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Source: Wildlife Biology, 6(4) : 265-270

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/wlb.2000.025

Distribution, movements and habitats of sage grouse *Centrocercus urophasianus* on the Upper Snake River Plain of Idaho: changes from the 1950s to the 1990s

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Leonard, K.M., Reese, K.P. & Connelly, J.W. 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. - Wildl. Biol. 6: 265-270.

The sage grouse *Centrocercus urophasianus* population level on the Upper Snake River Plain of Idaho has declined significantly over the past 40 years. We investigated migration patterns and seasonal ranges of these birds to compare to patterns from the 1950s and 1960s. Furthermore, we examined landscape changes that occurred between 1975 and 1992. Migration patterns have not changed since the 1950s. The grouse currently migrate up to 125 km and use an annual population range of at least 2,764 km^2. The major landscape change since 1975 that occurred in sage grouse habitat was a decline in the total amount of winter range. Between 1975 and 1992, 29,762 ha of sagebrush *Artemisia* spp. rangeland were converted to cropland, a 74% increase in cropland. Regression analysis suggested a relationship between sagebrush habitat loss and grouse population decline ($R^2 = 0.59$, $P = 0.002$). Approximately 1,244 km^2 of privately-owned sagebrush on the study area could potentially be converted to cropland, which we predict would have serious negative implications for the sage grouse population.

Key words: annual range, Centrocercus urophasianus, habitat loss, migration, movements, sagebrush, sage grouse, seasonal ranges

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Sage grouse *Centrocercus urophasianus* were once abundant and widespread throughout much of western North America (Patterson 1952, Aldrich 1963). Sage grouse are dependent on sagebrush *Artemisia* spp. rangelands (Patterson 1952). Since 1900, millions of hectares of sagebrush habitat across the species' range have been severely altered or eliminated by agricultural, rangeland and urban development (Patterson 1952, Schneegas 1967, Dobkin 1995). Therefore, the range of sage grouse across North America has been reduced accordingly. For example, in a comparison of pre-1984 and 1985-1994 averages of males per lek, Connelly & Braun (1997) reported a range-wide average decline of 33% in breeding populations. Five states, i.e. Idaho, Montana, Nevada, Wyoming and Oregon, still have large, widely distributed sage grouse populations, but all of these are declining, and the species' status is even less secure in the remainder of its range (Braun 1993, Connelly & Braun 1997).

Annual movements of sage grouse are dictated by the

distribution of their seasonal habitats. Populations may be migratory (Dalke, Pyrah, Stanton, Crawford & Schlatterer 1963, Connelly, Browers & Gates 1988) or non-migratory (Wallestad 1975). Sage grouse of the Upper Snake River Plain of Idaho migrate at least 80-160 km between winter habitat, leks and summer habitat (Dalke et al. 1963).

Although sage grouse population levels on the Upper Snake River Plain are still high relative to other populations in Idaho, these populations are also declining. Breeding populations, indicated by both the number of males on leks and total number of leks, in this region may be at a new low (Crowley & Connelly 1996). Although lek counts fluctuate over time, they have remained at particularly low levels since the early 1980s. Mean number of males per lek (18.8) for 1982-1995 is 45% lower than the mean (34.2) for 1951-1981. These dynamics are also reflected in trends from brood route counts and hunter effort surveys (Crowley & Connelly 1996).

Despite no loss of sagebrush habitat over the last 30 to 40 years in certain areas (Pyrah 1954, Stanton 1958, Schlatterer 1960), other areas have been greatly altered through conversion to agricultural fields. Here we quantify sage grouse habitat loss and changes in migration patterns in this area over time using results of Pyrah (1954), Crawford (1960), Schlatterer (1960), Dalke, Pyrah, Stanton, Crawford & Schlatterer (1960), Dalke et al. (1963), and Gray (1967) as reference data.

Study area

The study area was on the Upper Snake River Plain of southeastern Idaho, USA (44°12'N, 111°55'W). We divided our study area into a core area, in which the majority of fieldwork was conducted, and an extended area. The boundaries of the core area were formed by the Centennial Mountains to the north, Interstate Highway 15 to the west, State Highway 20 to the east, and State Highway 33 to the south. The area contained approximately 2,600 km^2 of sagebrush habitat. The extended area included additional sagebrush habitat to the northwest and west, bounded by the southern ends of the Beaverhead, Lemhi and Lost River mountain ranges, and included sagebrush habitat extending to the southwest in an area known as the Big Desert.

