Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats

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EXECUTIVE SUMMARY

Greater sage-grouse (*Centrocercus urophasianus*) once occupied parts of 12 states within the western United States and 3 Canadian provinces. Populations of greater sage-grouse have undergone long-term population declines. The sagebrush (*Artemisia* spp.) habitats on which sage-grouse depend have experienced extensive alteration and loss. Consequently, concerns raised for the conservation and management of greater sage-grouse and their habitats have resulted in petitions to list greater sage-grouse under the Endangered Species Act. In this report, we assessed the ecological status and potential factors that influenced greater sage-grouse and sagebrush habitats across their entire distribution. We used a large-scale approach to identify regional patterns of habitat, disturbance, land use practices, and population trends. We included literature spanning the last 200 years, landscape information dating back 100 years, and population data collected over the last 60 years.

We described the primary issues that influenced greater sage-grouse and sagebrush habitats for an area that exceeded >2,000,000 km^2 (>770,000 mi^2) in size. To do this, we compiled, integrated, and analyzed data obtained from agencies and organizations within 14 states, >13 federal agencies, and 2 nations. We did not make recommendations or suggest management strategies. Rather, our goal was to present an unbiased and scientific documentation of dominant issues and their effects on greater sage-grouse populations and sagebrush habitats.

We organized the Conservation Assessment into 4 main sections. In the first section, (Chapters 1 and 2), we present background information on greater sage-grouse and sagebrush habitats. We first introduce the factors that have contributed to widespread concern about conservation and management of greater sage-grouse and sagebrush habitats. We also describe the historical and legal administration as well as the current stewardship of sagebrush habitats. We then provide information on the conservation status of the species across its range-wide distribution. The second section (Chapters 3-5) provides information on the basic ecology of greater sage-grouse and sagebrush habitats. Our objectives were to develop the underlying foundation on which to assess information presented in the remainder of the document. In the third section (Chapters 6-12), we describe the current situation and trends in greater sage-grouse populations and the dominant factors that individually and cumulatively influence sagebrush habitats. In the fourth section (Chapter 13), we integrate the habitat and population trend information into a synthesis of the conservation status for greater sage-grouse and sagebrush ecosystems in western North America.

Sagebrush Habitats

Sagebrush ecosystems dominate approximately 480,000 km^2 throughout western North America. Almost all (70%) of the existing sagebrush habitats are publicly owned and managed by a state or federal agency. The U.S. Bureau of Land Management is the primary agency responsible for management of public lands containing sagebrush and has stewardship for 50% of the sagebrush habitats in the United States. Multiple use is the dominant management objective on almost all sagebrush habitats.

Using a landscape perspective, we described the current status of sagebrush ecosystems (Chapter 5), trends within these systems (Chapter 7), and assessed impacts of anthropogenic change with respect to sage-grouse (Chapter 12). In most cases, we quantified the changes, the regional distribution of a factor, or the area influenced by the disturbance.

The sagebrush biome has changed since settlement by Europeans. The current distribution, composition and dynamics, and disturbance regimes of sagebrush ecosystems have been altered by interactions among disturbance, land use, and invasion of exotic plants. The primary areas in which sagebrush habitats currently cover a large regional portion of the landscape were in central Washington; southeastern Oregon, northern Nevada, and southwestern Idaho; and central Wyoming. Landscapes were highly fragmented surrounding these regions.

The number of fires and total area burned have increased across much of the sagebrush biome over the past 20 years (for which records are more reliable). Cheatgrass (*Bromus tectorum*) and other exotic plant species have invaded lower elevation sagebrush habitats across much of the western part of the biome, further exacerbating the role of fire in these systems. At higher elevations, juniper (*Juniperus* spp.) and pinyon (*Pinus* spp.) woodland invasions into sagebrush habitats also have altered disturbance regimes.

Land conversions were significant factors in separating habitat patches and fragmenting landscapes. Sage-grouse populations and sagebrush habitats that once were continuous now are separated by agriculture, urbanization, and development in the Snake River corridor in southern Idaho. Highly productive regions throughout the sagebrush biome that had deeper soils and higher precipitation have been converted to agriculture in contrast to the low elevation, more xeric climates that characterized the larger landscapes still dominated by sagebrush. Agriculture currently influences 56% of the Conservation Assessment Area and 49% of the sagebrush habitats by fragmenting the landscape or facilitating movements of potential predators, such as common ravens (*Corvus corax*) on greater sage-grouse.

Urbanization and increasing human populations throughout much of the sagebrush biome have resulted in an extensive network of roads, powerlines, railroads, and communications towers and an expanding influence on sagebrush habitats. Roads and other corridors promote the invasion of exotic plants, provide travel routes for predators, and facilitate human access into sagebrush habitats. Human-caused fires were closely related to existing roads. Less than 5% of the existing sagebrush habitats were >2.5 km from a mapped road.

We evaluated the influence of livestock grazing primarily by the effect on habitats resulting from management practices and habitat treatments. Numbers used by agencies (e.g., permitted Animal Unit Months) do not provide the information on management regime, habitat condition, or kind of livestock that can be used to assess the direct effects of livestock grazing at large regional scales. Indices of seral stage used to relate current conditions to potential climax vegetation may not correlate with current understanding of the state-and-transition dynamics of sagebrush habitats. Over half of the public lands have not been surveyed relative to standards

and guidelines established for those lands. Although large treatments designed to remove sagebrush and increase forage palatable to livestock no longer are conducted, habitat manipulations, water developments, and fencing still are done to manage livestock grazing. Widespread water developments throughout sagebrush habitats increased the amount of area that can be grazed. More than 1,000 km of fences have been constructed each year on public lands from 1996 to 2002; linear density of fences exceeded 2 km/km^2 in some regions of the sagebrush biome. Fences provide perches for raptors, and modify access and movements by humans and livestock, thus exerting a new mosaic of disturbance and use on the landscape.

Energy development for oil and gas influences sagebrush habitats by physical removal of habitat to construct well pads, roads, and pipelines. Indirect effects include habitat fragmentation and soil disturbance along roads, spread of exotic plants, and increased predation from raptors that have access to new perches for nesting and hunting. Noise disturbance from construction activities and vehicles also can disrupt sage-grouse breeding and nesting. Development of oil and gas resources will continue to be a significant influence on sagebrush habitats and sage-grouse because of advanced technological capability to access and develop reserves, high demand for oil and gas resources, and the large number of applications submitted (4,279 in fiscal year 2002) and approved each year.

Some land use factors that we considered, such as military training, may have very intense effects on habitats but are restricted to relatively small regions across the entire sagebrush biome. In contrast, livestock grazing influences sagebrush ecosystems across the entire biome. The cumulative impacts of the disturbances and the interactions among disturbance regime, invasive species, and land use have the most significant influence on the trajectory of sagebrush ecosystems rather than influences attributed to any single source.

Sage-grouse populations depend on relatively large expanses of sagebrush-dominated shrub steppe. However, the appropriate patch size needed for winter and breeding habitats used by greater sage-grouse is uncertain. It is likely that this patch size is not a fixed amount but depends on various factors including migration patterns and productivity of the habitat.

Greater Sage-grouse Populations

We describe the population biology (Chapter 3) and habitat needs (Chapter 4) of sage-grouse. Chapter 6 addresses sage-grouse databases, distribution, and population trends. We also review information on genetics (Chapter 8), hunting (Chapter 9), predation and disease (chapter 10) and current monitoring techniques (Chapter 11).

Sage-grouse are a relatively long-lived species of upland game bird with low reproductive rates. Sage-grouse are entirely dependent on sagebrush habitats for successful reproduction and winter survival. Disease and hunting have generally not been major factors in sage-grouse population change but new information suggests West Nile Virus may pose a significant threat.

All state and provincial fish and wildlife agencies monitor sage-grouse breeding populations annually, but monitoring techniques vary among areas and years both within and among agencies. This variation complicates attempts to understand grouse population trends and make comparisons among areas. However, virtually all states and provinces have increased monitoring efforts, especially over the last 10 years. Range-wide, population monitoring efforts increased by 737% between 1965 and 2003. The largest increases in effort occurred in Montana and Wyoming, two of the key sage-grouse states. Our analysis indicated that 2,637 leks are now censused annually.

We conducted a comprehensive analysis of sage-grouse population changes throughout their range by accumulating and analyzing all available male counts at 5,585 leks identified since agencies began routine monitoring of this species. We applied several different techniques to evaluate greater sage-grouse populations in North America. These techniques included: 1) changes in the average and median number of males per active lek; 2) changes in the average and median number of males per lek (including leks that are inactive); 3) annual changes in the number of males attending leks monitored in consecutive years (rate of change data); 4) evaluation of spatial patterns of lek extirpation; 5) evaluation of patterns of range extirpation; and 6) delineation and evaluation of distinct breeding populations.

The overall distribution of potential pre-settlement habitat was estimated to have been 1,200,483 km^2 and the current distribution to be 668,412 km^2. Approximately 56% of the potential pre-settlement distribution of habitat is currently occupied. The area currently occupied by sage-grouse is clearly smaller than was occupied in pre-settlement times.

With most of the analysis of sage-grouse numbers, we focused on the 1965-2003 period. Although many states and provinces were collecting data prior to 1965, this 39-year range provided an opportunity to analyze data after a sample of leks had been identified and protocols for data collection had been established and implemented. Eleven of 13 (85%) states and provinces showed significant long-term declines in size of active leks. Similarly, eight of 10 states (80%) showed population declines over the same time frame. Two of 10 (20%) appeared to be stable or slightly increasing. Only California had an increase in both the population index and lek size.

When sage-grouse breeding populations were delineated based on separation by distance and unsuitable habitat, trends for populations were similar to those of the states. Our analysis of the entire sage-grouse population indicated that sage-grouse declined dramatically from the 1960s to the mid-1980s and then tended to stabilize. This analysis indicated that these changes were often not density-independent. If trends characteristic of the 1960s through the mid-1980s continued, sage-grouse had a relatively high likelihood of being extirpated. However, those trends have not continued. As a result, data suggest sage-grouse populations in most areas have been relatively stable or slightly declining during the last 15-20 years. In many areas numbers increased between 1995 and 2003. Although there are areas that presently could be considered population strongholds, some populations are still declining rather precipitously in various portions of the species range.

Annual rates of change suggest a long-term decline for greater sage-grouse in western North America and support the trend information obtained from lek attendance (males/lek) data. Sage-grouse populations declined at an overall rate of 2.0% per year from 1965 to 2003. From 1965-85, the population declined at an average rate of 3.5%. From 1986 to 2003, the population declined at a lower rate of 0.4% and fluctuated around a level that was 5% lower than the 2003 population. A total of 50,566 male sage-grouse were counted on leks in 2003 throughout western North America. However, we are not optimistic about the future of sage-grouse because of long-term population declines coupled with continued loss and degradation of habitat and other factors (including West Nile Virus).

