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Long-term changes in sage grouse *Centrocercus urophasianus* populations in western North America

John W. Connelly & Clait E. Braun

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Available data indicate that sage grouse *Centrocercus urophasianus* have declined throughout their range. This species presently occurs in 11 U.S. States and in two Canadian provinces. In nine states having long-term data, breeding populations have declined by 17-47% ($\bar{x}$ = 33%) from the long-term average. Six states have long-term information on sage grouse production. In five of these states, production has declined by 10-51% ($\bar{x}$ = 25%) from the long-term average. Habitat deterioration, loss, and fragmentation have reduced the quantity and quality of nesting and early brood-rearing habitat causing population declines. Factors appearing to be largely responsible for the changes in habitats and, ultimately, sage grouse populations over wide areas of western North America are discussed, and hypotheses that could be tested to provide better insight into sage grouse population declines are suggested. Once these changes are better understood, conservation strategies that address protection and rehabilitation of sagebrush *Artemisia* spp. rangelands should be developed and implemented in each state and province to halt the decline of sage grouse and initiate recovery.

Key words: Artemisia, Centrocercus urophasianus, habitat, North America, population decline, sage grouse

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Concern about the status of sage grouse *Centrocercus urophasianus* populations was first raised in the early 1900s (Hornady 1916). During the 1920s and 1930s sage grouse were generally declining throughout the species' range (Gabrielson & Jewett 1940, Rush 1942, Patterson 1952:12, Autenrieth 1981). However, population increases were reported in the late 1940s and 1950s (Patterson 1952:15, Edminster 1954, Autenrieth 1981). Additional population declines were reported in the 1960s and 1970s (Wallestad 1975a, Swensen, Simmons & Eustace 1987), and were associated with sagebrush *Artemisia* spp. loss due to herbicide or mechanical treatment. More recently, concern has been expressed regarding declines in sage grouse populations throughout much of the species' range (Dobkin 1995).

Unfortunately, most information on the status and population trends of sage grouse relates to relatively small areas (e.g. a portion of the state) (Braun 1995), and to monitoring effects of land use treatment (Wallestad 1975b, Connelly, Reese, Wakkinen, Robertson & Fischer 1994). To our knowledge, no one has examined the widespread status and population trends of this species. Therefore, this paper synthesizes information on sage grouse populations and qualitatively assesses trends. We also suggest expla-

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nations for these trends and hypotheses that should be tested to allow a better understanding of sage grouse and the factors that limit this species.

Methods

All states and provinces that presently or historically supported sage grouse were contacted for information on distribution, abundance, and population trends. Additional information on fire and other sagebrush manipulation practices were obtained by reviewing state and federal land management agency records in southeastern Idaho (Crowley & Connelly 1996).

Nine U.S. states and one Canadian province provided long-term data on breeding populations. These data were obtained by monitoring spring lek attendance (Jenni & Hartzler 1978, Beck & Braun 1980) using methods established by the Western States Sage Grouse Technical Committee (Autenrieth, Molini & Braun 1982). Seven states provided data on production obtained from juvenile/adult hen ratios in the harvest. These ratios were calculated by assigning sex and age to wings of harvested birds collected from hunters (Eng 1955, Autenrieth et al. 1982).

Although these data were collected across the range of sage grouse, not all populations were sampled. However, in all states represented, data were collected on the same grouse populations in a similar fashion over many years (i.e. 12 - >30 years).

