HISTORICAL AND CURRENT APPROACHES TO MONITORING GREATER SAGE-GROUSE

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Abstract. By the late 1940s, biologists began to develop systematic techniques for monitoring for greater sage-grouse (*Centrocercus urophasianus*). Early monitoring efforts were not uniform and different techniques often were employed by various agencies, making comparisons difficult. Here we review early techniques used to monitor greater sage-grouse populations, describe the development of systematic monitoring practices, describe current approaches to monitoring and discuss data sets now available for hunted and non-hunted populations. We used the literature and early state reports to obtain information on monitoring techniques and kinds of data obtained by state and provincial wildlife agencies. We also sent a detailed questionnaire to representatives from 11 western states and 2 Canadian provinces asking for information on techniques currently used, data sets obtained, and data management practices used for monitoring and evaluating populations of greater sage-grouse. Although lek data appear useful for assessing change at relatively broad scales (e.g., watershed, states) those data may not accurately reflect trends at smaller scales (e.g., lek complexes). Our results indicate that further standardization of techniques and replicate counts are necessary. Agencies should agree on a single protocol with established guidelines to allow better assessment of population trends at varying scales. Agencies also should be cautious about relating lek trends to harvest (and thus production data from wings) except at large scales.

Introduction

Concern over declines in the distribution and abundance of greater sage-grouse (*Centrocercus urophasianus*) date to at least the early 1900s (Hornady 1916). In the decades that followed, numerous other investigators voiced similar worries (Girard 1937, Patterson 1952, Rogers 1964, Autenrieth 1981) and hunting seasons for sage-grouse were often curtailed because of fears that populations were too low to support harvests (Rogers 1964, Autenrieth 1981, Connelly et al. 2004, Connelly et al. 2005). Because of these concerns, biologists began to develop systematic monitoring techniques to assess population trends (Batterson and Morse 1948, Patterson 1952, Jenni and Hartzler 1978, Beck and Braun 1980). Unfortunately, early monitoring efforts were not uniform and different techniques often were employed by various agencies, making comparisons among areas, years, and agencies difficult.

Numerous studies throughout their range have reported on characteristics of greater sage-grouse populations (Jenni and Hartzler 1978, Emmons and Braun 1984, Fischer 1994, Connelly and Braun 1997, Schroeder 1997, Lyon 2000, and many others). Connelly et al. (2000) provided guidelines for managing sage-grouse populations and habitats and identified monitoring as an important component of a management program for sage-grouse. Additionally, techniques for monitoring sage-grouse populations and habitats were recently summarized (Connelly et al. 2003).

Most population studies have relied on published techniques for monitoring sage-grouse (Jenni and Hartzler 1978, Emmons and Braun 1984, Aldridge 2000, Connelly et al. 2000, Connelly et al. 2003). Nonetheless some population monitoring techniques have not been described in detail (e.g., brood routes) and others were based on work conducted in a single study area or over a relatively short time (1-2 field seasons). Until recently (Connelly et al. 2004), none of the techniques had been rigorously evaluated to determine their effectiveness in detecting change.

Although Beck and Braun (1980) provided some critical insight into lek counts, no one has provided a synthesis or critical evaluation of all principal techniques used to assess trends in sage-grouse population or summarized the

various data sets currently available for greater sage-grouse. Hence, our intent is to review the early techniques used to monitor greater sage-grouse populations, describe the development of systematic monitoring practices, describe current approaches to monitoring, and discuss data sets now available for both hunted and non-hunted populations.

Methods

We reviewed the literature and early (1940s-1960s) state reports to obtain information on monitoring techniques and the kinds of data obtained by state and provincial wildlife agencies. We also sent a detailed questionnaire to representatives from 11 western states and 2 Canadian provinces asking for information on techniques currently used, data sets obtained, and data management practices used for monitoring and evaluating populations of greater sage-grouse. To help standardize responses and thus reduce variation because of differences in terminology, we provided the following definitions within our questionnaire:

(1) *Lek*—a traditional display area where ≥ 2 male grouse have attended in ≥ 2 of the previous 5 years;

(2) *Lek count*—a tally of male sage-grouse on a lek or group of leks with no assumption that the leks represent all or part of a single breeding population;

(3) *Lek route*—a count of male sage-grouse on a group of leks that are relatively close and represent all or part of a single breeding population; and

(4) *Lek survey*—a classification of leks as active or inactive, often done from an aircraft.

All states and provinces returned completed questionnaires. Because none of the respondents indicated that the questions were difficult to understand or ambiguous, we did not follow up the first questionnaire with additional questions or phone calls.

