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FEDERAL AID IN WILDLIFE RESTORATION

UPLAND BIRD POPULATION DYNAMICS AND MANAGEMENT

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Period Covered: 01 February 1992 through 31 December 2001

Report Title: Changes in the Distribution and Abundance of Greater Sage-Grouse in Washington

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ABSTRACT

Greater sage-grouse (*Centrocercus urophasianus*) historically occurred in shrub-steppe and meadow-steppe communities throughout much of eastern Washington. The decline in distribution has been dramatic; 74% of 68 lek complexes documented since 1960 are currently vacant. Many vacant lek complexes (52%) are in areas where sage-grouse have been extirpated since 1960. The current range is about 8% of the historic range, occurring in 2 relatively isolated areas. Based on changes in number of males counted on lek complexes, the sage-grouse population size in Washington declined by approximately 85% from 1960 to 2001; the 2001 spring population was estimated to be about 700 birds. Historic and recent declines of greater sage-grouse are linked to conversion of native habitat for production of crops and degradation of the remaining native habitat. Although declines in populations of sage-grouse appear to be slowing, the small size and isolated nature of the 2 remaining populations may be a long-term problem. Management should be directed toward protecting, enhancing, expanding, and connecting the existing populations.

INTRODUCTION

Greater sage-grouse historically occurred in California, Oregon, Washington, Nevada, Idaho, Arizona, Utah, Montana, New Mexico, Colorado, Wyoming, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, British Columbia, Alberta, and Saskatchewan (Aldrich 1963). They have been extirpated from British Columbia, Arizona, New Mexico, Oklahoma, Kansas, and Nebraska (Connelly and Braun 1997; Braun 1998). All remaining populations have been reduced in size and distribution. Although populations in Wyoming, Montana, Colorado, Idaho, Utah, Oregon, California, Nevada, South Dakota, and North Dakota are considered sufficient to support hunting seasons (each $ 5,000 birds during breeding season except South Dakota and North Dakota), those in Washington, South Dakota, Alberta, and Saskatchewan are too small (each # 2,000 birds) (Braun 1998).

The range-wide reduction of greater sage-grouse has been caused by 3 primary factors. First, several million ha of native sagebrush-dominated shrub-steppe have been converted to cropland, primarily for production of wheat (Yocom 1956; Swenson et al. 1987; Dobler et al. 1996; Connelly and Braun 1997). Second, several million ha of the remaining shrub-steppe have been manipulated to remove sagebrush (Carr and Glover 1970; Klebenow 1970; Martin 1970; Wallestad 1975; Braun et al. 1977). Third, the quality of remaining shrub-steppe habitat has declined as a result of grazing pressure from livestock (Dalke et al. 1960, 1963; Klebenow 1969; Eng and Schladweiler 1972; Wallestad and Pyrah 1974; Wallestad and Schladweiler 1974; Beck 1977; Connelly et al. 1991).

Abundance and distribution of greater sage-grouse have clearly declined within Washington (Yocom 1956; Washington Department of Fish and Wildlife 1995; Hays et al. 1998). These declines led to the elimination of legal harvest in 1988 and state listing of sage-grouse as a threatened species in 1998 (Hays et al. 1998). Sage-grouse in Washington are also being considered for federal listing as a threatened or endangered species by the U.S. Fish and Wildlife Service (C. D. Warren, pers comm.). The objective of this report is to describe historic changes in distribution and abundance of sage-grouse that resulted in their 1998 listing and relate them to changes in habitat quantity and quality. An additional objective is to discuss the significance of this information in relation to development of management strategies necessary to recover greater sage-grouse in Washington.

METHODS

Lek surveys

Male sage-grouse congregate on lek sites during spring to perform breeding displays and to mate with females (Schroeder et al. 1999). Although most lek sites are traditional, some leks occasionally change or "shift" locations, as documented with observations of marked individuals between years (MAS, unpubl. data). In addition, some males attend temporary "satellite" leks until they are able to become established on relatively permanent "core" leks. Many of these specific sites form clusters defined here as "lek complexes". Although the definition of lek complexes is somewhat arbitrary, lek sites within a complex are usually < 3 km from one another. Lek complexes are clearly spatially separated from adjacent lek complexes by $ 6 km.

We examined survey results of complexes conducted between 1960 and 2001 (Washington Department of Fish and Wildlife 1995; Hays et al. 1998) to obtain information on sage-grouse distribution and populations. Most complexes surveyed prior to 1970 were relatively large and opportunistically visited by members of bird-watching organizations and personnel of the Washington Department of Fish and Wildlife (Department of Game previously). These surveys typically consisted of a single count of males attending a complex during the breeding season and did not represent a standardized effort. The Department of Fish and Wildlife expanded surveys from 1970 to 1991, including additional searches for new and/or previously undiscovered complexes and multiple ($ 3) visits to specific complexes. Some original data from the 1970s were lost so that only single "high" counts remain, despite many complexes having been observed on more than one occasion. During 1992–2001 personnel of the Washington Department of Fish and Wildlife and the U.S. Army attempted to visit all sage-grouse lek complexes in Washington on $ 3 occasions each year.

Distribution

We examined historic information on distribution of greater sage-grouse throughout Washington based on direct observations and published literature (McClanahan 1940; Yocom 1956; Aldrich 1963; Connelly and Braun 1997; Schroeder et al. 2000). Since most early descriptions of their range in Washington were based on relatively large-scale North American maps, they were often inaccurate. We refined the historic range of sage-grouse in Washington on the basis of occupancy information within areas not included on previous maps. We also removed some areas from the historic range that were unlikely to have supported sage-grouse.

Locations of lek complexes and > 1,000 miscellaneous observations of sage-grouse between 1990 and 2001 were used to define current distributions. All active lek complexes and virtually all recent observations were within the boundaries for the current populations. The current distribution excludes 21 observations associated with recently vacated leks or birds that appeared to be "wandering" long distances from existing populations.

Abundance

Numbers of males attending lek complexes were analyzed using the highest number of males observed on a single day for each complex for each year. Although this technique is used throughout the North American range of greater sage-grouse, it may have numerous biases (Jenni and Hartzler 1978, Emmons and Braun 1984). First, yearling males appear to visit lek complexes less frequently than adults. Second, the number (or proportion) of yearlings in the population is unknown. Third, attendance at complexes tends to peak relatively late in the breeding season. Fourth, the number of males not visiting lek complexes is unknown. Fifth, the maximum count of males on a lek complex tends to be positively correlated with the number of counts. Sixth, some males (particularly yearlings) visit more than 1 lek complex within a breeding season. All but the last of these potential biases would tend to produce relatively low estimates of the number of males in the population. Consequently, counts of males on leks are used to produce conservative estimates of population size.

Average attendance at all lek complexes was used to evaluate annual population changes and to provide a technique for comparing populations of sage-grouse in Washington with those in other regions (Willis et al. 1993, Braun 1995, Connelly and Braun 1997). Rates of change were estimated by comparing total number of birds counted at all lek complexes in consecutive years. Because sampling was occasionally biased by effort and/or size and accessibility of lek complexes, those not counted in consecutive years were excluded from the sample for a given interval. Annual rates of change were used to estimate spring populations backward between 2001 and 1960. The 2001 population was estimated by multiplying total number of males counted on all lek complexes in that year by 2.6; this assumes all males are counted and the male:female ratio is approximately 1.0:1.6 (Washington Department of Fish and Wildlife 1995; Hays et al. 1998; Schroeder et al. 1999). This male:female ratio was similar to ratios in the literature ranging between 1.0:1.1 and 1.0:2.6 (Girard 1937, Patterson 1952, Rogers 1964, Braun 1984).

Habitat

Primary habitats used by greater sage-grouse include shrub-steppe and meadow-steppe (Daubenmire 1970) as determined from research on radio-marked sage-grouse (Schroeder et al. 2000). Range-wide changes in habitat were examined with aid of the Thematic Mapper (TM) sensor on the Landsat satellite. Digital data (1993) from TM channels 3, 4, 5, and 7 representing reflective light energy from the red, near-infrared, and 2 mid-infrared wavelength bands, respectively, were used in an unsupervised cluster analysis which produced 175 possible habitat types (Jacobson and Snyder 2000). Field data from ground reconnaissance in 1995–97 provided characterization of these habitat types, and that information was used to combine slightly varying habitats into 4 general types including: 1) shrub-steppe (including meadow-steppe and steppe, Daubenmire 1970); 2) cropland; 3) CRP (federal Conservation Reserve Program in which cropland was converted to perennial grass; usually crested wheatgrass, *Agropyron cristatum*); and 4) other (wetland, barren, forest/shrub, and sand dunes).

RESULTS

Distribution

Most available evidence indicates that greater sage-grouse were once widely distributed throughout much of central and eastern Washington (Fig. 1). Early explorers and naturalists such as Meriwether Lewis, William Clark, and David Douglas observed large numbers of sage-grouse along the Columbia including the mouths of the Snake and Yakima rivers and in the Priest Rapids and Grand Coulee regions (Jewett et al. 1953; Yocom 1956). Early descriptions of the historic sage-grouse range were not consistent, particularly in southeastern Washington. Although Jewett et al. (1953) and Aldrich (1963) believed they once occupied all of Whitman, Columbia, and Walla Walla counties and most of Spokane, Garfield, and Asotin counties, Yocom (1956) suggested the original range was smaller. Our revised map differs from previous maps in numerous ways including addition of the Methow River corridor and reduction of the occupied area along the Washington-Idaho border. The estimated historic distribution of sage-grouse in Washington spanned 57,741 km^2.

Although changes in distribution of greater sage-grouse in Washington were noted as early as 1920 (Jewett et al. 1953), populations were not consistently monitored until 1960. We documented 68 lek complexes with 2,823 observations of displaying males between 1960 and 2001 (Fig. 1). Sage-grouse also were observed on 1,392 additional occasions in the same period. Fifty lek complexes active for at least 1 year during 1960-2001 (73.5%) are now vacant; 26 (52.0%) are outside the current distribution (Fig. 1). The remaining 24 vacant complexes (48.0%) appear to reflect declines in density within currently occupied portions of the range.

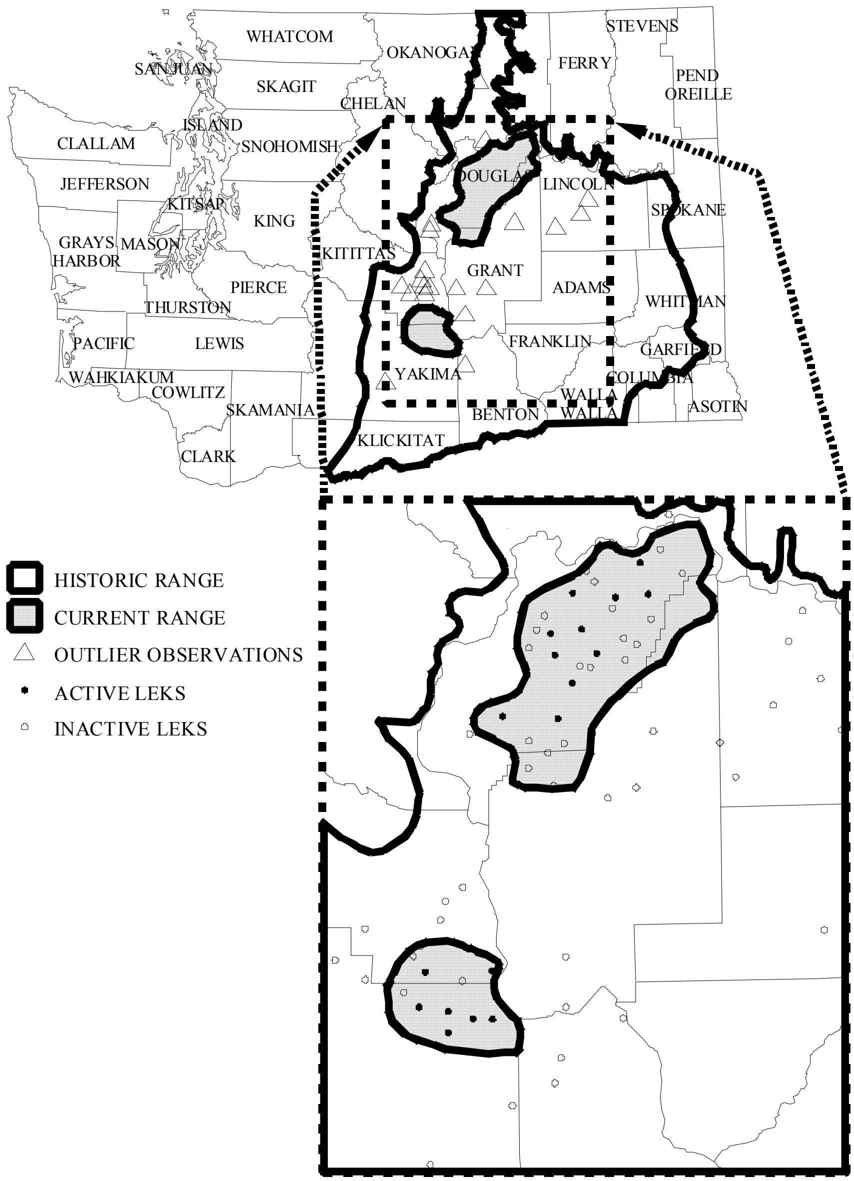

Fig. 1. Historic and current (2001) greater sage-grouse distribution in Washington. Inactive lek complexes were active for $ 1 year during 1960-2001.

Based on distribution of active lek complexes and 1,044 miscellaneous observations during 1990-2001, sage-grouse persist in 2 relatively isolated populations separated by about 50 km; Yakima/Kittitas (1,154 km^2 northeast of Yakima) and Douglas/Grant (3,529 km^2 northeast of Wenatchee) (Fig. 1). The current range of sage-grouse covers approximately 4,683 km^2 or about 8.1% of the historic range; they have been observed on 2,847 occasions within their current range since 1990. In contrast, they have been observed on only 21 occasions outside the current range in this period. There are at least 3 possible reasons for observations outside the current range. First, sage-grouse may move long distances between seasonal ranges and/or during dispersal (Connelly et al. 1988; Schroeder et al. 1999). For example, some observations may represent dispersal movements by sage-grouse through otherwise unacceptable habitat. Second, because of a relatively rapid contraction of known populations, some sightings of sage-grouse in former portions of their range may represent small, remnant, declining, and/or poorly understood populations. Third, some observations outside core areas may be misidentifications.

Abundance

The first declines in abundance were noted in the late 1800s on the western edges of the Palouse Prairie, with more recent declines observed throughout the Columbia Basin (Jewett et al. 1953; Yocom 1956). Although early declines in abundance were poorly documented, they resulted in increased hunting restrictions (Yocom 1956) with hunting closed throughout the state from 1933 through 1949. Although restrictive hunting seasons (season length, 2-11 days; bag limit, 1 bird) were reestablished between 1950 and 1987 (excluding 1957), all hunting was again closed in 1988 (Washington Department of Fish and Wildlife 1995).

Regional comparisons of populations revealed striking differences. The Lincoln/Grant County population declined 100% from an estimated 361 birds in 1970 to zero in 1985. The Yakima/Kittitas County population declined 60.9% from 711 birds in 1970 to 278 birds in 2001. The Douglas/Grant County population declined 75.8% from 1,635 birds in 1970 to 395 birds in 2001. A dramatic annual variation in population size is illustrated by the Douglas/Grant County population, which was lower in 1985-86 and in 1992-97 than in 2000.

An average of 12 active lek complexes were counted each year, 1960-2001, even though 9 of the first 10 years included counts of only 1 to 4 complexes. Although males on active complexes were counted an average of 5 times each year, some were counted more than 20 times, others only once. Because some original data for those counted on multiple occasions were lost, the average number of counts is a low estimate.

The average maximum count of males on lek complexes was 22.4 (95% CI = 20.7 - 23.9) for 519 annual counts between 1960 and 2001. The 2001 population estimate, based on counts of 379 male sage-grouse, was 673: 278 in the Yakima/Kittitas population and 395 in the Douglas/Grant population. The population declined an average of 3.2% (SE = 4.8%) per year from 1960 to 2001; it declined in 24 of 41 (58.5%) year-to-year intervals. These annual changes were used to back-estimate population size; the estimated population in 1960 was 4,353 (Fig. 2). The estimated decline was 84.5% between 1960 and 2001. The largest declines were observed during the 1960s and early 1970s, and again in 2001.

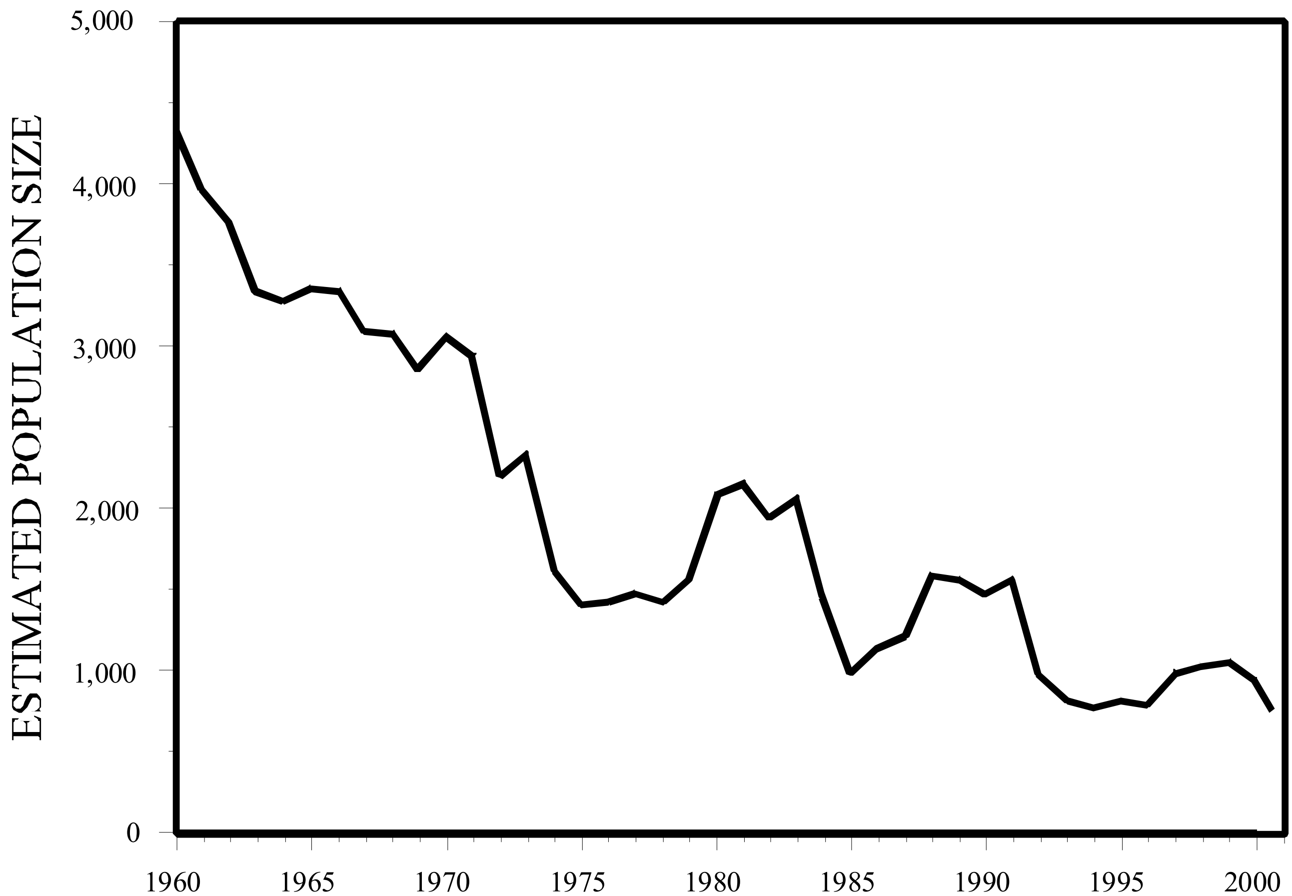

Fig. 2. Estimated greater sage-grouse population size in Washington, 1960-2001.

Habitat

Although habitat within the original range of sage-grouse in Washington was clearly dominated by shrub- and meadow-steppe (about 90%; Dobler et al. 1996), most habitat has been converted to cropland and is now used for the production of crops or is in CRP (Table 1). The first declines in distribution were related to cultivation of the Palouse Prairie, primarily for production of wheat. Declines continued as cultivation expanded throughout the Columbia Basin, initially for production of wheat and secondarily for irrigated crops including fruit. Irrigation was supported and expanded with reservoirs behind dams along the Columbia River, including the first and largest, Grand Coulee, completed in 1942. Many remaining areas of uncultivated habitat are unsuitable for sage-grouse because of the lack of sagebrush, perennial grasses, and/or forbs (Schroeder et al. 2000).

The current range of greater sage-grouse in Washington is characterized by 57.0% shrub-steppe (including meadow-steppe), 26.6% cropland, 13.0% CRP, and 3.4% other (Table 1). This is in contrast to areas where sage-grouse are extirpated; 42.3% shrub-steppe, 42.8% cropland, 5.5% CRP, and 9.4% other. The Yakima/Kittitas range is dominated by shrub-steppe habitat (96.6%) in a substantially higher proportion than in the Douglas/Grant distribution (44.3%). Sage-grouse appear to exist in the Douglas/Grant area due to the high quality and configuration of remaining shrub-steppe and relatively abundant CRP (16.7%).

Table 1. Historic and current habitat (1993 Thematic Mapper) in relation to historic and current distribution of greater sage-grouse in Washington.

Range or population of greater sage-grouse	Area dominated by each habitat (%)				Area (km^2)
	Shrub-steppe[a]	Cropland	CRP	Other	Total
Douglas/Grant population	44.3	35.1	16.7	3.9	3,529
Yakima/Kittitas population	95.6	0.5	1.9	1.9	1,154
Total occupied range	57.0	26.6	13.0	3.4	4,683
Unoccupied range	42.3	42.8	5.5	9.4	53,058
Historic range	43.5	41.5	6.1	8.9	57,741

[a]Shrub-steppe includes shrub-steppe, meadow-steppe, and steppe habitats described by Daubenmire (1970).

DISCUSSION

Although the current estimates of abundance (about 700) and distribution (2 isolated populations) likely are conservative, the dramatic nature of the sage-grouse declines in Washington are clear. For example sage-grouse are no longer regularly observed in portions of the range that were recently occupied. Most lek complexes documented since 1960 are now vacant. Similarly, although the population decline between 1960 and 2001 was estimated to be about 85%, it is likely that this estimate was too low. Sixteen lek complexes were not included in the analysis of past populations because there were no counts of males on them. Most of these complexes appear to have become vacant prior to 1980. If the 1960 population were re-estimated assuming that these extra complexes were of average size (22.6 males) in 1960 and vacant in 2001, the revised population decline would be closer to 96%.

Although over-harvest may have been a factor in the historic decline of greater sage-grouse in Washington (Yocom 1956), the clearest explanation for the decline is conversion of native shrub- and meadow-steppe habitat to cropland (Washington Department of Fish and Wildlife 1995, Dobler et al. 1996). The vast majority of cultivated land no longer supports sage-grouse. Cultivated land in the northern distribution of sage-grouse (Douglas/Grant County area) is a partial exception because of its favorable juxtaposition with the remaining native shrub- and meadow-steppe habitat. Sage-grouse have also benefitted in the Douglas/Grant County area because of re-vegetation of about 600 km^2 of cropland as part of the CRP. Although CRP habitat is often dominated by introduced species such as crested wheatgrass, some areas provide useful cover for nesting sage-grouse, especially when invaded by a diversity of plant species including sagebrush and forbs.

Most remaining shrub- and meadow-steppe habitat in Washington is associated with relatively steep topography and/or shallow soils that are difficult to cultivate (Dobler et al. 1996; JEJ, in prep.). Intensive grazing by horses, sheep, and cattle is one explanation for the inability of native habitats to support sage-grouse. Many areas that are lightly grazed now illustrate the aftereffects of a long legacy of heavy livestock grazing (such as reduced cover of forbs and perennial grasses); livestock were common in many areas of Washington long before 1900 (Daubenmire 1970). In the Douglas/Grant area, nesting sage-grouse typically avoid habitat with a history of heavy grazing (MAS, in prep.). In other large areas of shrub- and meadow-steppe such as the Yakama Indian Reservation, the Hanford Site (U.S. Department of Energy), and Lincoln County, sage-grouse have been extirpated in the last 40 years. In all 3 cases, grazing by livestock has been exacerbated by large wildfires. An exception is the region dominated by the Yakima Training Center (YTC, U.S. Department of Defense) in the

Yakima/Kittitas area. Sage-grouse have persisted here for 3 apparent reasons. First, steep, irregular topography has made some areas less accessible to livestock, safeguarding isolated pockets of native habitat. Second, military activities have closed some areas to grazing, which may have protected important habitats. Third, grazing frequency and/or intensity were limited in traditional military use areas to avoid compounding the impact of both training and grazing.

