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Steven M. Huffaker, Director

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Subproject 53

Progress Report

SAGE-GROUSE ECOLOGY

Study I: Greater Sage-grouse Habitat and Population Trends in Southern Idaho

Study II: Mortality Patterns of Juvenile Greater Sage-grouse

July 1, 2004 to June 30, 2005

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

PROGRESS REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Sage-Grouse Ecology
PROJECT:	W-160-R-32		
SUBPROJECT:	53	**STUDY NAME:**	Greater Sage-grouse Habitat and Population Trends in Southern Idaho
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GREATER SAGE-GROUSE (*CENTROCERCUS UROPHASIANUS*) HABITAT AND POPULATION TRENDS IN SOUTHERN IDAHO

Abstract

Additional funding provided by the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) has allowed the Department to begin expansion of this work from the initial assessment of sage-grouse populations and sagebrush rangeland on and near the Curlew National Grasslands (CNG) and the eastern portion of Owyhee County. In these areas, breeding populations showed distinct declines in the early 1980s with more severe declines during the early 1990s. Twenty-three percent of the CNG and 32% of BLM land remain in 11-25% sagebrush canopy cover and, thus may provide suitable nesting and early brood-rearing habitat for sage-grouse. However, this is likely an overestimate of good nesting and brood cover available to grouse because the herbaceous understory was not considered in habitat classification. Habitat in the eastern portion of Owyhee County is highly fragmented. Understory forbs and grasses in sagebrush-dominated areas vary from sparse to relatively dense native stands. Because of increased funding, initial efforts began in FY 2001 to map sage-grouse distribution across southern Idaho. Maps were developed at the 1:100,000 scale. The maps have 6 basic layers. Sage-grouse stronghold habitats are those areas with sufficient breeding habitat and stable to increasing population trends. Isolated habitats are those areas where breeding habitat remains but are isolated from other sage-grouse populations. Key areas are those areas where sagebrush (*Artemisia* spp.) occurs with relatively intact understory, and sage-grouse use all or a portion of these areas sometime throughout the year. The other 3 layers are those areas surrounding sage-grouse use areas that have potential for rehabilitation (juniper invasion areas, crested wheat (*Agropyron cristatum*) seedings, and sagebrush with annual grass understory). The maps will be used as base maps to identify nesting areas and their relation to leks, brood-rearing areas, and winter-use areas. They will also be used to help biologists and land managers with landscape level management decisions. Updates and maintenance are continuing as cover changes due to development, rehabilitation, and wildfires.

Recommendations

1. Continue statewide sage-grouse population and habitat assessment at a level supported by the current budget.

2. Continue to seek outside funding to support the expanded work.

3. Identify and prioritize areas within the state for assessment.

Introduction

Sage-grouse populations throughout the west are closely tied to sagebrush habitats (Patterson 1952, Braun et al. 1977, Braun 1987). The dependence of sage-grouse on sagebrush for winter habitat has been well documented (Eng and Schladweiler 1972; Beck 1975, 1977; Robertson 1991). Similarly, the relationship between sagebrush and sage-grouse nest success has been thoroughly described (Klebenow 1969, Wallestad and Pyrah 1974, Wakkinen 1990, Connelly et al. 1991). Despite the well-known importance of this habitat to sage-grouse and other sagebrush obligates (Braun et al. 1976), the quality and quantity of sagebrush habitats continue to decline (Braun 1987, Swenson et al. 1987). Schneegas (1967) reported that 2-2.5 million ha of sagebrush grassland had been treated from 1937-1967, and Braun et al. (1976) stated that an additional 3.9-8.4 million ha had been altered since 1967. Patterson (1952) indicated that sage-grouse have not adjusted, and doubtlessly will not adjust, their life processes to fit a pattern of land use that eliminates or seriously disturbs large tracts of sagebrush habitats.

Braun et al. (1977) previously described guidelines for maintenance of sage-grouse habitats. Since publication of those guidelines, much more information has been obtained on the relative size of sagebrush habitats used by these grouse (Connelly 1982, Connelly et al. 1988, Wakkinen et al. 1992), the seasonal importance of sagebrush habitats (Benson et al. 1991, Connelly et al. 1991), the effects of pesticides on this species (Blus et al. 1989), and the effects of fire on sage-grouse (Benson et al. 1991, Robertson 1991, Fischer 1994). The new information was incorporated into revised guidelines for managing sage-grouse populations and habitats (Connelly et al. 2000*b*). Unfortunately, good baseline data on the quantity and quality of sage-grouse habitat that currently exist are still lacking. Moreover, long-term population trend data have not been compiled and analyzed for most of the state. Much of these data are available from files of various state and federal agencies. Collecting and compiling this information is a relatively simple, although time consuming, task. However, this sort of assessment has been completed for part of southeastern Idaho (Crowley and Connelly 1996, 1997) and it provides a solid basis for more intensive habitat assessment using GIS and satellite imagery (Homer et al. 1993).

Objective

To assess long-term trends in quantity and quality of sage-grouse habitats and associated changes in populations throughout southern Idaho.

Study Area and Methods

In FY 1998, the statewide assessment considered the Greater Curlew Valley area containing 524,050 acres in Oneida County. In FY 1999, this work was expanded to include approximately 1,300 km^2 of the eastern portion of Owyhee County. In the Curlew Valley, mean annual precipitation ranges from 33 cm in the valleys to 46 cm in the mountains, half of which falls during winter as snow. Precipitation patterns are similar, but the amount is slightly greater in Owyhee County. The Curlew Valley area contains farmland, Conservation Reserve Program (CRP) fields, and rangeland classified as a sagebrush/bluebunch wheatgrass (*Artemisia tridentata*/*Agropyron spicatum*) habitat type. The eastern portion of Owyhee County consists of sagebrush-dominated areas fragmented by crested wheatgrass seedings and large burns, often dominated by cheatgrass (*Bromus tectorum*). Other areas in Owyhee County are dominated by low sage (*A. arbuscula*) and a mixture of mountain (*A. vaseyana*) and Wyoming (*A. wyomingensis*) big sage with bluebunch wheatgrass and Idaho fescue (*Festuca idahoensis*) understory.

Disturbance to native stands of vegetation has been widespread in both areas (Gardner et al. 1997, J. W. Connelly, personal observation). Most of the remaining sagebrush habitat is now found on public lands administered by the U.S. Forest Service (USFS) and BLM. Sagebrush stands on these lands have been periodically subjected to prescribed fire, wildfire, herbicide treatments, and other sagebrush eradication techniques.

Breeding populations have been monitored throughout most of southern Idaho for the last 25-50 years using standard lek censusing procedures (Jenni and Hartzler 1978). Lek counts were used to assess sage-grouse population trends in both areas. The mean number of males per lek was determined by year, and data from satellite leks were not included (Gardner et al. 1997). During the mid-1980s, many lek routes were established across the state. A lek route is a series of leks counted in 1 breeding area. Maximum number of males per route are recorded each year and general trends are obtained from these counts. Numerous lek routes occur throughout southern Idaho. Data from all lek routes have been collected since the mid-1990s to assess statewide population trends.