Results and Discussion

Early years: searching for a protocol

Sage-grouse hunting seasons changed markedly in most western states during the early and mid-20th century (Patterson 1952, Rogers 1964, Autenrieth 1981) and sage-grouse hunting was completely closed at times (1918-1941 in Idaho, 1937-1943 in Colorado, and 1933-1949 in Washington). Despite these changes, there was little evidence of any systematic monitoring of populations until the late 1940s and 1950s (Batterson and Morse 1948, Patterson 1952, Schroeder et al. 2000). Thus, early management decisions appeared to have been based largely on anecdotal information, as illustrated by Leopold's (1931) analysis of the 'perceptions' of grouse abundance by many interviewees in the north-central states. A similar type of strategy, though certainly with less analysis, was employed by the western states. For example, in 1899 the Washington State Legislature authorized each county to appoint a game warden to enforce the laws set by the legislature. It is not clear what information, if any, the legislature used to set the laws.

In the 1940s and 1950s, agencies began to implement a variety of approaches to document sage-grouse status and trends. These methods included the King strip census, walking and roadside counts, lek counts, and brood routes (Patterson 1952, Rogers 1964). In the 1930s, investigators counted birds on leks in Idaho and Utah, but did not describe the techniques used as a method for monitoring populations (Girard 1937, Rasmussen and Griner 1938). Oregon was the first state to report routine use of lek counts for monitoring sage-grouse breeding populations (Batterson and Morse 1948), although it is possible other states may have been using this technique without adequate documentation. For example, early lek counts in Washington consisted of annual visits to prominent, accessible, and large leks, with little consideration for a standardized protocol (Schroeder et al. 2000).

1950s-1960s: developing a strategy

The 1950s marked a major point in management of greater sage-grouse because many agencies and universities conducted research on the species. In an important work that still has relevance after >50 years, Patterson (1952) reported on the ecology and management of sage-grouse in Wyoming and discussed monitoring methods and changes in sage-grouse populations. Publication of this book was followed by development of the Western States Sage Grouse Workshop (now the Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee) at a meeting of the Western Association of Fish and Wildlife Agencies in 1954 in Las Vegas, Nevada.

During the early 1960s, Idaho biologists were raising sage-grouse in captivity to study molt patterns and wing characteristics of different sex and age classes (Pyrah 1961,

1963). Additionally, four publications appeared that would guide sage-grouse population monitoring efforts for the next 40 years. These included a method for obtaining age and gender ratios from wings (Eng 1955), a Wyoming sage-grouse methodology handbook (June 1960), a study of the ecology, productivity and management of sage-grouse in Idaho (Dalke et al. 1963), and sage-grouse investigations in Colorado (Rogers 1964). Together these provided guidance for monitoring sage-grouse on leks and collecting wings to assess sex and age composition of the harvest.

1970s-1980s: implementation

Relatively systematic monitoring of sage-grouse populations was reasonably widespread by the 1970s. Most efforts were aimed at assessing sage-grouse breeding populations through lek counts and lek surveys. These efforts were improved and somewhat standardized as a result of papers on patterns of lek attendance (Jenni and Hartzler 1978, Emmons and Braun 1984) and a technical bulletin on sage-grouse management practices published by the Western States Sage Grouse Technical Committee (Autenrieth et al. 1982).

Jenni and Hartzler (1978) supported the validity of the lek census technique originally proposed by Batterson and Morse (1948) and Patterson (1952). Nevertheless, those authors pointed out that the original approach was more restrictive than necessary and that peak counts of males could be obtained by counting leks from 0.5 hr before to 1.5 h after sunrise during the first 3 weeks following the peak of breeding. Emmons and Braun (1984) showed that timing of counts clearly could affect the number of males observed and also emphasized the importance of counting all leks in a given area to account for interlek movements. Additionally, those authors recommended that four counts be made of all leks within a particular area, rather than three counts, to compensate for variation in lek attendance throughout the season.

The technical bulletin on sage-grouse management practices (Autenrieth et al. 1982) distinguished between lek surveys and lek counts and provided detailed information on how to count leks. This bulletin also provided information on how to conduct brood counts and obtain harvest information. Production was monitored by examination of wings from hunter-killed birds. Different techniques for obtaining wings were described and included check stations, wing barrels, and mail-in wing surveys. Autenreith et al. (1982) also suggested that at least 100 wings from adult and yearling females were needed to obtain reliable data on production. Additionally, some agencies monitored production with brood counts through the 1970s. These efforts to assess production, however, were largely abandoned by the 1980s because of concerns over the lack of replication, comparisons among years, and adequate sample sizes (Connelly et al. 2003).