The future for sage-grouse on the YTC is uncertain. Although livestock grazing is no longer permitted, habitat restoration in areas with long histories of grazing is a long and difficult process (Daubenmire 1970). Additional risks include direct damage to habitat caused by military vehicles and increased risk of fires. Despite potential problems, the YTC is adjacent, or close, to other large tracts of federal and state land that have potential to be managed for the benefit of sage-grouse. These areas include the Hanford Site (U.S. Department of Energy); Arid Lands, Saddle Mountain, and Columbia National Wildlife refuges (U.S. Department of Interior); Yakima Indian Reservation; and Oak Creek, Wenas, Wahluke Slope, and Quilomene Wildlife areas (Washington Department of Fish and Wildlife).

The Douglas/Grant County population contrasts dramatically with the Yakima/Kittitas County population in that it is virtually all on private land. Nevertheless, many critical habitats are not at immediate risk. First, the best remaining shrub- and meadow-steppe habitats are relatively small and considered scablands; shallow soil and/or steep terrain have made them difficult to cultivate. Second, although some heavily grazed rangelands no longer support healthy communities of bunch grasses that are needed by nesting sage-grouse, they still provide critical winter habitat. Third, enrollment in CRP has been expanded by about 30% and extended until at least 2008; planting requirements have been strengthened to include greater plant diversity and emphasis on native species. Whether the CRP represents a long-term step toward the protection of sage-grouse is dependent on renewal of CRP in 2008.

Population viability also is an issue for greater sage-grouse in Washington. Research on greater prairie-chickens (*Tympanuchus cupido*) in Illinois indicates that small populations may have negative genetic and fertility responses to isolation (Bouzat et al. 1998; Westemeier et al. 1998). Since some have suggested breeding populations should contain at least 500 individuals (Franklin 1980; Frankel and Soulé 1981; Frankel 1983), it is clear that Washington populations are at risk; 278 in Yakima/Kittitas County and 395 in Douglas/Grant County. Because most male and some female sage-grouse do not breed successfully in their lifetime (MAS, in prep.), viable sage-grouse populations should probably include more than 700 individuals. Increased population viability of sage-grouse in Washington may be obtained by increasing the density of sage-grouse on currently occupied range, expanding the range into adjacent unoccupied habitats, and/or connecting the 2 existing populations with additional breeding habitat or substantial dispersal corridors.

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Report Title: Changes in the Distribution and Abundance of Columbian Sharp-tailed Grouse in Washington

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ABSTRACT

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) were historically found in shrub steppe, meadow steppe, steppe, and deciduous shrub communities throughout much of eastern Washington. The current range, consisting of 8 relatively small, isolated, remnant populations, is less than 3% of the historic range. Information collected since 1960 indicate declines in both distribution and abundance have been dramatic; 64% of 111 known lek complexes are currently vacant. Many of the vacant lek complexes (46%) are in areas where sharp-tailed grouse have been extirpated since 1954. Based on annual changes in number of birds counted on lek complexes, the number of sharp-tailed grouse in Washington declined by about 96% since 1960 to 448 birds in 2001. The historic and recent declines of sharp-tailed grouse appear to be linked to the dramatic declines in quantity of native habitat and degradation of the remaining native habitat.

INTRODUCTION

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) historically occurred in California, Oregon, Washington, Nevada, Idaho, Utah, Montana, Colorado, Wyoming, and British Columbia (Aldrich 1963). Although the historic range of Columbian sharp-tailed grouse is indistinct, it likely extended into northwestern New

Mexico (Dickerman and Hubbard 1994). By the early 1970s, Columbian sharp-tailed grouse were extirpated from California, Nevada, and Oregon. However, as a result of recent transplant efforts, a small population of sharp-tailed grouse has been reestablished near Enterprise, Oregon (Snyder et al. 1999). Efforts are also underway to reestablish sharp-tailed grouse near Jackpot, Nevada (S. Stiver, pers. comm.). All remaining populations of sharp-tailed grouse have been reduced in both numbers and distribution (Giesen and Braun 1993; Connelly et al. 1998; McDonald and Reese 1998). Although populations in British Columbia, Idaho, and Colorado are considered sufficient to support limited hunting seasons ($ 5000 birds in each population), populations in Washington, Montana, Utah, and Wyoming are too small (# 1000 birds) (J. W. Connelly, pers. comm.).

The abundance and distribution of Columbian sharp-tailed grouse have clearly declined within the state of Washington (Yocom 1952; Buss and Dziedzic 1955; Hays et al. 1998; Schroeder et al. 2000). In 1998, this decline lead to the state listing of the Columbian sharp-tailed grouse as a threatened species in Washington (Hays et al. 1998). The long-term decline in the status of sharp-tailed grouse has been attributed to the dramatic alteration of native habitat due to cultivation and degradation (Buss and Dziedzic 1955; McDonald and Reese 1998). The native habitats include grass-dominated nesting habitat and deciduous shrub-dominated wintering habitat, both of which are critical for sharp-tailed grouse (Giesen and Connelly 1993; Connelly et al. 1998). The objective of this report is to describe the historic changes in the distribution and abundance of Columbian sharp-tailed grouse that resulted in their 1998 listing and relate these changes to changes in habitat quantity and quality. An additional objective is to discuss the significance of this information in relation to the development of alternative management strategies necessary to recover sharp-tailed grouse in Washington.

METHODS

Distribution

We examined historic information on the distribution of sharp-tailed grouse throughout Washington based on direct observations and published literature (McClanahan 1940; Yocom 1952; Buss and Dziedzic 1955; Aldrich 1963; Zeigler 1979; Connelly et al. 1998; McDonald and Reese 1998). Because most of the earlier descriptions of the sharp-tailed grouse distribution in Washington were based on relatively large-scale maps of their distribution in North America, they were often inaccurate. Consequently, we refined the historic distribution of sharp-tailed grouse in Washington based on available information on their presence within areas that were not included on the previous maps. We also removed some areas from the historic distribution that were clearly mountainous and unlikely to have supported sharp-tailed grouse in the past.

We examined survey results of traditional display sites (leks) conducted between 1954 and 1999 (Washington Department of Fish and Wildlife 1995; Hays et al. 1998) to obtain information on changes in sharp-tailed grouse distribution and populations. Most of the leks that were surveyed between 1954 and 1969 were relatively large and opportunistically visited by members of bird-watching organizations and personnel of the Washington Department of Fish and Wildlife (Department of Game at that time). Surveys of leks prior to 1970 typically consisted of a single count of the birds attending a lek during the breeding season and they did not represent a standardized effort. The Washington Department of Fish and Wildlife and the Colville Confederated Tribes expanded the surveys between 1970 and 1989, including additional searches for new and/or previously undiscovered leks and multiple ($ 2) visits to specific leks. Between 1990 and 2001 personnel of the Washington Department of Fish and Wildlife, The Colville Confederated Tribes, and The Nature Conservancy attempted to visit all sharp-tailed grouse leks in Washington on $ 2 occasions.

Many leks occasionally change or shift locations on an annual basis (MAS, unpubl. data). Many of these specific annual locations form clusters of locations in which the most widely separated annual locations are # 1 km apart; these clusters are defined here as lek complexes. Although the definition of lek complexes is somewhat arbitrary, lek complexes are clearly spatially separated from each other. Lek locations and > 1,000 miscellaneous observations of sharp-tailed grouse between 1990 and 2001 were used to define current distributions. All of the active lek complexes and virtually all of the recent observations were within the boundaries for the current populations. The current distribution excluded 21 observations that were associated with recently vacated leks or birds that appeared to be “wandering” long distances from existing populations.

Abundance

Attendance numbers for lek complexes were analyzed by using the highest number of birds observed on a single day for each lek complex for each year. Average attendance at all lek complexes was used as a method to evaluate annual population change and to provide a technique for comparing populations of sharp-tailed grouse in Washington with populations in other regions (Connelly et al. 1998). Rates of population change were analyzed by comparing the total number of birds counted at all lek complexes counted in consecutive years; or in 2 cases in the 1960s, 2 year intervals.

Because sampling was occasionally biased by size and accessibility of lek complexes, lek complexes not counted in consecutive years or on both ends of a specific 2 year interval were excluded from the sample for that specific interval. Annual rates of population change were then used to estimate annual spring populations backward between 2001 and 1960. The 2001 initial population was estimated by multiplying lek attendance numbers for each lek complex by 2; this technique assumes that lek counts include mostly males and that the male:female sex ratio is approximately 1:1 (Hays et al. 1998).

Harvest information for sharp-tailed grouse in Washington was analyzed in relation to estimated population size and compared with estimates of harvest rate in other regions (Connelly et al. 1998). The primary reason for evaluating harvest was to determine if the estimates of past population size, and hence population declines, were realistic. Estimates of sharp-tailed harvest were only available for the 1974-1980 period in Washington; the harvest estimates were obtained with questionnaires sent to about 10% of the hunters as part of an annual assessment of harvest (Washington Department of Fish and Wildlife 1998). Data on bag checks of hunters between 1959 and 1980 were also compared with estimated population size. Because sharp-tailed grouse and sage grouse (*Centrocercus urophasianus*) were combined in a single prairie grouse category, only data from regions with substantially more harvested sharp-tailed grouse than sage grouse were included. Analysis of harvest data consisted of a correlation between spring population size and harvest (Proc CORR, SAS Institute 1988). Linear regressions of harvest data and population size in relation to year were done with year as the independent variable (Proc REG).

Habitat

Changes in habitat within the historic range of sharp-tailed grouse were examined with the aid of 1990 vegetation maps produced by the Interior Columbia Basin Ecosystem Management Project (ICBEMP) (Quigley et al. 1996) and interpreted by McDonald and Reese (1998). The habitat categories for ICBEMP included grassland, sagebrush (*Artemisia* spp.), herbaceous wetland, wetland shrub, cropland, and non-habitat (for sharp-tailed grouse). The potential habitats used by sharp-tailed grouse likely include grassland, sagebrush, herbaceous wetland, and wetland shrub, as determined with research on radio-marked sharp-tailed grouse (Oedekoven 1985; Marks and Marks 1988; Gardner 1997; McDonald 1998). Historic and current quantities of potential sharp-tailed grouse habitat were compared within the historic distribution.

Habitat within the historic and current distribution of sharp-tailed grouse was examined with the 1993 aid of the Thematic Mapper (TM) sensor onboard the Landsat satellite. Digital data from TM channels 3, 4, 5, and 7 representing reflective light energy from the red, near-infrared, and two mid-infrared wavelength bands respectively, were used in an unsupervised cluster analysis which produced 175 possible habitat types (Jacobson and Snyder 2000). Field data from ground reconnaissance during 1995-1997 provided characterization of these habitat types, and that information was used to combine these slightly varying types into 5 general habitat types including: 1) shrub steppe (including meadow steppe and steppe, Daubenmire 1970); 2) cropland; 3) CRP (federal Conservation Reserve Program in which cropland was converted to perennial grass; usually crested wheatgrass, *Agropyron cristatum*); 4) forest; and 5) other (wetland, barren, and sand dunes). CRP was included in the cropland category in the ICBEMP analysis.

RESULTS

Distribution

Most available evidence indicates that sharp-tailed grouse historically were widely and abundantly distributed throughout eastern Washington (Fig. 1). Lewis and Clark observed them on the plains of the Columbia (Bent 1932) and David Douglas observed large numbers while traveling on the Columbia River between The Dalles (Washington-Oregon border) and Kettle Falls (close to British Columbia) in 1826 and 1827 (Douglas 1914).

Because earlier descriptions of the historic distribution of sharp-tailed grouse in Washington often included mountainous areas that likely were not occupied and excluded areas that were apparently occupied (McClanahan 1940; Yocom 1952; Jewett et al. 1953; Aldrich 1963; McDonald and Reese 1998), the historic distribution was a modified version (Fig. 1). The revised map differs from previous maps in numerous ways including the addition of the Methow River corridor and the exclusion of the Blue Mountains and Kettle River Range; it spans 79,865 km^2.

One hundred eleven lek complexes in Washington were documented with 1,491 observations of displaying birds between 1960 and 2001 (Fig. 1). Sharp-tailed grouse were observed on 2,112 additional occasions during the same time period. Although most lek complexes consisted of only one known location, one lek complex consisted of $ 10 locations that appeared to move on an annual or biannual basis. Movements of lek locations appeared to be more common with smaller lek complexes or with leks monitored for many years. Seventy (63.1%) of the lek complexes are currently vacant (Fig. 1). Thirty-three (46.5%) of the vacant lek complexes are in portions of the historic range that are no longer occupied. The remaining 38 vacant lek complexes (53.5%) appear to reflect declines in density within occupied portions of the historic range.

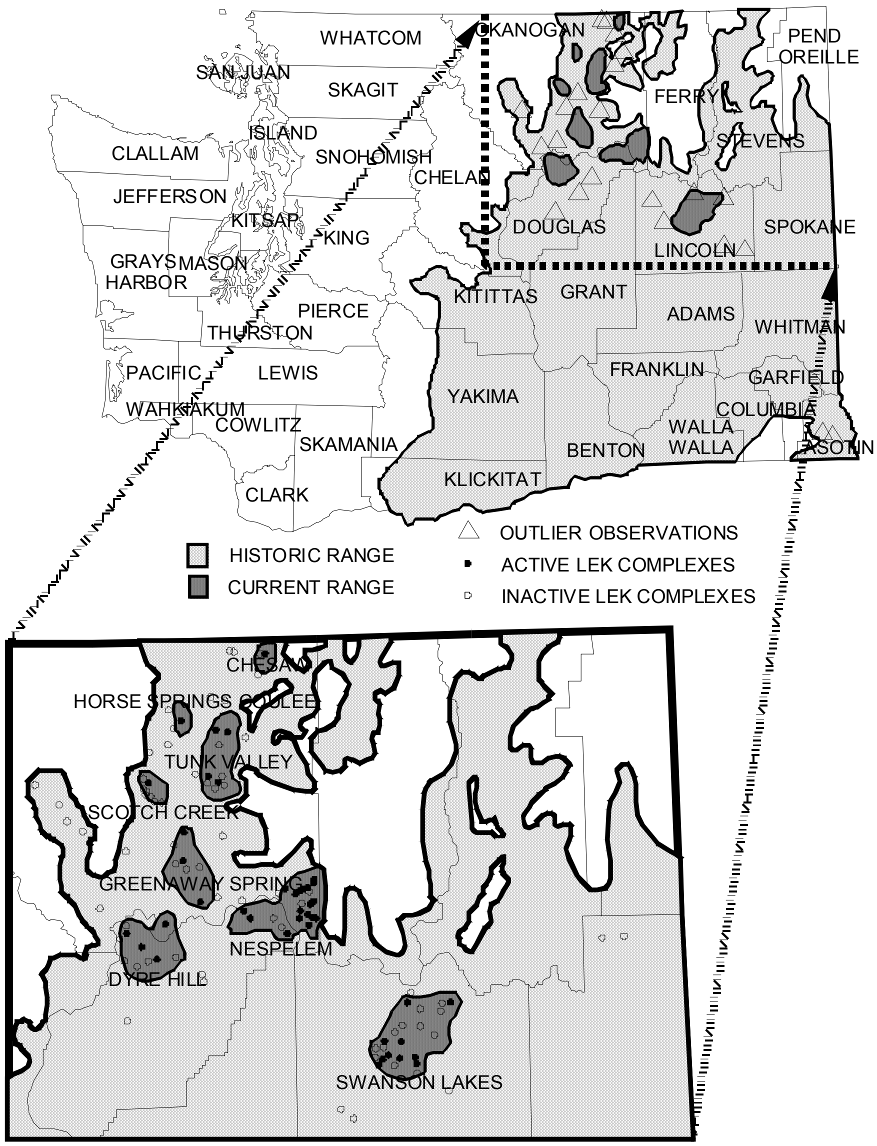

Figure 1. Historic and current distribution of sharp-tailed grouse in Washington, 2001. Inactive lek complexes were active for $ 1 year during 1960-2001.

Based on the distribution of active lek complexes and 1,897 miscellaneous observations between 1990 and 2001, sharp-tailed grouse appear to persist in eight relatively isolated populations that are separated by at least 20 km; Chesaw (70 km^2 area east of Oroville), Horse Springs Coulee (61 km^2 area west of Tonasket), Tunk Valley (342 km^2 area southeast of Tonasket), Scotch Creek (79 km^2 area northwest of Omak), Greenaway Spring (340 km^2 area southeast of Okanogan), Dyre Hill (308 km^2 area south of Brewster), Nespelem (513 km^2 area north of Grand Coulee), and Swanson Lakes (521 km^2 area west of Davenport) (Fig. 1). The current distribution of sharp-tailed grouse covers approximately 2,234 km^2 or about 2.8% of the historic distribution. A relatively recent and rapid decline in distribution is illustrated by 21 observations of Columbian sharp-tailed grouse outside the current distribution since 1990 (Fig. 1). Most of the recent observations outside the established range represent known populations that have disappeared or been reduced since 1990. In contrast, sharp-tailed grouse have been observed on 2,764 occasions within their current distribution since 1990.

Abundance

Major declines of sharp-tailed grouse appeared to occur throughout the Palouse prairie between the late 1800s and the 1920s (Buss and Dziedzic 1955). Declines in other portions of Washington were steady throughout most of the 1900's (McClanahan 1940; Yocom 1952; Aldrich 1963; Miller and Graul 1980). Although early declines in the abundance of sharp-tailed grouse were poorly documented, they resulted in increased hunting restrictions (Yocom 1952). Hunting of sharp-tailed grouse was terminated in Whitman County in 1919 and statewide between 1933 and 1952. Although restrictive hunting seasons (2 day length, 2-4 bag limit) were eventually re-established between 1953 and 1987 (excluding 1957) in portions of Okanogan, Lincoln, Grant, and Douglas counties, statewide hunting was terminated in 1988 (Washington Department of Fish and Wildlife 1995). Sharp-tailed grouse hunting is still permitted on the Colville Indian Reservation by Tribal members, but the harvest rate appears to be very low (MAM, unpubl. data).

The average maximum count of birds on lek complexes was 9.8 for 766 annual counts between 1960 and 2001. Counts on lek complexes averaged 6.8 for 22 leks in 2001. Average attendance at lek complexes between 1960 and 1999 tended to decline at an annual rate of 1.6%. The 2001 population estimate for Washington was 448.

Results for the analysis of annual changes in attendance at lek complexes indicate that the population declined an average of 4.9% (SE = 2.4%) per year between 1960 and 2001 (Fig. 2). The population declined in 28 of 39 (71.8%) year-to-year intervals (2 intervals were longer due to the lack of lek counts in 1967 1969). These annual changes were used to "back-estimate" the population; the estimated population in 1960 was 10,371. The overall population declined almost continually between 1960 and 2001, particularly during the 1960s and 1970s, when the estimated population declined from about 10,000 to less than 1,000 birds (Fig. 2). The overall estimated decline was 95.7% between 1960 and 2001.

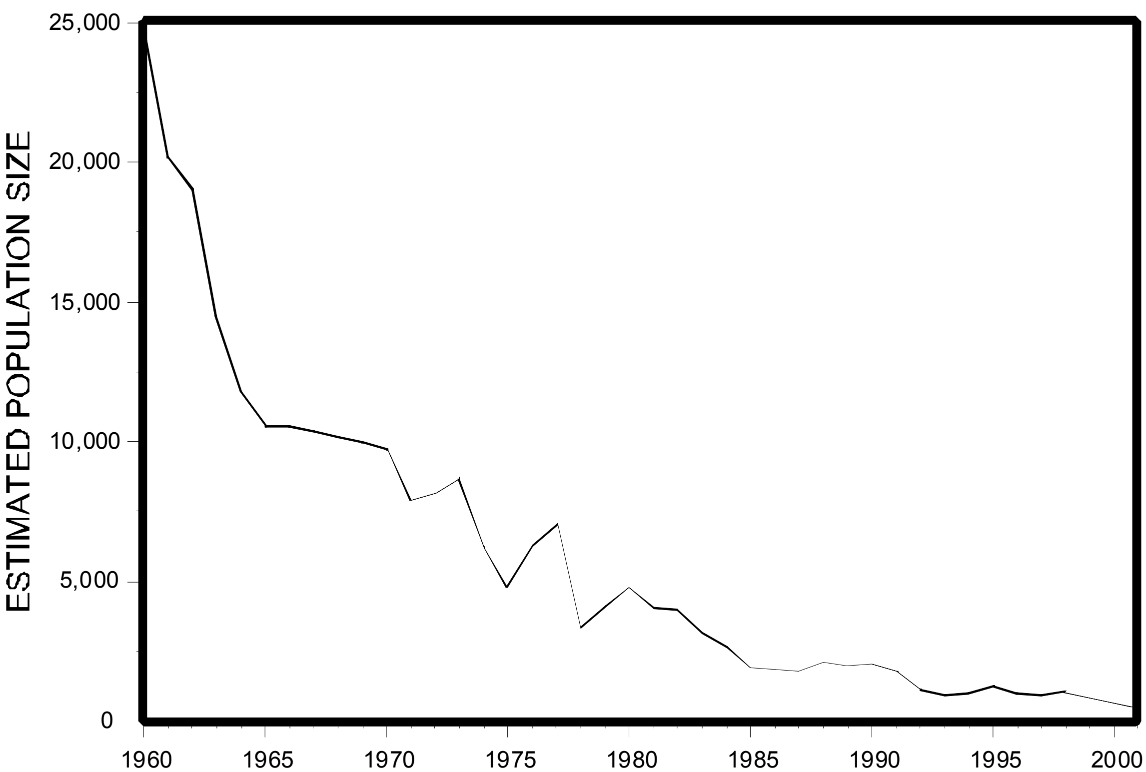

Figure 2. Estimated population size for sharp-tailed grouse in Washington, 1960-2001.

Harvest data collected during the 1974-1980 period indicated that the average annual harvest was about 467 birds; an average of 18.4% (SE = 1.6%) of the estimated spring population. There was no clear relationship between spring population size and harvest during the following autumn ($r^2 = 0.01$, $P = 0.80$), perhaps because the sample size was only 7. Regular bag checks of hunters during 1959-1980 resulted in observation of 294 (range of 1 - 38/year) prairie grouse (the vast majority sharp-tailed grouse). Estimated population size tended to be positively correlated with the annual number of prairie grouse in the bag check ($r^2 = 0.17$, $P = 0.06$). Number of prairie grouse in the bag check declined at a significant (r^2 = 0.24, P = 0.02) and comparable rate (66%) to the decline in the estimated population (81%) during the 1959-1980 interval.

Habitat

Historic densities of sharp-tailed grouse were likely highest where shrub steppe, meadow steppe, and steppe habitats were intermixed with riparian, mountain shrub, and forest edge habitats (Yocom 1952; Oedekoven 1985; Marks and Marks 1988; Meints et al. 1992; Giesen and Connelly 1993; Gardner 1997). Historic habitat (ICBEMP) within the historic distribution of Columbian sharp-tailed grouse consisted of 44.1% sagebrush, 25.0% grassland, 0.7% herbaceous wetland, 0.4% wetland shrub, and 29.8% non habitat (McDonald and Reese 1998). Current habitat (ICBEMP) within the historic distribution consisted of 15.6% sagebrush, 1.3% grassland, 0.0% herbaceous wetland, 0.1% wetland shrub, 51.2% cropland, and 31.8% non habitat (McDonald and Reese 1998). The overall habitat changes illustrate a 75.8% decline in native sharp-tailed grouse habitat from 70.2% in the late 1800s to 17.0% in 1990. These results are consistent with 1986 data illustrating a 59% loss of shrub steppe habitat due to cultivation in Washington (Dobler et al. 1996).

Habitats (TM) found within the current distribution of sharp-tailed grouse include 67.8% shrub steppe, 11.3% cropland, 5.2% CRP, and 14.2% forest (Table 1). This is in contrast to areas where sharp-tailed grouse are extirpated; 36.4% shrub steppe, 38.0% cropland, 4.4% CRP, and 17.7% forest. Primary sharp-tailed grouse habitats (shrub steppe and CRP) were 78.9% more common within occupied areas than unoccupied areas. Although the Dyre Hill area was relatively unusual in that there was 49.9% cropland, its abundant cropland appeared to be partially compensated for with 12.0% CRP (Table 1).

DISCUSSION

The maximum attendance of birds at lek complexes in Washington averaged 9.8 for annual counts between 1960 and 2001 and 6.8 for 22 counts in 2001. The estimates for Washington were generally lower than average counts of Columbian sharp-tailed grouse in other regions including 8.8 - 12.1 in Idaho (Parker 1970; Marks and Marks 1987), 9.9 - 11.4 in Colorado (Rogers 1969; Giesen and Braun 1993), 12.0 in Utah (Hart et al. 1950), and 7.9 - 17.2 in British Columbia (Ritcey 1995). Although estimates of annual variation in lek attendance are often used to evaluate population trends (Giesen and Braun 1993; Ritcey 1995; Connelly et al. 1998), average lek size can be influenced by the number of small or satellite leks that are occupied by young and/or subordinate males that are unable to become established on the primary leks (Rippin and Boag 1974). Data on average lek attendance also ignores lek complexes that become vacant, as shown in numerous situations in Washington. Consequently, it is likely that the best surveys of sharp-tailed grouse require a relatively complete count of birds on all leks in a region.