A GIS database developed at Utah State University, using Landsat thematic imagery from July 1993, was used to assess the extent and condition of sagebrush rangelands in the Curlew study area (Gardner et al. 1997). Rangeland was classified as having <10%, 11-25%, or >25% sagebrush canopy coverage. The 11-25% classification represented optimal sagebrush canopy cover for sage-grouse. In addition to sagebrush cover types, areas dominated by grass/forb cover (e.g., CRP fields) were also identified. Land ownership boundaries were added to the database for descriptive analysis. Analysis methods generally follow those of Homer et al. (1993), Crowley and Connelly (1996, 1997), and Reynolds et al. (1996). Vegetation data are currently being analyzed to complete this assessment.

Additional funding was obtained in FY 2000 from BLM and USGS. This funding allowed a biologist to be assigned to work on this project full-time. Therefore, data on sage-grouse populations (lek counts) and sagebrush habitats (mapping prescribed burns and wildfires; mapping other land-use changes; and detailed mapping of sage-grouse range including breeding, summer, and winter, throughout southern Idaho) are now being compiled and analyzed for all of southern Idaho. The relationship between known leks and other seasonal habitats will be investigated.

Results

Population trends

Statewide - Recent analysis of lek data indicated that the existing database contains incomplete counts along lek routes as well as data from counts made during unfavorable weather. To improve the quality of these data, original data sheets are being reviewed and unreliable counts are being deleted from analysis of population trends. Nineteen lek routes distributed across southern Idaho had sufficient data to assess population trends since 1994. Most populations had a slight dip during 1994-1996. Following a relatively wet year in 1996, populations for the most part increased until 2000 and began to drop off again during 2001 and 2002. During 2004, lek counts across the state were stable to increasing with a few exceptions in the Southwest Region (Cow Creek), Magic Valley Region (Grassy Hills, Brown's Bench, Black Pine), Upper Snake Region (Stibal), and Southeast Region (Curlew). The overall 5-year average across the state appears to be stable.

Curlew Valley Area - Twenty-one leks (not including satellite leks) have been documented within the study area between 1966 and 1998. Seven leks (33%) were on BLM land, 9 (43%) on USFS land, and 5 (24%) on private land. For these leks, male attendance averaged 15 birds/lek from 1966 to 1997, approximately half of the statewide average for the same period. During spring 1999, 11 new leks were located in the study area. Of these, none were on BLM land, 8 on USFS land, and 3 on private land. Maximum male counts on the new leks ranged from 2-34 birds and the average size of the new leks was 12 males. Two routes have been established from these leks in the Curlew area, the Curlew lek route and the Rockland lek route. The Rockland lek route has increased substantially since 1999. The 2003 lek count was 118, more than double the previous 2 years counts of 58 and 50 in 2002 and 2001, respectively. However, the Curlew lek route has declined from 21 in 2000 to 5 in 2003. This could be related to a wildfire during the mid-1990s that burned much of the habitat within the Curlew Route. It is speculated that many of the birds from the original Curlew Route have shifted to the Rockland Route.

Breeding populations showed distinct declines in the early 1980s, with more severe declines during the early 1990s. Sage-grouse lek attendance reached an all-time low in the study area during 1995. From 1996 through 1999, only 2 of 7 (29%) known leks on BLM land and 3 of 9 (33%) known leks on USFS lands were active. Due to the continued decline of active sage-grouse leks and numbers of males/lek, the hunting season in and around the Curlew was closed during fall 2002. The season will remain closed until sage-grouse populations in the area begin to stabilize.

Owyhee County - Seven new leks were identified near Grasmere during 1999. Of these, 6 occurred on dry lakebeds and 1 was in a crested wheatgrass seeding. The new leks ranged from 1-19 males and the average size was <12 males. One new route (Sheep Creek) was established as a result of these new leks. Counts of males along the route are static with about 50 males counted each spring since 1999. Some birds attending these leks move south to summer range in the alfalfa fields near Riddle and into Nevada.

Habitat Trends

Curlew Valley Area - Privately-owned land comprises 41% of the study area; BLM administers 40% of the area, and USFS manages 17% of the study area. Nine percent (47,896 acres) of USFS land is a separate administrative unit called the CNG. About 67% of the study area could be considered historic sagebrush habitat and about 51% (177,540 acres) remains sagebrush rangeland. Fifty-seven percent of historic sagebrush habitat on the CNG and 49% of BLM land is now either classified as grass/forb or <10% sagebrush canopy cover and, thus, considered poor sage-grouse habitat. Twenty-three percent of the CNG and 32% of BLM remain in the 11-25% sagebrush canopy cover class and, thus may provide suitable nesting and early brood-rearing habitat for sage-grouse. Overall, about 17% of historic sagebrush habitat within the study area contains sagebrush cover suitable for nesting and early brood rearing.

Owyhee County - No quantitative assessments were made of habitat within this study area. Generally, higher-elevation breeding habitat on the southern portion of the study area appears in better ecological condition with a healthy herbaceous understory compared to the more xeric northern portion of the study area. The eastern portion of this study area is highly fragmented by wildfire and crested wheatgrass seedings.

Statewide - No quantitative assessments of habitat are currently being collected across the state. However, ArcView® GIS shapefiles of prescribed burns and wildfire occurring from 1990 to 2002 have been obtained from BLM. Personnel from BLM and IDFG have developed a detailed map of sagebrush distribution and sage-grouse range in Idaho. This map identifies areas where sage-grouse populations appear to be strong or stable (source habitats, stronghold areas, isolated habitats) and areas where sage-grouse populations appear to be declining or threatened due to major habitat loss and fragmentation (conifer invasion, crested wheatgrass seedings, sagebrush with annual grass understory). Additional layers may be added to the map such as all historic and active lek sites, nest locations and how they relate to active leks, and winter-use areas. The purpose of this mapping effort is to provide wildlife and habitat managers with information to prioritize sage-grouse populations for protection from wildfire and other land-use changes, and where to improve existing degraded habitat to increase or stabilize the range of sage-grouse in Idaho. It can also be used as a visual tool to identify changes in habitat, sage-grouse range, and land-use change from the 1950s to present. The 2003 version of the statewide map and 1:100,000 scale maps can be downloaded from the SAGEMAP website (http://SAGEMAP.wr.usgs.gov). The shapefiles for the habitat and population layer can be downloaded as well as .pdf files of each 1:100,000 BLM map. The shapefiles for the 2004 version of the habitat planning maps can be obtained through BLM or IDFG.

Discussion

Sage-grouse populations have declined throughout the species' range (Connelly and Braun 1997); the Greater Curlew Valley study area and eastern Owyhee County were no exceptions. However, the declines within both study areas appeared more severe than those in the remainder of Idaho (Gardner et al. 1997). Fire and drought may have major impacts on sage-grouse populations (Connelly and Braun 1997, Connelly et al. 1994, Connelly et al. 2000*a*). Both study areas, along with much of the Intermountain West, suffered from drought in the late 1980s and early 1990s. Moreover, the CNG has a routine prescribed burning program to control sagebrush, and wildfires on both USFS and BLM lands were relatively frequent from 1961 to 1996 (Gardner et al. 1997). Wildfires were also relatively frequent in the Owyhee County study area during the 1970s, 1980s, and 1990s.