By the early 1980s, a variety of databases were being developed in most states and provinces. Much of this information dealt with breeding populations, but information was also being acquired on production and harvest (Table 1). Even though the first data were being collected as early as the 1940s and 1950s in most states and provinces (Table 2), most agencies did not develop data sets adequate for analysis until the mid-1960s (Connelly et al. 2004). By the late 1980s, data were available for every state and province. In addition, 85% of 13 agencies reported changing monitoring methods since initiating their monitoring programs. Changes in methods may have been relatively slight, at times representing only an increase in the number of leks counted. The most common change reported was an increase in replicate counts from 1 or 2 / year to 3 /year. Other agencies reported changing

Table 1. Databases on sage-grouse populations developed by the early 1980s throughout much of the species' range. This does not include intensive short-term research with the aid of banded birds or radio-telemetry.

Lek data	**Production Data**	**Harvest Data**
Lek distribution	Chicks/hen	Birds/hunter
Lek size	Number of unsuccessful hens	Hours/bird
Number of active leks	Brood size	Birds harvested
Lek size categories	Gender ratios	
Breeding population trend		

Table 2. Start of data collection and reported numbers of leks censused from our questionnaire and the agency database.

State/Province	Start of data collection	Questionnaire[a]	Database[b]
AB	1968	35	29
CA	1953	64	45
CO	1953	278	171
ID	1951	352	319
MT	1952	498	546
ND	1951	17	27
NV	1956	110	182
OR	1944	124	153
SD	1971	20	16
SK	1987	35	16
UT	1959	170	144
WA	1954	20	47
WY	1948	375	945
Totals	1944-1987	2,098	2,640

[a]Respondents asked to report 2002 data.

[b]Average of 2000-2003 data.

from a system of lek surveys and sporadic counts to a more systematic lek route approach. In all instances, reported changes were made to increase sampling effort and improve the overall population assessment.

1990s-present: current monitoring techniques and data sets

Monitoring techniques.—Our questionnaire indicated that all states and provinces in the range of sage-grouse (n = 13) collect data on lek attendance. In addition, all states with hunting seasons (n = 10; sage-grouse are not hunted in Washington, Alberta, Saskatchewan) collect information on wings from harvested birds and conduct harvest surveys. Oregon is the only state or province that routinely conducts brood routes. Of 13 states and provinces, 4 use lek counts, 2 use lek counts and lek routes, 1 uses lek counts and lek surveys, 1 uses only lek surveys, and 5 use a combination of all 3 census techniques.

Lek data.—Each agency was asked how many leks were counted in their respective state or province. We compared these responses to data obtained from each agency's sage-grouse lek database. We used an average of leks counted from 2000 to 2003 rather than a single year to account for respondents that might give an "average" or approximate number of leks counted. There were many discrepancies between answers of respondents and information contained in their databases (Table 2). Overall, 7 respondents overstated the number of leks actually counted and 6 understated the number counted. Nonetheless, the number of leks reported by all respondents only understated actual counts by 26% (Table 2). This outcome indicates that at a broad scale, biologists had a reasonable understanding of lek monitoring programs but at smaller scales (within a state or province or part of a state or province) some respondents did not have a complete understanding of the work actually being undertaken or they did not understand the question.

Harvest data.—Ten states allow sage-grouse hunting. Of these, 5 estimated that they contact 75-100% of the sage-grouse hunters to obtain harvest data. An additional 2 states reported contacting 10-30% of the hunters while 3 states indicated that they did not know what proportion of hunters were contacted for harvest information.

All states reported collecting wings from harvested birds to obtain data on age and gender composition. These wings normally are classified during an annual 'wing bee'. Five states indicated that they provide annual training to wing bee participants, while 2 states reported sporadic training, and 1 reported no training for participants. Two states did not use wing bees but instead indicated that they asked one or more individuals considered experts to interpret the wings.

States with hunting seasons reported collecting 8 to 2,500 wings (Table 3). Nine of 10 states analyze wing data by administrative unit but North Dakota and South Dakota only report having 1 administrative unit.

Table 3. Sample size of wings by state and administrative unit within state, 2002.

State	Number of wings	Administrative Units	Wings/Unit
CA	150	4	38
CO	250	3	83
ID	1986	34	58
MT[a]	200	4	50
ND	30	1	30
NV	2500	10	250
OR	550	6	92
SD	8	1	8
UT	325	4	81
WY	1440	18	80

[a]Does not analyze data by administrative unit.