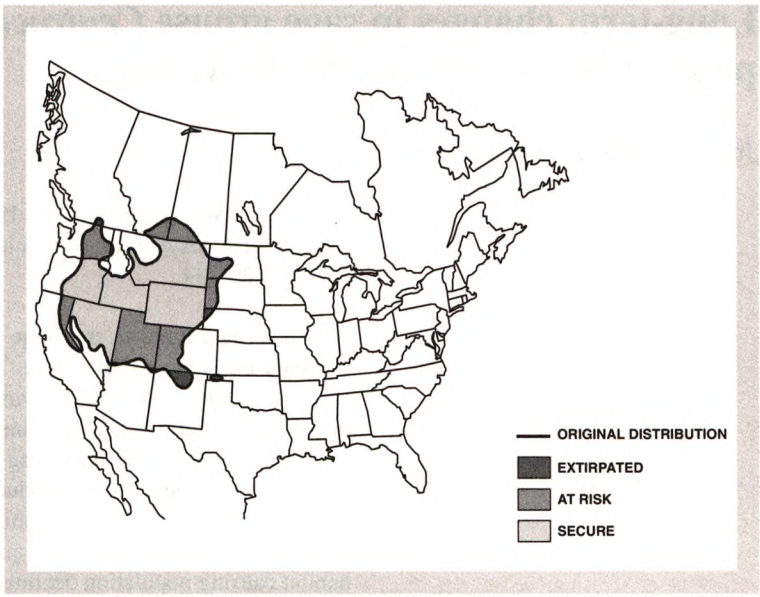


Figure 1. Distribution and status of sage grouse in western North America. Populations have been extirpated in Arizona, British Columbia, New Mexico, and Oklahoma.

Distribution and abundance

Historically, sage grouse occurred in at least 15 states and three provinces (Fig. 1). Presently, this species is found in 11 states and two provinces. In six of the 11 states and both the provinces, sage grouse populations could be considered at risk because of long-term declines and fragmented habitats.

Breeding population trends

We obtained breeding population data from nine states and one province (Table 1). Seven states provided data on breeding populations that spanned >30 years and three states had monitoring data that extended >40 years. All states and provinces that had data on breeding populations indicated that population size was declining. A comparison of long-term averages (through 1984) to data collected over the last 10 years indicated that breeding populations declined by 17-47% with a range-wide average of -33% (see Table 1). In states, historically having the largest sage grouse populations (Colorado, Idaho, Montana, Oregon, Wyoming), numbers declined by

Table 1. Changes in sage grouse breeding populations in western North America.

	Males per lek				
	Long-term		>1985		
State/province	$\bar{x}$	N[a]	$\bar{x}$	N[a]	Change (%)[b]
Alberta	17	10	11	6	-38
Colorado	39	27	27	11	-31
Idaho	33	34	20	11	-40
Eastern Montana	33	4	23	10	-30
Southwestern Montana	42	22	29	9	-32
North Dakota	17	31	12	10	-27
Oregon	30	38	21	12	-30
South Dakota	18	13	10	9	-45
Utah	23	26	16	8	-30
Washington	23	21	12	10	-47
Wyoming	36	26	30	10	-17
Average	28	23	19	10	-33

[a] Number of years censused.
[b] Overall decline between long-term average and 1985-94 average.

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an average of 30%. In states and provinces with smaller populations (Alberta, North Dakota, South Dakota, Utah, Washington) numbers declined by an average of 37%.

Production trends

Seven states provided data on juvenile production, i.e. the ratio of juveniles to adult females in the fall hunting harvest. Because of small samples, data from North Dakota were not used in our analysis. Four of the six states provided production data that spanned >30 years (Table 2). A comparison of long-term averages (through 1984) to short-term averages (last 10 years) indicated that sage grouse production declined in five of six states by 10-51%. Production in Utah remained virtually unchanged over time (see Table 2). Range-wide, sage grouse production declined by an average of 25%.

Factors responsible for changes

Sage grouse population declines have been attributed to many factors including predation (Batterson & Morse 1948, Autenrieth 1981, Willis, Keister, Immel, Jones, Powell & Durbin 1993), pesticides (Blus, Staley, Henny, Pendleton, Craig, Craig & Halford 1989), sagebrush removal (Swensen et al. 1987), herbicide application to sagebrush rangelands (Wallestad 1975a,b), hunting (Zunino 1987), and fire (Connelly et al. 1994, Fischer 1994). However, sage grouse populations have experienced widespread declines. Therefore, factors causing recent range-wide declines should be widespread. Adult survival and nest success rates have varied but do not indicate that predation was a major problem throughout the range of sage grouse (Connelly, Fischer, Apa, Reese & Wakkinen 1993, Zablan 1993, Connelly et al. 1994, Sveum 1995), unless nesting habitat was in poor condition (Gregg 1991). Similarly, some grouse populations that have declined were not hunted or were subject to relatively low exploitation (Wallestad 1975a, Braun & Beck 1985, Braun 1995). Herbicide use has declined on public rangelands since the 1970s (Braun 1987) and pesticides have only been identified as a problem in Idaho (Blus et al. 1989). Livestock grazing, weather patterns, and fire were the only known factors occurring throughout most of the range of sage grouse that could be related to widespread population declines through deterioration, loss, or fragmentation of habitat.