Conclusion

This report is the first detailed assessment of range-wide population and habitat data for greater sage-grouse. The information and analysis included in this report can be used to monitor future population changes and responses to management activities. As such, we hope that the information that we have presented now can be the foundation for increasing our understanding of the ecology of sagebrush-dominated landscapes and species that depend upon them.

Montana

Montana manages and protects greater sage-grouse under the statutory authority of Title 87 of Montana Code Annotated 2003. Montana Department of Fish Wildlife and Parks' authority is described in part by the following:

> *"MCA 87-1-201. (Temporary, until March 2006) Powers and duties.*
> *(1) The department shall supervise all the wildlife, fish, game, game and nongame birds, waterfowl, and the game and fur-bearing animals of the state and may implement voluntary programs that encourage hunting access on private lands and that promote harmonious relations between landowners and the hunting public. It possesses all powers necessary to fulfill the duties prescribed by law and to bring actions in the proper courts of this state for the enforcement of the fish and game laws and the rules adopted by the department.*
> *(2) The department shall enforce all the laws of the state respecting the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds within the state."*

The Montana Fish, Wildlife and Parks Commission provide policy for the Department in the matters of wildlife management as set forth in the following MCA:

> *"MCA 87-1-301. Powers of commission. (1) The commission:*
> *(a) shall set the policies for the protection, preservation, management, and propagation of the wildlife, fish, game, furbearers, waterfowl, nongame species, and endangered species of the state and for the fulfillment of all other responsibilities of the department as provided by law;*
>
> *87-2-101. Sage-grouse are classified as upland game birds by statute.*
>
> *87-1-102, chapter 3, and this chapter, unless the context clearly indicates otherwise, the following definitions apply:*
> *(15) 'Upland game birds' means sharptailed grouse, blue grouse, spruce (Franklin) grouse, prairie chicken, sage hen or sage grouse, ruffed grouse, ring-necked pheasant, Hungarian partridge, ptarmigan, wild turkey, and chukar partridge."*

Nevada

Nevada manages greater sage-grouse under statutory authority of the Nevada Revised Statutes (NRS) and Nevada Administrative Code (NAC). Statute and code identify the Nevada State

Board of Wildlife Commissioners with the establishment of broad policy for the management and protection of the State's wildlife. Nevada Department of Wildlife is the agency charged with the execution of State law, Commission regulation and policy. Significant law and regulations are:

> *"NRS 501.110 Classification of wildlife.*
> *1. For the purposes of this title, wildlife must be classified as follows:*
> *... Wild birds, which must be further classified as either game birds, protected birds or unprotected birds. Game birds must be further classified as upland game birds or migratory game birds.*
> *NRS 501.181 Duties; regulations. The Commission shall:*
> *1. Establish broad policies for:*
> *(a) The protection, propagation, restoration, transplanting, introduction and management of wildlife in this state*
> *Nevada Administrative Code 503.040 Wild birds. Wild birds include all species classified as game, protected and unprotected birds.*
> *1. Upland game birds, which include: Centrocercus urophasianus."*

North Dakota

North Dakota manages and protects greater sage-grouse through Title 21.1 of state statutes. The Game and Fish Department is authorized under the following laws:

> *"20.1-01-03. Ownership and control of wildlife is in the state - Damages Schedule of monetary values - Civil penalty. The ownership of and title to all wildlife within this state is in the state for the purpose of regulating the enjoyment, use, possession, disposition, and conservation thereof, and for maintaining action for damages as herein provided. Any person catching, killing, taking, trapping, or possessing any wildlife protected by law at any time or in any manner is deemed to have consented that the title thereto remains in this state for the purpose of regulating the taking, use, possession, and disposition thereof. The state, through the office of attorney general, may institute and maintain any action for damages against any person who unlawfully causes, or has caused within this state, the death, destruction, or injury of wildlife, except as may be authorized by law. The state has a property interest in all protected wildlife.*
>
> *This interest supports a civil action for damages for the unlawful destruction of wildlife by willful or grossly negligent act or omission. The director shall adopt by rule a schedule of monetary values of various species of wildlife, the values to represent the replacement costs of the wildlife and the value lost to the state due to the destruction or injury of the species, together with other material elements of value. In any action brought under this section, the schedule constitutes the measure*

CHAPTER 4

Greater Sage-Grouse Habitat Characteristics

Abstract. Greater sage-grouse (*Centrocercus urophasianus*) depend on sagebrush (*Artemisia* spp.) for much of their annual food and cover. This close relationship is reflected in the North American distribution of sage-grouse, which is closely aligned with sagebrush, and in particular big sagebrush (*A. tridentata*) and silver sagebrush (*A. cana*). This relationship is perhaps tightest in the late autumn, winter, and early spring when sage-grouse are dependent on sagebrush for both food and cover. However, sage-grouse also depend on sagebrush at other times of year, primarily for protective cover, such as for nests during the breeding season. Other habitat characteristics may be less overtly important than sagebrush, but may be nearly as important. For example, herbaceous cover may provide both food and cover during the nesting and early brood-rearing seasons, thus playing a major role in the population dynamics of sage-grouse.

Introduction

Sage-grouse are closely allied with the large, woody sagebrushes of western North America and depend on these for food and cover during all periods of the year (Patterson 1952, Connelly et al. 2000*a*). Due to sage-grouse dependence on sagebrush habitats they are considered a sagebrush obligate (Braun et al. 1976). Sagebrush habitats across the range of sage-grouse may vary considerably (Tisdale and Hironaka 1981, West and Young 2000), and the specific habitat components used by the species can vary due to biotic and abiotic factors. Large, woody species of sagebrush including big sagebrush, silver sagebrush, and threetip sagebrush (*A. tripartita*) are used by sage-grouse throughout the year in all seasonal habitats (Griner 1939, Patterson 1952, Dalke et al. 1963). Other species of sagebrush such as low sagebrush (*A. arbuscula*) and black sagebrush (*A. nova*) provide important seasonal habitat components during spring and winter (Griner 1939, Patterson 1952, Dalke et al. 1963). Other shrub species such as rabbitbrush (*Chrysothamnus spp.*), antelope bitterbrush (*Purshia tridentata*), and horsebrush (*Tetradymia canescans*) have also been used for nesting and hiding cover by sage-grouse (Patterson 1952, Dalke et al. 1963, Connelly et al. 1991).

Summer habitats used by sage-grouse include riparian and upland meadows and sagebrush grasslands (Griner 1939, Patterson 1952, Dalke et al. 1963). Sage-grouse have also been documented using a variety of human-modified habitats, such as irrigated and non-irrigated croplands and pasturelands (Patterson 1952, Sime 1991). Disturbed areas such as roads, plowed fields, gravel pits, and stock ponds have been used as lekking sites (Patterson 1952, Connelly et al. 1981, Gates 1985). The value of these modified habitats to sage-grouse depends upon the usefulness of the habitat and the juxtaposition of the modified habitat in relationship to adjacent sagebrush habitats (Patterson 1952, Sime 1991). Although we attempt to provide comparable measures of seasonal habitats in the following examination, it should be noted that habitat values can depend on the techniques used to examine them (Connelly et al. 2003). Similar, greater sage-grouse have not been studied in detail in all portions of their range (e.g. North and South

Dakota). Consequently, care should be taken when extrapolating observations for range-wide considerations.

Breeding Habitats

Sage-grouse breeding habitats are defined as those where lek attendance, nesting, and early brood-rearing occur (Connelly et al. 2000*a*, Connelly et al. 2003). These habitats are sagebrush-dominated rangelands, typically consisting of large, relatively contiguous sagebrush stands, and are critical for survival of sage-grouse populations (Connelly et al. 2000*a*, Leonard et al. 2000). The following discussion includes information on habitat selection and relevant functions of the three components of breeding habitats (lekking, nesting, and early brood-rearing).

Leks

General Description. Leks are a traditional courtship display and mating areas attended by sage-grouse in or adjacent to sagebrush dominated nesting habitat (Patterson 1952, Wakkinen et al. 1992). Sage-grouse are polygamous and exhibit consistent breeding behavior each year on ancestral strutting grounds (leks; Patterson 1952, Wiley 1978). Scott (1942) reported a lek as active in 1940; this lek was still active 28 years later (Wiley 1973). Leks are situated in relatively open areas with less herbaceous and shrub cover than surrounding areas (Dingman 1980, Klott and Lindzey 1990). Wiley (1973) reported that selection of leks by sage-grouse occurs at course and fine resolutions. At course resolutions, leks appear to be located in sparser shrubby vegetation (Wiley 1973). At fine resolutions, male sage-grouse choose sod-forming grasses or bare ground for display. Lek selection at both resolutions increased the displaying males' conspicuousness and freedom of movement (Wiley 1973:103). Lek habitat is not considered limiting to sage-grouse populations (Schroeder et al. 1999).

Leks may be natural openings within sagebrush communities or openings created by human disturbances, including dry stream channels, edges of stock ponds, ridges, grassy meadows, burned areas, gravel pits, sheep bedding grounds, plowed fields, and roads (Patterson 1952, Dalke et al. 1963, Rogers 1964, Connelly et al. 1981, Hofmann 1991). Leks are typically surrounded by potential nesting habitat, and are adjacent to relatively dense sagebrush stands (Wakkinen et al. 1992). These sagebrush stands are used for escape, thermal, and feeding cover (Patterson 1952, Gill 1965).

Gentle terrain is a common characteristic of leks (Rogers 1964), as is their location in valley bottoms or draws (Patterson 1952, Rogers 1964). Nisbet et al. (1983) developed a lek preference model that included slope (<10%), precipitation (>25 cm), distance to nearest water source (<2,000 m), and predicted encroachment by pinyon (*Pinus spp.*)-juniper (*Juniperus spp.*) woodlands. Rogers (1964) reviewed characteristics of 120 leks throughout Colorado during 1953-1961 and found that, on average, 50% were in sagebrush; 54% were on gentle slopes; 55% were in bottoms; only 5% were within 200 m of a building; and that although 42% were >1.6 km

from an improved road, 26% were within 100 m of a county or state highway. Nisbet el al. (1983) reported 41 leks in Nevada and Utah were preferentially located in black sagebrush habitats (based on use versus availability). Smith (2003) reported that sagebrush within 1.5 km of active leks in North and South Dakota was taller than sagebrush around inactive leks. In addition, he found that sagebrush density, forb cover, and bare ground were greater around (i.e., within 1.5 km of) active leks in North Dakota than around inactive leks. Petersen (1980) reported mating areas (arenas) within leks in North Park, Colorado, had an average canopy cover of only 7.3% and a mean vegetation height of 5.3 cm; sagebrush species present included big sagebrush, alkali sagebrush (*A. longiloba*), and black sagebrush.