Table 1. Distribution of habitats (1993 Thematic Mapper) in Washington in relation to sharp-tailed grouse populations.

Range or population of sharp-tailed grouse	Area dominated by each habitat (%)					Area (km^2)
	Shrub-steppe[a]	CRP	Cropland	Forest	Other	Total
Total population	67.8	5.2	11.3	14.2	1.5	2,234
Tunk Valley	69.6	1.2	1.5	27.5	0.2	342
Greenaway Spring	78.7	2.1	3.6	14.5	1.2	340
Chesaw	4.6	3.9	0.0	49.9	0.2	70
Horse Springs Coulee	89.4	0.0	3.4	6.7	0.6	61
Scotch Creek	69.3	0.9	4.7	23.7	1.4	79
Dyre Hill	42.0	12.0	44.5	0.7	0.8	308
Nespelem	65.7	6.9	5.1	19.6	2.7	513
Swanson Lakes	77.0	5.6	13.0	2.4	2.0	521
Unoccupied range	36.4	4.4	38.0	17.7	3.4	77,631
Historic range	37.3	4.4	37.3	17.6	3.4	79,865

[a]Shrub-steppe includes shrub-steppe, meadow-steppe, and steppe habitats described by Daubenmire (1970).

The total number of Columbian sharp-tailed grouse in Washington was estimated to be 448 in 2001, consisting of eight relatively distinct populations. The distribution of sharp-tailed grouse declined about 97% from historic levels and the overall abundance declined about 96% since 1960. This observed decline is consistent with limited information from the declining numbers of prairie grouse in the bags of Washington hunters. The large magnitude of the downward trends in the distribution and abundance of sharp-tailed grouse in Washington indicate the overall conclusions are not likely to be altered by potential biases associated with lek counts including lek movement and detectability, variability in lek attendance by both males and females, and poorly defined male:female sex ratio.

The harvest rate of sharp-tailed grouse in Washington averaged 18% of the estimated spring population during 1974-1980 (only dates for which harvest statistics were available). Harvest rates of 3 - 10% of spring populations were observed for Columbian sharp-tailed grouse in Idaho (Connelly et al. 1998). The high estimate for harvest rate in Washington may have been the result of at least 3 possibilities including: 1) the overall population may have been underestimated; 2) the harvest may have been overestimated; and/or 3) harvest rate may have been relatively high. Although it is difficult to address the potential impact of harvest on the past sharp-tailed grouse populations (Yocom 1952), it is clear that most populations in Washington continued to decline, even though the last hunting season was in 1987.

The declining distribution and abundance of sharp-tailed grouse in Washington are clearly related to the long-term changes in habitat availability (Yocom 1952; Buss and Dziedzic 1955). The overall quantity of potential habitat has declined about 76% from historic levels (McDonald and Reese 1998) and the overall quantity of shrub steppe has declined about 59% (Dobler et al. 1996). The effects of widespread habitat alteration are clear in many areas, but particularly in Whitman County where sharp-tailed grouse were virtually eliminated as > 80% of the Palouse prairie was cultivated between the late 1800s and the 1920s (Buss and Dziedzic 1955). These observations are consistent with 1990 data showing that shrub steppe and CRP were about 79% more common within occupied areas than unoccupied areas. Although the primary factor resulting in the loss of native habitat was conversion of native habitat to dryland farming (Yocom 1952; Buss and Dziedzic 1955), dams along the Columbia River resulted in additional loss of habitat due to flooding and indirect loss of habitat due to expansion of irrigated farming.

Although habitat quality is difficult to measure on a large scale, declining quality of shrub steppe habitat in eastern Washington appears to be a significant factor in the decline of numerous species, including sharp-tailed grouse (Dobler et al. 1996). Numerous factors have been identified to explain the declining suitability of shrub steppe habitat including: 1) removal of sagebrush as part of various agricultural practices; 2) degradation of native habitat as a result of livestock overgrazing; and 3) fragmentation of native habitat into small, isolated patches (Hays et al. 1998).

The long-term prospects for management of sharp-tailed grouse habitat and populations are complicated by land ownership, current land-use realities, and small isolated populations. Twenty-one of the 41 active leks (51.2%) are on private land, 9

(22.0%) are on state or federal land, and 11 (26.8%) are on Colville tribal land. Three of the remaining 8 populations are dominated by state land, one is dominated by state and federal land, and one is dominated by Colville tribal land. The 3 populations < 100 km^2 in size (Chesaw, Horse Springs Coulee, Scotch Creek; Table 1) may be too small to support viable populations (Hamerstrom et al. 1957; Bouzat et al. 1998; Westemeier et al. 1998). All current populations appear to be separated from the nearest population by distances of $ 20 km; a substantial quantity of the habitat between existing populations consists of wheatfields, orchards, and reservoirs associated with dams. Although much of the habitat management on state, federal, and tribal land is currently designed to benefit sharp-tailed grouse, it may be critical to expand management to incorporate both public and private lands into integrated management areas that are large enough to support viable populations (Hamerstrom et al. 1957; Westemeier et al. 1998).

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Job Title: Job 1. Continue analysis and publication of research on sage grouse and Columbian sharp-tailed grouse in north-central Washington

Period Covered: 01 February 1992 through 31 December 2001

Report Title: Dispersion of nests in relation to leks for greater sage-grouse in fragmented habitat in north-central Washington

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ABSTRACT

Management guidelines for prairie grouse in general, and greater sage-grouse (*Centrocercus urophasianus*) in particular, often recommend using lek locations to predict critical nesting areas. For example, sage-grouse management guidelines published in 1977 recommended treating all habitat within 3.2 km of a lek location as potential breeding habitat. Revised guidelines in 2000 expanded this definition to include potential breeding habitat within 5.0 km of a lek location in situations where habitat is not uniformly distributed. These recommendations were based on research showing that most females nest relatively close to leks. Because most research on sage-grouse has been conducted in relatively continuous habitat, I examined the dispersion of nests in relation to lek locations in a highly fragmented landscape in north-central Washington. A total of 204 nests for 82 females were observed during 1992-1998. The average distance between the first nest for each female and the lek where she was captured was 7.3 km and the average distance to the nearest lek was 5.1 km. Approximately 74% of all 204 nests were > 3.2 km from the nearest lek and 46% were > 5.0 km from the nearest lek. Thus, 93 of 204 nests were in habitat not protected by the 5 km guidelines. Although nest sites tend to be closer to leks than random points, these results indicate that use of an arbitrary radius around lek locations will not efficiently encompass potential breeding habitat. Ongoing efforts to delineate specific habitats with the use of satellite imagery are likely to be more effective for identifying critical habitat.

INTRODUCTION

Populations of greater sage-grouse (Centrocercus urophasianus) are declining throughout substantial portions of their distribution (Connelly and Braun 1997). These declines have been attributed to widespread habitat conversion and degradation (Braun 1998). Losses in habitat quantity and quality subsequently have resulted in reduced success of nests and broods, both of which are believed to be factors in the population declines (Connelly et al. 1991, Gregg et al. 1994, Schroeder 1997, Aldridge 1998).

Guidelines for management of greater sage-grouse habitats published in 1977 recommended protection and maintenance of potential breeding habitats within 3.2 km of traditional display sites, or leks (Braun et al. 1977). The guidelines were expanded in 2000 to include habitat within 5.0 km of leks in areas where habitat was not uniformly distributed (Connelly et al. 2000). Unfortunately, there are few data that support or contradict these recommendations.

This research evaluated the distribution of nests in relation to lek location in north-central Washington. Because the area is clearly fragmented (Jacobson and Snyder 2000), it offers a comparison to previous research that has been conducted in relatively continuous habitat. Several factors are considered including year, age, nest order, lek where captured, and nearest lek. The ultimate objective is to determine the best and/or most efficient management strategy for delineating potential nesting habitat.

METHODS

Greater sage-grouse were studied on a 3,529 km^2 area centered near the town of Mansfield in Douglas County, Washington (47^{o}50'N, 119^{o}40'W, Fig. 1). This area defines a continuous population of sage grouse that is separated from the nearest adjacent population approximately 50 km to the SSW (Schroeder et al. 2000). The habitat consists of a fragmented mix of dryland wheat (35%) and shrub-steppe habitat (44%) dominated by big sagebrush (*Artemisia tridentata*), threetip sagebrush (*Artemisia tripartita*), bluebunch wheatgrass (*Agropyron spicatum*), and bluegrass (*Poa* spp.). Most of the remaining habitat (17% of total area) consists of cropland that was converted to the federal Conservation Reserve Program (CRP) in the 1980's and is dominated by planted grasses such as crested wheatgrass (*Agropyron cristatum*). The three basic habitat types are interwoven throughout the area in a pattern of fragmentation that is very unusual for an extant population of greater sage-grouse (Jacobson and Snyder 2000).

Greater sage-grouse were trapped on seven different traditional display sites (leks) with the aid of walk-in traps (Schroeder and Braun 1991) during March and April, 1992-

1996 (Fig. 1). An additional 5 leks were not used for trapping because of low number of birds and/or inaccessibility. Sex and age were determined for all captured sage-grouse (Beck et al. 1975); all females were fitted with battery-powered radio transmitters attached to poncho-like collars (Amstrup 1980) or necklaces.

Females were located with a portable receiver and 4-element Yagi antenna at least once every three days to collect data on nest location and success. Nests were considered successful if \$ 1 egg hatched. Most females were located either visually or with triangulation techniques designed to determine whether the female was on her nest. Variation in intensity of transmitter signals also was used as an indication of female behavior; radio transmitters emitted a constant signal when a female was on her nest and a variable signal when she was walking or flying. Fixed-wing aircraft were used to locate lost birds. "Visual" observations of females on nests consisted of triangulation from a distance of about 20-30 m from the nest site; this minimized disturbance of females and allowed nest sites to be located following hatch or failure. All locations were recorded to the nearest meter using Universal Transverse Mercators (Zone 11).

Analysis of nest distribution in relation to lek location was conducted with general linear models (Proc GLM, SAS Institute 1989). Independent variables included age, year, the lek location where each female was captured, and the lek location closest to each female□s nest. In situations where statistical independence was critical, only a female□s first detected nest location was used in the analysis. Distances between nests and the nearest lek were examined in relation to the proportion of potential nesting habitat with 5 km of each lek. Potential habitat included all shrub-steppe and CRP, which supplied the general habitat for 203 of 204 nests. Habitat abundance was determined with 1993 satellite imagery based on earlier research (Jacobson and Snyder 2000, Schroeder et al. 2000).

The observed distribution of nest locations was compared with two different sets of 1000 randomly generated nest locations. The first set of random locations consisted of points randomly placed within the overall population perimeter (3,529 km^2, Fig. 1). The second set of random locations consisted of points randomly placed within a minimum convex polygon defined by the outermost leks (n = 5, Fig. 1). Results were considered significant at α # 0.05.

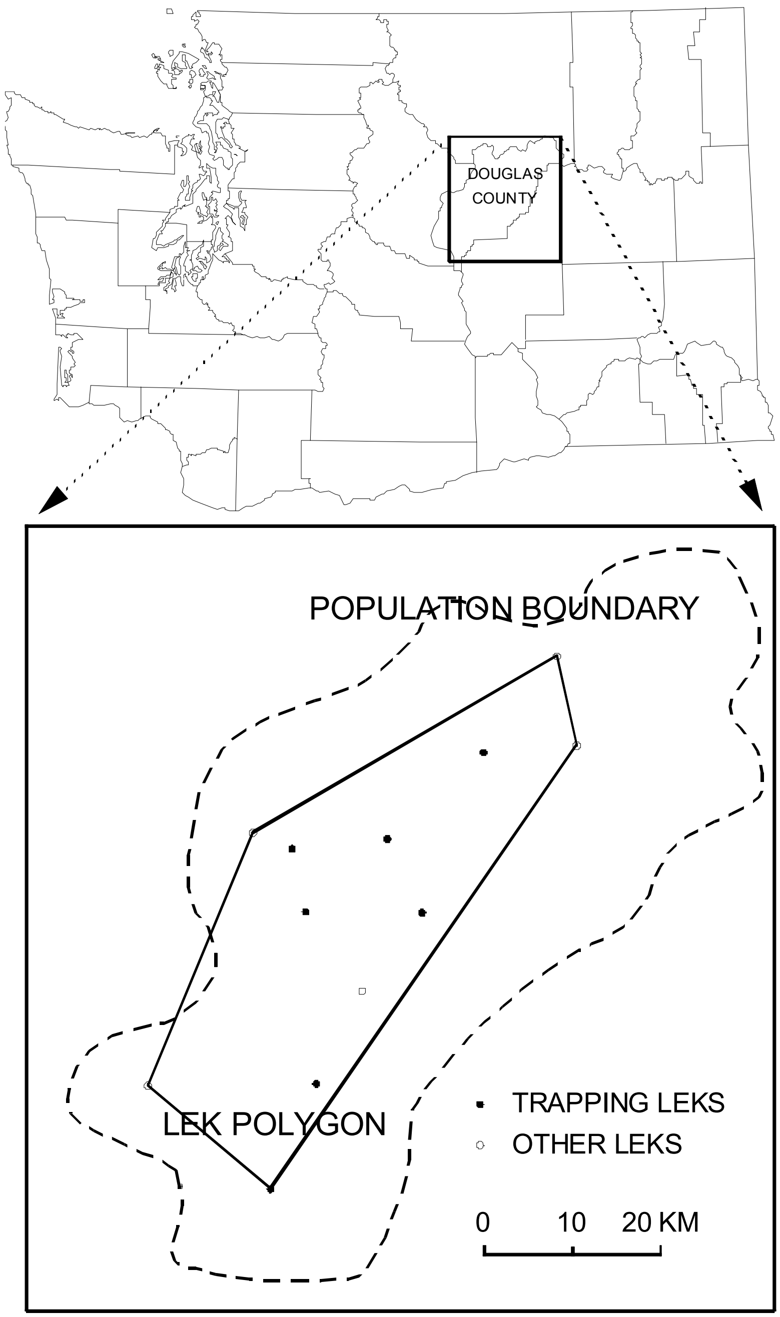

Fig. 1. Location of greater sage-grouse study area(s) and leks in north-central Washington, 1992-1998.

RESULTS

Eighty-eight female greater sage-grouse were captured on leks and fitted with radio transmitters: 20 adults and 2 yearlings in 1992; 12 adults and 4 yearlings in 1993; 12 adults and 9 yearlings in 1994; 9 adults and 12 yearlings in 1995, and 7 adults and 1 yearling in 1996. Nest data were obtained for 82 radio-marked females (Fig. 2); this sample did not include 5 females that died prior to being located at a nest site and 1 female that disappeared (damaged radio transmitter and/or undetected movement). Because many females were observed on multiple nests (within and between years), a total of 204 nests were found for radio-marked females; 25 in 1992, 30 in 1993, 37 in 1994, 55 in 1995, 42 in 1996, 14 in 1997, and 1 in 1998. Individual females were found nesting up to 6 times and monitored for up to 4 breeding seasons.

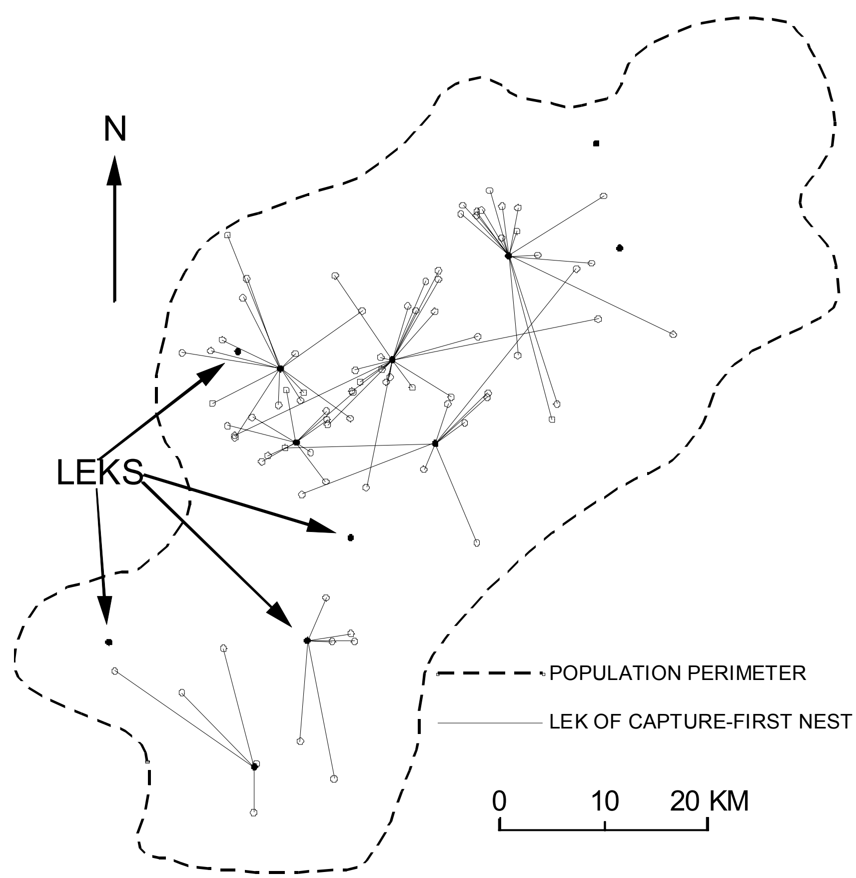

Fig. 2. Distribution of greater sage-grouse nests (only first nest for each female) in relation to lek where each female was captured in north-central Washington, 1992-1996.

The average distance between 204 nests and the lek where each female was captured was 7.68 km (median = 6.51 km, SD = 5.55 km). When only the first discovered nest for each female was used (*n* = 82), the average nest - capture lek distance was 7.26 km (median = 6.27 km, SD = 4.62 km). Age (F = 1.193, df = 1, P = 0.278), year (F = 1.120, df = 4, P = 0.353), and capture lek (F = 1.025, df = 6, P = 0.416) were not significant explanations for the variation in nest - capture lek distance (Fig. 3). In addition, direction of movement between a female's first nest and the lek where she was captured was not noticeably different than random (χ^2 = 3.463, df = 7, P = 0.839).

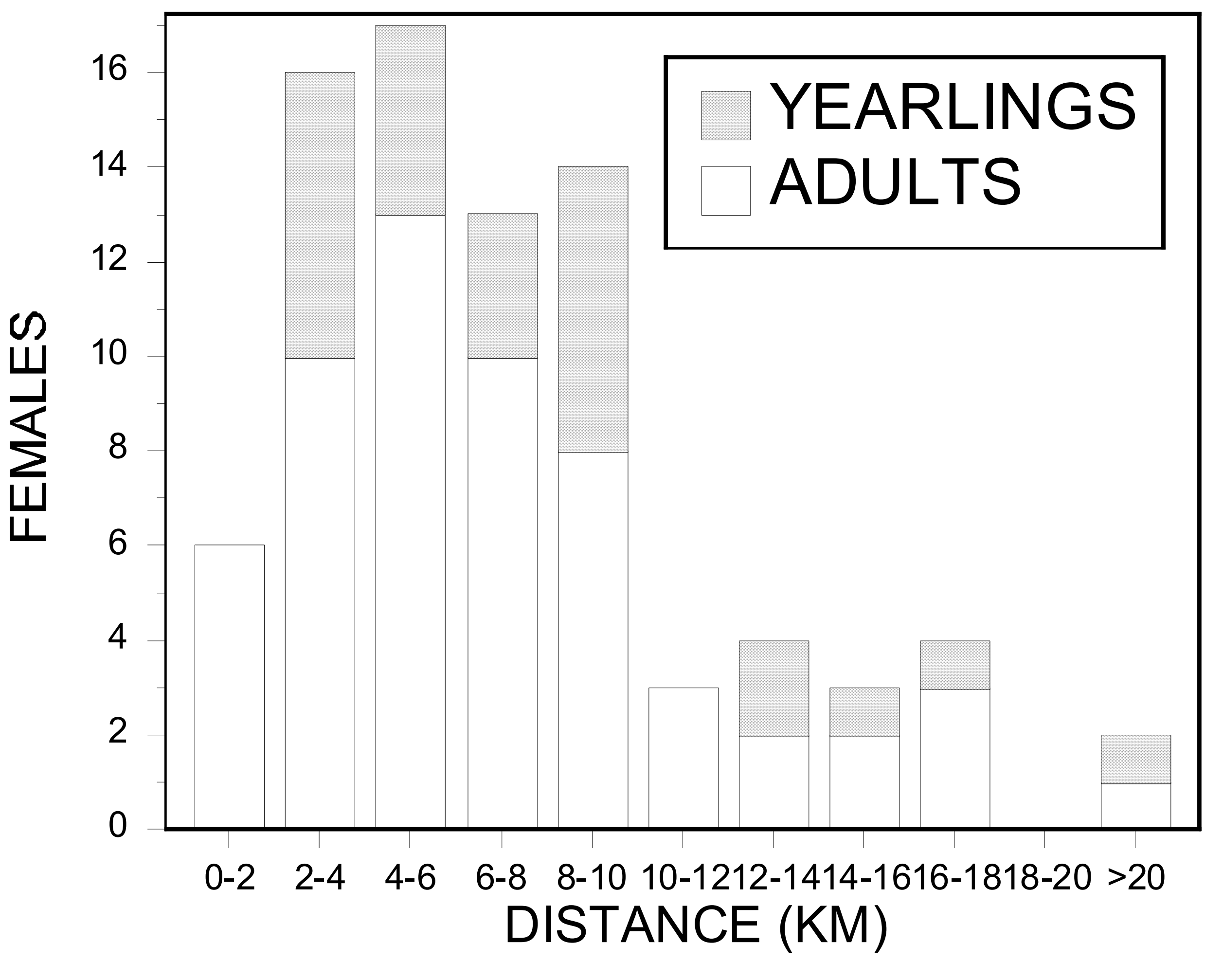

Fig. 3. Distribution of distances between 82 greater sage-grouse nest sites and leks where each female was captured in north-central Washington, 1992-1996.

The average distance between 204 nests and the nearest lek was 4.99 km (median = 4.91 km, SD = 2.68 km). When only the first discovered nest for each female was used (*n* = 82), the average nest - nearest lek distance was 5.06 km (median = 4.84, SD = 2.58 km); significantly less than the distance been nests and the lek where each female was captured (*t* = 3.758, P < 0.001, Fig. 4). This data is supported by the observation of 39 out of 82 females (47.56%) nesting closer to a different lek than the lek where they were captured. Age (*F* = 0.338, df = 1, *P* = 0.563), year (*F* = 0.667, df = 4, *P* = 0.617), capture lek (*F* = 0.904, df = 6, *P* = 0.497), and nearest lek (*F* = 1.325, df = 11, *P* = 0.229) were not significant explanations for the variation in nest - nearest lek distance.

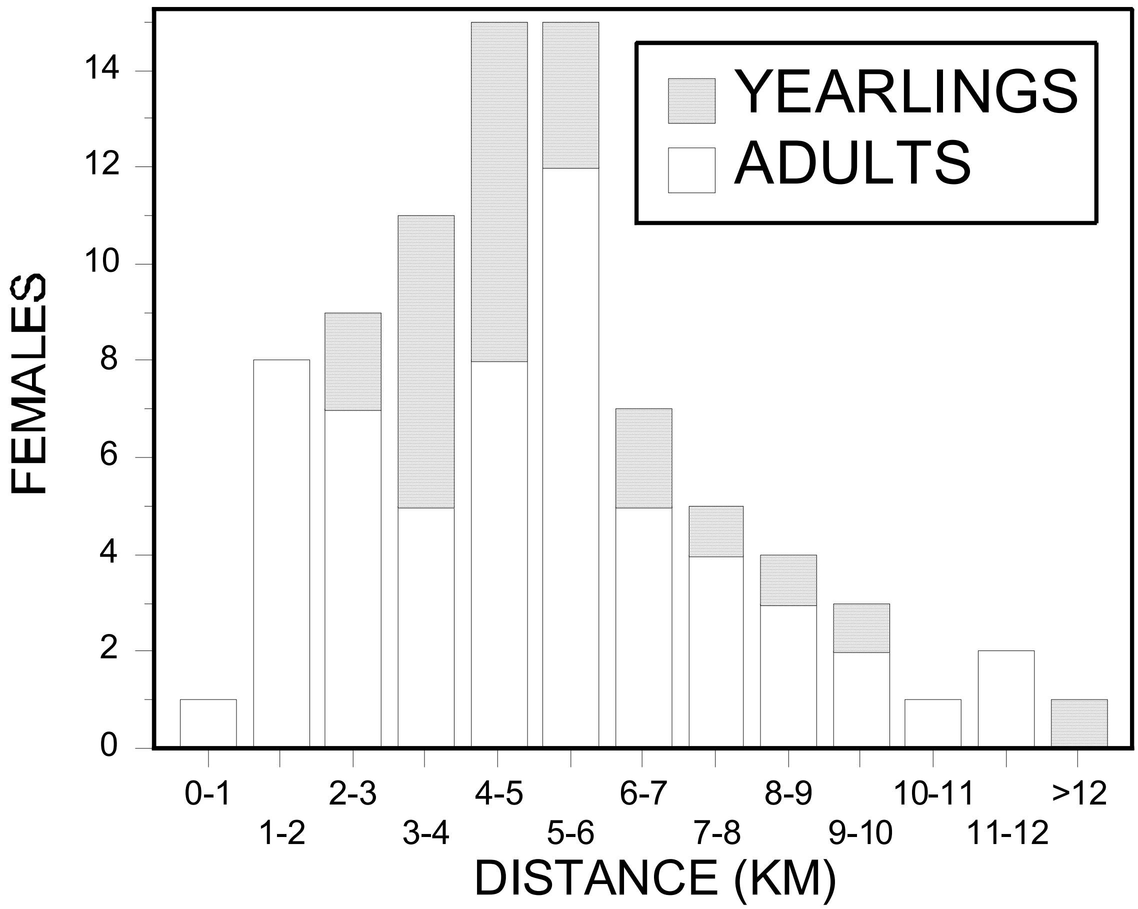

Fig. 4. Distribution of distances between 82 greater sage-grouse nest sites and nearest leks in north-central Washington, 1992-1996.