Table 2. Changes in sage grouse production in western North America.

	Chicks per hen				
	Long-term		>1985		
State/province	$\bar{x}$	N[a]	$\bar{x}$	N[a]	Change (%)
Colorado	1.40	22	1.26	11	-10
Idaho	2.96	25	2.05	10	-31
Montana	2.51	23	2.08	8	-17
Oregon	2.46	34	1.21	11	-51
Utah	2.16	12	2.19	8	+ 1
Wyoming	2.46	7	1.65	10	-33
Average	2.33	21	1.74	10	-25

[a] Number of years censused.

Livestock grazing

Livestock grazing management is a complex issue because it varies temporally and spatially. Moreover, grazing patterns and use of habitats are dependent on weather conditions (Vallentine 1990:310). Thus, there is little direct evidence linking grazing practices to sage grouse population levels. However, grass height and cover influence sage grouse nest site selection and success (Wakkinen 1990, Gregg 1991, DeLong 1993). Thus, indirect evidence suggests that excessive grazing (i.e. removal of a relatively large proportion of herbaceous growth) during the breeding season may have negative impacts on sage grouse populations (Dobkin 1995). More information is needed on the relationship of livestock grazing to sage grouse production and quality of breeding habitat. Controlled field experiments should be designed to evaluate the relationship of grazing pressure (i.e. disturbance and removal of herbaceous cover) to sage grouse nest success and juvenile survival.

Weather

Patterson (1952:68) reported that drought during the 1930s coincided with declining sage grouse populations throughout much of the species' range. A prolonged drought occurred over much of western North America from the mid-1980s to the early 1990s (Fischer 1994, Hanf, Schmidt & Groshens 1994). From 1990 to 1992, mean precipitation along the eastern part of the Snake River Plain in Idaho was 22% below the long-term average (Fischer 1994). Similarly, Hanf et al. (1994) reported that precipitation in sage grouse habitat of central Oregon was less than the historical average and related low precipitation to declining sage grouse populations. Hanf et al.

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(1994) suggested that drought impacted grouse populations by reducing herbaceous cover at nests and reducing the quantity and quality of food available for grouse during spring. Fischer, Reese & Connelly (1996) identified a decrease in insect populations (i.e. chick food) during drought. Thus, drought may negatively have affected populations by decreasing the quality of brood rearing habitat.

We suggest that states or provinces with relatively extensive data (i.e.≥15 years) on sage grouse production examine the relationship between weather conditions and production. Natural resource agencies also should consider establishing permanent transects in important sage grouse breeding habitats to assess the influence of weather on forb and insect production.

Fire

Prior to and during the recent drought, thousands of hectares of sagebrush rangelands were burned by wild fire or prescribed fire. Little information was readily available on total area burned within the range of sage grouse over the last 40-50 years. However, data on fire in southeastern Idaho indicated an increasing frequency of wild fires and prescribed burns (Table 3). The total area burned on the Upper Snake River Plain of southeastern Idaho increased by >2,000% between 1959 and 1989 (see Table 3). Moreover, of the 59,895 ha of sagebrush burned during the 1980s, 61% was attributed to wild fires. Of all wild fires for which a cause could be determined from 1950 to 1994 (N = 123), 76% were caused by man (Crowley & Connelly 1996).