Specific Description. Dalke et al. (1963) and Klebenow (1973) documented leks on open or cleared areas 0.04 to 4 ha in size in southeastern Idaho. Scott (1942) observed leks that generally ranged from 0.25-16 ha, but recorded one lek that was 20 ha and with 400 strutting males. Hofmann (1991) reported a mean size of 36 ha for the four largest leks in a study in central Washington.

In non-migratory populations, leks may occur near the center of seasonal ranges (Eng and Schladweiler 1972, Wallestad and Pyrah 1974, Wallestad and Schladweiler 1974). Migratory populations typically do not exhibit this pattern (Dalke et al. 1963, Wakkinen et al. 1992). Travel by females dispersing between wintering and nesting areas, rather than vegetation type, may influence lek locations in some instances (Bradbury et al. 1989, Gibson 1996).

Leks often occur in complexes, composed of the primary lek and one or more satellites. Satellite lek attendance fluctuates depending upon population size, and satellite leks may not be used in years when populations are low (Dalke et al. 1963). In a study of 31 leks in Idaho, mean interlek distance (i.e., distance between nearest-neighbor leks) was about 1.6 km (Wakkinen et al. 1992). Of 13 leks examined in the Upper Snake River Plain in Idaho, 10 were in threetip sagebrush (Klebenow 1969). For two of these leks, interlek distance was 0.8 km, and for eight others, 2.4 km. In Wyoming, lek density averaged 6.8 leks per 100 km^2 (n = 29) within a water-reclamation project area, and 8.4 leks per 100 km^2 (n = 18) in nearby, undeveloped sagebrush habitats (Patterson 1952). In a non-peer reviewed report, Willis et al. (1993) reported similar lek densities in Oregon and found 4.3 leks per 100 km^2 at Hart Mountain National Antelope Refuge and 4.7 leks per 100 km^2 at Jackass Creek.

During the breeding season, males display in early morning and evening hours, traveling up to 2.1 km (Ellis et al. 1987) from the lek to day-use feeding and resting areas. Male day roost locations in northeastern Utah were generally 0.5-0.8 km from the lek (Ellis et el. 1989), and 82% of male day roost locations in central Montana were between 0.3 and 1.8 km from the lek (Wallestad and Schladweiler 1974). In central Montana, sagebrush canopy cover at 51% of male day-roost locations was between 20 and 40%, and no day-roost locations were recorded in areas with ≤10% sagebrush canopy cover (Wallestad and Schladweiler 1974).

Ellis et al. (1989) found in daytime, male sage-grouse in northeastern Utah used areas near leks that had comparatively greater canopy cover (mean = 31%) and taller shrubs (mean = 53 cm) than did nearby non-use areas. Minimum core day-use areas of males were 0.25 km^2 in size, and the birds often walked to such sites from leks for feeding and loafing (Ellis et al. 1989).

Relevant Features. Leks are typically adjacent to sagebrush with adequate cover for nesting hens as well as protection for both sexes from predators (Patterson 1952). Leks are characterized by low, sparse vegetation and higher amounts of bare ground than adjacent sites (Scott 1942, Petersen 1980, Klebenow 1985, Bradbury et al. 1989). The most important characteristic for leks may be their proximity and configuration with nesting habitat for females, consistent with theories of lek evolution and mating behavior (Gibson 1996).

Nesting

General Description. Sage-grouse nesting habitat is often a broad area within or adjacent to winter range or between winter and summer range (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*a*). The understory of productive nesting habitat should be composed of native grasses and forbs that provide a food source of insects, concealment of the nest and hen, and herbaceous forage for pre-laying and nesting hens (Gregg 1991, Schroeder et al 1999, Connelly et al 2000*a*).

Sage-grouse females move into the vicinity of their nest location within a few days of being bred, and remain relatively sedentary until they nest (Patterson 1952). Spring is a period when birds are changing diets from sagebrush to forbs as forbs become available (Barnett and Crawford 1994). Forbs provide increased levels of calcium, phosphorus, and protein that may affect nest initiation rate, clutch size and reproductive rates (Barnett and Crawford 1994, Coggins 1998). Little information is available documenting pre-nesting habitat selection.

Sage-grouse nest in many different sagebrush-dominated cover types and most nests are located under sagebrush plants (Patterson 1952, Gill 1965, Wallestad and Pyrah 1974, Petersen 1980, Drut at al. 1994*a*, Gregg et al. 1994, Sveum at al. 1998*b*). Throughout Wyoming, between 92% (Patterson 1952) and 100% (Rothenmaier 1979, Holloran 1999) of nests were under sagebrush, 90% of nests were located under silver sagebrush plants in southern Canada (Aldridge and Brigham 2002), and 94% of nests were under big sagebrush plants in northern Colorado (Petersen 1980). In southeastern Idaho, Connelly et al. (1991) reported that 21% of sage-grouse hens nested under shrub species other than sagebrush. Popham and Gutiérrez (2003) reported that 41% of sage-grouse nests in California were located under shrubs other than big sagebrush. Other plants that sage-grouse nest under include greasewood (*Sarcobatus vermiculatus*), bitterbrush, rabbitbrush, horsebrush, snowberry (*Symphoricarpos spp.*), shadscale (*Atriplex confertifolia*), mountain mahogany (*Cercocarpus spp.*), and basin wildrye (*Leymus cinereus*; Patterson 1952, Klebenow 1969, Wakkinen 1990, Connelly et al. 1991, Popham and Gutiérrez 2003). Patterson (1952) also located nests on bare ground with no sagebrush overstory.

Throughout the range of studied sage-grouse populations, nests were consistently located under larger bushes (Wakkinen 1990, Gregg 1991, Fischer 1994, Delong et al. 1995, Holloran 1999) with more obstructing cover (Wakkinen 1990, Fischer 1994, Popham and Gutiérrez 2003) within shrub patches. In addition, selected nesting habitat had more sagebrush canopy cover (Klebenow 1969, Fischer 1994, Sveum et al. 1998*b*, Holloran 1999, Aldridge and Brigham 2002) and taller sagebrush (Wallestad and Pyrah 1974, Sveum et al. 1998*b*, Holloran 1999, Lyon 2000, Slater 2003) compared to available habitats. Other relatively consistent differences between selected nesting sites and randomly selected sites included: higher sagebrush density (Klebenow 1969, Holloran 1999, Aldridge and Brigham 2002), taller live and residual grasses (Wakkinen 1990, Holloran 1999), more live and residual grass cover (Klebenow 1969, Lyon 2000), and less bare ground (Sveum et al. 1998*b*, Lyon 2000, Slater 2003).

Additionally, increased spring forb cover (14.5–18.2% vs. 6.8–12.8%), food forb cover (3.1–5.6% vs. 0.5–1.9%), and tall (>18 cm) grass cover (4.7–17.2% vs. 0.3–4.7%) was correlated with increased overall nest initiation rates (99 vs. 65%), renesting rates (30 vs. 14%), and nesting success rates (37 vs. 22%) in southeastern Oregon (Coggins 1998). Mean distance from lek-of-capture to selected nest sites was 4.6 km in southeastern Idaho (Wakkinen et al. 1992) and 8.6 km (range 0.4 – 63.8 km) in west-central Wyoming (Lyon 2000). In southwestern Wyoming, between 75% and 87% of nests were located within 5 km of the lek-of-capture (Slater 2003). In central Montana, 68% of hens nested within 2.5 km of the lek-of-capture, but 2 hens nested >4.8 km (Wallestad and Pyrah 1974). No differences were found between nest-to-lek versus random point-to-lek distances in southeastern Idaho, suggesting nests in this study were placed without regard to lek location (Wakkinen et al. 1992).

Measurement of distances between consecutive-year nests (females followed through consecutive nesting seasons) suggests female fidelity to nesting areas. Mean distance between consecutive-year nests averaged 552 m in southwestern Wyoming (Berry and Eng 1985), 710 m in central Wyoming (Holloran 1999), and 683 m in west-central Wyoming (Lyon 2000). Median distance between consecutive-year nests was 740 m in southeastern Idaho (Fischer et al. 1993), and 67% of consecutive-year nests were <600 m apart in southwestern Wyoming (Slater 2003).

Specific Description. Sage-grouse hens in southeastern Idaho nested under taller bushes with a larger area and greater lateral obstructing cover compared to random sites within the same shrub patch (Wakkinen 1990). Fischer (1994) continued Wakkinen's study for an additional 3 years and indicated that nests were located in areas with increased nest bush total area and height, ground obstructing cover, lateral obstructing cover, sagebrush density of shrubs ≥40 cm tall, and total shrub canopy cover compared to dependent random sites (i.e., random locations between 40 and 200 m from the nest; Fischer 1994). Mean height of nest bush (46.4 cm) was greater than the mean height of shrubs in the surrounding area (Holloran 1999). Additionally, although presented in non-peer reviewed reports, nest locations in western (Heath et al. 1997) and south-central (Heath et al 1998) Wyoming had taller live and residual grasses, more residual

grass cover, and less bare ground within 2.5 m compared to plots between 50 and 200 m from the nest but located within the same sagebrush stand.

Selection of specific habitat features, such as sagebrush height and canopy cover within a landscape by nesting sage-grouse has been extensively documented. Connelly et al. (2000*a*) suggested that nesting habitat within sagebrush stands should contain between 15 and 25% canopy cover. Females preferentially selected areas with sagebrush 36 to 63.5 cm tall and with canopies 15 to 50% for nesting in Utah (Rasmussen and Griner 1938. Rothenmaier (1979) reported that mean sagebrush canopy cover was 21.6% (12–29%) and average sagebrush height was 30.6 cm (22.6–38.1 cm) within a 37.2-m^2 plot surrounding nests in southeastern Wyoming. In western Wyoming, 83% of nests were under bushes between 25 and 51 cm tall (average nest bush height 35.6 cm; Patterson 1952). In central Montana, all nests were located in areas with >15% sagebrush canopy cover (Wallestad and Pyrah 1974). Petersen (1980) reported sagebrush height and canopy cover was 32 cm and 24% within 15 m of nests in northern Colorado.

In southeastern Idaho, nests within a threetip sagebrush type were found in areas with higher big sagebrush density (13.3 vs. 1.6 plants/122-m2), basal area of grasses (3.7 vs. 2.9%), and threetip sagebrush canopy cover (14.1 vs. 12.5%) compared to random plots within the same habitat type (Klebenow 1969). Overall, total shrub canopy cover was greater at nests compared to random locations (18.4 vs. 14.4%; Klebenow 1969). Fischer (1994) reported that nests had higher nest bush total area, ground obstructing cover, lateral obstructing cover, and total shrub canopy cover compared to random sites. In Wyoming, higher total shrub canopy cover and taller live sagebrush occurred in the nest area than at random sites (Holloran 1999, Lyon 2000, Slater 2003).