The area was covered by well-drained eolian and alluvial soils of varying depths over basalt lava flows (Grow 1993). The topography was gently rolling, but the terrain was quite rough because of lava formations. Elevation increased from southwest to northeast and ranged within 1,500-2,050 m a.s.l. The central portion of the area, where most leks were located, was between 1,600 and 1,800 m a.s.l.

Temperature and precipitation also changed from southwest to northeast. During 1950-1995 mean temperatures in January ranged from -7°C to -10°C across the area and mean temperatures in July ranged from 16°C to 20°C. Mean annual precipitation ranged within 23-74 cm (U.S. Department of Commerce 1992).

The area was largely sagebrush grassland. Mountain big sagebrush *Artemisia tridentata vaseyana* was the most common sagebrush, but basin big sagebrush *A. t. tridentata*, Wyoming big sagebrush *A. t. wyomingensis*, three-tipped sagebrush *A. tripartita* and black sagebrush *A. nova* occurred as well. A high diversity of forbs and grasses occurred throughout the area.

At the north end of the area, sagebrush mixed with stands of lodgepole pine *Pinus contorta* and aspen *Populus tremuloides*. These areas comprised the most mesic portion of the study area, and have been converted in part to pasture and cropland. Although the far southwestern part of the study area was the most xeric, it has undergone the greatest amount of conversion to agriculture and crops depend on irrigation.

Methods

In 1995 and 1996, we trapped sage grouse on and in the immediate vicinity of leks during the breeding season in late March - early May. Grouse were trapped on five leks in the Red Road area and on three northeast of Dubois. Birds were trapped by nighttime spotlighting (Giesen, Schoenberg & Braun 1982, Wakkinen, Reese, Connelly & Fischer 1992), walk-in traps and a 10 x 10 m drop net. The leks corresponded as closely as possible to those used by researchers in the 1950s (Dalke et al. 1963).

We determined sex and age of birds using plumage characteristics as described by Dalke et al. (1963). All birds were leg banded and females were weighed. Selected birds were fitted with a 16- to 17-g necklace- or poncho-mounted, battery- or solar-powered radio transmitter, with an expected battery life of approximately one year (Amstrup 1980).

Radio-monitoring was conducted from both the ground and the air. Birds were located an average of 1.8 times per month. We mapped all locations using Arc Info (Earth Systems Research Institute 1992) and Arc View (Environmental Systems Research Institute 1996) software and calculated distances from the lek of capture for all locations. We calculated seasonal and annu-

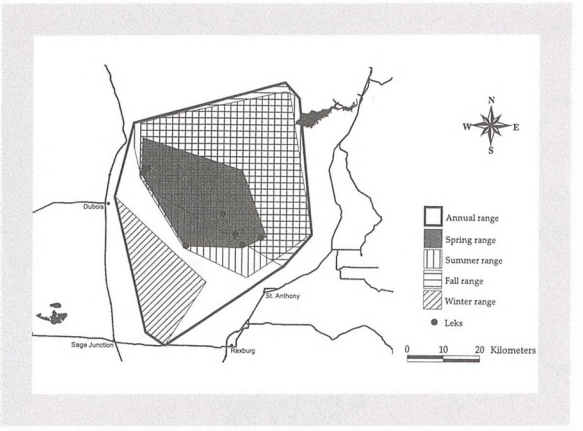

Figure 1. Annual and seasonal ranges of sage grouse on the Upper Snake River Plain of southeastern Idaho, during 1995-1996.

al ranges using the minimum convex polygon method (Hayne 1949, Jennrich & Turner 1969). We used this method to show the complete range of area used during a given time period, rather than to attempt to define areas of core use. Because we were not concerned with identifying differences between years, the locations for both years were pooled for analysis. These data were compared with historical information from Pyrah (1954), Stanton (1958), Crawford (1960), Schlatterer (1960), Dalke et al. (1960, 1963) and Gray (1967).