Less than 35% of federally-managed rangelands within the Curlew study area currently support acceptable sagebrush cover for sage-grouse nesting and early brood-rearing habitat. However, this is likely an overestimate of good nesting and brood cover available to grouse because the herbaceous understory was not considered in habitat classification. Some of the sagebrush understory in the study area is degraded because of land management practices and the presence of bulbous bluegrass (*Poa bubosa*), a highly competitive exotic (Gardner et al. 1997, Apa 1998). Sage-grouse hens select habitat with healthy herbaceous understories for nesting and early brood rearing (Klebenow 1969, Connelly et al. 1991, Gregg 1991). Remaining sagebrush rangelands within the study area should be assessed to determine how much of the remaining habitat provides quality nesting and brood-rearing conditions for sage-grouse.

A detailed map of sage-grouse range, which includes active lek sites, known nesting areas, and wintering areas, will be helpful to land managers from all agencies. This will allow federal and state agencies to work closely together to better manage the sagebrush steppe habitat in Idaho.

The 2004 version of the map showing sage-grouse stronghold areas, isolated habitats, key sage-grouse use areas, crested wheatgrass seedings, annual grass understory, and conifer invasion has been completed. The map is updated annually as new fires occur and we obtain additional information on sage-grouse habitat across the state (change from perennial grassland to stronghold, etc.).

Literature Cited

APA, A. D. 1998. Habitat use and movements of sympatric sage- and Columbian sharp-tailed grouse in southeastern Idaho. Dissertation, University of Idaho, Moscow, USA.

BECK, T. D. I. 1975. Attributes of a wintering population of sage-grouse, North Park, Colorado. Thesis, Colorado State University, Fort Collins, USA.

_____. 1977. Sage-grouse flock characteristics and habitat selection during winter. Journal of Wildlife Management 41:18-26.

BENSON, L. A., C. E. BRAUN, AND W. C. LEININGER. 1991. Sage-grouse response to burning in the big sagebrush type. Proceedings of Issues and Technology in the Management of Impacted Western Wildlife, Thorn Ecological Institute 5:97-104.

BLUS, L. J., C. S. STALEY, C. J. HENNY, G. W. PENDLETON, T. H. CRAIG, E. H. CRAIG, AND D. K. HALFORD. 1989. Effects of organophosphorus insecticides on sage-grouse in southeastern Idaho. Journal of Wildlife Management 53:1139-1146.

BRAUN, C. E. 1987. Current issues in sage-grouse management. Proceedings of the Western Association of Fish and Wildlife Agencies 67:134-144.

_____, T. BRITT, AND R. O. WALLESTAD. 1977. Guidelines for maintenance of sage-grouse habitats. Wildlife Society Bulletin 5:99-106.

_____, M. F. BAKER, R. L. ENG, J. W. GASHWILER, AND M. H. SCHROEDER. 1976. Conservation committee report on effects of alteration of sagebrush communities on the associated avifauna. Wilson Bulletin 88:165-171.

CONNELLY, J. W., JR. 1982. An ecological study of sage-grouse in southeastern Idaho. Dissertation, Washington State University, Pullman, USA.

_____, AND C. E. BRAUN. 1997. A review of long-term changes in sage-grouse populations in western North America. Wildlife Biology 3:229-234.

_____, H. W. BROWERS, AND R. J. GATES. 1988. Seasonal movements of sage-grouse in southeastern Idaho. Journal of Wildlife Management 52:116-122.

_____, W. L. WAKKINEN, A. D. APA, AND K. P. REESE. 1991. Sage-grouse use of nest sites in southeastern Idaho. Journal of Wildlife Management 55:521-524.

_____, K. P. REESE, W. L. WAKKINEN, M. D. ROBERTSON, AND R. A. FISCHER. 1994. Sage-grouse ecology final report. Federal Aid Job Completion Report. W-160-R-19, Subproject 9. Idaho Department of Fish and Game, Boise, USA.

_____, A. D. APA, R. B. SMITH, AND K. P. REESE. 2000*a*. Effects of predation and hunting on adult sage-grouse *Centrocercus urophasianus* in Idaho. Wildlife Biology 6:227-232.

_____, K. P. REESE, R. A. FISCHER, AND W. L. WAKKINEN. 2000*b*. Response of a sage-grouse breeding population to fire in southeastern Idaho. Wildlife Society Bulletin 28:90-96.

CROWLEY, C. M., AND J. W. CONNELLY. 1996. Sage-grouse population and habitat trends in southeastern Idaho and southwestern Montana. Unpublished report, Idaho Department of Fish and Game, Pocatello, USA.

_____, AND _____. 1997. Trends in agricultural lands in sage-grouse range in southeast Idaho and southwest Montana. Unpublished report, Idaho Department of Fish and Game, Pocatello, USA.

ENG, R. L., AND P. SCHLADWEILER. 1972. Sage-grouse winter movements and habitat use in central Montana. Journal of Wildlife Management 36:141-146.

FISCHER, R. A. 1994. The effects of prescribed fire on the ecology of migratory sage-grouse in southeastern Idaho. Dissertation, University of Idaho, Moscow, USA.

GARDNER, S. C., D. MEINTS, T. APA, S. FELTIS, J. KUMM, AND J. CONNELLY. 1997. Sage-grouse population trends and current habitat conditions in the Greater Curlew Valley assessment area, Idaho. Unpublished report, Idaho Department of Fish and Game, Pocatello, USA.

GREGG, M. A. 1991. Use and selection of nesting habitat by sage-grouse in Oregon. Thesis, Oregon State University, Corvallis, USA.

HOMER, C. G., T. C. EDWARDS, JR., R. D. RAMSEY, AND K. P. PRICE. 1993. Use of remote sensing methods in modeling sage-grouse winter habitat. Journal of Wildlife Management 57:78-84.

JENNI, D. A., AND J. E. HARTZLER. 1978. Attendance at a sage-grouse lek: implications for spring census. Journal of Wildlife Management 42:46-52.

KLEBENOW, D. A. 1969. Sage-grouse nesting and brood habitat in Idaho. Journal of Wildlife Management 33:649-661.

PATTERSON, R. L. 1952. The sage-grouse in Wyoming. Sage Books, Inc., Denver, Colorado, USA.

REYNOLDS, R. E., D. R. COHAN, AND M. A. JOHNSON. 1996. Using landscape information approaches to increase duck recruitment in the prairie pothole region. Transactions North American Wildlife and Natural Resource Conference 61:86-93.

ROBERTSON, M. D. 1991. Winter ecology of migratory sage-grouse and associated effects of prescribed fire in southeastern Idaho. Thesis, University of Idaho, Moscow, USA.

SCHNEEGAS, E. R. 1967. Sage-grouse and sagebrush control. Transactions North American Wildlife and Natural Resource Conference 32:270-274.

SWENSON, J. E., C. A. SIMMONS, AND C. D. EUSTACE. 1987. Decrease of sage-grouse (*Centrocercus urophasianus)* after ploughing of sagebrush steppe. Biological Conservation 41:125-132.

WAKKINEN, W. L. 1990. Nest site characteristics and spring-summer movements of migratory sage-grouse in southeastern Idaho. Thesis, University of Idaho, Moscow, USA.

_____, K. P. REESE, J. W. CONNELLY, AND R. A. FISCHER. 1992. An improved spotlighting technique for capturing sage-grouse. Wildlife Society Bulletin 20:425-426.

WALLESTAD, R. O., AND D. B. PYRAH. 1974. Movement and nesting of sage-grouse hens in central Montana. Journal of Wildlife Management 38:630-633.