In south-central Washington, nests were consistently located in areas with more shrub cover at or within 5 m of the nest compared to randomly-selected sites (Sveum at al. 1998*b*). Taller average sagebrush heights (40.4 vs. 23.4 cm) occurred near nests compared to random locations in central Montana (Wallestad and Pyrah 1974). Aldridge and Brigham (2002) reported sagebrush canopy cover was dominant at nest sites (31.9 ± 4.07%) in southern Canada and greater than that at random sites (15.7 ± 2.44%). Sagebrush canopy cover was the only variable that discriminated between nests and random sites (Aldridge and Brigham 2002). Herbaceous differences within 2.5 m of nests compared to random plots in Wyoming included taller residual grasses (Holloran 1999), more live (Lyon 2000) and residual grass cover (Lyon 2000), more total herbaceous (Lyon 2000), non-food forb (Holloran 1999), and total forb (Lyon 2000) covers, and less bare ground (Lyon 2000, Slater 2003). In Idaho, Wakkinen (1990) reported taller grasses occurred near nests compared to random locations. The covers of short grasses (<18 cm) and bare ground were consistently lower, and vertical cover height were consistently greater near nests compared to available sites (Sveum et al. 1998*b*).

Relevant Features. Studies have reported somewhat conflicting results regarding nest success in relation to vegetation at nest sites. Connelly et al. (1991) reported that sage-grouse nesting under sagebrush experience greater nest success (53%) than those nesting under non-

sagebrush (22%). Wallestad and Pyrah (1974) reported a significant relationship between nest success and vegetation characteristics in Montana. Successful nests (n = 31) were in areas of higher sagebrush density than unsuccessful nests (n = 10), and canopy cover of sagebrush was greater (27%) in stands with successful nests compared to unsuccessful nests (20%). In southeastern Oregon, the canopy cover of medium height shrubs (40-80 cm) and tall grasses (>18 cm) was higher at successful nests than unsuccessful nests or random sites (Gregg et al. 1994).

Contrasting to Connelly et al. (1991) nesting success for non-sagebrush nests (42%) was higher than sagebrush nests (31%) in California (Popham and Gutiérrez 2003). In southeastern Idaho, Wakkinen (1990) found vegetation characteristics had no relationship to nesting success. Sveum et al. (1998*b*) found no differences in nesting success between nests placed beneath big sagebrush shrubs than under other shrub species in Washington.

Herbaceous vegetation characteristics that were consistently higher at successful versus unsuccessful sage-grouse nests throughout the range of studied populations included live and residual grass height (Wakkinen 1990, Sveum et al. 1998*b*, Aldridge and Brigham 2002, Hausleitner 2003), residual vegetative cover (Gregg et al. 1994, Sveum et al. 1998*b*), forb cover (Holloran 1999, Hausleitner 2003) and visual obstruction (Wakkinen 1990, Popham 2000, Slater 2003). Successful nests in southern Canada had taller grasses and palatable forbs, and less grass cover compared to unsuccessful nests (Aldridge and Brigham 2002). In California, percent rock cover (rocks >10 cm in diameter; 27.7 vs. 14.5%), total shrub height (65.5 cm vs. 49.2 cm), and visual obstruction (40.2 vs. 32.5 cm) were greater at successful than unsuccessful nest sites (Popham and Gutiérrez 2000). Nests destroyed by avian predators in southwestern Wyoming consistently had less overhead cover (live sagebrush and total shrub canopy cover) within 15 m of the nest and increased lateral cover (herbaceous cover and height) within 2.5 m of the nest compared to nests in general and mammalian-destroyed nests (Slater 2003). Hausleitner (2003) reported that successful nests in northwestern Colorado had higher average forb (9.3 vs. 7.2%) and grass cover (4.8 vs. 3.9%) within 10 m of the nest, and taller grasses at the nest (15.4 vs. 11.7 cm) and at 1 m from the nest (18.2 vs. 13.5 cm) compared to unsuccessful nests. Additionally, in southeastern Idaho, successful nests tended to have taller grass and more lateral obstructing cover within 2.5 m of the nest compared to unsuccessful nests (Wakkinen 1990). In central Wyoming, food-forb cover within 2.5 m tended to be higher at successful nests relative to unsuccessful nests (2.1 vs. 1.3%; Holloran 1999).

Successful artificial nests placed between 800 and 1440 m from active and inactive sage-grouse leks in southern Canada consistently had more forb and total sagebrush canopy cover, taller grasses, and lower numbers of sagebrush plants within 0.5 m compared to unsuccessful artificial nests (Watters et al. 2002). DeLong et al. (1995) reported that a combination of greater amounts of tall (>18 cm) grass and medium height (40-80 cm) shrub cover within 1 m of artificial sage-grouse nests in southeastern Oregon increased the probability of success. However, in northwestern Utah, the proportion of artificial nests along 1.6-km transects radiating perpendicularly from active sage-grouse leks that were destroyed increased with more

horizontal cover (density board centered at artificial nest and read from 10 m), and more herbaceous cover and taller sagebrush within 20 m of artificial nests (Ritchie et al. 1994). Although no relationship between lek-of-capture to nest distances and nesting success were reported in southeastern Idaho (Wakkinen et al. 1992), Popham and Gutiérrez (2003) found that mean distance from lek to nest site was greater for successful than unsuccessful nests in California (3.6 versus 2.0 km, respectively). High nest densities surrounding a lek may result in increased predation through destruction of multiple nests in a given area by a single predator (Neimuth 1992, Popham 2000).

Early Brood-rearing

General Description. Early brood-rearing habitat is defined as sagebrush habitat within the vicinity of the nest used by sage-grouse hens with chicks up to 3 weeks following hatch (Connelly et al. 2000*a*). Compared to selected nesting habitat, early brood-rearing locations in central Wyoming had less live sagebrush (15.8 vs. 25.4%) and total shrub (19.3 vs. 30.5%) canopy cover, shorter average sagebrush heights (25.5 vs. 31.4 cm), and more total herbaceous (37.3 vs. 29.6%) cover (Holloran 1999). Additionally, total forb (9.3 vs. 7.3%), food-forb (3.6 vs. 1.8%) and bare ground (7.3 vs. 5.0%) cover tended to be higher at selected early brood-rearing than nesting habitat (Holloran 1999).

Specific Description. Hens rear their broods for the first 2-3 weeks in the vicinity of their nest (Berry and Eng 1985). Early brood-rearing areas were located 0.2-5.0 km (mean = 1.1 km) from the nest in west-central Wyoming (Lyon 2000). Slater (2003) found 80% of early brood locations were within 1.5 km of the nest in southwest Wyoming. Movements from nest to early brooding areas in northern Colorado were between 0.3 and 2.3 km (mean = 0.8 km; Petersen 1980). During June and July in central Montana, brood use areas averaged 86 ha (Wallestad 1971).

In central Montana, 100% of the brood observations during June were in sagebrush-grassland habitats (Peterson 1970). Between 75-80% of brood locations from June 1 through June 15 were in areas with 1-25% sagebrush canopy cover (Wallestad 1971). In south-central Wyoming, 68% of sage-grouse brood locations were in sagebrush-grass or sagebrush-bitterbrush habitats (Klott and Lindzey 1990). Brooding females during the early brood-rearing stages in south-central Washington preferentially selected for big sagebrush-bunchgrass habitats and against grassland habitats (areas devoid of sagebrush); 70% of locations were within big sagebrush-bunchgrass habitats (Sveum et al. 1998*a*).

Brood-use sites within big sagebrush-dominated habitats in southeastern Idaho had lower big sagebrush density (64 vs. 104 plants) and canopy cover (8.5 vs. 14.3%), and higher percent frequency of yarrow (*Achillea millefolium*; 23.5 vs. 9.4%), lupine (*Lupinus caudatus*; 18.3 vs. 7.5%), dandelion (*Taraxacum officinale*; 12.0 vs. 3.1%) and common salsify (*Tragopogon dubius*; 2.2 vs. 0.3%) compared to random locations within the same vegetation type (Klebenow 1969). A combination of more residual grass and total forb cover, and shorter effective

vegetation height were the best predictors of early brood-rearing use compared to available habitats in central Wyoming (Holloran 1999). Early brood-rearing locations had less live sagebrush (15.8 vs. 20.2%) and total shrub (19.3 vs. 24.1%) canopy cover, more residual grass (2.9 vs. 2.0%), total forb (9.3 vs. 6.6%), and total herbaceous (37.3 vs. 29.4%) cover, relative to available habitats (Holloran 1999). In west-central Wyoming, early brood-rearing locations had less live sagebrush density (1.9 vs. 2.3 plants/m^2), live sagebrush (21.5 vs. 27.0%), total shrub canopy cover (30.0 vs. 35.0%), and bare ground (23.5 vs. 39.6%) compared to available habitat (Lyon 2000). Lyon (2000) also found more total herbaceous (24.8 vs. 9.1%) cover compared to available habitat. Early brood-rearing locations had more sagebrush cover compared to random locations (8.7 vs. 4.5%) in southern Canada (Aldridge and Brigham 2002). Total forb (25 vs. 8%) and food forb (8 vs. 2%) cover were higher, and residual herbaceous cover (1 vs. 3%) and height (1 vs. 3 cm) were lower within 10 m of early brooding areas compared to random locations in south-central Washington (Sveum et al. 1998*a*).

When broods were found in grass-forb open areas in south-central Wyoming, use sites had more shrub cover relative to random openings, and dandelion, knotweed (*Polygonum spp.*), yarrow, and common salsify were more abundant at sage-grouse brooding sites than at random sites (Klott and Lindzey 1990). In southeastern Oregon, key forbs (those occurring in the crops of at least 10% of collected chicks or having aggregate mass ≥1%) cover (4 vs. 1%) were higher in habitats preferentially selected by broods relative to habitats selected in less than available proportions (Drut et al. 1994*b*). In southeastern Idaho, Fischer (1994) reported higher Hymenoptera (ants, bees, wasps) abundance and higher Orthoptera (grasshoppers, crickets) frequency (no difference in abundance), but no difference in abundance of Coleoptera (beetles) at brood use vs. random sites. However, Slater (2003) reported no vegetative or insect quality differences between selected early brood-rearing and random locations in Wyoming. During the early stages of life, sage-grouse broods consistently selected areas with more forb (Klebenow 1969, Klott and Lindzey 1990, Sveum et al. 1998*a*, Holloran 1999) and total herbaceous (Holloran 1999, Lyon 2000) cover, and less shrub canopy cover (Klebenow 1969, Holloran 1999, Lyon 2000) than at randomly-selected areas.

Relevant Features. The availability of forb-rich habitats in close proximity to adequate protective cover appears to be an important consideration in brood habitat (Kebenow 1969, Sveum et al. 1998*a*, Klott and Lindzey 1990, Holloran 1999, Lyon 2000). These habitat features appear to be related to the selection of food items by chicks, particularly forbs (Drut et al. 1994*b*) and insects (Fischer 1994). The literature is somewhat ambiguous concerning the management of these specific habitat types.