To examine landscape change, we obtained Landsat satellite images from the U.S. Geological Survey's Earth Resources Observation Systems (EROS) Data Center. They provided a matched triplicate set of scenes from 1975 (the earliest available), 1985 and 1992, which covered all but a small corner of the study area. In general, most land use changes were confined to the southwestern portion of the study area. Therefore, we used only this area, approximately 2,249 km^2, of the larger images for the analysis. We refer to this smaller area as the subset area.

Using image processing software, we classified the subset images into cropland and non-cropland areas. We used simple linear regression to investigate relationships between habitat loss and the sage grouse population level. In order to assess potential future habitat loss, we identified the location and amount of privately-held rangeland in the study area. Private land is most vulnerable to conversion to cropland or other uses.

Results

Trapping

In 1995, we captured three females and 41 males. Of these, all females and 25 males were radio-marked. In 1996, we captured 11 females and 18 males and marked all females and 14 males with radio transmitters.

Movements

From 53 radio-marked sage grouse, we obtained 355 locations: 170 in 1995 and 185 in 1996, not including initial capture locations. The annual range of sage grouse encompassed 2,764 km^2 (Fig. 1). Spring range for both sexes was calculated from March through May locations (N = 75), and encompassed 673 km^2. Summer (June through August) range (N = 157) included all of the spring range and covered 1,825 km^2. Fall (September through November) range (N = 118) largely overlapped summer range and included 1,564 km^2. Winter (December through February) range (N = 5), distinct from other seasonal ranges, encompassed 439 km^2 (see Fig. 1). Sage grouse bred on leks in the central portion of their range, moved north and east in the summer, and moved southwest beyond the leks to winter. Only five birds, four males and a female, were observed to complete annual round trips from leks of capture between years. The straight-line distance of these annual movements ranged within 92-125 km, with a mean of 107 km. The mean distance sage grouse moved from lek of capture, for sexes combined, ranged from 3.5 km in spring to 27.7 km in winter (Table 1).

When compared to previously mapped movements, locations of radio-marked sage grouse were sufficient to show that migration patterns remain essentially the same as they were in the 1950s (Fig. 2). The seasonal range maps also confirm this.

Land use changes

The one major landscape change since 1975, in the southwestern part of the study area, was the great

Table 1. Mean distances (km) sage grouse moved from lek of capture, according to sex and season, on the Upper Snake River Plain of southeastern Idaho, during 1995-1996. All birds were captured in late March - early May.

	Spring			Summer			Fall			Winter		
Sex	$\bar{x}$	Range	N	$\bar{x}$	Range	N	$\bar{x}$	Range	N	$\bar{x}$	Range	N
Males	3.0	0.0-20.1	47	15.7	0.3-50.6	79	23	1.3-52.5	87			
Females	4.3	0.5-20.1	28	8.4	0.2-37.2	78	18.8	3.1-37.7	31			
Total	3.5	0.0-21.1	75	12.1	0.2-50.6	157	21.9	1.3-52.5	118	27.7	16.8-41.4	5