PROGRESS REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Sage-Grouse Ecology
PROJECT:	W-160-R-32		
SUBPROJECT:	53	**STUDY NAME:**	Mortality Patterns of Juvenile Greater Sage-grouse
STUDY:	II		
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PERIOD COVERED: July 1, 2004 to June 30, 2005

MORTALITY PATTERNS OF JUVENILE GREATER SAGE-GROUSE

Abstract

Research on survival of juvenile greater sage-grouse (age 10 weeks to first breeding season), conducted during 1997-1998, has been completed and a draft manuscript (Appendix A) has been submitted for publication. The graduate student did not complete the thesis, so the data was analyzed and publication produced by another University of Idaho student. During 1999-2001, a doctoral study (University of Idaho) was conducted on greater sage-grouse chick mortality (age 0 to 10 weeks). Initial data analysis suggests that 70-80% of sage-grouse chicks die by 3 weeks of age, a much higher mortality rate than that associated with older juveniles. Red fox (*Vulpes vulpes*), raptors, and environmental conditions appear to be the major causes of chick mortalities. Completion report in the form of a dissertation is expected by December 31, 2005.

Recommendations

1. Complete analysis of chick survival, dispersal, and habitat use data.

2. Completion of dissertation is expected by December 31, 2005.

APPENDIX A

Survival of Juvenile Greater Sage-Grouse in Southeastern Idaho

Greater sage-grouse (*Centrocercus urophasianus*) historically occupied sagebrush (*Artemisia* spp.) rangelands in at least 13 states and 3 Canadian provinces, and now occur in 11 states and 2 provinces (Schroeder et al. 2004). Range-wide, populations declined 3.5% per year from 1965 to 1985 and 0.4% per year from 1986 to 2003 (Connelly et al. 2004). These declines are attributed to loss, degradation, and fragmentation of sagebrush steppe habitat resulting from long-term impacts including agricultural expansion (Swenson et al. 1987), drought (Connelly and Braun 1997), fire (Connelly et al. 2000*b*, Connelly et al. 2004), invasive species (Connelly et al. 2004), and livestock-related activities (Beck and Mitchell 2000, Crawford et al. 2004). Continuing changes to sage-grouse habitats include communication towers, mining and energy developments, roads, power lines, fences, reservoirs, and urbanization (Braun 1987, Braun 1998, Connelly et al. 2004). These changes have affected brood-rearing habitats, potentially driving population declines through low survival of juveniles (Connelly and Braun 1997, Beck et al. 2003, Crawford et al. 2004).

Sage-grouse are long-lived birds, but adult males typically have shorter life spans than adult females (June 1963, Connelly et al. 1994, Zablan et al. 2003). Lower survival in adult males is likely related to rapid weight loss and increased vulnerability of males on leks during breeding season (Beck and Braun 1978, Connelly et al. 1994). Average annual survival rates for sage-grouse banded on leks in Colorado and primarily recovered by hunters were 59% and 37% for adult (>1 year of age) females and males and 77% and 63% for sub-adult (<1 year of age) females and males (Zablan et al. 2003). Annual survival rates for radio-marked adult sage-grouse in southeastern Idaho over 8 years ranged from 60 to 78% (Connelly et al. 1994). In southwestern Idaho, annual survival rates over 3 years were 54–87% for adult males and 42–80% for adult females, and for sub-adult (10 weeks to 15 months of age) females over 2 years was 22–55% (Wik 2002). In northwestern Colorado, survival rates pooled over 2 years were 57% for adult females and 75% for yearling females (Hausleitner 2003).

Estimates of chick (0–10 weeks of age) and juvenile (10–40 weeks of age) survival are limited and have not been based on standardized time periods, making comparisons difficult. Crawford et al. (2004) averaged partial estimates from 3 studies to compute a mean survival rate of 10% for juvenile sage-grouse from hatching to the first potential breeding season. Survival of juveniles from hatching to autumn was 38% in Wyoming (June 1963). Chick survival between hatching date and 50 days after hatching (7 weeks of age) was estimated to be 33% in Washington (Schroeder 1997) and 18% in Alberta (Aldridge and Brigham 2001). In contrast, mortality rates for chicks from all North American grouse species range from 40 to 50% from hatching to autumn (Bergerud 1988).

We investigated survival rates of juvenile sage-grouse occupying different habitats (Connelly et al. 1988, Connelly et al. 2003*a*) to better understand survival of different age classes of greater sage-grouse in southeastern Idaho. We defined juveniles as birds from 10 weeks of age until entering their first breeding season in March (approximately 40 weeks of age). We based our definition on the fact that young males outweigh young and adult females by 10–12 weeks post hatching and weights of young female and adult female sage-grouse are nearly equal by October (Patterson 1952, Dalke et al. 1963). Our objectives were to: (1) estimate survival rates of juvenile greater sage-grouse in mountain valley and lowland populations, (2) document mortality patterns for juvenile greater sage-grouse in mountain valley and lowland populations, and (3) evaluate relationships between seasonal movements and survival rates of juvenile sage-grouse.

Study Areas

Medicine Lodge, the mountain valley study area, consisted of 157-km^2 in Clark County, Idaho (44º 18' N, 112º 27' W), and was administered by private landowners (50%), U.S. Bureau of Land Management (BLM [46%]), and the state of Idaho (4%). Elevations range from 1,664 to 2,282 m above mean sea level with topography of moderate to high relief. Main topographical features include creek drainages, basalt outcroppings, mountain ridges, and peaks. Livestock ponds, wet meadows, springs, seeps, and creeks were common. Vegetation was dominated by mountain big sagebrush (*Artemisia tridentata vaseyana*) at higher elevations in the north, xeric sagebrush composed of Wyoming big sagebrush (*A. t. wyomingensis*) and basin big sagebrush (*A. t. tridentata*) on deeper soils in the south, and low sagebrush (*A. arbuscula*) on ridgetops with underlying shallow soils throughout Medicine Lodge. Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) stands occurred at higher elevations (Table 1). Portions of the area were previously strip-sprayed to remove sagebrush and planted with crested wheatgrass (*Agropyron cristatum*). Predominant land use was livestock grazing.

Table Butte, the lowland study area, consisted of 451-km^2 in Clark (77%) and Jefferson (23%) counties, Idaho (44º 06' N, 112º 24' W), with lands administered by the BLM (57%), private landowners (39%), and the state of Idaho (4%). Elevations range from 1,463 to 1,812 m, and topography is of low relief with outcrops of basalt scattered throughout the landscape. Free water was scarce. The surrounding private land was predominately crop agriculture dominated by alfalfa and potato production. A xeric sagebrush community composed of Wyoming big sagebrush, basin big sagebrush, and some threetip sagebrush (*A. tripartita*) covered most of the unfragmented rangelands (Table 1). A portion of the area burned in the early 1990s and was dominated by seeded crested wheatgrass. Conservation Reserve Program lands bordered alfalfa fields in the eastern portion of Table Butte. Livestock grazing and cropland agriculture were the dominant land uses.

The climate of both study areas is continental, characterized by cold winters and hot summers. We obtained climatic data (Western Regional Climate Center 2005) from a weather station at the U.S. Sheep Experiment Station in Dubois, Idaho (1,664 m; 44º 15' N, 112º 12' W). Average monthly temperatures from September through March were 1.3 C in 1997–1998 and 1998–1999, similar to the 30-year (1971–2000) average of 0.1 C. September through March cumulative precipitation was 13 cm in 1997–1998 and 14 cm in 1997–1998, slightly drier than the 16 cm, 30-year average (Western Regional Climate Center 2005).