Summer and Late Brood-Rearing Habitats

General Description

Late brood-rearing habitats are those habitats used by sage-grouse following desiccation of herbaceous vegetation in sagebrush uplands (Klebenow and Gray 1968, Savage 1969, Fischer

et al. 1996*b*). Gates (1983) and Connelly et al. (1988) observed sage-grouse associated with agricultural lands and irrigated lawns during the summer period. Sage-grouse often use sagebrush habitats for late brood-rearing throughout the summer but select habitats based on availability of forbs. This is often accomplished by moving up in elevation or selecting sites where moisture collects and maintains forbs throughout the summer (Martin 1970, Wallestad 1971, Fischer et al. 1996*b*, Hausleitner 2003). Fischer et al. (1996*b*) found that sage-grouse moved to late brood-rearing habitats when vegetal moisture was ≤60%. The beginning of late brood-rearing also coincides with the change in diets of sage-grouse chicks from predominantly insects to forbs (Patterson 1952, Klebenow and Gray 1968, Klebenow 1969, Peterson 1970, Drut et al. 1994). These habitats are generally used from July to early September but vary annually due to annual weather conditions (Patterson 1952, Dalke et al. 1963, Gill and Glover 1965, Savage 1969, Wallestad 1971, Connelly et al. 1988).

Sage-grouse use a variety of sagebrush habitats and other habitats (e.g., riparian, wet meadows and alfalfa [*Medicago spp.*] fields) during summer. These sites typically provide an abundance of forbs and insects for hens and chicks (Schroeder et al. 1999, Connelly et al. 2000*a*). As vegetation in upland sagebrush habitats desiccate, hens move to more mesic sites to summer and rear broods (Klebenow 1969, Gates 1983, Connelly et al. 1988, Fischer et al 1996b). These movements vary in response to such factors as plant moisture, vegetal cover, and elevation (Dalke et al. 1960, Wallestad et al. 1975, Connelly 1982). Sage-grouse in southeastern Idaho moved as far as 82 km from breeding and nesting to summer ranges (Connelly et al. 1988). Klebenow and Gray (1968) observed grouse migrating as far as 8-24 km to summer ranges at higher elevations ranging from 1,600 m to over 2,150 m. Fisher et al. (1997) recorded movements up to 62 km from nesting to summer habitats. Wallestad (1971) reported that some broods only traveled short distances to summer habitats, whereas others moved as much as 5 km.

Sage-grouse movements to breeding, nesting and summer ranges may also be influenced by tradition. For instance, Fisher et al. (1997) reported significantly more sage-grouse than expected moved to traditional summer grounds, rather than to closer (15-20 km) irrigated agricultural fields. Wallestad (1971) also observed hens moving 5 km to summer habitat, bypassing a comparable area that was 3.2 km closer.

Unsuccessful hens and cocks move from sagebrush habitat as forbs desiccate and will occupy a variety of habitats during the summer, including irrigated hayfields and wet meadows that are adjacent to sagebrush habitats (Gates 1983, Connelly et al. 1988). Connelly et al. (1988) and Gregg et al. (1993) reported that movements of broodless hens to mesic areas in the summer preceded that of brooding hens' arrival and that flocks were generally segregated by sex. Segregated flocks were also observed by Dalke et al. (1963) during the summer.

Seasonal Differences

Sage-grouse use many different habitats during the late brood-rearing period, such as sagebrush, wet meadows, and irrigated farmland adjacent to sagebrush habitats (Gates 1983,

Connelly et al. 1988). Klebenow (1969) reported broods in Idaho typically move up in elevation, following the gradient of food availability. Wallestad (1971) observed that some broods remained in the sagebrush by seeking out microhabitats such as small swales or ditches where forbs were still available. A lack of shift in habitat selection between early and late brood-rearing may also suggest there is no difference in the availability of forbs in the area (Aldridge and Brigham 2002). Aldridge (2000) suggested that broods do not move from sagebrush uplands to more mesic sites during wet years, and that wetland complexes may be limiting in dry years because of low food availability, and ultimately, low recruitment.

Specific Description

Adult and juvenile sage-grouse tend to use sagebrush adjacent to mesic areas during summer as loafing sites and for cover (Savage 1969). Midday locations had greater shrub cover and height compared to morning and afternoon loafing locations (Sveum et al. 1998*a*). Dunn and Braun (1986) reported grouse select feeding habitat near edges of cover types with more horizontal and vertical cover and less variation in shrub densities and size compared to random sites. Hens with broods also used sites with more horizontal cover and greater variation in sagebrush canopy cover than random sites to roost, but fed in open homogeneous areas during the morning and afternoon periods (Braun 1986). In Colorado, Hausleitner (2003) found that female night-roost sites had less bare ground and visual obstruction, but greater forb cover than at random sites. These areas may increase the opportunity of foraging by hens with broods with high energic demands and provide open cover types with greater escape potential from predators (Hausleitner 2003). Sveum et al. (1998*a*) found that morning and afternoon locations differed from midday and random locations by having taller (≥18 cm) grass and less shrub cover and height. Klott and Lindzey (1990) reported broods used large openings and meadows, foraged on the edges and avoided the centers.

Peterson (1970) found that forb canopy cover averaged 33% at brooding sites in Montana over 2 distinctly different summers (in terms of precipitation). In Colorado, young broods used areas with low forb canopy cover (mean = 6.9%) after hatching and then quickly moved to wet meadows with far greater (mean = 41.3%) forb canopy cover (Schoenberg 1982). Hausleitner (2003) reported females selected brood-rearing sites with higher average forb canopy cover (8% vs. 4%) and less bare ground than random sites. Sveum et al. (1998*a*), reported that hens selected areas with 19-27% forb canopy cover for late brood-rearing in Washington. In Idaho, Apa (1998) found sites used by sage-grouse broods had twice as much forb cover as did independent sites. However, researchers in southeast Alberta recorded an average forb cover in late brood-rearing habitat of 12.6% and suggested that 12-14% forb canopy cover might represent the minimum needed for brood habitat (Aldridge and Brigham 2002).

Sage-grouse chicks consume a wide variety of forbs and insects depending on availability. Drut et al. (1994*a*) found that chicks consumed 122 different foods, which included 34 genera of forbs, 2 genera of shrubs and 1 genus of grass, and 41 families of invertebrates.

Food availability appears to be a strong determinant of which vegetation types are selected by broods during different periods of the summer (Wallestad 1971).

Relevant Features

The availability and use of forbs in summer habitats by sage-grouse has been reported by many investigators (Patterson 1952, Peterson 1970, Gregg et al. 1993, Apa 1998, Sveum et al. 1998*a*, Aldridge and Brigham 2002, Hausleitner 2003). Juvenile sage-grouse rely heavily on animal matter (insects) and forbs for food during the first few months after hatching (Patterson 1952, Klebenow and Gray 1968, Braun et al. 1977). Succulent forbs dominate the diet of chicks from about 2 weeks of age (Nelson 1955, Klebenow and Gray 1968) until 3 months, when sagebrush then becomes the primary food component (Peterson 1970). Coggins (1998) reported an increase in forb availability may allow hens to remain in upland brood-rearing habitats longer which could contribute to increased chick survival due to decreased brood movements.

Patterson (1952) implied that water was important to sage-grouse and suggested that its availability could affect summer distributions. However, although theorized in a non-peer reviewed report, movements to agricultural lands or high elevation summer ranges are probably in response to lack of succulent forbs in an area rather than a lack of free water (Connelly and Doughty 1989). It has further been suggested that grouse do not commonly use water developments even during relatively dry years, but instead obtain moisture from consuming succulent vegetation (Connelly 1982). Water developments tend to attract other animals and thus may serve as a predator "sink" for sage-grouse (Connelly and Doughty 1989). Free water reservoirs can, however, provide islands of succulent vegetation (Wallestad 1971).

Autumn Habitats

Autumn is a transitional period for sage-grouse (Wambolt et al. 2002), when their diets change from a variety of forbs, insects, and sagebrush to predominantly sagebrush (Rasmussen and Griner 1938, Patterson 1952, Leach and Hensley 1954, Gill 1965, Wallestad et al. 1975). Autumn habitats used by sage-grouse can vary widely, based on availability, elevation, topography, water, distance between summer and winter habitats, and weather conditions. These habitats are generally used from as early as late August to as late as mid-December (Patterson 1952, Dalke et al. 1963, Gill and Glover 1965, Savage 1969, Wallestad 1971, Connelly 1982, Connelly et al. 1988).

During early autumn, in addition to sagebrush, habitats may include upland meadows, riparian areas, greasewood bottoms, alfalfa fields, and irrigated native hay pastures (Patterson 1952, Gill 1965, Savage 1969, Wallestad 1971, Connelly 1982). As vegetation in these habitats desiccates or is killed by frost, sage-grouse begin using sagebrush habitats more often and form larger flocks (Patterson 1952, Savage 1969). During early autumn in Colorado, sage-grouse abandoned irrigated native hay meadows in response to the cessation of irrigation, mowing of hay, and killing frosts (Gill and Glover 1965). During a seven-year study in eastern Idaho, sage-

grouse gathered in large flocks near water during the autumn migration, watering from 10 to 30 minutes daily (Dalke et al. 1963).

Autumn habitats used by sage-grouse in northeastern Wyoming supported higher densities of sagebrush (3.1-7.4 plants/m^2) than the study area as a whole (Postovit 1981). Wallestad (1971) found that sage-grouse used habitats with greater sagebrush cover in the autumn than during the late brood-rearing period. This shift coincided with the transition to a diet of sagebrush, as sage-grouse broods that had occupied bottomland vegetation types (greasewood and alfalfa fields) shifted back into sagebrush in late August and September (Wallestad 1971). Connelly and Markham (1983) reported that some sage-grouse did not return to sagebrush habitats until October or November. During the autumn in Colorado, sage-grouse used the same upland sagebrush habitats used for breeding; however, their use in the autumn appeared random, and not tied to lek location, as it was during the breeding season (Gill 1965).

In Idaho, movements from autumn sagebrush habitats to winter range were generally slow and meandering, beginning in late August and continuing into December (Connelly et al. 1988). During periods of early, severe winter snowstorms, sage-grouse may begin migrations to winter habitats, but at the onset of milder weather later in the autumn may return to sites adjoining late brood-rearing habitat (Patterson 1952). Sage-grouse in Utah typically moved to winter range around mid-November; this movement appeared to be independent of snow depth (Welch et al. 1990).

Winter Habitats

General Description

Winter habitats of sage-grouse are dominated by sagebrush that provides shelter and food during this time of the year (Rassmussen and Griner 1938, Patterson 1952, Remington and Braun 1985, Robertson 1991). Variation in topography and availability of sagebrush above the snow under various conditions determine the location of these habitats (Beck 1977, Connelly 1982, Robertson 1991).

