek attendance was 86 percent for yearling males and 92 percent for adult males. Contrary to this, Walsh et al. (2004) reported that adult male sage-grouse had an average daily attendance rate of 42

percent whereas; the daily attendance rate for yearlings was 19 percent.

As inferred above, long-term studies are needed since generated data will likely better portray other factors that may affect population success, such as weather and its corresponding effects on reproduction and vegetation. Also needed are more studies based on manipulative field experiments that may more accurately reflect real-world scenarios. The effect habitat fragmentation is having on sage-grouse also requires additional attention. From a spatial perspective, a better understanding of the spatial extent of suitable habitat patches that will provide seasonal requirements such as, nesting, brood-rearing, and wintering is needed (Montana Sage-Grouse Work Group, 2005).

The following bulleted items reflect specific research needs for the greater sage-grouse that may aid in the further understanding of population declines or potentially facilitate practices which may lead to increases to population trends. The following ideas and statements were taken from Rowland and Wisdom, 2002; Connelly et al., 2004; Montana Sage-Grouse Work Group, 2005; Holloran and Anderson, 2005; and Stiver et al., 2006.

- Continue monitoring the number of males on leks as an index of population trends to determine population success.
- Develop a monitoring strategy that will measure long-term sage-grouse abundance and distribution trends.
- Evaluate the consequences of using pesticides and herbicides on the herbaceous understory and insect availability.
- Evaluate the effects of hunting on sage-grouse and what would constitute an optimal harvest rate.
- Focus on explaining the long-term decline.
- Establish and compile information on extent and availability of suitable habitat.
- Identify current occupancy of existing sagebrush steppe habitat.

- Determine behavioral, genetic, demographic and population dynamics and ramifications of dispersal.
- Research juvenile responses to a developing gas field: What is the spatial extent of the area searched by disturbed juvenile males prior to establishing a territory on a lek? Is territorial establishment timing of juvenile males influenced by displacement?
- Investigate the effects on vital rates (e.g., survival, nesting initiation and success probabilities, and chick productivity rates) of the juvenile females displaced from their natal lek, nesting, or brooding areas.
- Assess sage-grouse mortality rates, factors that influence them, and effectiveness of actions taken to reduce them.
- Determine relationships between predation, habitat fragmentation, and habitat conditions.
- Evaluate impacts of existing roads, including 2-tracks, in relation to known lek locations and sage-grouse wintering areas.
- Develop techniques to increase herbaceous diversity and density in sagebrush steppe.
- Better define the effect the West Nile Virus is having on population trends.
- Complete analysis of cause-effect relationships between pervasive land uses and population responses of sage-grouse.
- Complete a broad scale assessment to identify important areas requiring additional protection or conservation during land use planning and leasing of energy reserves.
- Provide for long-term monitoring of siting requirements to assess effects of current and future energy development on sage-grouse.

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