Coyotes (*Canis latrans*), red fox (*Vulpes vulpes*), common ravens (*Corvus corvax*), golden eagles (*Aquila chrysaetos*), soaring hawks (*Buteo* spp.), and weasels (*Mustela* spp.) were common predators of sage-grouse in both study areas. There was much less cropland, no low-lying power lines, and relatively few pasture fences in Medicine Lodge compared to Table Butte. Grouse in Table Butte were exposed to agricultural hazards such as agrochemicals (Blus et al. 1989), farm machinery, fences, power lines, and vehicles, as well as non-native predators including dogs, domestic cats, and red fox.

Methods

Trapping and Marking

We trapped yearling and adult female sage-grouse in March and April on 7 leks in and adjacent to both study areas to facilitate trapping of juveniles during summers 1997 and 1998. Females breeding on these leks commingled, but separated following nesting to rear broods. We trapped and marked juveniles from the first week of August through the first week of October, but we did not trap during full moons or the 1-week mid-September hunting season. While trapping and handling birds, we followed animal welfare protocols of Gaunt and Oring (1997) and the University of Idaho Animal Care and Use Committee.

We used a spotlighting technique (Giesen et al. 1982, Wakkinen et al. 1992, Connelly et al. 2003*b*) to trap sage-grouse. We used roosting locations of radio-marked yearling and adult females as well as observations of sage-grouse broods in evening hours to locate juveniles during the trapping period. We restrained all captured grouse in burlap sacks to reduce stress. To reduce hen-brood separation, we held all captured birds in partitioned cardboard boxes or paper sacks and released birds at the point of capture.

We assigned captured sage-grouse to age and gender categories based on mass (Eng 1955, Pyrah 1961, Dalke et al. 1963), plumage characteristics (Bihrle 1993), and length of primary feathers (Beck et al. 1975, Idaho Department of Fish and Game 1989). We weighed each juvenile and, depending on mass, we fitted individuals with 15 or 18 g radio-transmitters with built-in mortality sensors (Advanced Telemetry Systems, Inc., Isanti, Minnesota) and a numbered aluminum leg band. Radio-transmitters were ≤3% of the body mass of each juvenile grouse.

Monitoring

We detected locations of radio-marked grouse with radio-telemetry from the ground by visual observations of the birds or by circling the estimated location using the loudest signal strength (Springer 1979). Relocations were made from a fixed-wing aircraft twice each year, when several marked birds could not be located from the ground. We relocated birds on the ground that we initially located from the air. We recorded the Universal Transverse Mercator (UTM) coordinates (datum, NAD27; projection, UTM Zone 12) at each location with a GPS unit or by examining 7.5-minute, United States Geological Survey topographical maps. We documented fate (alive or dead) for each bird based on pulse signals. When pulse signals indicated mortality, we collected forensic evidence to identify cause of death (Thirgood et al. 1998).

Space Use and Movements

We conducted home range analyses in ArcView 3.3 (Environmental Systems Research Institute, Inc., Redlands, California, USA, 1992–2002) to delineate study area boundaries. We used the Home Range extension for ArcView (Rodgers and Carr 2002) to select 90% of all sage-grouse diurnal locations from 1 September through 29 March, 1997–1998 and 1998–1999 in each study area with the harmonic mean method (Dixon and Chapman 1980) and then placed a minimum convex polygon (Mohr 1947) around these locations using the Animal Movements Program extension for ArcView (Hooge and Eichenlaub 1997). We used a 100% minimum convex polygon to delineate the area all grouse used from 1 September through 29 March, 1997–1998 and 1998–1999.

We clipped 30-m resolution vegetation coverage grids from Idaho GAP (Scott et al. 2002) to the 90% minimum convex polygon for each study area. We reclassified the vegetation in each study area as agriculture, forest, grassland, low intensity urban, low sagebrush, mountain big sagebrush, riparian, other shrubs, and xeric big sagebrush (basin and Wyoming) cover types. We used Frag Stats 3.3 (McGarigal and Marks 1995) to evaluate fragmentation metrics at the cover type scale including patch density, mean patch area, and perimeter to area ratio of patches for agriculture, grassland, low sagebrush, mountain big sagebrush, and xeric big sagebrush. The subset of cover types we selected were important for sage-grouse relative to space use in the study areas.

We designated seasons as summer (Jun–Aug), fall (Sep–Nov), winter (Dec–Feb), and spring (Mar–May, [Leonard et al. 2000]). We evaluated linear distances juvenile sage-grouse moved from fall to winter range using the Pythagorean theorem to compute distance moved by each bird from the UTM coordinates at the earliest location in fall following capture (Sep or Oct) to the UTM coordinates at the latest location in winter, excluding the location of death.

We used a 3-way ANOVA to evaluate differences in gender, year, and study area, and interactions, for distances moved from fall range to winter range (PROC GLM; SAS Institute 2001) and pooled non-significant interactions into sampling error. We assessed normality and equal variance in movement distances with appropriate plots (Proc UNIVARIATE; SAS Institute 2001). Because of its effect on normality and equal variance, we removed 1 female captured in Table Butte in 1997 that moved 32.8 km from fall to winter range. This bird also made long-distance movements the following year, which did not correspond with movement patterns of other birds. Retaining this bird in our analysis affected our ability to detect differences among variables. We normalized and homogenized variances of the remaining set of response data through a log10 transformation. We report statistical differences based on the transformed data, but report raw estimates of movement distances to improve interpretability of results. We conducted *post hoc* multiple comparisons with the Tukey-Kramer HSD test.

Survival

We evaluated juvenile sage-grouse survival for the 30-week period extending from 1 September through 29 March in 1997–1998 and 1998–1999. On average, we monitored grouse from the Table Butte study area 6.3 times (range = 1–15) and grouse from the Medicine Lodge study area 3.5 times (range = 1–7) during the 30-week period over each year. Grouse were censored if their radio-transmitters were lost or quit functioning, and were right-censored if they survived past 29 March. Each year, survival of right-censored birds was confirmed with aerial flights conducted shortly after 29 March.

We evaluated survival by year (1997 and 1998), gender (male and female), and study area. We estimated survival with the Kaplan-Meier product limit estimator (Kaplan and Meier 1958) modified for staggered entry (Pollock et al. 1989). We computed the variance for survival estimates following Greenwood (1926). We compared survival rates between groups with a log-rank test (Cox and Oakes 1984:105). We did not have a sufficient sample of birds to test for differences in survival between years at Medicine Lodge, however, we found no difference in survival between years at Table Butte ($\chi = 0.03$, $P = 0.862$); we used this evidence to pool data within study areas across years.

Results

Trapping

We captured and radio-marked 58 juveniles during 1997 and 1998. Twenty-six juveniles were radio-marked in 1997 and 32 in 1998. Female to male ratios for radio-marked juvenile sage-grouse were 0.9:1 during 1997 and 1:1 during 1998. Of the radio-marked juveniles, 15 (26%) were captured in Medicine Lodge (3 in 1997 and 12 in 1998) and 43 (74%) were captured in Table Butte (23 in 1997 and 20 in 1998).