Sage-grouse habitat selection during winter is influenced by several factors, including snow depth and hardness, topography (e.g., elevation, slope, and aspect), and vegetation height and cover (Gill 1965, Schoenberg 1982, Robertson 1991, Schroeder et al. 1999). In North Park, Colorado sage-grouse selected either relatively exposed, windswept ridges or draws and swales (Beck 1977, Schoenberg 1982). Both windswept ridges and draws provided access to sagebrush above snow for food and cover (Beck 1977, Schoenberg 1982).

Fidelity to winter areas has not been well studied, although some evidence of fidelity to winter areas among years has been demonstrated in Washington (Schroeder et al. 1999) and Wyoming (Berry and Eng 1985). In Utah, Welch et al. (1990) found that sage-grouse showed less fidelity to winter range than to other seasonal ranges.

Winter habitats of sage-grouse generally are dominated by big sagebrush; however, low sagebrush and silver sagebrush communities also are used during winter (Schroeder et al. 1999, Crawford et al. 2004). Sage-grouse in Idaho and Nevada often use low sagebrush habitats while other sagebrush-dominated habitats are used in proportion to their availability (Connelly 1982, Klebenow 1985). However, in Oregon, 98% of winter observations were in mountain big sagebrush (Hanf et al. 1994).

Specific Description

During winter, sage-grouse rely almost exclusively on sagebrush exposed above snow for forage, (Patterson 1952, Schroeder et al. 1999, Connelly et al. 2000*a*, Crawford et al. 2004). In central Montana, sage-grouse foraged during winter in big sagebrush with a mean canopy cover of 28%, and observations in dense (>20%) cover were more common than those in less dense sagebrush (Eng and Schladweiler 1972).

During winter, sage-grouse may roost in snow burrows or snow forms, apparently for energy conservation (Beck 1977, Back et al. 1987). In Montana, winter roost sites were in sagebrush with a mean canopy cover of 26%, and usually on flat terrain (Eng and Schladweiler 1972). In Colorado, characteristics (e.g., shrub height, percent slope) of winter feeding-loafing sites (n = 173) did not differ from roosting sites (n = 26) (Beck 1977).

Relevant Features

The spatial distribution of sage-grouse in winter often is related to snow depth (Patterson 1952; Dalke et al. 1963; Gill 1965; Klebenow 1973, 1985; Beck 1975, 1977; Welch et al. 1990). At the onset of winter, sage-grouse typically move to lower elevations with greater exposure of sagebrush above snow (Patterson 1952) and taller sagebrush; in migratory populations, this movement may extend up to 160 km (Patterson 1952). During more severe winters, a large proportion of the sagebrush may be beneath snow and thus unavailable for roosting or foraging.

Shrub density and structure, including height and canopy cover, also influence habitat selection by sage-grouse during winter. Connelly et al. (2000*a*) recommended that canopy cover of sagebrush in both arid and mesic sites should be maintained at 10 to 30% in wintering habitat and further reported that grouse use shrub heights of 25-35 cm above the snow. In Colorado, female sage-grouse used more dense (68 plants/0.004 ha) stands of mountain big sagebrush (*primarily A. t. vaseyana*) than did males (46 plants/0.004 ha; Beck 1977). Height of sagebrush on winter ranges is typically 25-80 cm (Crawford et al. 2004). Schoenberg (1982) found that sage-grouse selected wintering areas having greater sagebrush cover than at random sites and sagebrush heights were 2-3 times greater at use verses random sites. Connelly (1982) reported total height of sagebrush at winter use sites by sage-grouse was greater than at random sites, and provided evidence suggesting that sage-grouse moved to taller sagebrush as snow depth increased.

Shrub canopy cover on winter ranges generally varies from 6-43% (Schroeder et al. 1999). Studies in central Oregon found that sagebrush canopy cover was typically >20% at winter-use sites (Hanf et al. 1994). Within these sites, however, grouse tended to use patches with lower canopy cover (12-16%); in this study, most of the winter use sites were in mountain big sagebrush (Hanf et al. 1994). In central Montana, sage-grouse selected dense (>20% canopy cover) stands of big sagebrush during winter (Eng and Schladweiler 1972), whereas in central Idaho they preferred black sagebrush when these shrubs were available above the snow (Dalke et al. 1963). Robertson (1991) reported Wyoming big sagebrush canopy cover and height were consistently greater at use sites when compared to random sites.

In Utah, Homer et al. (1993) used satellite imagery to classify winter habitat of sage-grouse into seven shrub categories. Wintering grouse preferred shrub habitats with medium to tall (40-60 cm) shrubs and moderate shrub canopy cover (20-30%; Homer et al. 1993). Sage-grouse avoided winter habitats characterized by medium (40-49 cm) shrub height with sparse (<14%) sagebrush canopy cover. Cover of grasses and forbs for wintering habitats generally is irrelevant, because of the nearly complete reliance of sage-grouse upon sagebrush during this period (Homer et al. 1993).

Topography also influences use of winter habitats by sage-grouse. Flocks are typically found on south- or southwest-facing aspects (Beck 1977, Crawford et al. 2004) and on gentle slopes (<5%; Beck 1977). Microsites ameliorate effects of wind, especially at low temperatures (Sherfy and Pekins 1995), and contribute to maintaining energy balance. In eastern Idaho, the mean distance moved between summer and winter ranges was 48.2 km for 28 hens; this movement involved a decrease in mean elevation of 446 m (Hulet 1983).

Landscape Context Issues

General Description

Sage-grouse populations typically inhabit large, interconnect expanses of sagebrush and thus have been characterized as a landscape-scale species (Patterson 1952, Wakkinen 1990). Historically, the distribution of sage-grouse was closely tied to the distribution of the sagebrush ecosystem (Wambolt et al. 2002, Schroeder et al. 2004). However, populations of sage-grouse have been extirpated at places throughout their former range (Schroeder et al. 1999, Wambolt et al. 2002), concomitant with habitat loss and degradation, so that the species' current distribution is less closely aligned with that of sagebrush.

Causes for habitat loss, fragmentation, and degradation in sagebrush are many and varied, and include brush control and other means to remove sagebrush (Klebenow 1970, Martin 1970, Wallestad 1975), inappropriate livestock management, energy development, urbanization, and the infrastructure necessary to maintain these activities (Hulet 1983, Evans 1986, Beck and Mitchell 2000, Bunting et al. 2002, Braun et al. 2002, Lyon and Anderson 2003). Increased fire

frequency in lower elevation sagebrush habitats, often closely tied to invasion of annual grasses such as cheatgrass, has resulted in losses of sagebrush over large expanses in the Intermountain West and Great Basin (Mack 1981, Miller et al. 1994, Crawford et al. 2004). In addition, decreased fire frequency in higher elevation sagebrush habitats and impacts from inappropriate livestock grazing and other factors have resulted in conifer encroachment and subsequent reduction of the herbaceous understory and sagebrush canopy cover over large areas (Miller and Rose 1995, Miller and Eddleman 2001, Crawford et al. 2004).

Prescribed fire has also been an issue. Pyle and Crawford (1996) found that prescribed fire in Oregon decreased sagebrush cover, but increased total forb cover and diversity, hypothesizing that prescribed fire may increase forbs in montane sagebrush habitats used for brood-rearing. However, Fischer et al. (1996*a*) found that forb cover was similar in burned and unburned areas of Wyoming big sagebrush in Idaho, but the abundance of hymenoptera was lower in burned habitats. Sage-grouse abundance was not different between burned and unburned areas, and the authors indicated that fire did not enhance sage-grouse brood-rearing habitats (Fischer et al. 1996*a*). Slater (2003) found that sage-grouse were willing to used areas impacted by both prescribed burns and wildfires in Wyoming, but that the area's suitability appeared to be related to age of the burn and the availability of alternate shrubs. Additionally, Nelle et al. (2000) reported that fire had long-term negative impacts on sage-grouse nesting and brood-rearing habitats in mountain big sagebrush stands (*A. t. vaseyana*). Connelly et al. (2000*b*) indicated that prescribed burning during a drought resulted in a large decline of the sage-grouse breeding population. Byrne (2002) documented avoidance of burned habitats by nesting and brood rearing sage-grouse hens in Oregon and concluded that fire provided no apparent value in low sagebrush and Wyoming sagebrush cover types. Finally, in a modeling exercise, Pedersen et al. (2003) warned that although small fires may benefit sage-grouse, large fires occurring at high frequencies may lead to the extinction of sage-grouse populations. They defined a large fire as one that burns >10% of the spring use area and they defined high frequencies as 17 years between fires.

The use of herbicides and insecticides also has the potential to directly and indirectly impact sage-grouse. The impacts can be through direct contact (Ward et al. 1942, Post 1951, Blus et al. 1989) or through the indirect alteration of components of the habitat. These alterations can include the removal of sagebrush (Carr and Gover 1970, Klebenow 1970) and the reduction of forbs or insects (Eng 1952).

Few studies have been conducted to examine landscape-level issues regarding sage-grouse populations and habitats. Leonard et al. (2000) found a negative relationship between mean numbers of males/lek and agricultural development during a 17-year period in the Upper Snake River Plain in Idaho; nearly 30,000 ha of sagebrush in the study area were converted to cropland from 1975 to 1992. In North Park, Colorado, Braun and Beck (1996) examined lek counts in relation to habitat loss from both plowing and spraying with 2,4-D of >28% of the study area, a site known as "one of the best sage-grouse habitats in Colorado." Initial spraying of >1,600 ha occurred in 1965, with an additional 500 ha sprayed and 1,460 ha plowed and

seeded during the following 5 years (Braun and Beck 1996). The 5-year mean of males on active leks declined from 765 (1961-1965) to 575 (1971-1975; Braun and Beck 1996). Numbers rebounded by 1976-1980, however, and even exceeded the pre-treatment levels (five-year mean = 1,109 males).

A recent study comparing the percentage of tilled versus non-tilled land surrounding sage-grouse leks in North Dakota revealed that abandoned leks had a higher percentage of tilled lands within a 4-km buffer of leks than did active leks (Smith 2003). However, there was no increase in the percentage of tilled land from the 1970s to the late 1990s, suggesting that if the amount of tilled land was a factor in lek abandonment, this effect had occurred prior to the 1970s (Smith 2003).

Conserving large landscapes with suitable winter habitat may be important for conservation of sage-grouse (Eng and Schladweiler 1972). Sage-grouse in North Park, Colorado concentrated during winter in 7 small areas that totaled only 85 km^2; these areas comprised only 7% of the sagebrush in the entire study area (Beck 1977). Swenson et al. (1987) found marked declines in sage-grouse abundance in Montana when a large (30%) percentage of the winter habitat was plowed, primarily for grain production. Eng and Schladweiler (1972) suggested that sagebrush removal in winter habitats may be especially detrimental because of the relatively long periods that winter habitat may be occupied by sage-grouse annually. Maintaining intact winter habitat for sage-grouse may also be an issue in areas of energy development (e.g., natural gas fields, coal-bed methane), especially if several populations converge in a common wintering area (Lyon 2000).