The amount and frequency of fire in sagebrush rangelands of southeastern Idaho may not have been typical of all sage grouse habitat. However, at this time there is no evidence to suggest that similar patterns did not occur throughout large portions of the species' range, and anecdotal reports indicate that fire was a widespread phenomenon in other parts of southern Idaho, Oregon, Colorado and Nevada during the 1980s (Dobkin 1995, A.R. Sands, pers. comm.). Fire not only eliminates potential winter and nest habitat (Robertson 1991, Fischer 1994) but also reduces insect populations (Fischer et al. 1996), which are needed by chicks early in life (Johnson & Boyce 1990). Further, big sagebrush *A. tridentata* does not resprout following fire. Thus, reestablishment of sagebrush stands suitable for sage grouse nesting and winter habitat will generally take 15-30 years (Peterson 1995). Fire may negatively impact sage grouse populations by eliminating or fragmenting relatively large blocks of wintering or nesting habitat.

Table 3. Occurrence of fire (ha burned) in sagebrush rangeland on the Upper Snake River Plain of southeastern Idaho, 1950-94.

Years	Wild fire	Prescribed fire	Totals
1950-59	2,523	291	2,814
1960-69	18,129	32	18,161
1970-79	19,135	3,297	22,432
1980-89	36,590	23,305	59,895
1990-94	3,887	9,519	13,406
Totals	80,264	36,444	116,708

A careful analysis of sage grouse population trends, and fire frequency and extent throughout sage grouse range is needed to better understand the role of fire in fragmenting sagebrush habitats and affecting sage grouse populations. Although well designed and replicated experiments are not generally possible (Fischer 1994), data on fire frequency and extent can be obtained from state and federal resource agencies. When combined with data on sage grouse populations, general inferences can be drawn with respect to the effect of fire on sage grouse.

Management implications

Much data exist on sage grouse populations and habitat requirements throughout most of the species' range. However, this information does not seem sufficient to fully explain recent sage grouse population declines. The major factor occurring throughout sage grouse range is loss or degradation of brood habitat (Dobkin 1995). Thus, based on available data throughout the species' range and documented habitat changes in Idaho, we suggest the decline may be due to low juvenile survival caused by decreasing quantity and quality of early brood rearing habitat. Bergerud (1988) suggests that reproductive success is sufficient to account for yearly changes in grouse numbers regardless of habitat availability, predation, or winter severity. Similarly, Peterson & Silvy (1994, 1996) indicate that reproductive success, as measured by juvenile to adult ratios, is related to declining populations of Attwater's prairie-chicken *Tympanuchus cupido attwateri*. Drought and fire may be the primary agents causing a decline in brood rearing habitat for sage grouse. Moreover, an unfavourable situation due to drought and an increase in wild fire may have been made worse in many areas by vigorous prescribed burning programs implemented by land management agencies during the 1980s.

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Fire was historically rare in many (Winward 1984), if not most (Braun 1987), sagebrush habitats occupied by sage grouse and these contentions were supported by the fact that most sagebrush species are fire intolerant (Winward 1984, Peterson 1995). In addition, because habitat degradation appears to affect grouse productivity and fire frequency has been increasing, we have inferred that fire has had a negative influence on sage grouse populations.

Therefore, we strongly disagree with Winward's (1991) call for an intensive prescribed fire program in sagebrush habitats because of the increased frequency of wild fire (Dobkin 1995, Crowley & Connelly 1996) and the detrimental effects such a program would likely have on sage grouse and other sagebrush obligate species. Instead, we recommend that each state and province with sage grouse populations inventory their current sagebrush habitats and assess the trends of these habitats. Relating changes in sage grouse populations (especially production) to weather patterns as well as fire frequency and extent would provide evidence to support or refute our hypothesis regarding the cause of sage grouse population declines. We also suggest that each state and province develop a conservation strategy that addresses sage grouse population and habitat trends, prescribed burning and other sagebrush management practices, and appropriate conservation measures during drought conditions.

We note that most sage grouse populations have relatively low annual turnover (Zablan 1993, Connelly et al. 1994) and reproductive rates (Eng 1963, Connelly et al. 1993, 1994). Thus, population recovery may be relatively slow even if environmental and habitat conditions improve.

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