Space Use and Movements

Xeric big sagebrush was the dominant cover type in each study area (Table 1). Agriculture covered 28% of Table Butte and only 6% of Medicine Lodge, and patches of agricultural cover were nearly 8 times larger on average in Table Butte than in Medicine Lodge (Table 1). Patch density was highest for low sagebrush in Medicine Lodge and for grassland cover in Table Butte. Xeric big sagebrush provided patches of cover with more complex or elongated boundary shapes than other cover types in both study areas based on largest perimeter to area ratios (Table 1).

We delineated a 100% minimum convex polygon for the area used by all sage-grouse from 1 September through 31 March, 1997–1998 and 1998–1999, based on 317 diurnal locations of grouse following capture and located through aerial and ground monitoring. Of these locations, 50 were from 13 birds in Medicine Lodge and 267 were from 40 birds in Table Butte. After removing 1 outlier location from consideration, we delineated the Medicine Lodge study area boundaries from 44 of 50 locations from 13 birds. We delineated the Table Butte study area with

241 of 267 locations from 40 birds. Movement analyses were based on 234 locations in fall and 74 locations in winter, which corresponds to 97% of all locations from August through March. We evaluated distances moved from fall to winter ranges for 5 grouse (2 females, 3 males) captured in Medicine Lodge and 22 grouse (9 females, 14 males) captured in Table Butte.

There were no differences in fall to winter movements for year or gender main effects or for the gender × year, study × year, or the gender × study × year interactions. Juvenile sage-grouse captured in Medicine Lodge moved further (= 16.2 km, range = 12.1–24.2 km, $F_{1,22} = 9.64$, $P = 0.005$) from summer to winter range than juvenile grouse captured in Table Butte (= 12.8 km, range = 7.3–19.1 km). There was a difference in movement distances for the gender × study area interaction ($F_{1,22} = 8.14$, $P = 0.009$). We found no difference (Tukey-Kramer HSD test $P = 0.094$) in movements between females (= 20.6 km, range = 17.0–24.2 km) and males (= 13.3 km, range = 12.1–14.1 km) captured in Medicine Lodge. Females captured in Medicine Lodge moved further (Tukey-Kramer HSD test $P < 0.05$) from summer to winter habitat than females (= 12.0 km, range = 7.3–19.1 km) and males (= 13.4 km, range = 9.6–18.4 km) captured in Table Butte. Three grouse (2 females, 1 male) crossed Interstate 15 to access habitat in Fremont and eastern Clark counties. We located these birds at 11 locations (4% of all Table Butte locations) from 1 November to 22 December in 1997 and 1998.

Survival

One female from Medicine Lodge died within 1 day of capture in 1997; following a necropsy we determined this bird died from capture-related stress, and was, thus, not considered in survival analyses. One male trapped in Table Butte in 1998 lost his radio collar 6 weeks after he entered the study on 1 September and was censored. Of the remaining 56 birds, 11 (20%) died from 1 September through 31 March, 1997–1998 and 1998–1999. The remaining 45 birds (Medicine Lodge = 9; Table Butte = 36) survived and became sub-adult sage-grouse. Mortality by study area was 5 of 14 (36%) in Medicine Lodge and 6 of 43 (14%) in Table Butte. Two deaths occurred in September (18%), 5 in October (46%), 1 in November (9%), 2 in December (18%), and 1 in March (9%). All mortalities in Medicine Lodge were attributed to natural predators (avian = 80%; mammal = 20%), while mortality associated with human activities (legal harvest = 17%; power line collisions = 33%) accounted for 50% of mortalities in Table Butte. All mortalities associated with human activities in Table Butte occurred during September and October. Of total mortalities, avian predation was the cause of death for 36% of grouse, followed by mammal predation (27%), power line collisions (18%), legal harvest (9%), and unknown (9%) cause. We found no difference ($\chi = 0.15$, $P = 0.699$) in survival between female ($\hat{S} = 0.78$, SE = 0.08, $n = 27$) and male ($\hat{S} = 0.82$, SE = 0.07, $n = 30$) juvenile sage-grouse. Survival was lower ($\chi = 3.12$, $P = 0.077$) at Medicine Lodge ($\hat{S} = 0.64$, SE = 0.13, $n = 14$) than at Table Butte ($\hat{S} = 0.86$, SE = 0.06, $n = 43$).

Discussion

Once young sage-grouse reached 10 weeks of age, they experienced low-to-moderate mortality (14–36%) through March. Mortality in both study areas was concentrated in fall with only 3 deaths occurring from December through March. Our estimates of juvenile sage-grouse survival are higher than estimates of survival for chicks from hatching to 7 weeks (Schroeder 1997, Aldridge and Brigham 2001), hatching through autumn (June 1963), and hatching until birds enter breeding season (Crawford et al. 2004). A comparison of our results with previous estimates suggests high mortality of sage-grouse chicks (0–10 weeks of age) probably most influenced previous estimates of juvenile survival. We did not investigate survival of chick sage-grouse and it is difficult to know whether recruitment was higher or lower for sage-grouse inhabiting the 2 study areas. Greater concentrations of predators, use of agrochemicals, and other human-related activities in and near agricultural areas may have reduced survival of chicks in Table Butte compared to Medicine Lodge, even though estimates of juvenile survival were lower in Medicine Lodge.

Low recruitment in prairie grouse reflects low juvenile survival rates or low reproductive potential for adult females. Clutch sizes for sage-grouse average 6.6–9.1 eggs (Schroeder et al. 1999), reflecting a relationship between low adult mortality rates and low clutch size among North American grouse (Bergerud 1988). Average nest success (nests hatching ≥1 egg) for sage-grouse ranges from 15 to 86% (Schroeder et al. 1999). In southeastern Idaho, percentage of females known to initiate nesting was 55% for yearlings and 78% for adults, nest success between age classes averaged 52%, and renesting rate for unsuccessful first nesters was 15% (Connelly et al. 1993). Renesting rates in areas with smaller populations were 36% in Alberta (Aldridge and Brigham 2001), and 82% for yearling females and 88% for adult females in Washington (Schroeder 1997). These findings suggest reproductive success among female sage-grouse is highly variable. Our study suggests that survival of chick sage-grouse may be the factor most limiting recruitment in sage-grouse populations and needs further study.

Population viability analysis for sage-grouse in North Park, Colorado, incorporating sensitivity and elasticity analyses of vital rates indicated that adult and juvenile survival followed by adult and juvenile fecundity most limited population growth (Johnson and Braun 1999). Reproductive success, measured through mean juvenile-to-adult ratios in summer, of the endangered Attwater's prairie-chicken (*Tympanuchus cupido attwateri*) in Texas was less than that for greater prairie-chickens (*T. c. pinnatus*) in summer and fall across its range of distribution (Peterson and Silvy 1996). In addition, average nest success and chicks per brood prior to brood breakup were also lower for Attwater's compared to greater prairie-chickens (Peterson and Silvy 1996). These results indicate that declines in prairie grouse populations are likely related to low juvenile survival or poor reproductive success among females.