Only Nevada appears to have sufficient sample sizes per administrative unit (Autenreith et al. 1982) to allow meaningful inferences. Even though Montana does not analyze wing data by administrative unit, sample sizes for this state may not be adequate to characterize populations over the entire state.

Data management.—Five agencies reported storing data in a single electronic format, 8 indicated that data were stored in ≥2 formats, and 3 reported that their data were recorded on paper and stored in various filing cabinets. When asked to assess the overall quality of their data (given a choice of excellent, good, fair, and poor), 8 respondents indicated that their monitoring data were good, indicating that the data sets generally reflected population changes. Four respondents indicated that they considered their data fair, indicating that their data sets likely reflect population changes, but databases are not extensive. One state indicated that their data was fair to poor, indicating that they had little confidence that at least some of their data reflected population changes.

Towards an integrated approach

Wildlife agencies have compiled relatively large databases on greater sage-grouse over the last 50 years. Some of these data sets are extensive with apparently reasonable sample sizes and sampling effort (e.g., lek counts, wing analyses for some states), other data sets are limited and of questionable value (e.g., brood counts, wing analyses for some states). This is a particularly important issue in states or regions where sage-grouse populations or harvest have declined. For example, the original criteria that at least 100 wings are necessary to provide a useful analysis of harvest (Autenreith et al. 1982) is increasingly difficult to meet, even in areas with a large harvest. Brood counts also may be difficult to interpret in areas where weather can influence bird behavior and consequently the number of birds available to be observed. Connelly et al. (2004) indicated that lek data were the only extensive, widespread data sets that would allow an assessment of population change over the range of this species. Moreover, lek data were the only population data available for states and provinces without sage-grouse hunting seasons.

The efficacy of sage-grouse lek counts to assess population change has been criticized (Beck and Braun 1980, Walsh et al. 2004). Some of these criticisms were directed at field methods and sampling effort, whereas others questioned the usefulness of those data, arguing that male sage-grouse did not regularly attend leks. Moreover, conflicting data have been published on patterns of lek attendance. Walsh et al. (2004) reported that seven radio-marked adult male sage-grouse had an average daily attendance rate (n = 15 leks censused during 1 season) of 42% while the daily attendance rate for nine radio-marked yearling males was 19%. In contrast, Emmons and Braun (1984) observed that mean lek attendance (n = 4 leks censused over 2 seasons) was 92% for adult males (n = 17) and 86% for yearling males (n = 16); 94% of radio-marked adult male sage-grouse and 90% of radio-marked yearling male sage-grouse attended leks during the period of high male counts. Both studies (Emmons and Braun 1984, Walsh et al. 2004) were conducted in northern Colorado in breeding habitats that ranged from 2,200 to 2,964 m. Why differences in attendance rates were so great between these studies is uncertain, but differences may be due to sample sizes and experimental approach.

Two different approaches have been used to assess

whether lek counts reflect actual population size. First, populations that have been extirpated in the last 20 years invariably show declining trends in lek counts prior to their extirpation (Connelly et al. 2004). In addition to declines in the number of males on leks, these populations are characterized by declines in the number of active leks. Second, populations were simulated that had 'known' rates of population change (Connelly et al. 2004). When these 'known' populations were sub-sampled with current lek-count strategies, those counts reflected the modeled system. The likelihood of detecting a trend in a population was proportional to the actual trend in the population.

Conclusions and Management Implications

Although lek data appear useful for assessing change at relatively broad scales (e.g., watershed, discrete populations, states and provinces) those data may not accurately reflect trends at smaller scales (e.g., lek complex, single management unit). Our results indicate that further standardization of techniques and replicate counts are necessary. Agencies should agree on using a single protocol with established guidelines (Connelly et al. 2003) to allow better assessment of population trends at varying scales. Because grouse from >1 breeding range may move to a single summer range where they are subsequently harvested, integrating data on breeding populations and harvest may be difficult. Agencies should be cautious about relating lek trends to harvest (and thus production data from wings) except at large scales. Wing samples from some states are clearly inadequate to reliably assess production or gender composition of the harvest. These states should consider either increasing sample sizes or combining data with that of adjacent states (if they are dealing with the same population; Connelly et al. 2004, Schroeder et al. 2004). If of these alternatives are not feasible, agencies should consider using the resources it devotes to wing collections to improve monitoring efforts for breeding populations.

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