Habitat also was examined as a possible explanation for variation in nest-lek distances. The proportion of potential nesting habitat (shrub-steppe and CRP) within 5 km of the 12 leks in north-central Washington varied from 39.84 - 96.72%. The average distance between nests and the nearest lek was not significantly related to the proportion of potential nesting habitat for each lek ($F = 1.290$, df = 1, $P = 0.259$, Fig. 5).

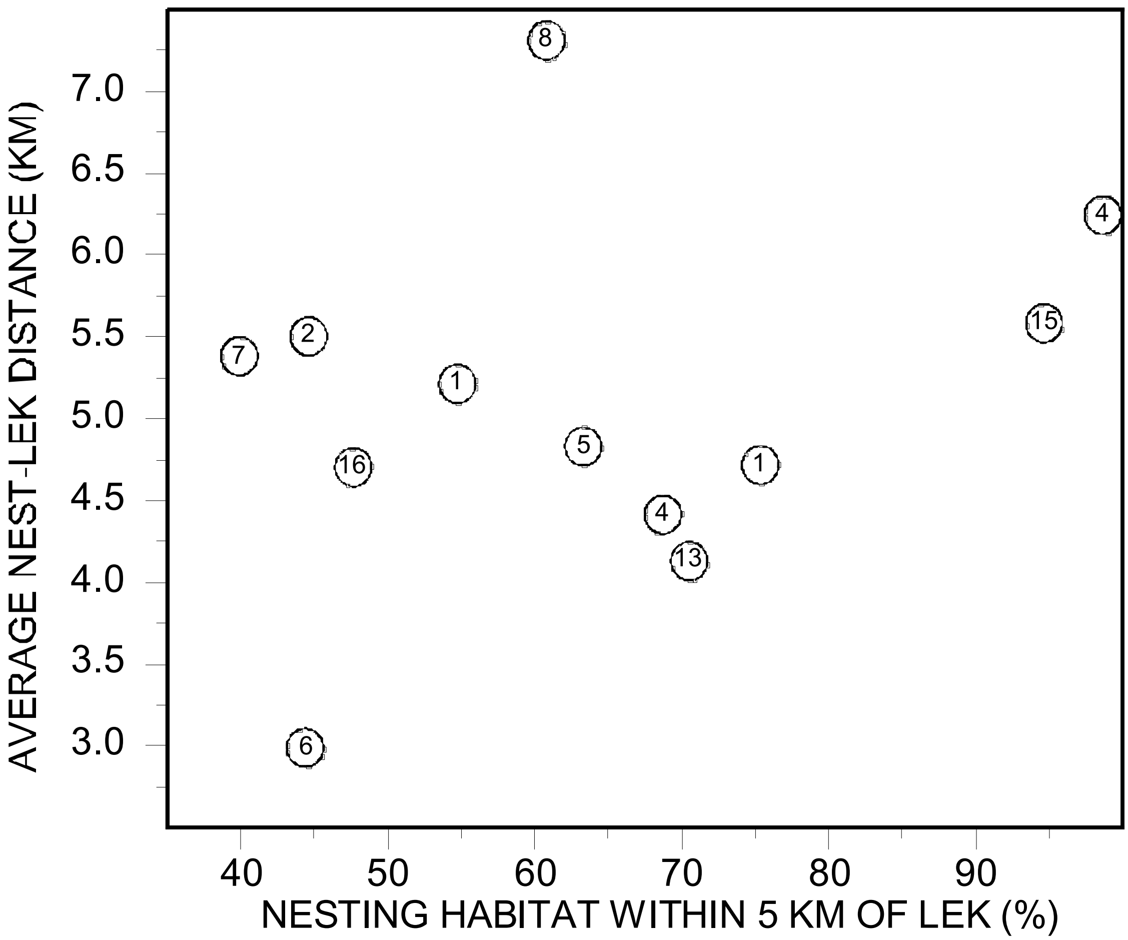

Fig. 5. Relationship between proportion of potential nesting habitat within 5 km of each lek and the average distance to the nearest nesting female greater sage-grouse in north-central Washington. Sample size for each lek is given in circle.

Random locations within the perimeter for the overall population of greater sage grouse in north-central Washington (Fig. 1) were 6.39 km from the nearest lek ($n = 1000$, SD = 2.940 km, Fig. 6). The average random location - nearest lek distance was significantly larger than the actual nest - nearest lek distance ($t = 4.431$, $P < 0.001$).

When 1000 random locations were placed within a convex polygon defined by the 5 outermost leks in the population (Fig. 1), the average random location - nearest lek distance was 5.610 km (SD = 2.761 km, Fig. 6). The average random location - nearest lek distance was not significantly larger than the actual nest - nearest lek distance (t = 1.849, P = 0.068).

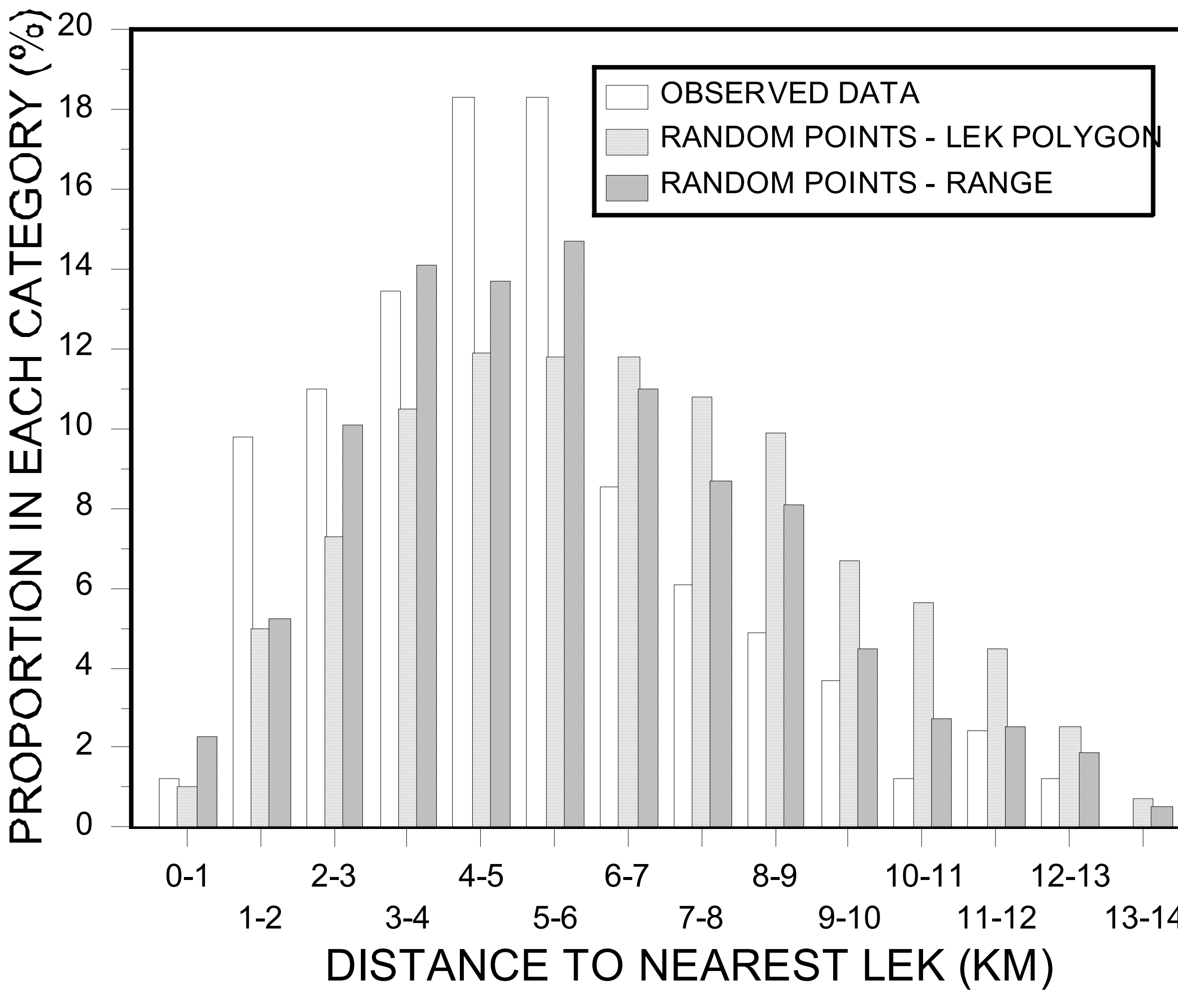

Fig. 6. Distribution of distances between 82 greater sage-grouse nest sites and nearest leks in relation to distances between 2 sets of 1000 random points and the nearest lek; one set selected within a minimum convex polygon around the 5 outmost leks and one set selected within estimated population range.

DISCUSSION

The distances between nests and the leks did not appear to be influenced by age, year, lek where captured, and/or the lek nearest the nest in north-central Washington. These average nest-lek distances were relatively large when compared with other populations of greater sage-grouse (Table 1). One possible explanation for the difference is that only 44.3% of the native shrub-steppe habitat remains in north-central Washington (Schroeder et al. 2000) and that much of the remaining habitat is highly fragmented (Jacobson and Snyder 2000). In contrast, most earlier research was conducted on areas where the vast majority of the habitat was intact. Another possibility for the large nest-lek distances in north-central Washington is that some of the leks have been disappearing because of long-term population declines (Schroeder et al. 2000). Although the loss of leks would result in increases in nest-lek distances, it is likely that the population declines and habitat loss/fragmentation are not independent factors.

Table 1. Distribution of nests in relation to leks for several studies of greater sage-grouse.

		Nest-capture lek distance		Nest-nearest lek distance	
Study	State	*n*	Distance (km)	*n*	Distance (km)
This study	Washington	82	7.3	82	5.1
Fischer 1994	Idaho	94	3.4	110	1.3
Wakkinen 1990, Wakkinen et al. 1992	Idaho	36	4.6	37	1.5
Autenrieth 1981	Idaho			306	3.4
Wallestad and Pyrah 1974	Montana	22	2.6		
Petersen 1980	Colorado	28	4.0	28	2.8

Although regional differences in habitat abundance and availability may explain some of the general trends in nest-lek distance, habitat distribution was not very successful in explaining variation within the north-central Washington population. There was no clear relationship between abundance of potential nesting habitat within 5 km of leks and nest-lek distance despite variation in habitat availability between 40 and 97%. Possible reasons for this lack of a detectable difference are varied but include the lack of differentiation within general habitat categories based on quality. For example, the quality of shrub-steppe and CRP as nesting habitat varies dramatically within north-central Washington and this qualitative information could not be included in this analysis.

Comparisons of the actual data on nest-lek distances with random points indicated that the observed nests were not randomly distributed throughout the study area. This observation appears to be due, in part, to the process for selecting the study area perimeter. For example, the population perimeter was determined with the aid of radio-marked birds tracked throughout the year, including the winter (Schroeder et al. 2000). This may have resulted in a perimeter that encompasses substantial quantities of habitat that are not used regularly by nesting females. Evaluation of the available data on nests (Fig. 2) indicates that nest density may be relatively low in the outer portions of the population. However, it must also be noted that the trapping effort was lighter (or absent) on the peripheral leks. When a minimum convex polygon surrounding the outmost leks was used to select random points (Fig. 1), the resulting distributions of observed and random nest-lek distances were comparable. This similarity occurred despite the fact that the minimum convex polygon encompassed some habitat that was outside the defined population. When the potential biases in the methodologies for selecting random points are considered, it is clear that is difficult to predict the distribution of nests, based on lek location, at least on a local basis. These results are comparable with research from California (Bradbury et al. 1989) and Idaho (Wakkinen et al. 1992) suggesting that nest site selection may be somewhat independent of lek location.

MANAGEMENT IMPLICATIONS

This research has significant implications on the management of greater sage-grouse in north-central Washington, and in other regions as well. Current guidelines for the management of greater sage-grouse habitats recommend protection of suitable habitats within 5 km of all occupied leks in areas with habitat that is not uniformly distributed (Connelly et al. 2000). These guidelines represent an expansion of the area protected from previous research and guidelines recommending protection of habitat within 3.2 km of leks (Braun et al. 1977). These guidelines may not be sufficient to protect enough habitat for greater sage-grouse in the fragmented areas of north-central

Washington. A radius of protection of 3.2 km would include 26.0% of the 204 nests found in this study and a radius of 5.0 km would include 54.4% of the nests (Fig. 7). In order to encompass 80% of the nests, a radius of 6.8 km would be needed; 12.8 km would be needed to encompass all the nests found in this study.

The large areas of protection needed around leks indicate that mapping of critical habitats, regardless of lek location, may be a more efficient method for selecting habitat for protection rather than selecting an arbitrary perimeter around a lek. The former technique also provides the advantage of being technically feasible with current satellite and Geographical Information Systems Technology (Jacobson and Snyder 2000) and in targeting specific habitats, regardless of their proximity to active leks. In contrast, selection of an arbitrary radius around a lek may result in protection of habitat that is not needed for, or selected by, greater sage-grouse. For example, approximately 37% of the habitat within 5 km of the 12 leks in north-central Washington is cropland, primarily winter wheat. Furthermore, if a larger radius is used (such as 10 km), the areas of protection around each lek will overlap each other, include areas outside the estimated population perimeter (Fig. 1), and not include habitat inside the estimated population perimeter.

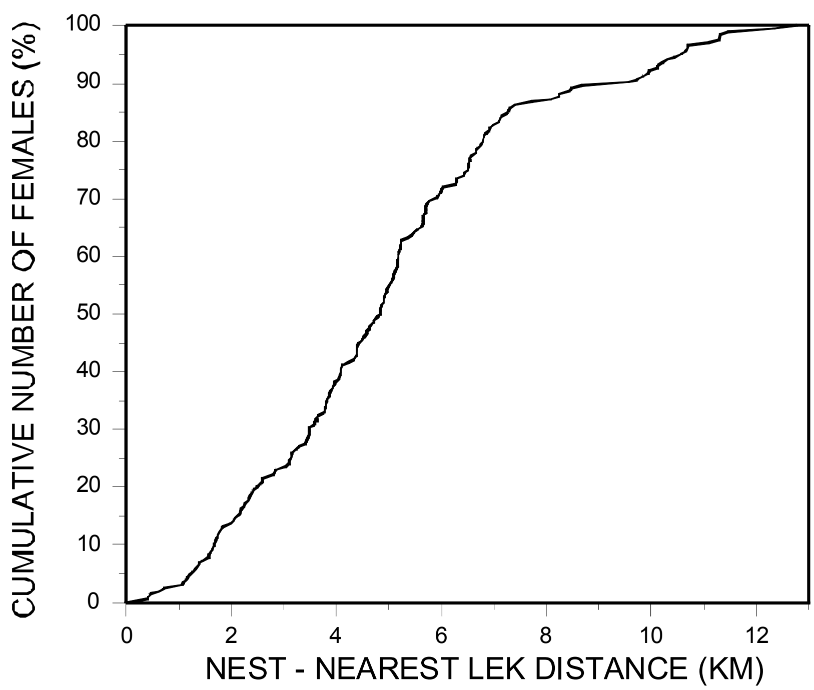

Fig. 7. Cumulative nest-nearest lek distances for 204 greater sage-grouse nests in north-central Washington, 1992-1998.

ACKNOWLEDGMENTS

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Job Title: Job 1. Continue analysis and publication of research on sage grouse and Columbian sharp-tailed grouse in north-central Washington

Period Covered: 01 February 1992 through 31 December 2001

Report Title: Fidelity of greater sage-grouse to breeding areas in a fragmented landscape in north-central Washington

Author: Michael A. Schroeder and Leslie A. Robb

Personnel: Marc Hallet, David W. Hays, Daniel J. Peterson, D. John Pierce, Michael A. Schroeder, and Washington Department of Fish and Wildlife

ABSTRACT

One hundred sixteen (28 male and 88 female) Greater Sage-Grouse (*Centrocercus urophasianus*) were captured and fitted with radio-transmitters in a fragmented area of north-central Washington. Although 21 of 22 adult males (including 3 birds captured as yearlings) were observed visiting only one lek, 4 of 9 yearling males were observed visiting 2 leks. The average distance between visited leks was 10.6 km, which was similar to the average distance between neighboring leks. Twenty-four of 78 females (not counting 10 females with only 1 lek visit) were observed visiting at least 2 leks, 8 females visited at least 3 leks. The average distance between visited leks was 13.1 km. The average distance between a female's first nest and her renest (following failure of the first nest) was 2.0 km for adults and 6.3 km for yearlings. The average distance between a female's nest in one year and her subsequent nest in the next year was 1.6 km when her first nest was successful and 5.2 when her first nest was unsuccessful. These results indicate that fidelity of Greater Sage-Grouse in north-central Washington is substantially lower than in other areas. In addition to the general trends, there were unusual examples of adult females moving substantial distances to renest (26.6 km) and nest in subsequent years (32.4 km). Although the relationship between the behavior of Greater Sage-Grouse and the fragmented habitat is a possible explanation for the unusual observations, there was no direct evidence showing a correlation between fidelity and habitat availability.

INTRODUCTION

Most birds of breeding age display at least a moderate amount of philopatry to their first breeding areas. Even when birds abandon a breeding area, they rarely shift their location more than a few territories (Greenwood and Harvey 1982). Observations of grouse have been similar to other species of birds. For example, Greater Sage-Grouse (Fischer et al. 1993), Lesser Prairie-Chicken (*Tympanuchus pallidicintus*, Giesen 1998), Greater Prairie-Chicken (*Tympanuchus cupido*, Schroeder and Braun 1993), Blue Grouse (*Dendragapus obscurus*, Jamieson and Zwickel 1983), and Willow Ptarmigan (*Lagopus lagopus*, Schieck and Hannon 1989) appear to display overwhelming fidelity to their first breeding areas.

Most populations of grouse have been studied in relatively intact habitats and with relatively healthy populations. Consequently, it might not be surprising that breeding aged birds tend to display philopatry to their first breeding site. It also is possible that a lack of fidelity to a breeding location, particularly by an adult bird, would be an indication of severe stress due to factors such as population pressures and/or declines in habitat quality.

I examined fidelity of breeding-aged Greater Sage-Grouse in north-central Washington to their breeding sites. This population offered some unique opportunities when compared with other populations of grouse, as well as other populations of Greater Sage-Grouse. The habitat was highly altered and fragmented, thus appearing to reduce the potential incentives to display fidelity to the same breeding area for many years. In addition, the population had been declining for many years (Schroeder et al. 2000), thus illustrating some intrinsic problems with the health of the population and/or habitat. Finally, radio-marked birds were followed for relatively long periods of time, thus allowing examinations of multiple breeding seasons.

METHODS

Greater Sage-Grouse were studied in an isolated population on a 3,529 km^2 area centered near Mansfield, Washington (47^{o}50'N, 119^{o}40'W; Schroeder et al. 2000). The habitat was dominated by a fragmented mix of dryland wheat (35%), shrub-steppe habitat (44%), and the federal Conservation Reserve Program (CRP, 17%). Shrub-steppe was dominated by big sagebrush (*Artemisia tridentata*), threetip sagebrush (*Artemisia tripartita*), bluebunch wheatgrass (*Agropyron spicatum*), and bluegrass (*Poa* spp.) and CRP was dominated by planted grasses such as crested wheatgrass (*Agropyron cristatum*).

Greater Sage-Grouse were trapped on seven different traditional display sites (leks) with the aid of walk-in traps (Schroeder and Braun 1991) during March and April, 1992-1996. An additional 5 leks were not used for trapping because of their small number of bird and/or inaccessibility. All captured birds were identified by age and sex (Beck et al. 1975) and fitted with battery-powered radio transmitters attached to poncho-like collars (Amstrup 1980) or necklaces.

Birds were located with a portable receiver and 4-element Yagi antenna throughout the breeding season to collect data on lek visitation, nest location, and nest success. Locations were recorded to the nearest meter using Universal Transverse Mercators (Zone 11). Most birds were located either visually or with triangulation techniques designed to determine whether birds were on leks or nests. Variation in intensity of transmitter signals also was used as an indication of behavior; radio transmitters emitted a constant signal when a female was on her nest and a variable signal when a bird was walking or flying. Fixed-wing aircraft were used to locate lost birds. "Visual" observations of females on nests consisted of triangulation from a distance of about 20-30 m from the nest site; this minimized disturbance of females and allowed nest sites to be located following hatch or failure. Nests were considered successful if $ 1 egg hatched.

Analysis of distances between consecutive nests was conducted with general linear models (Proc GLM, SAS Institute 1989). Independent variables included age, year, habitat availability with 3 km of the previous nest, and the success of the previous nest; except in the case of first nest-renest distances where all first nests were unsuccessful. Habitat availability was determined with 1993 satellite imagery based on earlier research (Jacobson and Snyder 2000, Schroeder et al. 2000) and included the proportion of potential nesting habitats (combination of CRP and shrub-steppe) within 3 km of the nest site. Results were considered significant at α # 0.05.

RESULTS

One hundred sixteen Greater Sage-Grouse were captured on leks and fitted with radio transmitters including 22 females and 6 males in 1992, 16 females and 9 males in 1993; 21 females and 5 males in 1994; 21 females and 7 males in 1995, and 8 females and 1 male in 1996. Lek visitation data included observations of 26 males and 78 females that were observed on leks following their capture. The additional 2 males and 10 females were not observed on leks after being captured.

Nineteen males captured as adults were observed visiting leks on a total of 186 occasions after being captured; all but 1 visit (99.5%) was on the same lek where captured. This result included 4 males that were observed on leks in subsequent years. In contrast to the adults, males captured as yearlings were significantly more likely to visit more than 1 lek within a year ($\chi^2 = 6.392$, df = 1, $P < 0.011$). Four of 9 yearling males with multiple lek observations were observed on different leks than the lek where they were first captured. In contrast, none of 3 males captured as yearlings was observed visiting more that 1 lek in its second year (as an adult), including 2 of the 4 males observed visiting more that one lek during their yearling years. One of the yearling males apparently became established on a "new" lek during its second year (observed on 8 occasions). Two of 4 yearling males that visited a second lek, visited a lek that was not closest to their first lek. The average distance between their first and second leks was 10.57 km (SD = 3.81 km). This was comparable to the average 10.21 km distance between neighboring leks (n = 12, SD = 3.72 km).

There was no evidence of age-specific variation in lek visitation by females ($\chi^2 = 0.272$, df = 1, $P < 0.001$). When the age categories were combined, 30.77% of 78 females that were observed visiting a lek on at least 2 occasions were observed visiting at least 2 different leks. Four females (6.35% of 63 females with ≥ 3 observations on leks) were observed visiting 3 different leks. Although the likelihood of visiting more than 1 lek appeared to increase with the number of observations of females on leks, the proportion of females visiting more than 1 lek appeared to level off at about 45% (Fig. 1). Some of the visitation by females to more than one lek appeared to be associated with annual variation in home range. This was illustrated by the lower likelihood of females visiting more than one lek when only the observations within a year were included (Fig. 1). Nineteen of 32 (59.38%) first visits to a "new" lek were observed in a subsequent breeding season.

For example, one female was observed three times on the lek were she was captured in 1992 and 3 times on a different lek in 1993. Fourteen of 24 females (58.33%) that visited a second lek, visited a lek that was not closest to their first lek. Their average distance between their first and second leks was 13.06 km (SD = 7.42 km).

Nest data were obtained for 82 radio-marked females which excluded 5 females that died prior to being located at a nest site and 1 female that disappeared (damaged radio transmitter and/or undetected movement). Because many females were observed on multiple nests (within and between years), a total of 204 nests were found for radio-marked females; 25 in 1992, 30 in 1993, 37 in 1994, 55 in 1995, 42 in 1996, 14 in 1997, and 1 in 1998. Individual females were found nesting up to 6 times and monitored for up to 4 breeding seasons (Fig. 2). Percent availability of potential nesting habitat within 3.0

km of each nest site varied dramatically throughout the study area, 16.44 - 97.43%, with an average of 65.67% (SD = 17.48%).