Adult sage-grouse have low over-winter natural mortality, and most mortality occurs in spring and summer (Connelly et al. 2000*a*). We likewise found low over-winter mortality of juvenile sage-grouse. Therefore, specific causes of mortality during spring and summer could potentially be influencing population declines of sage-grouse, and identification of these factors may provide managers with information to develop recommendations and strategies for increasing numbers of sage-grouse. Exposure to wet and cold weather after hatching can limit survival of sage-grouse chicks (Patterson 1952), linking yearly survival to annual climate cycles. Predation is the largest direct cause of prairie grouse mortality through affecting nest success, juvenile survival, and adult survival (Schroeder and Baydack 2001); other factors responsible for juvenile mortality include accidents, hunting, disease, and parasites. Half of the deaths in the lowland population were attributable to human activities during September and October. In contrast, all deaths in the mountain valley population were related to predators from October through December when birds were moving to winter habitats.

Sage-grouse in Medicine Lodge moved farther from fall ranges to winter ranges than birds in Table Butte. Although our sample was limited, females from the mountain valley population moved farther than males and females from the lowland population. Female sage-grouse disperse greater distances than males (Dunn and Braun 1985), and juvenile prairie grouse may move further during autumn than adults, leading to higher mortality (Bowman and Robel 1977). Our results support the concept that mortality of juvenile sage-grouse in fall may increase as distances moved between seasonal ranges increases.

Management Implications

Low productivity and chick survival suggests recruitment is of great importance in maintaining sage-grouse populations (Connelly and Braun 1997, Crawford et al. 2004). Understanding survival and mortality patterns of juvenile sage-grouse is critical because recruitment has the greatest effect on growth of sage-grouse populations. Managers and researchers should focus efforts on factors that influence sage-grouse production, and chick and juvenile survival. A common way production is indexed in sage-grouse populations is through ratios of juveniles to adult (including yearling) hens obtained from the wings of hunter-harvested birds in autumn (Connelly and Braun 1997, Connelly et al. 2000*c*, Beck et al. 2003). These ratios have, at times, indicated stable to increasing populations when populations were declining, likely reflecting disproportionate harvest of adult females and juveniles near moist areas (Beck et al. 2003). Additional work on evaluating production should compliment our understanding of recruitment, which appears to be low in sage-grouse populations (Dunn and Braun 1985). Particular importance should be placed on studies evaluating chick and juvenile survival.

Both sage-grouse populations we studied were migratory, moving >10 km from fall to winter ranges (Connelly et al. 2000*c*). We found that juveniles migrating long distances to winter ranges may have higher mortality, increasing the need to conserve large continuous areas of sage-grouse habitat to reduce exposure to predators and other hazards. Conservation and enhancement of movement corridors and large unfragmented habitat patches appears critical to promoting high survival among juvenile sage-grouse from migratory populations.

Literature Cited

ALDRIDGE, C. L., AND R. M. BRIGHAM. 2001. Nesting and reproductive activities of greater sage-grouse in a declining northern fringe population. Condor 103:537-543.

BECK, T. D. I., AND C. E. BRAUN. 1978. Weights of Colorado sage-grouse. Condor 80:241–243.

_____, AND D. L. MITCHELL. 2000. Influences of livestock grazing on sage-grouse habitat. Wildlife Society Bulletin 28:993–1002.

_____, _____, AND B. D MAXFIELD. 2003. Changes in the distribution and status of sage-grouse in Utah. Western North American Naturalist 63:203–214.

_____, R. B. GILL, AND C. E. BRAUN. 1975. Sex and age determination of sage-grouse from wing characteristics. Colorado Division of Game, Fish and Parks, Outdoor Facts, Game Information Leaflet 49 (revised).

BERGERUD, A. T. 1988. Population ecology of North American grouse. Pages 578–685 *in* A. T. Bergerud and M. W. Gratson, editors. Adaptive strategies and population ecology of northern grouse. Volume II. Theory and synthesis. University of Minnesota Press, Minneapolis, USA.

BIHRLE, C. 1993. Upland game identification: a basic guide for aging and sexing the bird in your hand. North Dakota Outdoors 56(3):9–23.

BLUS, L. J., C. S. STALEY, C. J. HENNY, G. W. PENDLETON, T. H. CRAIG, E. H. CRAIG, AND D. K. HALFORD. 1989. Effects of organophosphorus insecticides on sage-grouse in southeastern Idaho. Journal of Wildlife Management 53:1139–1146.

BOWMAN, T. J., AND R. J. ROBEL. 1977. Brood break-up, dispersal, mobility, and mortality of juvenile prairie chickens. Journal of Wildlife Management 41:27–34.

BRAUN, C. E. 1987. Current issues in sage-grouse management. Proceedings of the Western Association of State Fish and Wildlife Agencies 67:134–144.

_____. 1998. Sage-grouse declines in western North America: what are the problems? Proceedings of the Western Association of State Fish and Wildlife Agencies 78:139–156.

CONNELLY, J. W., AND C. E. BRAUN. 1997. Long-term changes in sage-grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3:229–234.

_____, H. W. BROWERS, AND R. J. GATES. 1988. Seasonal movements of sage-grouse in southeastern Idaho. Journal of Wildlife Management 52:116–122.

_____, A. D. APA, R. B. SMITH, AND K. P. REESE. 2000*a*. Effects of predation and hunting on adult sage-grouse *Centrocercus urophasianus* in Idaho. Wildlife Biology 6:227–232.

_____, K. P. REESE, R. A. FISCHER, AND W. L. WAKKINEN. 2000*b*. Response of a sage-grouse breeding population to fire in southeastern Idaho. Wildlife Society Bulletin 28:90–96.

_____, M. A. SCHROEDER, A. R. SANDS, AND C. E. BRAUN. 2000*c*. Guidelines to manage sage-grouse populations and their habitats. Wildlife Society Bulletin 28:967–985.

_____, K. P. REESE, E. O. GARTON, AND M. L. COMMONS-KEMNER. 2003*a*. Response of greater sage-grouse *Centrocercus urophasianus* to different levels of exploitation in Idaho, USA. Wildlife Biology 9:335–340.

_____, _____, AND M. A. SCHROEDER. 2003*b*. Monitoring of greater sage-grouse habitats and populations. Idaho Forest, Wildlife and Range Experiment Station, Bulletin 80, College of Natural Resources, University of Idaho, Moscow, USA.

_____, S. T. KNICK, M. A. SCHROEDER, AND S. J. STIVER. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, Wyoming, USA

_____, R. A. FISCHER, A. D. APA, K. P. REESE, AND W. L. WAKKINEN. 1993. Renesting by sage-grouse in southeastern Idaho. Condor 95:1041–1043.

_____, K. P. REESE, W. L. WAKKINEN, W. L. ROBERTSON, AND R. A. FISCHER. 1994. Sage-grouse ecology. Federal Aid Completion Report W-160-R-21. Idaho Department of Fish and Game, Boise, USA.

COX, D. R., AND D. OAKES. 1984. Analysis of survival data. Chapman and Hall, New York, New York, USA.

CRAWFORD, J. A., R. A. OLSON, N. E. WEST, J. C. MOSLEY, M. A. SCHROEDER, T. D. WHITSON, R. F. MILLER, M. A. GREGG, AND C. S. BOYD. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2–19.

DALKE, P. D., D. B. PYRAH, D. C. STANTON, J. E. CRAWFORD, AND E. F. SCHLATTERER. 1963. Ecology, productivity, and management of sage-grouse in Idaho. Journal of Wildlife Management 27:811–841.