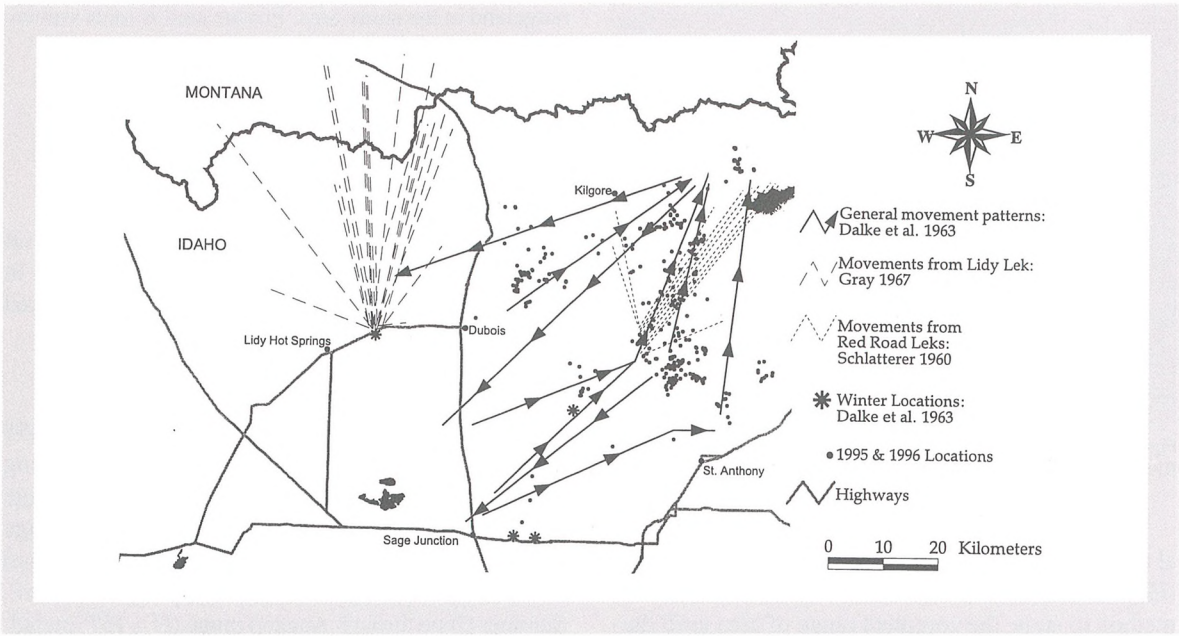

Figure 2. Comparison of sage grouse locations collected in 1995 and 1996, and movement patterns described between 1950 and 1960 on the Upper Snake River Plain of southeastern Idaho.

amount of agricultural conversion northeast of Sage Junction and near Dubois (see Fig.1). Based on surrounding areas and information in Dalke et al. (1960, 1963), all agricultural land in the area was probably sagebrush-dominated rangeland, and, therefore, represents lost sage grouse habitat. In 1975, 403 km^2 of the subset area were croplands. By 1985, agricultural use had expanded to 635 km^2, and 701 km^2 had been converted to farmland by 1992. No residual sagebrush cover remains within these converted areas. In the 17-year period examined, agricultural land use in this area increased by approximately 74%. Nearly all of the cropland development occurred within this portion of the study area, and field observations indicated that agricultural conversion has continued in the years since the most recent satellite image was obtained.

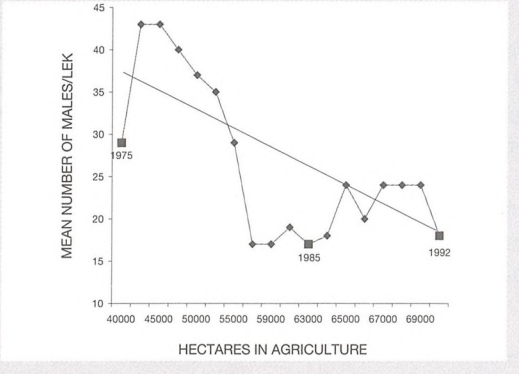

Figure 3. Mean number of sage grouse males per lek (Crowley & Connelly 1996), and hectares converted to agriculture within the study area on the Upper Snake River Plain of southeastern Idaho. Data points using actual hectare measurements are shown as squares and labelled with the year of data collection. Points using interpolated hectare estimates are shown as circles.

During the same 17-year period of this analysis, mean number of male sage grouse per lek declined. Regression analysis suggested a negative relationship between hectares of sagebrush converted to agriculture and sage grouse population levels ($R^2 = 0.59$, $P = 0.002$; Fig. 3). Within the extended study area, 1,244 km^2 of rangeland were privately owned. Most of this rangeland can be considered sage grouse habitat. Although private rangeland is more vulnerable to conversion to another cover type than most government-owned land, the amount of land actually suitable for conversion is unknown.