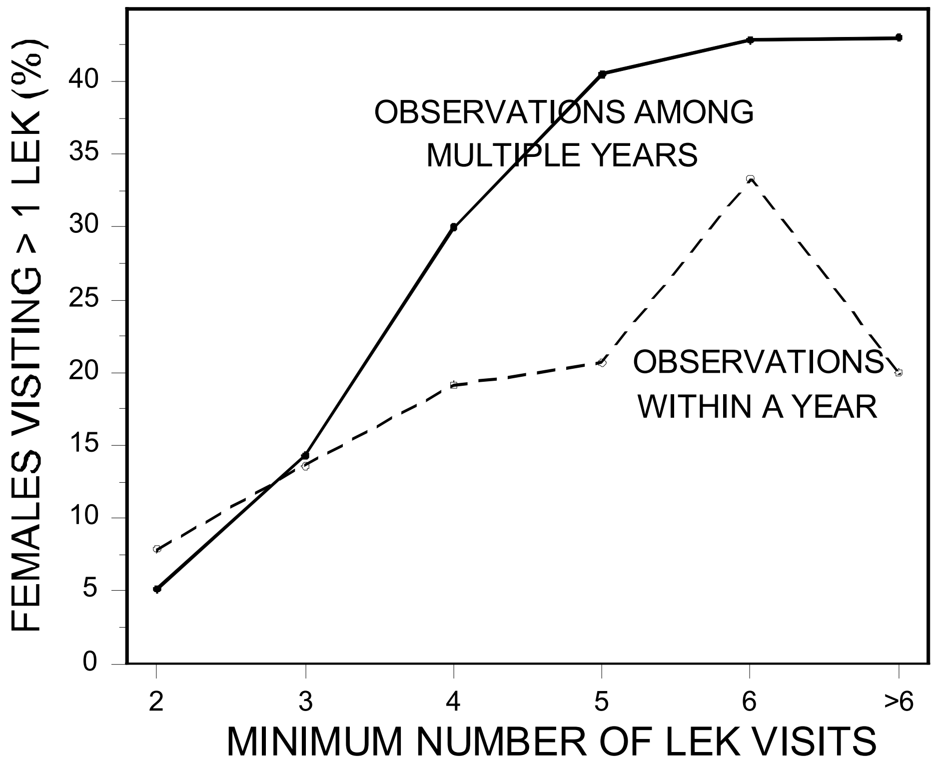

Fig. 1. Proportion of female greater sage-grouse visiting more than 1 lek in relation to the number of times they were observed on leks in north-central Washington, 1992-1998.

The average distance between a female□s first nest in a breeding season and her renest following failure of the first nest was 2.60 km (Table 1). Although some distances were large (range 0.03 - 26.58 km), 81.54% of the distances were < 3 km (Fig. 3). Although variation in habitat availability was not a significant factor (F = 0.07, df = 1, P = 0.796), both year (F = 2.48, df = 5, P = 0.042) and age (F = 5.76, df = 1, P = 0.020) explained some of the variation in first nest - renest distance. Distances tended to be higher in later years (1995 - 1997) than in earlier years (1992 - 1994) and higher for yearlings than adults (Table 1). In addition, yearlings moved farther than adults between first nests and renests. This result was consistent for 6 females observed renesting as both yearlings and adults; all 6 moved farther as yearlings then they did as adults (7.18 versus 2.11 km). In contrast to the general trends, the 2 largest distances between first nests and renests were observed for adults, including a distance of 26.58 km.

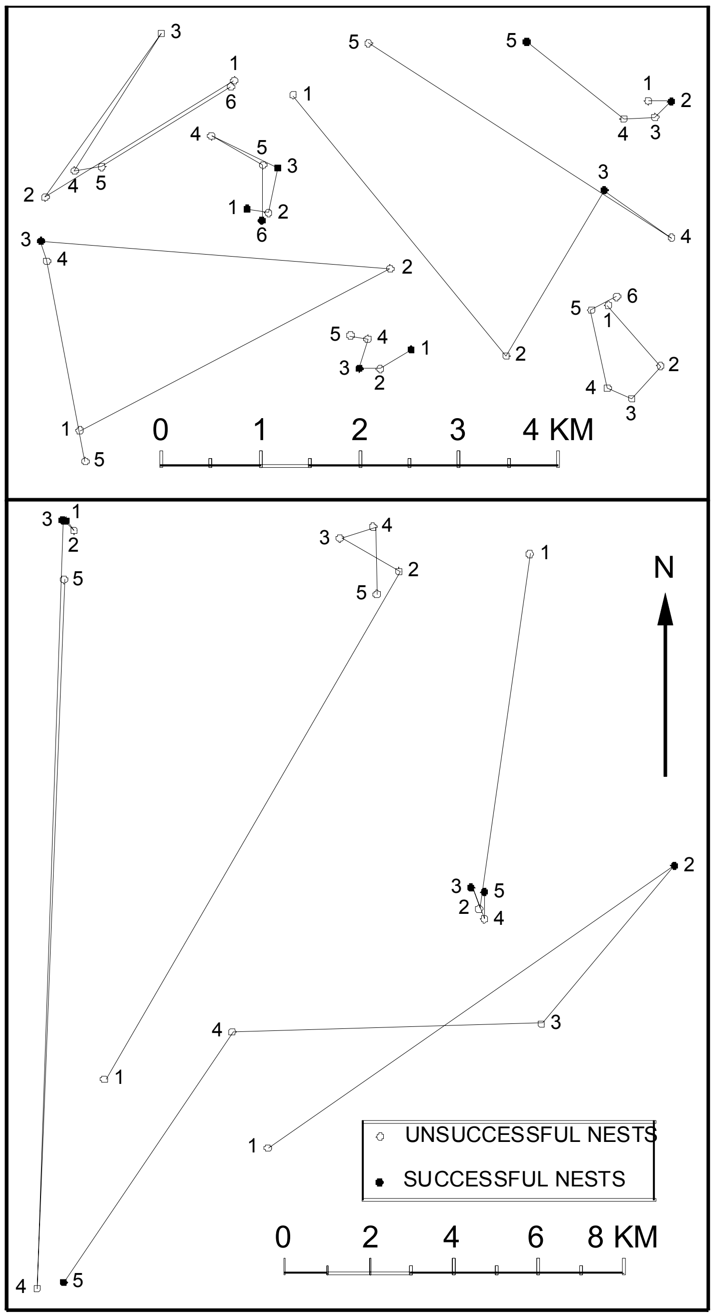

Fig. 2. Examples of nest distributions for female greater sage-grouse with at least 5 nests located in north-central Washington, 1992-1998. The nests are numbered in order of observed occurrence.

Table 1. Distances between first nests and renests following failure of the first nest and between nests in consecutive years for female Greater Sage-Grouse in north-central Washington, 1992-1998.

Category	n	Median (km)	Range (km)	0 " SD (km)
First nest - renest distance				
Adults				
1992-1994	23	0.59	0.03-2.52	0.77 " 0.62
1995-1997	33	1.26	0.20-26.58	2.87 " 5.30
Years combined	56	0.83	0.03-26.58	2.01 " 4.20
Yearlings				
1992-1994	5	3.58	2.26-11.84	6.00 " 4.11
1995-1997	4	5.94	0.44-14.25	6.64 " 6.39
Years combined	9	3.58	0.44-14.25	6.29 " 4.89
Ages combined				
1992-1994	28	0.71	0.03-11.84	1.71 " 2.64
1995-1997	37	1.56	0.20-26.58	3.28 " 5.46
Years combined	65	0.91	0.03-26.58	2.60 " 4.51
Distance between consecutive year’s nests				
Previous year□s nest successful	35	0.72	0.12-18.85	1.60 " 3.21
Previous year□s nest unsuccessful	22	1.30	0.17-32.90	5.19 " 9.85
Nests combined	57	0.84	0.12-32.90	2.99 " 6.76

The average distance between a female□s nests in consecutive years was 2.99 km (Table 1). Distances occasionally were large (range 0.12 - 32.90 km), but 84.21% of the distances were < 3 km (Fig. 4). Although year (F = 0.943, df = 5, P = 0.461), age (F = 1.458, df = 1, P = 0.232), and habitat (F = 1.30, df = 1, P = 0.260) were not significant explanations of the variation in distance between nests in consecutive years, the success of the previous years nest was significant (*F* = 4.011, df = 1, *P* = 0.050). Distances between a femaless nest and her following years nest were larger when the first years nest was unsuccessful (Table 1). One exceptional female moved 32.90 km between her first years nest and her second years nest. In her third breeding season she returned 32.40 km to the original nesting area she occupied during her first year (as a yearling). other adult made a similar return trip of 18.85 km.

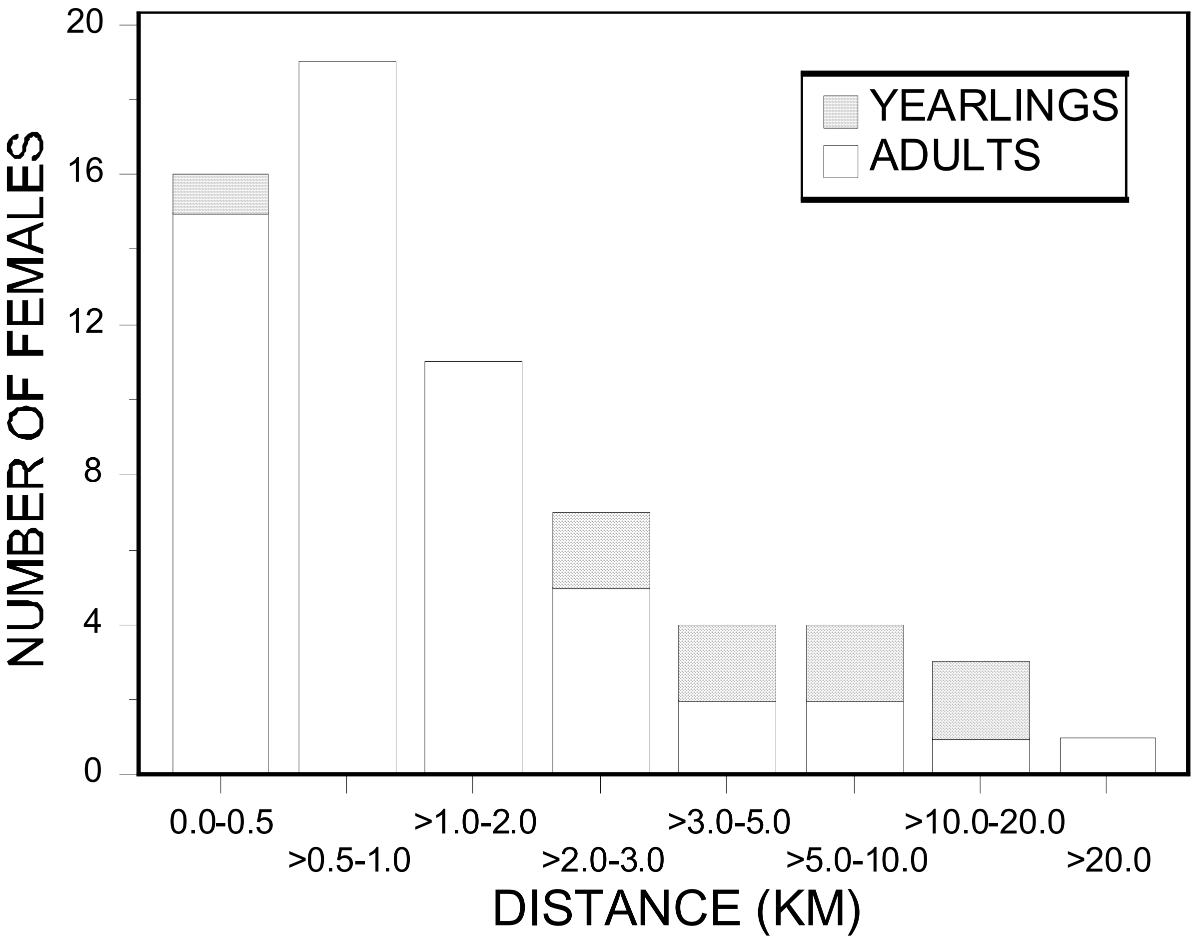

Fig. 3. Distribution of distances between 65 first nests and renests for greater sage-grouse in north-central Washington, 1992-1998.

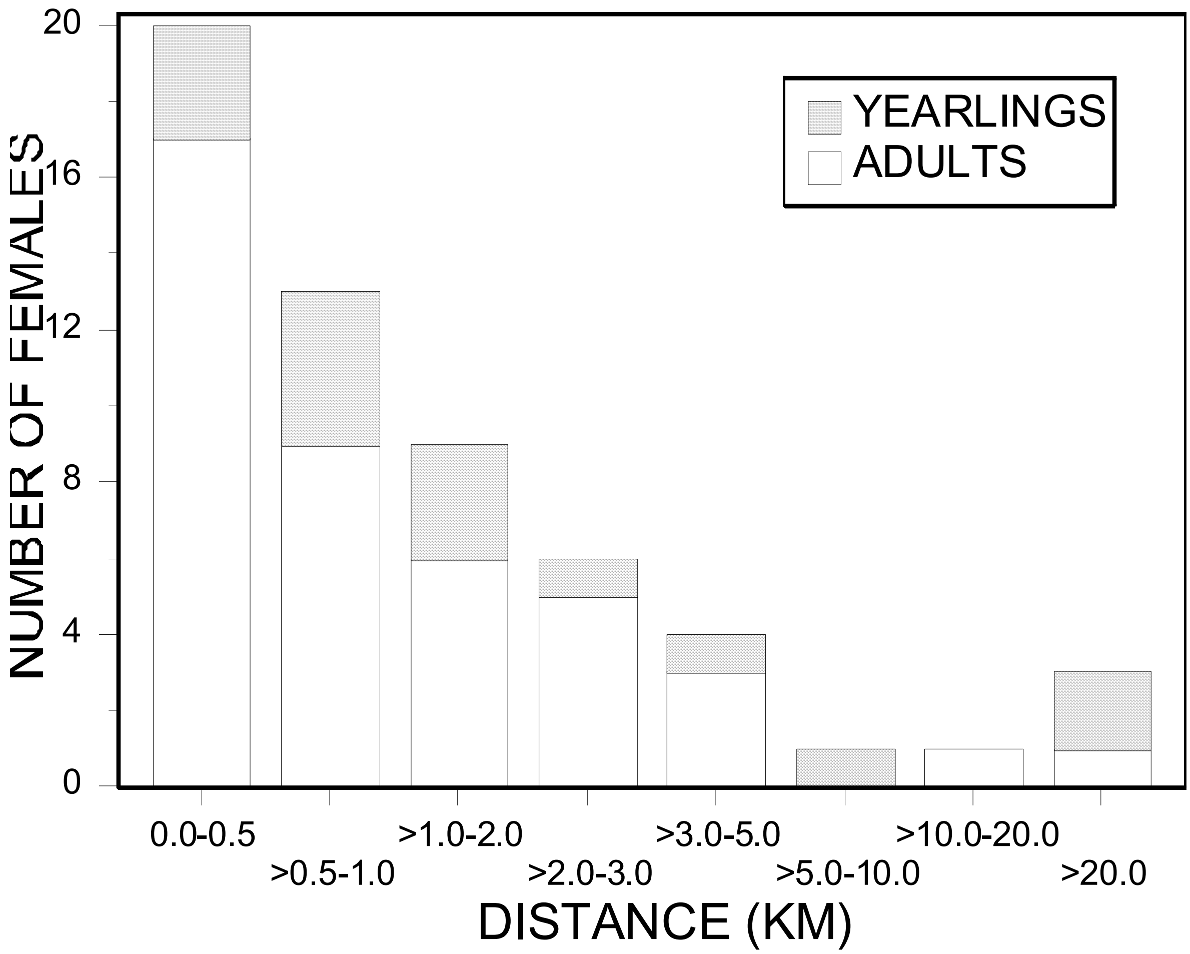

Fig. 4. Distribution of distances between 57 nests in consecutive years for greater sage-grouse in north-central Washington, 1992-1998.

DISCUSSION

All radio-marked adult males in north-central Washington were observed only on the lek where they were captured. In contrast, 4 of 7 yearling males were observed on 2 leks, an average of 10.6 km apart. These results illustrate slightly more fidelity to specific leks than was observed for Greater Sage-Grouse in Colorado where 3 of 11 adults and 11 of 11 yearlings visited more than 1 lek. Although multiple lek observations also were observed in other studies (33.3% of 42 in Idaho, Dalke et al. 1963; 6.7% of 15 in Montana, Wallestad and Schladweiler 1974; 18.5% of 54 in Colorado, Dunn and

Braun 1985; 46.7% of 15 in Oregon, Hanf et al. 1994), the age of those males was not determined. One possible explanation for the lack of movement by adult males between leks in north-central Washington is the large average distance between neighboring leks, 10.2 km (n = 12, SD = 3.7 km). In contrast, the average distance between neighboring leks in other areas was substantially smaller (1.2 km in Colorado, Braun and Beck 1976; 3.5 km in Idaho, Connelly and Ball 1978; 5.1 km in Montana, Berry and Eng 1985).

Approximately 30.8% of 78 radio-marked females visited at least 2 leks in north-central Washington. These results were comparable to the rate of multiple lek visitation by females in other regions (37.5% of 16 in Idaho, Dalke et al. 1963; 28.0% of 239 in Montana, Wallestad 1975; 10.8% of 37 in Colorado, Dunn and Braun 1985). The pattern of lek visitation by females in north-central Washington indicated that adjustments in home range were likely responsible for some of the observations. Most visits to "new" leks were in years following their capture. As with males, the average distance between leks visited by females was extremely large (13.1 km), especially when compared with the typical distance between neighboring leks in other regions.

The average distances between first nests and renests (2.8 km) and between nests in consecutive years (3.0 km) were large for Greater Sage-Grouse in north-central Washington. For comparison, Fischer et al. (1993) found an average distance of 0.7 km between consecutive year's nests for 22 females in Idaho. Even if the largest distances are not included in the Washington sample (distances greater than 10 km), the average first nest-renest distance was 1.6 km and the average distances between nests in consecutive years was 1.2 km.

In general, all species of grouse display substantial fidelity between consecutive nests. Consecutive nests of Greater Prairie-Chickens averaged <0.1 - 0.8 km apart (Toepfer and Eng 1988, Svedarsky 1988, Schroeder and Braun 1993). Consecutive nests of Lesser Prairie-Chickens were typically less than 1 km apart (Giesen 1998). Consecutive nests of Sharp-tailed Grouse averaged 0.4 km apart (Meints 1991). There is no evidence in the literature of a grouse (especially an adult) moving anywhere close to 32.4 km between consecutive year's nests or 26.6 km between a first nest and a renest, as was observed for Greater Sage-Grouse in this study.

There also was evidence that female movements were influenced by the success or failure of their nests. Females tended to move farther in subsequent years to nest when their previous year's nests were unsuccessful. Although distances between consecutive nests were not available, White-tailed Ptarmigan (*Lagopus leucurus*, Braun et al. 1993) and Willow Ptarmigan (Hannon et al. 1998) females were likely to change territories in years following the death of their mates and/or predation of their nests. This type of change resulted in the females being paired with older males, thus theoretically improving their opportunities for success in subsequent years (Martin 1985).

Fidelity of breeding-aged birds offers numerous potential advantages including maintenance of an established breeding territory or home range, reduction in potential costs of dispersal, and knowledge of an area's habitat and its potential predators and competitors. As the habitat of an area is altered however, the benefits of fidelity may decrease. This may explain, in part, why the average movements of Greater Sage-Grouse in north-central Washington are large, and why some birds move exceptional distances. The alteration and fragmentation of the habitat is clear; only 44% of the area remains in native shrub-steppe habitat, and much of the remaining shrub-steppe is fragmented into small pieces (Schroeder et al. 2000). The remaining shrub-steppe fragments are often along road-sides, fences, field edges, rocky outcrops, and rocky coulees. Because of this fragmentation, females may have to move relatively large distances in order to find alternate or new nest sites. Variation in habitat quality within the remaining habitat fragments may also explain the lack of a relationship between habitat availability and distance between nests. The highest quality habitats were often found in relatively small fragments whereas some of the relatively "intact" habitats were often in poor condition (Schroeder et al. 2000). Whether this variation in habitat availability and quality will have a cost in survival and reproductive output has yet to be determined (Schroeder 1997).

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Job Title: Job 1. Continue analysis and publication of research on sage grouse and Columbian sharp-tailed grouse in north-central Washington

Period Covered: 01 February 1992 through 31 December 2001

Report Title: Breeding Bird Diversity and Density in Relation to Restoration Efforts for Sharp-tailed Grouse on Wildlife Areas in North-central Washington

Author: Michael A. Schroeder

Personnel: Juli Anderson, Marc Hallet, Jim Olson, D. John Pierce, Michael A. Schroeder, and Washington Department of Fish and Wildlife

ABSTRACT

Research was initiated in 1993 to evaluate the diversity and density of breeding birds in relation to restoration efforts for sharp-tailed grouse on state-owned meadow- and shrub-steppe habitats in Washington. Fixed radius point surveys were conducted between 29 May and 17 June, 1993-2001, at the Swanson Lakes, West Foster Creek, Central Ferry Canyon, Chesaw, and Scotch Creek Wildlife Areas. A total of 146 different bird species were observed on the 5 wildlife areas; the average density at all survey points combined was 117 birds/km^2. Bird diversity and density were highest in wetland habitats, second highest in riparian habitats, and lowest in upland habitats. Density was highest on the Swanson Lakes Wildlife Area and diversity was highest on the Scotch Creek and Chesaw Wildlife Areas. Both density and diversity were lowest on the Central Ferry Canyon and West Foster Creek Wildlife Areas. Diversity and density were not obviously different between control (off wildlife areas) and treatment areas (on wildlife areas). These bird surveys are part of long-term research that is needed to evaluate habitat management and restoration efforts.

INTRODUCTION

The state of Washington has acquired numerous wildlife areas that are located, at least partially, in historic meadow- and shrub-steppe habitats. Some of these areas were in relatively poor condition at the time of acquisition due to past management practices such as cultivation of cereal grains and intense grazing by cattle. Consequently, management efforts are currently underway to restore these habitats, primarily for the improvement of sharp-tailed grouse populations (see Appendix A for scientific names of all birds listed in this report) populations. Although sharp-tailed grouse are considered an important indicator species in meadow- and shrub-steppe habitats (Schroeder et al. 2000), numerous other species offer an opportunity to evaluate both habitat quality and habitat change.

The purpose of this ongoing research is to evaluate restoration efforts on meadow- and shrub-steppe habitats in Washington. The specific questions to be addressed include: 1) Does the diversity and density of breeding birds vary between treatment (public) and control (private) habitats? 2) Does the diversity and density of breeding birds vary among habitats with different restoration histories (such as differences in grazing pressure, farming practices, and vegetative re-establishment)? 3) Does the diversity and density of breeding birds vary over time in specific habitats that are in the process of being restored?

METHODS

Breeding birds were surveyed on and near the Chesaw Wildlife Area (centered 2 km west of Chesaw [48° 57' N, 119° 5' W]), Scotch Creek Wildlife Area (centered 15 km northwest of Omak [48° 33' N, 119° 39' W]), Swanson Lakes Wildlife Area (centered 16 km south of Creston [47° 37' N, 118° 33' W]), West Foster Creek Wildlife Area (centered 12 km south of Bridgeport [47° 51' N, 119° 43' W]), and Central Ferry Canyon Wildlife Area (centered 6 km south of Brewster [48° 2' N, 119° 48' W]). All study areas contain various amounts of meadow- and shrub-steppe habitat; however, they differ with respect to numerous characteristics including precipitation, altitude, slope, substrate, historic vegetation, configuration of adjacent habitats, restoration history, and management strategy.

Habitats were classified according to three basic types; upland, riparian, and wetland. Upland habitats included all basic meadow-steppe, shrubsteppe, and steppe habitats. These areas typically consisted of well-drained soils historically dominated by big sagebrush (*Artemisia tridentata*), threetip sagebrush (*Artemisia tripartita*), and/or perennial grasses, primarily bluebunch wheatgrass (*Agropyron spicatum*). Riparian habitats included various types of drainages dominated (either currently or historically) by wet meadows, shrubs, and/or trees. Wetland habitats included vegetative associations near relatively permanent water such as ponds and lakes. Management strategies were divided into two categories for all wildlife areas; control (adjacent to wildlife area) and treatment (on wildlife area).

A fixed-radius point count was used to examine the presence, diversity, and density of breeding birds at specific point locations (Hutto et al. 1986). An attempt was made to select at least 5 locations for each habitat type, management strategy, and study area; however, wetland areas were too infrequent to adequately sample. Specific observations were conducted for 3 minutes at each location and included the number of individuals of each species detected within 200 m of the center point (clearly identifiable juveniles were not counted). Breeding bird surveys were conducted between 29 May and 17 June, 1993 to 2001. The surveys at Scotch Creek and Chesaw Wildlife Areas were initiated in 1993; surveys at the other wildlife areas were initiated in 1994. The comparability of future surveys will be maintained by conducting all surveys at identical locations, during the same interval of dates, and when weather conditions are moderate and comparable.