DIXON, K. R., AND J. A. CHAPMAN. 1980. Harmonic mean measure of animal activity areas. Ecology 61:1040–1044.

DUNN, P. O., AND C. E. BRAUN. 1985. Natal dispersal and lek fidelity of sage-grouse. Auk 102:621–627.

ENG, R. L. 1955. Sage-grouse production and movement study. Montana Fish and Game Department, Federal Aid Job Progress Report, Project W-74-R-1.

GAUNT, A. S., AND L. W. ORING, editors. 1997. Guidelines to the use of wild birds in research. Special Publication. The Ornithological Council, Washington, D.C., USA.

GIESEN, K. M., T. J. SCHOENBERG, AND C. E. BRAUN. 1982. Methods for trapping sage grouse in Colorado. Wildlife Society Bulletin 10:224–231.

GREENWOOD, M. 1926. The natural duration of cancer. Pages 1–26 *in* Reports on Public Health and Medical Subjects 33. His Majesty's Stationary Office, London, United Kingdom.

HAUSLEITNER, D. 2003. Population dynamics, habitat use and movements of greater sage-grouse in Moffat County, Colorado. Thesis, University of Idaho, Moscow, USA.

HOOGE, P. N., AND B. EICHENLAUB. 1997. Animal movements extension to ArcView: version 1.1. United States Geographical Survey, Alaska Biological Science Center, Anchorage, USA.

IDAHO DEPARTMENT OF FISH AND GAME. 1989. Sexing and aging sage-grouse wings by measuring the 10th primary. Unpublished report. Idaho Department of Fish and Game, Boise, USA.

JUNE, J. W. 1963. Wyoming sage-grouse population measurement. Proceedings of the Western Association of State Game and Fish Commissioners 43:206–211.

JOHNSON, K. H., AND C. E. BRAUN. 1999. Viability and conservation of an exploited sage-grouse population. Conservation Biology 13:77–84.

KAPLAN, E. L., AND P. MEIER. 1958. Nonparametric estimation from incomplete observations. Journal of the American Statistical Association 53:457–481.

LEONARD, K. M., K. P. REESE, AND J. W. CONNELLY. 2000. Distribution, movements and habitats of sage-grouse *Centrocercus urophasianus* on the Upper Snake River Plain of Idaho: changes from the 1950s to the 1990s. Wildlife Biology 6:265–270.

MCGARIGAL, K., AND B. J. MARKS. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. United States Forest Service, General Technical Report PNW-GTR-351. Pacific Northwest Research Station, Portland, Oregon, USA.

MOHR, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223–449.

PATTERSON, R. L. 1952. The sage-grouse in Wyoming. Sage Books, Denver, Colorado, USA.

PETERSON, M. J., AND N. J. SILVY. 1996. Reproductive stages limiting productivity of the endangered Attwater's prairie chicken. Conservation Biology 10:1264–1276.

POLLOCK, K. H., S. R. WINTERSTEIN, C. M. BUNCK, AND P. D. CURTIS. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53:7–15.

PYRAH, D. B. 1961. Sage-grouse investigations. Idaho Department of Fish and Game, Wildlife Completion Report, Federal Aid Project W-125-R-1. Idaho Department of Fish and Game, Boise, USA.

RODGERS, A. R., AND A. P. CARR. 2002. Home range extension for ArcView®GIS, version 1.1 C. Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada.

SAS INSTITUTE. 2001. SAS/STAT user's guide, release 8.2. SAS Institute, Inc., Cary, North Carolina, USA.

SCHROEDER, M. A. 1997. Unusually high reproductive effort by sage-grouse in a fragmented habitat in north-central Washington. Condor 99:933–941.

_____, AND R. K. BAYDACK. 2001. Predation and the management of prairie grouse. Wildlife Society Bulletin 29:24–32.

_____, J. R. YOUNG, AND C. E. BRAUN. 1999. Sage-grouse (*Centrocercus urophasianus*). Pages 1–28 *in* A. Poole, and F. Gill, editors. The birds of North America, No. 425. The Birds of North America, Incorporated, Philadelphia, Pennsylvania, USA.

_____, C. L. ALDRIDGE, A. D. APA, J. R. BOHNE, C. E. BRAUN, S. D. BUNNELL, J. W. CONNELLY, P. A. DEIBERT, S. C. GARDNER, M. A. HILLIARD, G. D. KOBRIGER, S. M. MCADAM, C. W. MCCARTHY, J. J. MCCARTHY, D. L. MITCHELL, E. V. RICKERSON, AND S. J. STIVER. 2004. Distribution of sage-grouse in North America. Condor 106:363–376.

SCOTT, J. M., C. R. PETERSON, J. W. KARL, L. K. SVANCARA, AND N. M. WRIGHT. 2002. A Gap analysis of Idaho: final report. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, Idaho, USA.

SPRINGER, J. T. 1979. Some sources of bias and sampling error in radio triangulation. Journal of Wildlife Management 43:926–935.

SWENSON, J. E., C. A. SIMMONS, AND C. D. EUSTACE. 1987. Decrease of sage-grouse *Centrocercus urophasianus* after ploughing sagebrush steppe. Biological Conservation 41:125–132.

THIRGOOD, S. J., S. M. REDPATH, P. J. HUDSON, AND E. DONNELLY. 1998. Estimating the cause and rate of mortality in red grouse *Lagopus lagopus scoticus*. Wildlife Biology 4:65–71.

WAKKINEN, W. L., K. P. REESE, J. W. CONNELLY, AND R. A. FISCHER. 1992. An improved spotlighting technique for capturing sage-grouse. Wildlife Society Bulletin 20:425–426.

WESTERN REGIONAL CLIMATE CENTER. 2005. Idaho climate summaries. Desert Research Institute, Reno, Nevada. Available online at www.wrcc.dri.edu/summary/climsmid

WIK, P. A. 2002. Ecology of greater sage-grouse in south-central Owyhee County, Idaho. Thesis, University of Idaho, Moscow, USA.

ZABLAN, M. A., C. E. BRAUN, AND G. C. WHITE. 2003. Estimation of greater sage-grouse survival in North Park, Colorado. Journal of Wildlife Management 67:144–154.

Table 1. Area and patch metrics for cover types important to greater sage-grouse, Medicine Lodge and Table Butte, southeastern Idaho, 1997–1999.

Location Cover type	Area (%)	Patch metrics Mean area (km^2)	 Density (No./km^2)	 Perimeter: area ratio
Medicine Lodge				
Agriculture	6	1.78	3	100
Grassland	1	0.05	22	448
Low sagebrush	15	0.18	84	418
Mountain big sagebrush	33	0.92	36	424
Xeric big sagebrush[a]	43	1.28	34	476
Total (%)	98[b]			
Table Butte				
Agriculture	28	14.05	2	58
Grassland	23	0.39	6	378
Xeric big sagebrush	48	1.81	27	448
Total (%)	99[c]			

[a] Basin and Wyoming big sagebrush.
[b] Remaining cover (2%) composed of forest, riparian, and other shrubs.
[c] Remaining cover (1%) composed of low intensity urban, riparian, and other shrubs.

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FEDERAL AID IN WILDLIFE RESTORATION

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sale of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. The Idaho Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be responsible, ethical hunters. Seventy-five percent of the funds for this project are from Federal Aid. The other 25% comes from license-generated funds.