Discussion

Movements

Migratory movements of sage grouse in our study were similar to those reported from the 1950s and 1960s. Pyrah (1954), Crawford (1960), Schlatterer (1960) and Dalke et al. (1963) indicated that sage grouse from all leks used the Shotgun Valley and Ca-

mas Meadows areas as summer range. We identified the Camas Meadows as an area of agricultural and wet meadows around Kilgore, and the Shotgun Valley as the valley bottom area east of Kilgore (see Fig. 2). These definitions correspond closely to those used in the previous studies (Dalke et al. 1963). Although we observed birds, both marked and unmarked, in the Shotgun Valley and Camas Meadows during the summer, most birds remained just to the southwest, where there was more sagebrush cover. We are uncertain whether this represents a real change in summer range, confusion in identification of areas, or an artifact of small sample sizes.

During the 1950s, sage grouse attending leks in the center of the study area (Red Road leks) were thought to use different wintering areas from birds attending leks northeast of Dubois (see Fig. 1). The Red Road birds tended to move to the southwest to winter around Sage Junction (see Fig. 2; Schlatterer 1960), while birds from northeast of Dubois tended to move more directly west to winter around Dubois (Dalke et al. 1963). Although information about current winter use is limited, five birds from Red Road area leks were located in January in the Sage Junction area, and another bird, trapped northeast of Dubois, wintered just east of Dubois. These movements corroborate earlier results on use of wintering areas.

The range polygons, which included up to 2,764 km^2 for year-round use, are only minimum estimates. This is especially true of the winter range polygon, which was based on a smaller sample size than the others. It is very likely that, throughout the year, some birds used additional areas that were not detected during the course of radio-monitoring.

The wide-ranging nature of these sage grouse is also indicated by the distances travelled from leks and also by annual movements. The distance of sage grouse migration in this area does not appear to have changed since the 1950s. The five annual distances of 92-125 km are within the range of 80-160 km reported by Dalke et al. (1963). It also appears that no major changes in movement patterns or seasonal ranges have occurred since the 1950s.

Land uses

The southwestern part of the study area, where most changes in land use have taken place, also encompasses historical and current winter habitat for sage grouse (Pyrah 1954, Crawford 1960). Dalke et al. (1963), during seven years of study, described numerous large flocks of sage grouse wintering northwest of Dubois, and also east of Sage Junction (see Fig. 2). Most of the habitat lost in the study area lies between these sites, suggesting that it may have included some important winter habitat. The winter locations of radio-collared sage grouse all lie within this general area of winter range, but all were in sagebrush habitat. A useful and feasible direction for future research would be to estimate the amount of high-quality winter habitat that remains available.

The converted habitat also was summer range for sage grouse breeding at leks to the west of our study area (Connelly 1982, Blus, Staley, Henny, Pendleton, Craig, Craig & Halford 1989). Although sage grouse hens with broods may feed in cropland in dry periods, this may be more of a hazard than a benefit. Blus et al. (1989) reported that organophosphorus insecticides, as commonly applied in cropland west of our study area, were capable of killing or debilitating substantial numbers of adult and juvenile sage grouse.

During the period of sage grouse population decline, sagebrush habitat conversion to cropland has been the most obvious landscape change in the study area. The regression analysis that related these changes was limited by its assumptions and by the necessity of using estimated data points. Nevertheless, the analysis suggested a moderate relationship between habitat loss of approximately 701 km^2 of sagebrush and population decline. Drought during 1987-1992 may also have contributed to the population decline (Fischer 1994, Connelly & Braun 1997), but this occurred after the majority of the conversion of sagebrush to cropland. Another 1,244 km^2 of private rangeland on the extended study area are potentially subject to cropland conversion. Although not all of this land may be suitable for conversion, the potential impacts to the sage grouse population could be great. If all private rangeland were converted to non-sagebrush cover types, the area lost as sage grouse habitat could equal approximately 45% of the size of their current annual range (2,764 km^2). We believe that the continued existence of the sage grouse population in the area would then be in jeopardy.

Acknowledgements - funding and support of this project were provided from the Idaho Department of Fish and Game (IDFG), the Bureau of Land Management (BLM), and the University of Idaho. We especially thank D. Aslett and M. Sands of Sand Creek WMA, as well as the staff of the Idaho Falls office of IDFG. J. Gardetto of the BLM provided valuable information. J. Hearshaw and C. Kraft volunteered with data collection. This is Contribution 911 of the Idaho Forest, Wildlife and Range Experiment Station and Federal Aid in Wildlife Restoration Project W-160-R-15.

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