Density (birds/km^2) and species diversity (number of bird species) were estimated for each point on the survey. Density and diversity were analyzed for each study area with general linear models incorporating year, management strategy, and habitat type as independent variables; all two-way interactions between independent variables were also included (Proc GLM, SAS Institute Inc. 1988). Results were considered significant at $\alpha = 0.01$. Non-significant variables were removed (stepwise) from the general linear model until all remaining variables were significant.

RESULTS

The number of bird species observed varied among wildlife areas (Table 1); maximum of 110 species at Scotch Creek and minimum of 59 species at West Foster Creek. A total of 146 species were detected on all areas (Table 2). The species diversity appeared to be higher on wildlife areas where wetlands were common; Swanson Lakes, Chesaw, and Scotch Creek.

The average density on all areas was 117 birds/km^2, variation by habitat, treatment, and wildlife area was tremendous (Table 1). Most of the variation appeared to be due to endemic, and sometimes subtle, variation in habitat; differences due to treatment wildlife area appeared to be dwarfed by habitat. The western meadowlark was the most abundant species on all areas. Other common species included vesper sparrows and red-winged blackbirds.

Table 1. The estimated total density (birds/km^2) of bird species observed at survey points in relation to wildlife area, habitat type, and management strategy (C = control, T = treatment) in north-central Washington, 1993-2001.

Area	Upland		Riparian		Wetland		
Category	Control	Treatment	Control	Treatment	Control	Treatment	Total
Central Ferry Canyon							
Number of points	5	5	5	5	0	0	20
Number of species	30	35	47	39	-	-	65
Density	70.43	74.01	70.23	86.34	-	-	75.25
Chesaw							
Number of points	5	6	13	5	3	1	33
Number of species	60	37	70	56	67	51	106
Density	90.19	62.19	105.76	111.23	341.59	298.86	123.60
Scotch Creek							
Number of points	8	13	10	19	1	1	52
Number of species	44	52	74	74	38	38	110
Density	73.06	67.47	101.51	101.87	304.16	737.42	104.88
Swanson Lakes							
Number of points	10	10	9	10	2	5	46
Number of species	39	39	63	67	42	70	93
Density	68.93	81.77	107.32	143.54	345.66	521.23	156.65
West Foster Creek							
Number of points	5	5	5	5	0	0	20
Number of species	24	29	44	52	-	-	59
Density	55.11	60.48	124.54	104.64	-	-	86.19

Table 2. The presence (+) or absence (-) of birds in relation to study area (SLWA = Swanson Lakes Wildlife Area, CFCWA = Central Ferry Canyon Wildlife Area, WFCWA = West Foster Creek Wildlife Area, CWA = Chesaw Wildlife Area, SCWA = Scotch Creek Wildlife Area), habitat (U = upland, R = riparian, W = wetland), and management strategy (C = control, T = treatment) in north-central Washington, 1993-2001.

	SLWA						CFCWA				WFCWA				CWA						SCWA					
	U		R		W		U		R		U		R		U		R		W		U		R		W	
Bird Species	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T
Western grebe	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-necked grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Horned grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Eared grebe	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+
Pied-billed grebe	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+	+
American white pelican	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
American bittern	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Great blue heron	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Black-crowned night heron	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canada goose	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	-	-	-
Mallard	+	+	+	+	+	+	-	-	+	-	-	-	+	+	+	+	+	+	+	+	-	+	+	+	+	+
Gadwall	-	+	+	+	+	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
American wigeon	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	+	+
Northern shoveler	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+
Cinnamon teal	+	-	+	+	+	+	-	-	-	-	-	-	+	+	-	-	+	-	+	+	-	-	-	-	+	+
Blue-winged teal	-	-	+	+	+	+	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	-	+	+	+	+
Green-winged teal	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+
Northern pintail	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruddy duck	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+	+
Canvasback	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	+
Redhead	-	+	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	+
Ring-necked duck	-	-	+	-	+	+	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	+
Lesser scaup	-	-	-	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	+
Barrow's goldeneye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Common goldeneye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	+
Bufflehead	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common merganser	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-
Hooded merganser	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+

	SLWA						CFCWA				WFCWA				CWA						SCWA					
	U		R		W		U		R		U		R		U		R		W		U		R		W	
Bird Species	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T
Sora	-	+	+	+	+	+	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	+	+	+	-	+
Virginia rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
American coot	+	+	+	+	+	+	-	-	-	-	-	-	+	+	-	-	+	+	+	+	-	+	+	+	+	+
American avocet	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-necked stilt	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common snipe	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+	-	+	+	+	-	-
Killdeer	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Wilson's phalarope	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Spotted sandpiper	-	-	-	+	-	+	-	-	-	-	-	+	+	+	-	-	+	+	+	-	-	-	-	-	+	-
Long-billed curlew	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Ring-billed gull	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
California gull	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black tern	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
Northern harrier	+	+	+	+	-	+	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-
Sharp-shinned hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Red-tailed hawk	+	+	+	+	-	+	-	-	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
Swainson's hawk	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-	+	+	-	-
Osprey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
American kestrel	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	-
Merlin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-
Sharp-tailed grouse	-	+	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-
Ruffed grouse	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	+	-	-	-
Blue grouse	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	-	+	+	+	+	+	-	+
California quail	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	-	-	+	-	-	-	-	+	+	+	-
Chukar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Gray partridge	+	+	+	+	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+	+	+	+	+	-	-
Ring-necked pheasant	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	-	-
Rock dove	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	+	+	+	-	-	-	+	+	+	+	-
Mourning dove	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+
Short-eared owl	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	+	-	-
Great-horned owl	+	-	+	+	-	-	-	-	+	-	-	-	-	+	-	-	-	+	-	-	+	-	+	+	-	-
Common poorwill	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	+	-	+	-	+	+	+	-	-
Common nighthawk	+	+	+	+	-	-	+	-	+	+	-	-	+	-	-	+	+	-	-	-	+	+	+	+	+	+
Black-chinned hummingbird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Northern flicker	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-	-

	SLWA						CFCWA				WFCWA				CWA						SCWA					
	U		R		W		U		R		U		R		U		R		W		U		R		W	
Bird Species	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T
Lewis woodpecker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Red-naped sapsucker	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	+	+	+	+	-	-	+	-	-	-
Downy woodpecker	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-
Hairy woodpecker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-
Eastern kingbird	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
Western kingbird	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
Olive-sided flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	-	-	-	-	+	-	-
Western wood-pewee	-	+	+	-	+	+	+	+	+	+	-	-	+	+	+	-	+	+	+	+	+	+	+	+	-	+
Say's phoebe	-	+	+	+	-	-	+	+	-	+	-	-	+	+	+	+	+	+	-	-	+	+	+	+	-	+
Dusky flycatcher	-	-	+	-	-	-	-	-	+	-	-	-	-	+	+	-	+	+	+	+	-	-	+	+	-	-
Willow flycatcher	-	-	+	+	+	+	-	-	+	-	-	-	-	+	+	-	+	+	+	+	+	-	+	+	+	-
Pacific-slope flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Horned lark	+	+	+	+	-	+	+	-	+	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-
Tree swallow	+	+	+	+	+	+	+	-	+	+	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
Violet-green swallow	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	-	+	+	-	-
Bank swallow	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	-	+	+	-	+	-	+	+	+
Northern rough-winged swallow	-	-	-	-	-	+	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-
Cliff swallow	-	-	+	-	+	+	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	+	+	+	+	-
Barn swallow	-	-	-	+	+	+	-	-	-	-	+	-	+	-	-	-	+	+	+	-	+	+	+	+	+	+
Steller's jay	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Clark's nutcracker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Black-billed magpie	+	-	+	+	-	+	-	+	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	-
American crow	+	-	-	+	-	+	+	-	-	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	-
Common raven	+	+	+	+	-	-	-	-	+	+	+	+	-	+	+	+	+	-	+	+	-	+	+	+	-	-
Mountain chickadee	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-
Black-capped chickadee	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	+	+	+	-	-	-	+	+	-	-
Brown creeper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Red-breasted nuthatch	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	+	+	-	-	-	-	+	-	-	-
Pygmy nuthatch	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
House wren	-	+	+	+	-	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-
Marsh wren	-	-	+	+	+	+	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	+	+	+	-	-
Rock wren	-	-	+	+	-	-	+	-	+	-	+	+	-	+	-	-	-	-	-	-	+	-	+	+	+	-
Canyon wren	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Ruby-crowned kinglet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	+	-	-	-
Golden-crowned kinglet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-

	SLWA						CFCWA				WFCWA				CWA						SCWA					
	U		R		W		U		R		U		R		U		R		W		U		R		W	
Bird Species	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T
Western bluebird	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-
Mountain bluebird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	-	+	+	-	-
Veery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Swainson's thrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
American robin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
Sage thrasher	+	+	+	+	-	+	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-
Gray catbird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-
Cedar waxwing	-	-	+	-	-	-	-	-	-	+	-	-	-	+	-	+	-	-	-	-	-	-	+	+	-	-
European starling	+	+	+	+	+	+	+	+	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+	+	+	-
Solitary vireo	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warbling vireo	-	-	-	+	-	-	-	-	+	+	-	-	-	-	+	-	+	+	-	+	-	-	+	-	-	-
Orange-crowned warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-
Yellow-rumped warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	-	+	-	-	-
Yellow warbler	-	-	+	+	+	+	-	-	+	+	-	-	+	+	+	-	+	+	+	+	+	-	+	+	+	-
MacGillivray's warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Wilson's warbler	-	-	+	-	-	-	-	-	+	-	-	-	+	+	-	-	+	+	+	+	-	+	-	+	-	-
Northern waterthrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Common yellowthroat	-	-	+	+	-	+	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-	+	+	-	-
Yellow-breasted chat	-	-	-	-	-	-	-	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Lazuli bunting	-	-	-	-	-	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-
Black-headed grosbeak	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Spotted towhee	-	-	-	-	-	+	+	+	+	+	+	-	+	+	+	-	+	-	-	-	+	-	+	+	-	-
Grasshopper sparrow	+	+	-	+	-	-	-	+	-	-	+	+	+	+	+	+	+	+	-	-	+	+	+	+	-	-
Vesper sparrow	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
Savannah sparrow	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
Song sparrow	-	-	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-
Brewer's sparrow	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	-	-
Chipping sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	+	+	-	+	+	-	-
Clay-colored sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-
Dark-eyed junco	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Lincoln's sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Lark sparrow	-	-	-	-	-	-	-	+	-	-	+	+	+	-	+	-	-	-	-	-	-	+	-	+	-	-
Bobolink	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Western meadowlark	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Yellow-headed blackbird	-	-	+	+	+	+	-	-	-	-	-	-	-	+	+	-	-	-	+	+	-	+	-	+	+	+

	SLWA						CFCWA				WFCWA				CWA						SCWA					
	U		R		W		U		R		U		R		U		R		W		U		R		W	
Bird Species	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T
Red-winged blackbird	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Brewer's blackbird	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Brown-headed blackbird	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	-
Northern oriole	-	-	+	+	-	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-
Western tanager	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	+	-	-
American goldfinch	+	-	+	+	-	-	+	+	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+	-
House sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Pine siskin	+	-	+	-	-	-	-	+	+	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-
Red crossbill	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cassin's finch	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-

Density for each wildlife area was analyzed in a general linear model with treatment, habitat, year, and all two-way interactions incorporated as independent variables. Although there were no significant independent variables associated with the Central Ferry Canyon Wildlife Area, habitat was a consistently significant variable for the other areas (Table 3). Wetland areas usually had the highest density of birds and upland sites usually had the lowest density of birds, regardless of treatment or year. Density significantly increased over time on both the Scotch Creek and Swanson Lakes areas, apparently due to the increasing populations of birds associated with wetland areas. This observation was also consistent with the significant habitat-year interaction for both areas; upland and riparian habitats did not show the same increase in density as wetland habitats did.

Diversity of birds showed similar tendencies as density in a general linear model. Habitat provided a significant explanation for all wildlife areas (Table 4). Wetland areas had the highest density of birds and upland sites had the smallest diversity, regardless of treatment or year. Diversity on Central Ferry Canyon and Chesaw tended to be lower on the wildlife area than off it, and the reverse was true at Swanson Lakes and Scotch Creek (see treatment and treatment*habitat interactions, Table 4). All differences in treatment appeared to be due to subtle differences in the habitat rather than the long term effects of management (no significant differences associated with year).

Table 3. Significant results for the analysis of bird density in general linear models with treatment (management strategy), habitat, year, and all 2-way interactions for 5 wildlife areas in north-central Washington, 1993-2001.

Independent variables	Central Ferry Canyon		Chesaw		Scotch Creek		Swanson Lakes		West Foster Creek	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Treatment										
Habitat			296.39	0.001	7.36	0.001	7.32	0.001	77.42	0.001
Year					11.47	0.001	8.89	0.003		
Treatment*habitat interaction										
Treatment*year interaction										
Habitat*year interaction					7.47	0.001	7.39	0.001		

Table 4. Significant results for the analysis of bird diversity in general linear models with treatment (management strategy), habitat, year, and all 2-way interactions for 5 wildlife areas in north-central Washington, 1993-2001.

Independent variables	Central Ferry Canyon		Chesaw		Scotch Creek		Swanson Lakes		West Foster Creek	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Treatment	24.89	0.001					17.30	0.001		
Habitat	21.55	0.001	94.66	0.001	97.28	0.001	93.69	0.001	106.32	0.001
Year										
Interactions										
Treatment*habitat interaction			5.66	0.001	8.39	0.001				
Treatment*year interaction										
Habitat*year interaction										

DISCUSSION

The results from 1993-2001 surveys indicated that density and diversity were highest in wetland and riparian habitats. Consequently, wildlife areas with abundant riparian and wetland habitats (Scotch Creek, Chesaw, and Swanson Lakes Wildlife Areas) had the greatest density and diversity. Although density tended to increase between 1993 and 2001, the increases appeared to be a result of increased standing water in wetland and riparian areas, particularly on the Swanson Lakes and Scotch Creek Wildlife Areas.

The quality of riparian sites associated with historic meadow- and shrub-steppe habitat appears to be relatively poor in north-central Washington. This may explain, in part, the decline of sharp-tailed grouse (Schroeder et al. 2000). The validity of these observations will hopefully be addressed as additional data are gathered on the diversity and density of birds in relation to the restoration of habitat.

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Appendix A. The species list of birds observed on 5 different wildlife areas in north-central Washington, 1993-2001.

Common name	Scientific name
Western grebe	*Aechmophorus occidentalis*
Red-necked grebe	*Podiceps grisegena*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps nigricollis*
Pied-billed grebe	*Podilymbus podiceps*
American white pelican	*Pelecanus erythrorhynchos*
American bittern	*Botaurus lentiginosus*
Great blue heron	*Ardea herodias*
Black-crowned night-heron	*Nycticorax nycticorax*
Canada goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
American wigeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Cinnamon teal	*Anas cyanoptera*
Blue-winged teal	*Anas discors*
Green-winged teal	*Anas crecca*
Northern pintail	*Anas acuta*
Ruddy duck	*Oxyura jamaicensis*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Lesser scaup	*Aythya affinis*
Barrow's goldeneye	*Bucephala islandica*
Common goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
American coot	*Fulica americana*
American avocet	*Recurvirostra americana*
Black-necked stilt	*Himantopus mexicanus*
Common snipe	*Gallinago gallinago*
Killdeer	*Charadrius vociferus*
Wilson's phalarope	*Phalaropus tricolor*
Spotted sandpiper	*Actitis macularia*
Long-billed curlew	*Numenius tahitiensis*
Ring-billed gull	*Larus delawarensis*

Continued.

Appendix A. Continued.

California gull	*Larus californicus*
Black tern	*Chlidonias niger*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Red-tailed hawk	*Buteo jamaicensis*
Swainson's hawk	*Buteo swainsoni*
Osprey	*Pandion haliaetus*
American kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Ruffed grouse	*Bonasa umbellus*
Blue grouse	*Dendragapus obscurus*
California quail	*Callipepla californica*
Chukara	*Alectoris chukar*
Gray partridge	*Perdix perdix*
Ring-necked pheasant	*Phasianus colchicus*
Rock dove	*Columba livia*
Mourning dove	*Zenaida macroura*
Short-eared owl	*Asio flammeus*
Great horned owl	*Bubo virginianus*
Common poorwill	*Phalaenoptilus nuttallii*
Common nighthawk	*Chordeiles minor*
Black-chinned hummingbird	*Archilochus alexandri*
Northern flicker	*Colaptes auratus*
Lewis woodpecker	*Melanerpes lewis*
Red-naped sapsucker	*Sphyrapicus varius*
Hairy woodpecker	*Picoides villosus*
Downy woodpecker	*Picoides pubescens*
Eastern kingbird	*Tyrannus tyrannus*
Western kingbird	*Tyrannus verticalis*
Olive-sided flycatcher	*Contopus borealis*
Western wood-pewee	*Contopus sordidulus*
Say's phoebe	*Sayornis saya*
Dusky flycatcher	*Empidonax oberholseri*
Willow flycatcher	*Empidonax traillii*
Pacific-slope flycatcher	*Empidonax difficilis*
Horned lark	*Eremophila alpestris*
Tree swallow	*Tachycineta bicolor*
Violet-green swallow	*Tachycineta thalassina*
Bank swallow	*Riparia riparia*

Continued.

Appendix A. Continued.

Northern rough-winged swallow	*Stelgidopteryx serripennis*
Cliff swallow	*Hirundo pyrrhonota*
Barn swallow	*Hirundo rustica*
Steller's jay	*Cyanocitta stelleri*
Clark's nutcracker	*Nucifraga columbiana*
Black-billed magpie	*Pica pica*
American crow	*Corvus brachyrhynchos*
Common raven	*Corvus corax*
Black-capped chickadee	*Parus atricapillus*
Mountain chickadee	*Parus gambeli*
Brown creeper	*Certhia americana*
Red-breasted nuthatch	*Sitta canadensis*
Pygmy nuthatch	*Sitta pygmaea*
House wren	*Troglodytes aedon*
Marsh wren	*Cistothorus palustris*
Rock wren	*Salpinctes obsoletus*
Canyon wren	*Catherpes mexicanus*
Ruby-crowned kinglet	*Regulus calendula*
Golden-crowned kinglet	*Regulus satrapa*
Western bluebird	*Sialia mexicana*
Mountain bluebird	*Sialia currucoides*
Veery	*Catharus fuscescens*
Swainson's thrush	*Catharus ustulatus*
American robin	*Turdus migratorius*
Sage thrasher	*Oreoscoptes montanus*
Gray catbird	*Dumetella carolinensis*
Cedar waxwing	*Bombycilla cedrorum*
European starling	*Sturnus vulgaris*
Solitary vireo	*Vireo solitarius*
Warbling vireo	*Vireo gilvus*
Orange-crowned warbler	*Vermivora peregrina*
Yellow-rumped warbler	*Dendroica coronata*
Yellow warbler	*Dendroica petechia*
MacGillivray's warbler	*Oporornis tolmiei*
Wilson's warbler	*Wilsonia pusilla*
Northern waterthrush	*Seiurus noveboracensis*
Common yellowthroat	*Geothlypis trichas*
Yellow-breasted chat	*Icteria virens*
Black-headed grosbeak	*Pheucticus melanocephalus*
Lazuli bunting	*Passerina amoena*

Continued.

Appendix A. Continued.

Spotted towhee	*Pipilo erythrophthalmus*
Grasshopper sparrow	*Ammodramus savannarum*
Vesper sparrow	*Pooecetes gramineus*
Savannah sparrow	*Passerculus sandwichensis*
Song sparrow	*Melospiza melodia*
Brewer's sparrow	*Spizella breweri*
Chipping sparrow	*Spizella passerina*
Clay-colored sparrow	*Spizella pallida*
Dark-eyed junco	*Junco hyemalis*
Lincoln's sparrow	*Melospiza lincolnii*
Lark sparrow	*Chondestes grammacus*
Bobolink	*Dolichonyx oryzivorus*
Western meadowlark	*Sturnella neglecta*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Red-winged blackbird	*Agelaius phoeniceus*
Brewer's blackbird	*Euphagus cyanocephalus*
Brown-headed cowbird	*Molothrus ater*
Northern oriole	*Icterus galbula*
Western tanager	*Piranga ludoviciana*
American goldfinch	*Carduelis tristis*
House sparrow	*Passer domesticus*
Pine siskin	*Carduelis pinus*
Red crossbill	*Loxia curvirostra*
Cassin's finch	Carpodacus cassinii

Job Title: Job 2. Efforts to translocate Columbian sharp-tailed grouse into critical areas of northcentral Washington will continue

Period Covered: 01 February 1998 through 31 December 2001

Report Title: Translocation of Sharp-tailed Grouse to the Scotch Creek Wildlife Area in North-central Washington

Author: Michael A. Schroeder

Personnel: Colville Indian Reservation, Ron Fox, Marc Hallet, Maureen Murphy, Jim Olson, Daniel J. Peterson, D. John Pierce, Michael A. Schroeder, David Ware, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife

ABSTRACT

Forty-three sharp-tailed grouse were captured near Rockland in southeastern Idaho and near Nespelem in north-central Washington in March-April, 1998 and 1999. Captured birds were fitted with radio transmitters and transported to the Scotch Creek Wildlife Area northwest of Omak, Washington. The release site was approximately 400 meters from the only active lek on the Scotch Creek Wildlife Area. The first three birds to die were among a group of seven birds that was released approximately 48 hours after capture during 1998; most of the other 40 birds were released either 4 or 24 hours after capture in 1998 and 1999. The overall survival rate for the first 4 months after release was 47.7%. Survival did not differ significantly by sex, year, source population, and time between capture and release. Although only 2 males were observed on the Scotch Creek lek prior to the translocation in 1998, a maximum of 11 birds was observed on the Scotch Creek lek following release in both 1998 and 1999. More than 1800 observations of radio-marked birds indicated that translocated birds moved throughout much of the Okanogan Valley. One female was observed 34 km from the release location. Females nested an average of 5.1 km from their release location; the distances were significantly less in 1999 than in 1998. Despite the long movements, most birds appeared to become established on, or adjacent to, the Scotch Creek Wildlife Area. The 2 females that were exceptions became established in the Tunk Valley and near Siwash Creek; both areas had existing populations of sharp-tailed grouse. The average date for initiation of incubation was 13 May and the rate of nest success was 53%. Thirteen chicks were known to be alive at the end of the breeding season. Research on the Scotch Creek Wildlife Area will continue as long as radio-marked birds can be located. Updated information on survival, movement, habitat use, and productivity will be evaluated to determine the success of the sharp-tailed grouse transplant and habitat restoration efforts on the Scotch Creek Wildlife Area, and the need and methodologies for future translocation efforts.

INTRODUCTION

Columbian sharp-tailed grouse (Tympanucus phasianellus columbianus) were historically found in many of the shrub-grass habitats of central and southeastern Washington (Yocom 1952, Aldrich 1963). Surveys indicate that sharp-tailed grouse are virtually extinct everywhere except Okanogan, Douglas, and Lincoln counties (Weddell et al. 1992, Washington Department of Fish and Wildlife 1995). Remaining populations appear to be small and localized within isolated areas of relatively intact habitat including shrub steppe, meadow steppe, steppe, and riparian shrub (Marshall and Jensen 1937, Yocom 1952, Marks and Marks 1988, Oedekoven 1985, Giesen and Connelly 1993, Gunderson 1990, Cope 1992, Meints et al. 1992, Connelly et al. 1998). The current range is < 3% of the original range and the population has declined 96% since 1954 to its current level of about 1000 birds (Hays et al. 1998).

The Washington Department of Fish and Wildlife (WDFW) has a goal to stabilize or increase the populations and distribution of sharp-tailed grouse in Washington. Consequently, the state has acquired sharp-tailed grouse habitat, initiated research on life history requirements, and developed management strategies to improve their populations where they currently exist and reestablish them in areas where they have been nearly, or completely, extirpated. The primary management strategy is to improve habitat on private and state-owned lands that are currently, or were historically, occupied by sharp-tailed grouse. Habitat improvements include the reduction or removal of grazing pressure, transition of cropland (mostly wheat) to grass-dominated habitats (such as in the Conservation Reserve Program [CRP]), restoration of native habitat, and planting of key components such as trees and shrubs. The secondary management strategy of the WDFW is to transplant sharp-tailed grouse into areas of Washington where they have been completely extirpated or where their populations have been reduced to the brink of extinction.

SCOTCH CREEK WILDLIFE AREA

The WDFW purchased the Scotch Creek Wildlife Area (SCWA), 15 km northwest of Omak (48° 32' N, 119° 41' W), in 1992 in an effort to slow the decline of sharp-tailed grouse. Although the SCWA contained approximately 2000 ha (> 4000 acres) of potential sharp-tailed grouse habitat, most of the habitat was in poor condition at the time of purchase. The estimated population of sharp-tailed grouse near the SCWA (including Silver Hill and Brown Lake areas northwest of Omak) illustrates the problems facing sharp-tailed grouse throughout the state of Washington (Fig. 1).