Fragmenting sagebrush habitats may also change course-resolution distribution patterns of sage-grouse. During a study in Colorado, in which >120 flocks (>3,000 birds total) were observed during 2 winters, only 4 flocks were found in altered (by spraying with 2,4-D, plowing, burning, or seeding) sagebrush habitats, although >30% of the study area had been treated (Beck 1977).

Although sage-grouse are considered a landscape species, conclusive data are unavailable on minimum patch sizes of sagebrush necessary to support viable populations of sage-grouse. In Wyoming, Patterson (1952) found that sage-grouse "packs" could range as widely as several thousand square kilometers. Migratory populations of sage-grouse may use areas exceeding 2,700 km^2 (Connelly et al. 2000*a*, Leonard et al. 2000). Sagebrush patches used by broods averaged 86 ha in early summer (June and July) in central Montana but diminished to 52 ha later in summer (August and September; Wallestad 1971).

Mosaics, Juxtaposition, and Diversity

Sagebrush habitats are generally characterized by the sagebrush overstory, which is, both spatially and temporally diverse due to the large area occupied by the sagebrush ecosystem (Miller and Eddleman 2001, Schroeder et al. 1999). Sage-grouse use of different heights and

canopy cover of sagebrush is seasonally, ranging between 29-80 cm in height and 19-38% canopy cover during the nesting season (Gregg 1991, Heath et al. 1997, Apa 1998, Aldridge and Brigham 2002). During other periods of the year (summer, autumn, winter) sagebrush heights range between 25-46 cm, with canopy cover from 12-43% (Eng and Schladweiler 1972, Robertson 1981, Schoenberg 1982, Hanf et al. 1994, Holloran 1999). Within the sagebrush ecosystem, a wide range of understory vegetation is used by sage-grouse during the breeding and brood-rearing periods (Wakkinen 1990, Gregg 1991, Fischer 1994, Holloran 1999, Aldridge and Brigham 2002). Wakkinen (1990) found sage-grouse using habitats for nesting with grass heights averaging 18 cm and grass canopy cover of 3-10% while Aldridge and Brigham (2002) had grass heights averaging 16 cm and canopy coverage averaging 32%. Early brood-rearing habitats reported by Holloran (1999) averaged 19 cm in height and 5% canopy cover for grasses, while Aldridge and Brigham (2002) reported findings of 45 cm and 34% respectively.

Although sage-grouse typically occupy large expanses of sagebrush habitats composed of a diversity of species and subspecies of sagebrush, they may also use a variety of other habitats such as riparian meadows, agricultural lands, steppe dominated by native grasses and forbs, scrub willow (*Salix spp.*), and sagebrush habitats with some conifer or quaking aspen (*Populus tremuloides*) (Patterson 1952, Dalke et al. 1963). These habitats are almost always intermixed in a sagebrush-dominated landscape (Griner 1939, Patterson 1952, Dalke et al. 1963, Savage 1969). Sage-grouse have been observed using habitats altered by man throughout their range. However, the ability of sage-grouse to use these habitats, and their value to sage-grouse in meeting their seasonal habitat requirements, are dependent on the juxtaposition of these habitats in relation to sagebrush. Altered habitats used by sage-grouse include alfalfa, wheat (*Triticum spp.*), crested wheatgrass (*Agropyron cristatum*), potatoes (*Solanum tuberosum*), and other crops (Patterson 1952, Gates 1983, Connelly et al. 1988, Blus et al. 1989, Sime 1991).

Migratory Corridors

Migratory corridors are determined by the relationship between habitat configuration and seasonal movements and habitat requirements of sage-grouse (Dalke et al. 1963, Connelly et al. 1988). These seasonal movements are generally traditional in nature and may occur between 2 or 3 seasonal ranges (Dalke et al. 1963, Beck 1977, Schoenberg 1982, Connelly et al. 1988, Wakkinen 1990, Robertson 1991, Fischer 1994, Connelly et al. 2000*a*). Wakkinen (1990) reported that sage-grouse did not readily change traditional movements in southeastern Idaho.

Differences in techniques used to measure movements of sage-grouse make comparisons among studies, or reporting of average seasonal ranges and migratory movements, difficult (Schroeder et al. 1999). In North Park, Colorado, adult sage-grouse hens moved on average 5.4 km from leks to nest sites, whereas yearling females traveled only 2.3 km (Petersen 1980). Distances moved by female sage-grouse from leks to nests in central Montana were similar between age classes, with adults moving 2.5 km, and yearlings 2.8 km (Wallestad and Pyrah 1974). Among male sage-grouse in Montana, the majority (76%) were within 1 km of their associated leks during the breeding season; however, movements up to 1.3 km from the lek were

common (Wallestad and Schladweiler 1974). Daily movements of males from leks to day-use areas in Utah were 0.5 to 0.8 km on average, and core day-use areas were a minimum of 0.25 km^2 (Ellis et al. 1985).

Sage-grouse may move much longer distances between seasonal ranges. Connelly (1982) reported movements of three male sage-grouse from leks to summer habitats with distances ranging from 42 to 50 km. Males (n = 14) in Washington on the Yakima Training Center dispersed an average maximum distance of 15.5 km from the lek (Hofmann 1991). In eastern Idaho, the mean distance moved between summer and winter ranges was 48.2 km for 28 hens; this movement involved a decrease in mean elevation of 446 m (Hulet 1983). Travel of 35 km from a lek to a winter area was recorded in southwestern Wyoming (Berry and Eng 1985). In Idaho, Dalke et al (1963) reported movements of sage-grouse along established routes of 80-160 km, depending upon the severity of winter weather, from winter habitats to leks. Unfortunately, the distribution, configuration, and characteristics of these migration corridors is largely unknown in most portions of the sage-grouse distribution.

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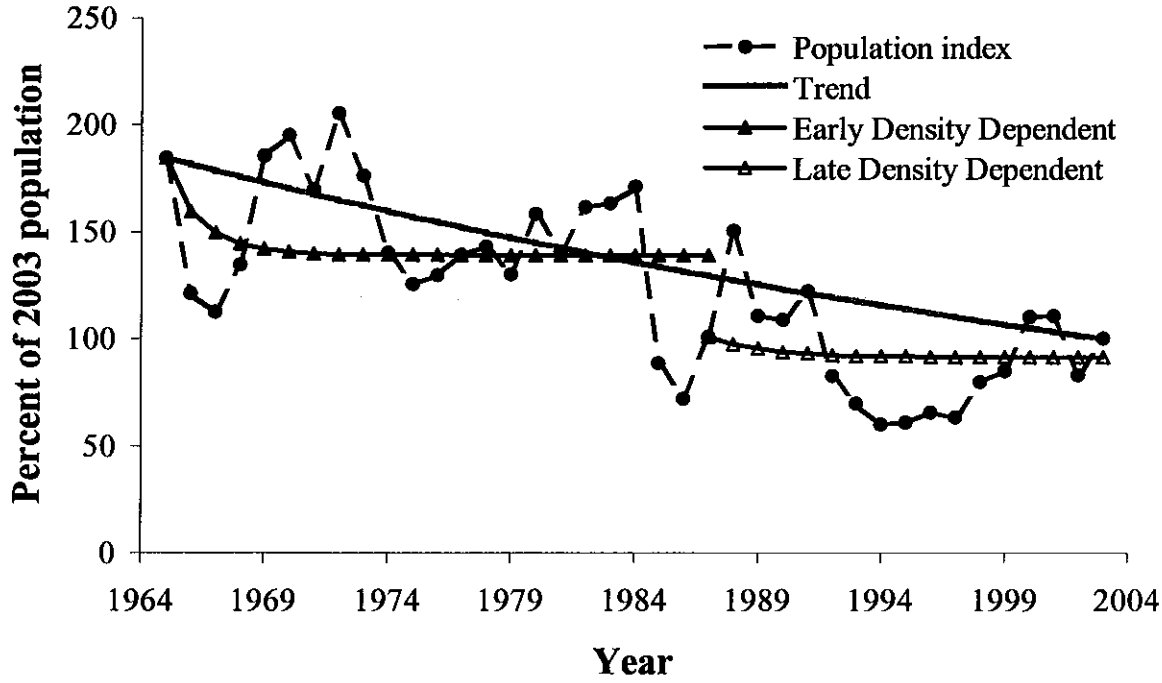
Fig. 6.14. Change in the population index for greater sage-grouse in Montana, 1965 -2003.



Nevada

Monitoring effort. Nevada has identified 1,077 sage-grouse leks within the state but monitoring efforts have been erratic. Because of inconsistent census efforts, we were able to assess change in lek size from 1965 to 2003 but could only examine changes in populations from 1974 to 2003. During the late 1960s and 1970s, relatively few leks were censused. However, the number of leks counted increased and then remained relatively stable until the late 1990s (Table 6.8). By 2000, monitoring efforts increased substantially when the average number of leks counted during 2000-03 increased by 146% over the average number of leks counted in 1995-99 (Table 6.8). Overall, the number of active leks monitored followed the same increasing pattern as total number of leks (Table 6.8).

Population Changes. The proportion of active leks remained relatively high over much of the assessment period. However, population trends indicated by average and median males per lek decreased over the assessment period by 48% and 57%, respectively (Table 6.8). Both average and median males per active lek declined by 37% and 42%, respectively over the assessment period (Table 6.8). Monitoring data (males/lek) indicated that lek size decreased significantly (r^2 =0.23, P = 0.00) from 1965 to 2003 (Fig. 6.15).

Beginning in the mid-1970s, the proportion of small leks increased. At the same time, the proportion of medium leks and large leks began to decrease (Fig. 6.16). From 1965 to 1979, 39% to 58% of the leks censused contained <20 males. From 1990 to 2003, this proportion increased to about 65%. The proportion of large leks decreased from 20% from 1965 to 1979 to 7% in 2000-03 (Fig. 6.16).

Annual rates of change suggest a long-term decline for sage-grouse in Nevada (Fig. 6.17) and support the trend information obtained from lek attendance (males/lek) and lek class size. Sage-grouse populations declined at an overall rate of 2.1% per year from 1974 to 2003. Our analysis provided some evidence of density dependence for the overall assessment period (likelihood = 0.74) and for the early (likelihood = 0.67) and late (likelihood = 0.53) periods. From 1974-85, the population declined at an average rate of 1.41% and fluctuated around a level that was approximately 2.1 times higher than the 2003 population. From 1986 to 2003, the population fluctuated around a level that was approximately 1.1% above the 2003 population and had an average change of -2.53% per year. Populations in the mid to late 1970s were approximately 1.2 to 3.5 times higher than 2003 populations (Fig. 6.17). Populations in the late 1960s and late 1970s fluctuated widely (Fig. 6.17) and there is no way of assessing whether these were actual changes in the populations or artifacts of sampling effort. The population reached a low in the mid-1990s and has not changed substantially since that time.