The WDFW initiated long-term strategies to improve habitat conditions on the SCWA in 1992. These strategies included the establishment of grasses, shrubs, and forbs for nesting cover and deciduous trees and shrubs for winter feeding areas. However, the extremely low population size of sharp-tailed grouse during the 1992-1999 period indicated that additional sharp-tailed grouse probably would be needed to restore the population.

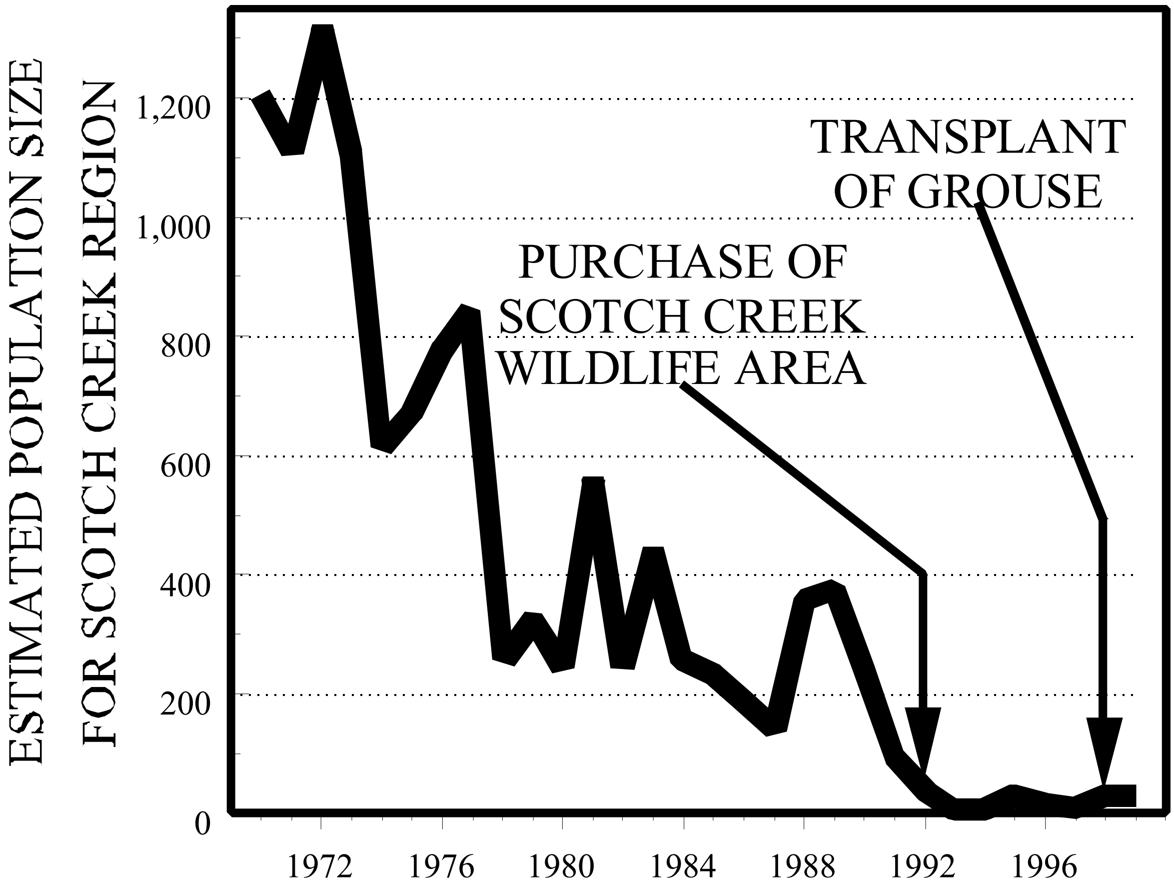

Fig. 1. Estimated populations of sharp-tailed grouse near the Scotch Creek Wildlife Area, 1970-1999.

METHODS

TRANSLOCATION

A project was initiated in 1998 to transport sharp-tailed grouse from source populations near Rockland, Idaho and Nespelem, Washington to the SCWArea in north-central Washington. The source population in Idaho was in habitat dominated by crested wheatgrass (*Agropyron cristatum*) and alfalfa and the source population in Washington was in habitat dominated by bluebunch wheatgrass (*A. spicatum*) and Idaho fescue (*Festuca idahoensis*). The SCWA release site was characterized by crested wheatgrass, alfalfa, and basin wildrye (*Elymus cinereus*); this habitat was comparable to the habitat in southeastern Idaho where most of the birds were captured.

Sharp-tailed grouse were trapped on leks with the aid of walk-in traps in Mar-Apr, 1998-1999 (Schroeder and Braun 1991). Birds captured in Idaho were released at SCWA 24 or 48 hours after capture; birds capture in Washington were released 4 hours after capture. Sex and age were determined for all captured birds (Henderson et al. 1967, Caldwell 1980). All released birds were banded with colored and numbered leg bands and fitted with necklace-mounted radio transmitters. Seven birds were release 48 hours after capture, 24 birds were released 24 hours after capture, and 12 birds were released 4 hours after capture. Birds lost about 5% of their body weight during the translocation process. Although one female was unable to fly when released (trapping injury), she appeared to recover and survived about 2 months.

BIRD LOCATION AND MOVEMENT

Sharp-tailed grouse were located either visually or with triangulation using a portable receiver and 4-element Yagi antenna. For triangulation, 3 or more azimuths were obtained 1.0 km of target transmitters and at angles-of-incidence greater than 35^{o} and less than 145^{o}. All locations were recorded using Universal Transverse Mercator (UTM) coordinates. No birds were flushed more than three times between April and August; no females were disturbed while on nests. Bird movement was estimated in reference to specific locations such as release site, lek, or nest sites.

NEST AND BROOD SUCCESS

Females were closely monitored during the nesting season to collect information on the timing of nest incubation, nest failure, and nest success. Most females were located either visually or with triangulation techniques designed to determine whether the female was on her nest. Variation in intensity of transmitter signals also was used as an indication of female behavior; radio transmitters emitted a constant signal when a female was on her nest and a variable signal when she was walking or flying. 'Visual' observations of females on nests consisted of triangulation from a distance of about 30 m from the nest site; this minimized disturbance of females and allowed nest sites to be located following hatch or failure. Clutch size was estimated by counting eggs and egg shells within 5 days of the female's departure from the nest site.

Nest success was calculated as the percent of nests that hatched ≥ 1 egg. Breeding success was estimated as the percent of females that hatched ≥ 1 chick during the breeding season (regardless of whether the chick was produced from a first nest or renest). Fledging success was estimated as the percent of females that produced a brood 50 days old. Date of first day of nest incubation and date of nest failure were estimated as the midpoints between consecutive observations. For example, if a female was on her nest on 14 April and off her nest on 16 April following nest failure, the date of nest failure was considered 15 April. Nesting likelihood was estimated with different types of information including the direct observation of nests, localized movements by females (non-nesting movements by sharp-tailed grouse were often extremely large and erratic), dates of lek visits, and observation of females with broods.

SURVIVAL

Survival of sharp-tailed grouse was estimated using the Kaplan-Meier product limit estimator (SAS Institute Inc. 1988, White and Garrott 1990). Because 'lost' radio-marked birds may have had broken radio transmitters, these birds were censored from the analysis on the approximate date they 'disappeared' (White and Garrott 1990). Survival was compared for females and males with the log rank test (SAS Institute Inc. 1988, White and Garrott 1990). Survival was also compared between years, source populations, and length of time between capture and release.

RESULTS

BIRD LOCATION AND MOVEMENT

More than 1,800 visual or remote (triangulation) observations of radio-marked birds were obtained during 1998 and 1999 (Fig. 2). Although the birds were all released northwest of Omak (southeast of Conconully), they were observed in many areas throughout the Okanogan Valley. Most of the translocated sharp-tailed grouse moved long distances following release (Fig. 3). One female was observed 34 km from the release location. Despite the long movements, all males and most females returned to the SCWA to breed, display, and/or nest. The only two females that did not return to SCWA were observed the farthest away from SCWA. Males were observed on up to three different prominent locations during a single morning; these sites were often several km apart. Nevertheless, most males eventually became established on the lek near the release location.

Although the longest movements tended to be made by females, the overall difference due to sex was not significant ($P > 0.05$). Likewise, there were not detectable differences in movement that were attributable to age, source population, and time between capture and release ($P > 0.05$). The only significant difference in maximum movements was associated with year. Birds captured in 1998 moved a maximum distance of 27.7 km, while birds captured in 1999 moved a maximum distance of 5.2 km following release ($F = 18.84$, $P < 0.001$).

Translocated females nested an average of 5.1 km from where they were captured (Fig. 4). Females nested closer to leks in 1999 (1.2 km) than they did in 1998 (8.9 km). The four longest distances between the release site and nest locations were observed in 1998.

NEST AND BROOD SUCCESS

Average date of incubation initiation for translocated females was 13 May (range 2 May - 24 May). Females captured within Washington during previous research in 1992-97 (unpublished data) nested on 3 May. Nine of 17 nests were successful (52.9%). Because one female was known to have renested, annual breeding success was 56.3%.

Seven of the successful nests were on the SCWA, one was near Siwash Creek, and one was in the Tunk Valley. Average clutch size was 11.6 eggs (SD = 0.8 eggs). Fertility of eggs was extremely low (60.3%). Three of the successful females were killed by predators relatively soon after hatching. The radio transmitter on one successful female stopped working within 2 weeks of hatch. Four of the remaining 5 successful nests appeared to have chicks alive after 50 days of age (total of 13 chicks).

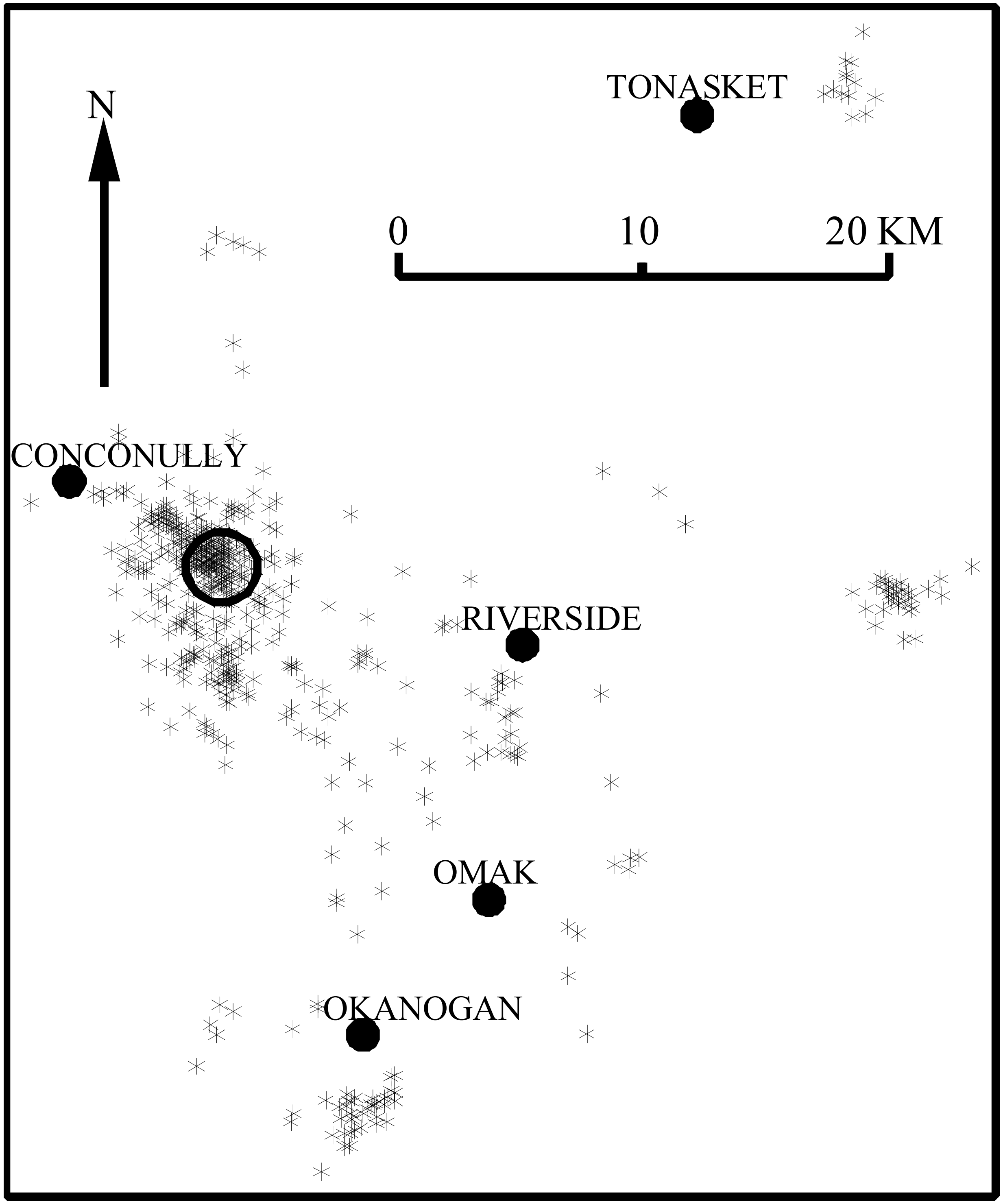

Fig. 2. Distribution of locations for translocated sharp-tailed grouse in north-central Washington, 1998-1999. The release site was in the center of the circle.

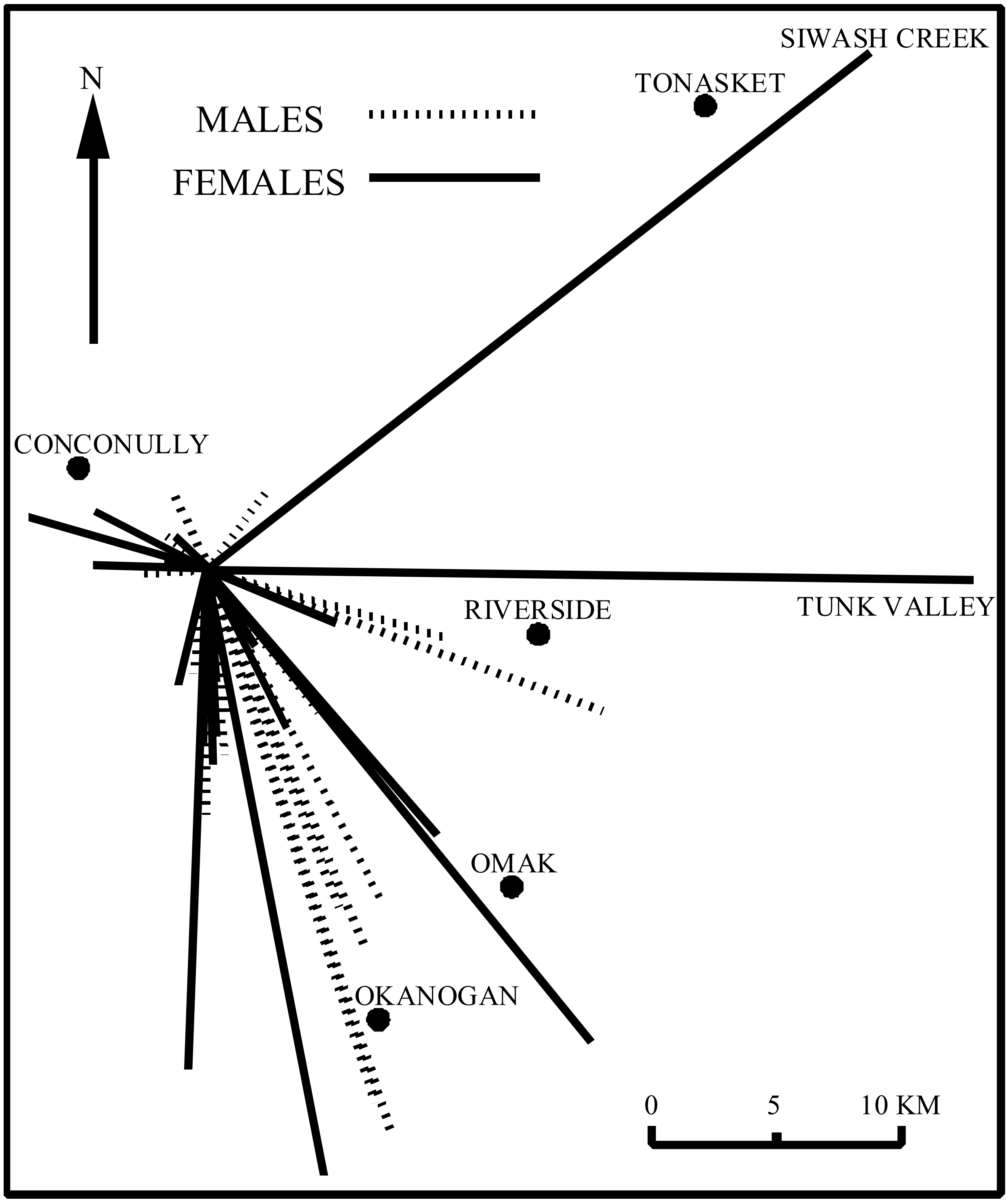

Fig. 3. Maximum dispersal by translocated sharp-tailed grouse in relation to the release site in north-central Washington, 1998-1999.

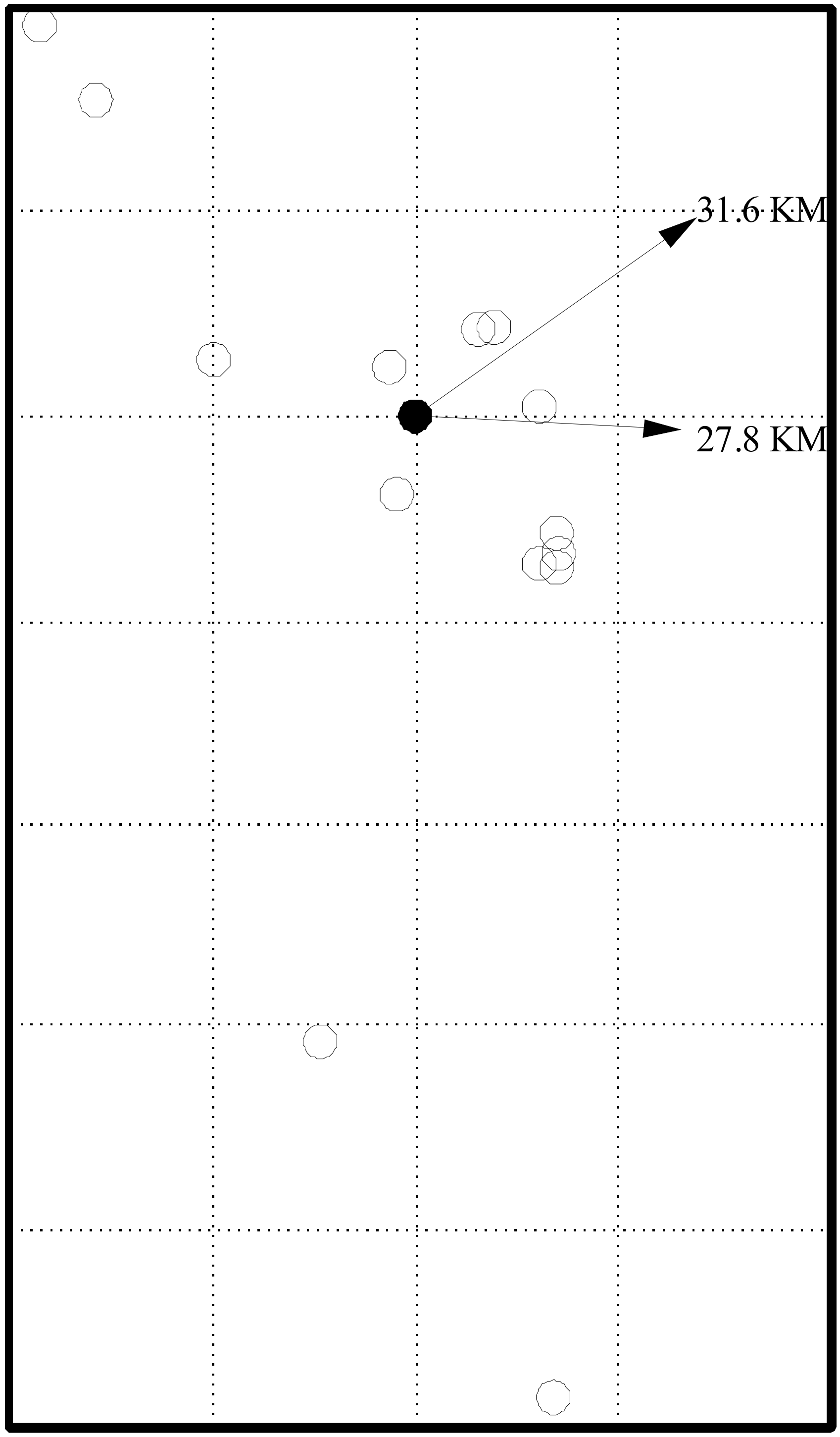

Fig. 4. Distribution of translocated sharp-tailed grouse nests in relation to their release site (solid circle) in north-central Washington, 1998-1999.

SURVIVAL

The estimated survival rate for the first 4 months following release was 47.7% (95% CI = 32.1 - 63.3%)(Fig. 5). Although survival tended to be higher for males, for birds captured in 1999, for birds captured on the Colville Indian Reservation, and for birds released relatively soon after capture, none of the differences were significant.

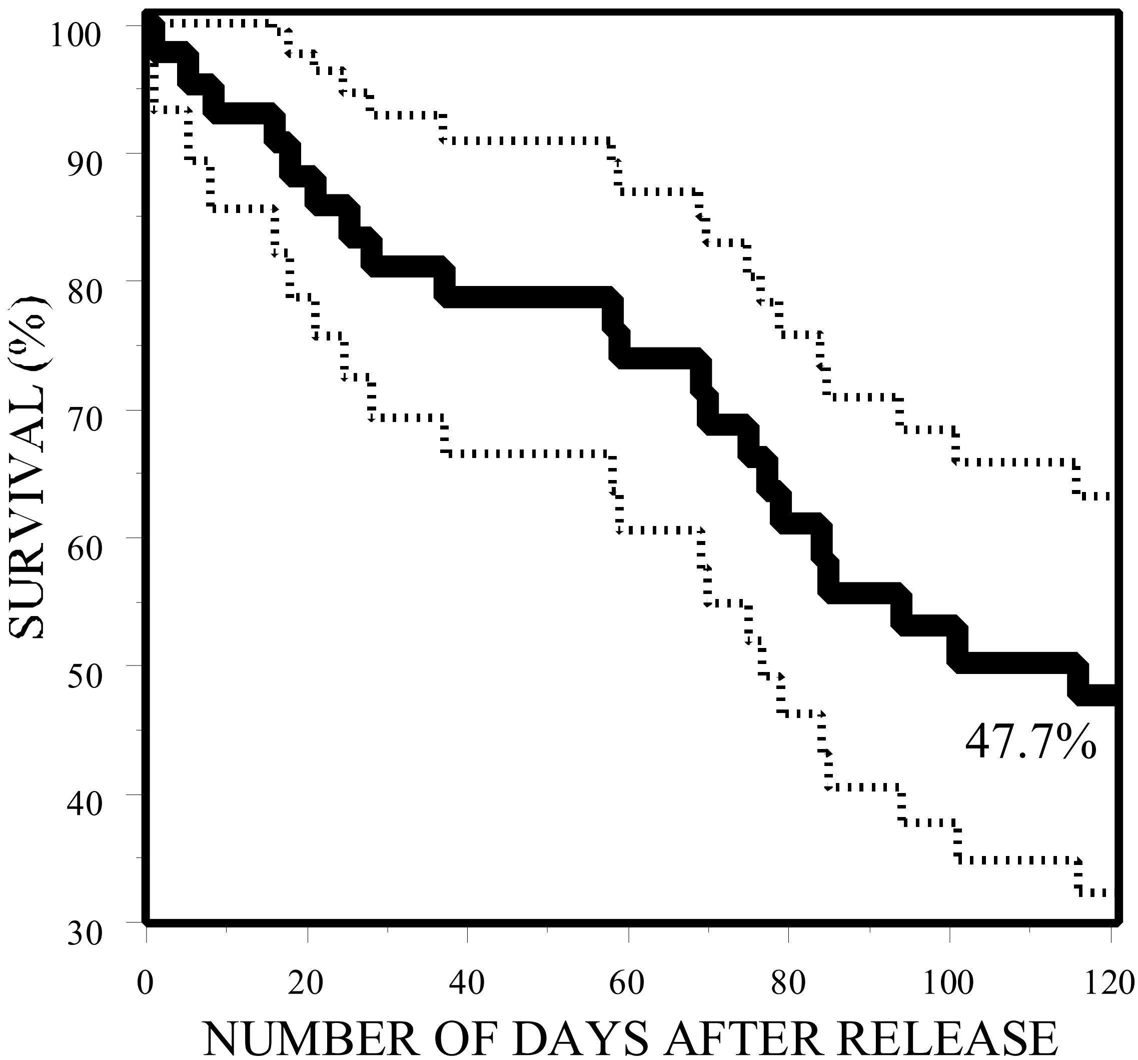

Figure 5. Estimated survival (95% CI) with the Kaplan-Meier product limit estimator for translocated sharp-tailed grouse in north-central Washington, 1998-1999.