Summary. There is little published information on sage-grouse population trends in Nevada. The current data sets are somewhat ambiguous and likely reflect erratic monitoring efforts. Therefore, results from this analysis should be viewed cautiously.

Table 6.8. Sage-grouse monitoring and population trends in Nevada, summarized over 5-year periods, 1965 - 2003.

Parameter	00-03	95-99	90-94	85-89	80-84	75-79	70-74	65-69
Leks counted[1]	182	74	64	52	68	33	22	22
Number of active leks[1]	145	66	62	51	65	24	17	21
Percent active leks	79	89	96	98	96	72	77	94
Average males/lek	15	16	19	22	27	25	22	29
Median males/lek	10	11	12	15	19	16	11	23
Average males/active lek	19	18	20	22	28	35	29	30
Median males/active lek	14	13	13	16	19	24	17	24

[1] Averaged over each year for each period.

Fig. 6.15. Changes in lek size for sage-grouse in Nevada, 1965-2003.

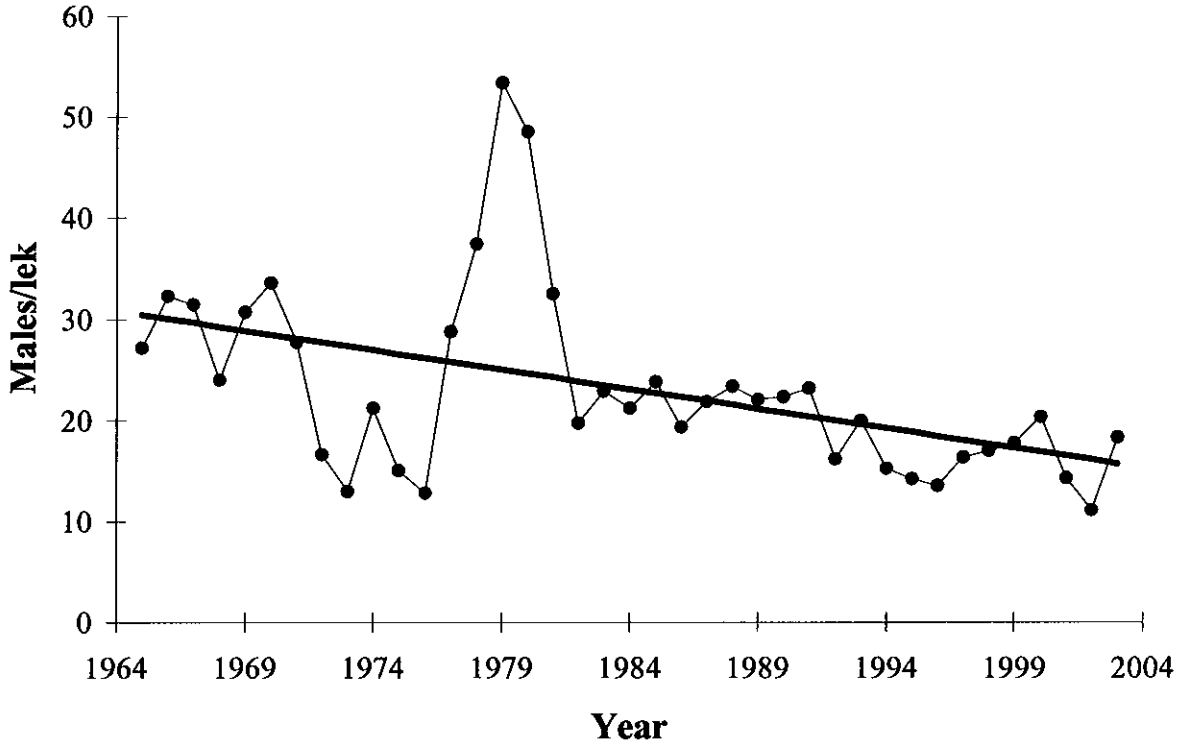


Fig. 7.16. Change in lek size class for Nevada, summarized over 5-year periods, 1965 - 2003.

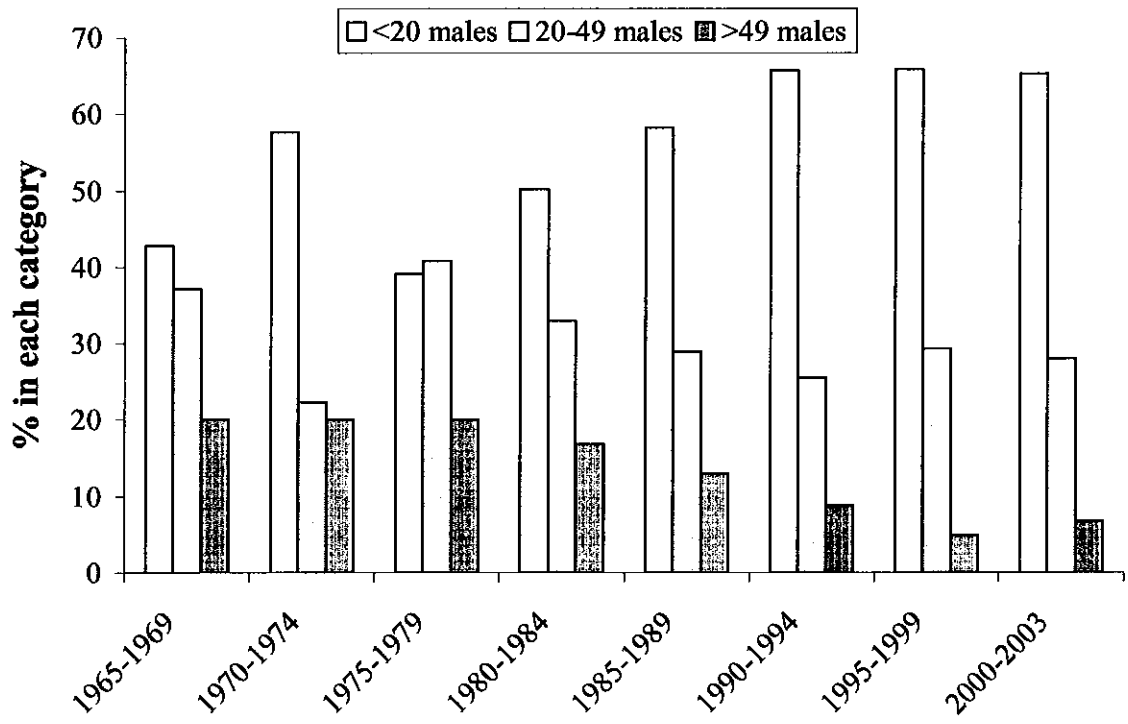
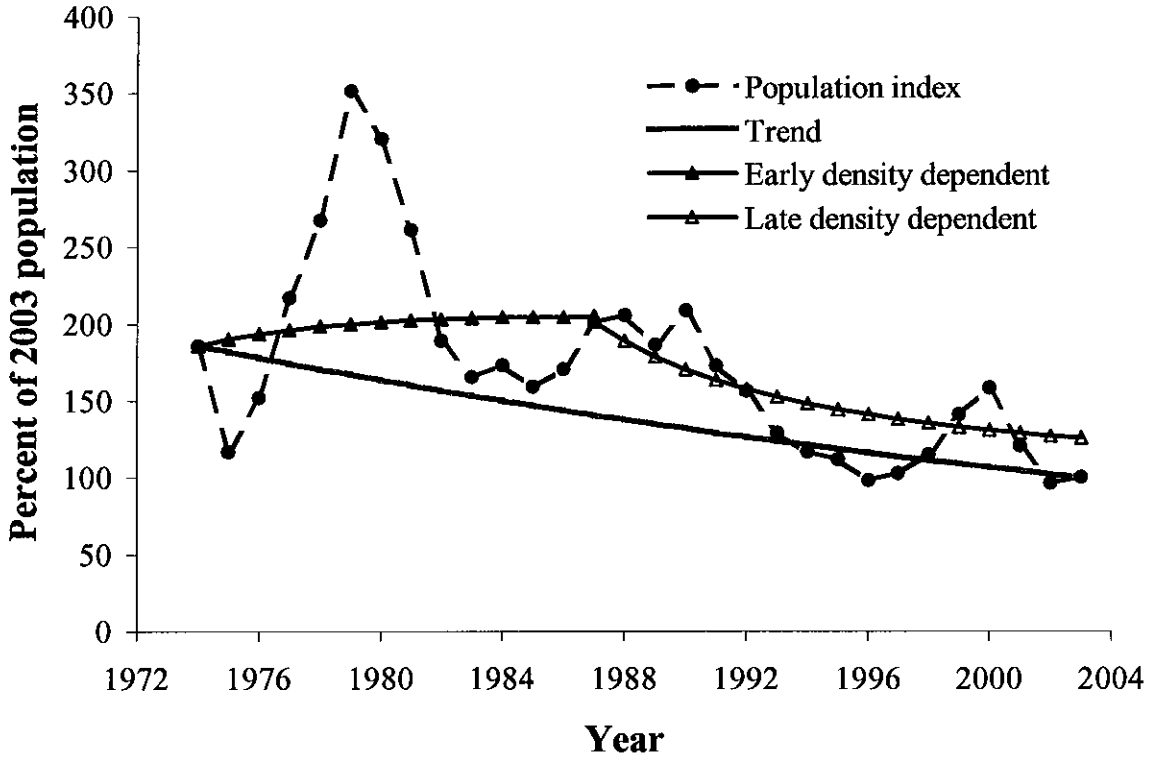


Fig. 6.17. Change in the population index for greater sage-grouse in Nevada, 1974-2003.



North Dakota

Monitoring effort. North Dakota identified 42 sage-grouse leks in the state and has rather consistently monitored their sage-grouse breeding population for over 40 years. Therefore, we used 1965 to 2003 as our assessment period. From 1965 to 2003, in 5-year periods, an average of 17 to 27 leks were monitored (Table 6.9). In 26 of 39 (67%) years, ≥ 20 leks were censused. The average number of leks counted per 5-year period increased by 42% from 1965 to 2003. Over these same 5-year periods, effective monitoring was relatively stable with an average of 14 to 21 active leks censused (Table 6.9). North Dakota did not employ a standard monitoring scheme of multiple counts spread over a 4-6 week period. Instead, all counts were conducted in about a one-week period during mid-April and observers attempted to count all leks ≥ 2 times (Smith 2003). However, this approach was consistently applied over the last 40 years.

Population Changes. The proportion of active leks decreased over the assessment period, averaging between 87% and 93% from the mid-60s to the mid-80s but decreasing to 58% by 2000-2003 (Table 6.9). Similarly, population trends indicated by average and median males per lek decreased over the assessment period by 38% and 80%, respectively (Table 6.9). Average and median males per active lek also indicated a decline over the assessment period, but this decline was not as great as that for males/lek (Table 6.9). Monitoring data (males/lek) indicated decreasing lek size (r^2 =0.35, P = 0.00) from 1965 to 2003 (Fig. 6.18). It appears that