DISCUSSION

Movements of translocated sharp-tailed grouse were extremely large in north-central Washington, particularly in 1998. Both males and females appeared to 'explore' most of the potential sharp-tailed grouse habitat within the region. Despite the large movements, only two females were known to have become established off the SCWA.

Both of these females moved to areas with existing populations of sharp-tailed grouse; these were the 2 closest 'known' populations to the SCWA. None of the other translocated birds appeared to 'find' existing populations of sharp-tailed grouse, other than the 2 males on the only remaining lek on the SCWA. The relatively small movements in 1999 may have occurred because of the larger number of established birds on SCWA.

Although all estimates of productivity and survival for these translocated birds were low, they were not substantially different from other translocation efforts (Gardner 1997). Success of translocation efforts is often a result of repeated translocations over a period of at least 3 years (Griffith et al. 1989, Toepfer et al. 1990).

Populations in north-central Washington are clearly becoming more isolated every year. The isolation of populations may have important ramifications on their genetic quality and/or recruitment. However, it is not yet clear if the Washington populations are declining because of their isolation or because of a combination of other factors. Evidence from previous research (McDonald 1998) indicates that most movements of radio-marked birds are not sufficient to allow for interchange of individuals between populations in north-central Washington. Isolation of populations may explain, in part, the low fertility rate for eggs of translocated females (Bouzat 1998).

Research on the transplanted sharp-tailed grouse will continue as long as radio-marked birds can be located. Updated information on survival, movement, habitat use, and productivity will be evaluated to determine the success of the sharp-tailed grouse transplant and habitat restoration efforts on the SCWA, and the need and methodologies for future translocation efforts.

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Job Title: Job 3. Obtain information on genetic variation and identification of sage grouse and Columbian sharp-tailed grouse within the remaining populations in North America

Period Covered: 01 February 2000 through 31 December 2001

Report Title: Genetic Analysis of Columbian Sharp-tailed Grouse: A Preliminary Study

Author: Kenneth I. Warheit and Michael A. Schroeder

Personnel: Colville Indian Reservation, Idaho Department of Fish and Game, Daniel J. Peterson, D. John Pierce, Michael A. Schroeder, Kenneth I. Warheit, and Washington Department of Fish and Wildlife

INTRODUCTION

The historical range of the Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) extended from the steppe- and shrub-dominated habitats in the inter-mountain regions from British Columbia south to California, Nevada, and Utah, and east to western Montana, Wyoming and Colorado. The subspecies has been extirpated from most of its range and exists now as remnant and isolated populations. The core of Columbian sharp-tailed grouse distribution now exists as scattered populations in southeast Idaho and northern Utah where 50-70% of the subspecies total abundance currently resides (USFWS, 1999). The decline of sharp-tailed grouse in Washington has been precipitous and extreme, and it now exist in only six to eight small and fragmented populations in Douglas, Lincoln, and Okanogan Counties (Hays et al., 1998).

As part of Washington Department of Fish and Wildlife's continuing assessment of the status of and recovery efforts for sharp-tailed grouse in the state, we have initiated a project to evaluate this subspecies' geographic structure and population genetics in Washington and neighboring states. One of the primary objectives of this study is to determine the genetic relationships of the existing Columbian sharp-tailed grouse populations. The purpose of this activity is to determine if cross-transplanting birds from neighboring populations within Washington or moving birds from viable population in Idaho and Utah into Washington is feasible and appropriate. In addition, a genetic analysis of Columbian sharp-tailed grouse populations would also permit us to evaluate the degree to which the small and isolated populations in Washington have experienced a loss of genetic diversity either through genetic drift or inbreeding. A loss in genetic diversity may be associated with or foretell a decrease in overall population fitness, similar to that which occurred in the congeneric greater prairie-chicken (*Tympanuchus cupido*; Bouzat et al., 1998a,b).

The purpose of this document is to report the results of a preliminary analysis of the population genetics of Columbian sharp-tailed grouse, primarily from two general localities in Washington and Idaho. The activities associated with the report were funded by US Department of Interior, Bureau of Land Management (BLM; Contract # HWP000025). The intent of this initial project was to develop laboratory protocols for the amplification and scoring of microsatellite loci, and to provide a preliminary assessment of genetic diversity and geographic structure of Columbian Sharp-tailed Grouse.

METHODS

We did not attempt to develop microsatellite loci for this project. Instead, we screened the literature and Genbank (Benson et al., 2000) for microsatellite loci developed for other Tetraonidae taxa, and evaluated their use in sharp-tailed grouse. Our initial literature search provided primer sequences for XX microsatellite loci, from which we tested appropriate amplification in sharp-tailed grouse. We developed polymerase chain reaction (PCR) protocols for XX of these loci, and based on their ease of use and relative variability in a subset of our samples, we used seven of these loci for all subsequent analyses (Table 1).

Table 1. Origin of each microsatellite locus used in this study. The Accession #s refer to the nucleotide database in Genbank, except the AF303097, which refers to an Accession # in the European Molecular Biology Laboratory (EMBC) database.

Locus	Developed in	Reference	Accession #
ADL146	Domestic chicken (*Gallus gallus*)	Cheng and Crittenden (1994); Bouzat et al. (1998a,b)	G01571
ADL162	Domestic chicken (*Gallus gallus*)	Cheng and Crittenden (1994); Bouzat et al. (1998a,b)	G01586
ADL230	Domestic chicken (*Gallus gallus*)	Cheng and Crittenden (1994); Bouzat et al. (1998a,b)	G01650
LLSD3	Red grouse (*Lagopus lagopus*)	Piertney and Dallas (1997)	X99053
LLSD4	Red grouse (*Lagopus lagopus*)	Piertney and Dallas (1997)	X99054
LLSD7	Red grouse (*Lagopus lagopus*)	Piertney and Dallas (1997)	X99057
TTD6	Black grouse (*Tetrao tetrix*)	Caizergues et al. (2001)	AF303097

We obtained a total of 63 blood samples from five general localities (Fig. 1; Table 2): Washington (Douglas and Okanogan Counties) [n=20]; Idaho (Power County) [31]; Montana (west of the continental divide, Powell County) [3]; Montana (east of the continental divide, Lewis and Clarke County) [6]; and Alaska (140 km southeast of Fairbanks) [3]. The Washington and Idaho samples are from Columbian sharp-tailed grouse, the Alaska samples are from Alaskan sharp-tailed grouse (*T. p. caurus*), and the Lewis and Clark County, Montana (eMT) samples are from the Plains sharp-tailed grouse (*T. p. jamesi*). The taxonomic identity of the Powell County, Montana (wMT) samples is in doubt (B. Deeble, pers. comm. 2001), but are thought to be from Columbian sharp-tailed grouse because the population exists west of the continental divide. Although for this report we treat the Washington and Idaho samples each as a single population, there is some geographic heterogeneity within each of these populations. In Washington, there are two localities from which the samples where drawn: Nespelem, Okanogan County [n=17] and Dyre Hill, Douglas County [3]. The average among-sample distance within each of these localities is 1.0 and 0.0 km, respectively, and the two localities are separated by about 61 km. The Idaho population is divided into roughly 4 subpopulations, with an additional six individuals scattered between these subpopulations. Although the average among-sample distance within each of these subpopulations is 0.0 km, the four subpopulations are separated by an average of 22 km. Despite this spatial heterogeneity in the Washington and Idaho samples, the results are similar regardless of whether the samples are pooled into two respective populations or are analyzed per subpopulations. As such, we report only the results from the pooled samples.

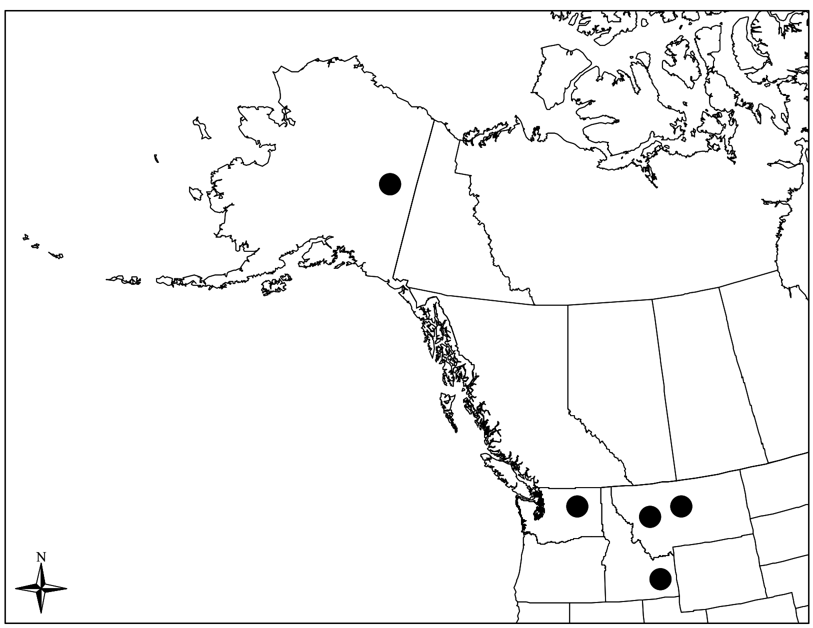

Figure 1. General localities of Sharp-tailed Grouse samples.

We used Qiagen DNeasy Spin Tubes for extracting DNA from each of the blood samples following the standard nucleated blood protocols provided with the kit. PCR microsatellite protocol development and locus amplification were conducted on MJ Research PTC-200 thermocyclers and the DNA fragments were visualized using florescently labeled primers and an Applied Biosystems ABI Prism 377 sequencer. Each sample was run with an internal size standard (Applied Biosystems GeneScan 500) and sized using GeneScan 3.1 and Genotyper 2.5 software. We conducted statistical analyses using Genepop 3.3 (Raymond and Rousset, 1995) and GDA 1d16c (Lewis and Zaykin, 2001), or using macros and programs developed by us and implemented on Microsoft Excel 2000.

Table 2. Sample sizes and number of alleles for each microsatellite locus per each locality. Western Montana (wMT) and eastern Montana (eMT) refer to the Powell County, Montana and Lewis and Clark County, Montana samples, respectively.

Locus	Sample Size					Number of Alleles				
	WA	ID	wMT	eMT	AK	WA	ID	wMT	eMT	AK
ADL146	14	31	2	6	3	3	5	3	3	2
ADL162	13	31	3	6	3	5	2	1	3	2
ADL230	18	31	3	6	3	7	6	5	5	3
LLSD3	17	31	3	6	3	5	5	3	4	2
LLSD4	20	31	3	6	3	11	14	4	7	4
LLSD7	19	31	3	6	3	7	8	5	5	5
TTD6	19	31	3	4	3	5	4	1	3	2
Overall	17.1	31.0	2.9	5.7	3.0	6.14	6.29	3.14	4.29	2.86

RESULTS AND DISCUSSION

Genetic Diversity within Population

Samples sizes are small for each of the populations, especially for the Alaska and two Montana populations where sample sizes per locus range from two to six individuals (Table 2). As such, no definitive conclusions should be made from these data concerning levels of genetic diversity within each of these populations, or the genetic divergence among the populations. The sample sizes from the Washington and Idaho populations are larger than those from the other localities and do provide sufficient power to discern significant differences where they occur (i.e., minimize the probability of making a Type II statistical error).

Genetic diversity can be used as a measure of population health and evolutionary potential. That is, it is assumed that a population, as a whole, has a greater potential to cope with a variety of environmental effects with a diverse array of genotypes than a population with reduced genetic diversity (see Hedrick, 1996 for caution in using this assumption). We provide several measures of genetic diversity for each of the populations, although the sizes for Alaska and Montana samples are insufficient to describe the true molecular variance for each population. LLSD4 is the most variable locus within each population, with as many as 14 alleles in the Idaho samples (Table 2). Overall, all loci are polymorphic in the Washington and Idaho samples, and both populations show similar levels of allelic diversity (Table 2) and expected heterozygosity (Table 3). This indicates that in terms of the number of alleles per locus, the Washington and Idaho samples show the same level of variability (Table 4). As expected, there is less allelic diversity in the wMT and Alaska populations where we sampled only three individuals from each locality. Although our eMT sample consisted of only six individuals, the expected heterozygosity in this populations was comparable to both the Washington and Idaho samples (Table 3).

Table 3. Expected and observed heterozygosities and deviations from Hardy-Weinberg (heterozygosity deficit).

Locus	Expected heterozygosity					Observed heterozygosity				
	WA	ID	wMT	eMT	AK	WA[a]	ID	wMT	eMT	AK
ADL146	0.519	0.576	0.833	0.439	0.333	0.357	0.581	1.000	0.500	0.333
ADL162	0.351	0.275	0.000	0.318	0.333	0.308	0.323	0.000	0.333	0.333
ADL230	0.852	0.746	0.933	0.788	0.733	0.611****	0.774	1.000	0.833	1.000
LLSD3	0.775	0.675	0.600	0.803	0.333	0.529***	0.677	0.667	0.833	0.333
LLSD4	0.860	0.873	0.867	0.924	0.800	0.650*	0.839	0.667	1.000	0.667
LLSD7	0.785	0.818	0.933	0.788	0.933	0.737	0.806	1.000	0.667	1.000
TTD6	0.670	0.673	0.000	0.679	0.333	0.421**	0.613	0.000	0.750	0.333
Overall	0.688	0.662	0.595	0.677	0.543	0.516	0.659	0.619	0.702	0.571

[a]Observed heterozygosity significantly less than expected heterozygosity (heterozygosity deficit), using an estimate of p-values based on Markov-chain method (Genepop).
*; p = 0.20 (adjusting for experimentwise error rate; actual probability is p = 0.04).
**; p = 0.10 (adjusting for experimentwise error rate; actual probability is p = 0.02).
***; p = 0.05 (adjusting for experimentwise error rate; actual probability is p = 0.01).
****; p = 0.01 (adjusting for experimentwise error rate; actual probability is p = 0.002).

Although the degree of allelic diversity in the Washington and Idaho samples are the same, the Washington population has a deficit in the number of observed heterozygotes, and as such, the population is not in Hardy-Weinberg equilibrium at two to four of the seven loci (Table 3). None of the other populations show a heterozygote deficit and all other populations are in Hardy-Weinberg equilibrium at all loci. What this means is that although both the Washington and Idaho samples have roughly the same number of alleles, those alleles are represented significantly more as homozygotes in Washington than in Idaho. In other words, the Idaho samples show significantly greater within-individual genetic diversity than the Washington samples.

A reduction in the number of heterozygotes and deviations from Hardy-Weinberg equilibrium can result from several different factors, including inbreeding, selection, mutation, and immigration, or can be an artifact of null or non-amplifying alleles. Since it is only the Washington population that has heterozygote deficiencies, and it would be unlikely that selection or altered mutation rates would be affecting only this population. Furthermore, as we show below, there appears to be little or no gene flow and therefore effectively no migration among all populations in this analysis. Therefore, the most plausible hypotheses for the deficiencies of heterozygotes in Washington is either null alleles or inbreeding. Null alleles can be in either a heterozygote or homozygote form. An individual with a heterozygote null allele has one non-amplifying allele (the null allele) and one amplifying allele. Since the one amplifying allele is the only allele that is visualized electrophoretically, the sample appears as a homozygote. A homozygote null allele has two non-amplifying alleles and since no alleles are visualized electrophoretically, the sample appears as a blank, thereby reducing the population's sample size for that locus. The per locus samples sizes for Washington population are considerably more variable than those for the other localities (Table 2) suggesting that null alleles may be present.

An alternative hypothesis for variable number of amplifying samples per locus is poor quality DNA. If a reduction in sample size for a particular locus is a function of homozygote null alleles and if there is a direct relationship between the number of homozygote and heterozygote null alleles (i.e., if a null allele is present it should occur in both homozygote and heterozygote states), there should also be a direct relationship across all loci between a population's sample size and the probability of heterozygote deficiency. That is, loci with small sample sizes should also have low p-values for heterozygote deficiency (low p-value indicates that the null hypothesis of no heterozygote deficiency has been rejected – i.e., there is indeed a heterozygote deficiency). However, as shown Fig. 2, there appears to be no relationship between p-values and sample size. In fact, except for one locus (LLSD7), those loci with the highest sample sizes seem to be the loci with a deficiency in heterozygotes. This suggests that the reduction in heterozygotes in the Washington population is not due to null alleles.

Table 4 shows the distribution of alleles for each locus in each of the five populations. In addition, we also provide an inbreeding coefficient (*f* or F_{IS}) for each locus and as a single measure of inbreeding averaged over all loci. This inbreeding coefficient measures the probability that alleles at a single locus from an individual are identical by descent. Alleles that are identical by descent are those from related individuals, and as such, this coefficient measures the degree to which the parents of an individual are related. From a heterozygosity perspective, this inbreeding coefficient measure the extent to which the observed heterozygosity in a population is less than the expected heterozygosity, and it is assumed that this reduction is the result of inbreeding. An inbreeding coefficient greater than zero suggests here that inbreeding is occurring in that population.

Table 4. Allele frequencies, with alleles measured in numbers of basepairs. Inbreeding coefficient (*f*) is the loss of heterozygosity resulting from inbreeding. The overall *f* is the average across all loci, with the upper and lower bounds from a bootstrap, resampling across loci.

	WA	ID	wMT	eMT	AK
ADL146					
188	8	36	1	9	5
190	18	9	2	1	1
192	2	17	1	2	-
F	0.32	-0.01	0.00	-0.33	-0.15
ADL162					
93	-	-	-	-	1
117	-	10	-	1	-
119	1	-	-	1	-
121	21	52	6	10	5
137	2	-	-	-	-
139	1	-	-	-	-
155	1	-	-	-	-
F	0.13	-0.18	0.00	0.00	-0.05
ADL230					
100	-	-	-	-	1
106	2	19	1	1	-
108	6	-	-	-	-
110	2	1	1	-	3
112	-	21	-	3	2
114	-	-	1	1	-
116	9	14	1	2	-
118	6	4	2	5	-
120	5	3	-	-	-
122	6	-	-	-	-
F	0.29	-0.04	-0.50	-0.09	-0.06

	WA	ID	wMT	eMT	AK
LLSD3					
121	-	2	-	-	-
123	-	-	-	3	-
127	3	-	-	-	-
131	12	22	1	2	1
133	6	3	-	-	-
135	-	8	-	3	-
137	9	27	4	-	5
139	-	-	1	4	-
141	4	-	-	-	-
F	0.32	0.00	0.00	-0.14	-0.04
LLSD7					
156	-	5	1	1	-
158	-	-	1	-	-
160	14	7	1	3	-
162	2	11	-	1	1
164	7	9	-	-	-
166	1	1	-	-	-
168	8	21	1	2	2
170	5	5	-	5	-
172	-	3	-	-	-
174	1	-	2	-	1
180	-	-	-	-	1
182	-	-	-	-	1
F	0.06	0.01	-0.09	-0.09	0.17

Table 4. Continued.

	WA	ID	WMT	eMT	AK
LLSD4					
181	-	1	-	-	-
185	5	4	-	-	-
187	-	2	1	-	-
189	12	-	-	-	-
191	1	-	-	-	-
195	-	2	-	-	-
197	1	-	-	-	1
199	1	-	-	-	-
201	-	5	2	2	-
203	4	9	1	-	-
205	1	3	-	-	3
207	4	17	2	2	-
209	1	2	-	2	-
211	4	9	-	-	1
213	6	5	-	1	-
215	-	1	-	2	1
217	-	1	-	2	-
223	-	1	-	-	-
225	-	-	-	1	-
F	0.25	0.04	0.20	0.27	-0.09
TTD6					
112	2	9	-	-	-
116	17	25	-	3	5
118	14	24	6	-	1
120	2	-	-	4	-
122	3	4	-	1	-
F	0.38	0.09	0.00	0.00	-0.13

	WA	ID	wMT	eMT	AK
Overall					
F	0.26	0.01	-0.06	-0.04	-0.07
Upper	0.33	0.04	0.14	0.04	0.10
Lower	0.17	-0.04	-0.24	-0.11	-0.28

In the Washington population, six of the seven loci show inbreeding coefficients greater than zero, while in the Idaho population, none of the loci show inbreeding coefficients greater than zero (Table 4). Overall, all populations, except Washington, shown an inbreeding coefficient not significantly different from zero, while the coefficient in Washington is 0.26 (Table 4). The upper and lower bounds of a bootstrap provide a means by which each of the coefficients can be tested for similarities. The range of inbreeding coefficients for Idaho, wMT, eMT, and Alaska samples are all overlapping indicating that the coefficients in these populations are the same and are equal to zero. However, the lower bound of the coefficient in Washington is 0.17 (Table 4), indicating that the coefficient is significantly positive and different from all other populations. These data suggest that the reduction in heterozygotes in Washington is a result of inbreeding.

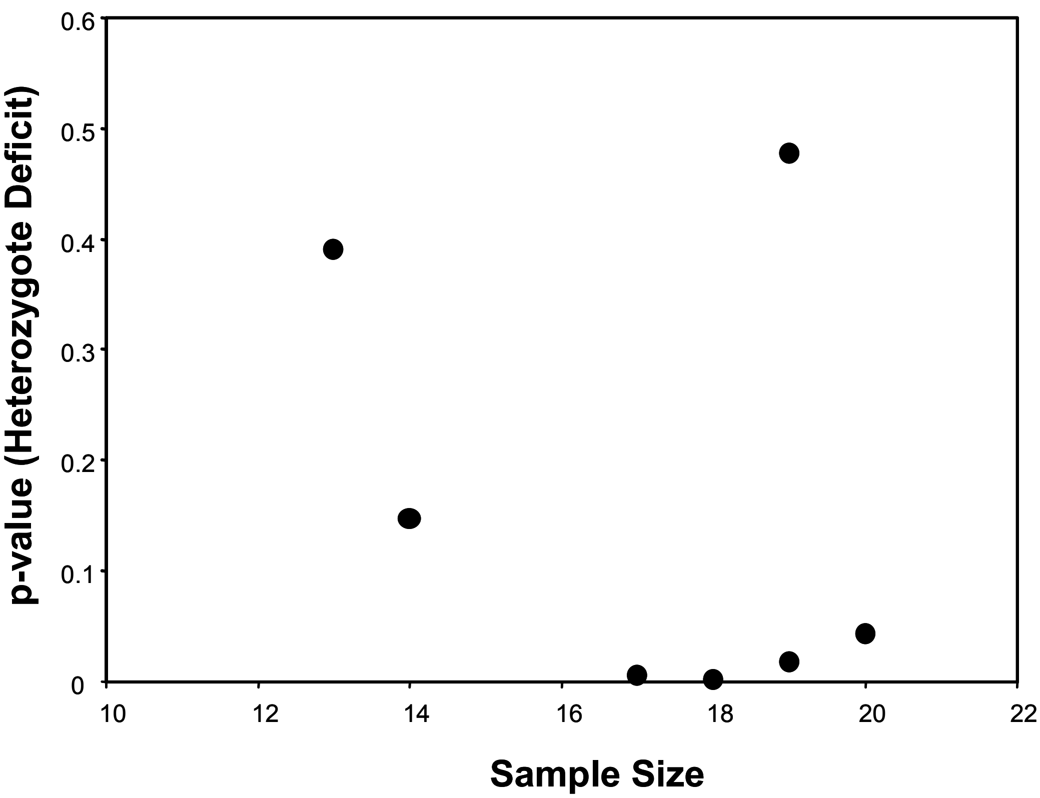

Fig. 2. Sample size versus p-value for heterozygote deficit for each locus.

Genetic Differentiation Among Populations

Because the Washington and Idaho samples were drawn from the same subspecies, while the Alaska and eMT samples represent two additional subspecies, our initial hypothesis was that the Idaho and Washington samples would be most similar to each other and significantly different from both Alaska and eMT. That hypothesis proved to be false. Since the identity of the wMT samples was unknown, but though to be from the Columbian sharp-tailed grouse, we also assumed that if indeed the wMT samples were from this subspecies, they would be genetically more similar to Washington and Idaho than the neighboring eMT samples (plains sharp-tailed grouse). We provide two measures of population differentiation (Table 5). In calculating the coancestry coefficient (θ), we did not assume Hardy-Weinberg equilibrium, and as such, θ measures to degree to which the genotypes for these seven microsatellite loci have differentiated between each pair of populations. Coancestry coefficients equal to zero indicate no differentiation. Each of the coancestry coefficients in Table 5 are significantly greater than zero, indicating that the genotypes in each of these populations are significantly different from each other. Furthermore, the largest coefficients (indicating greater differentiation) for each the Washington, Idaho, and wMT populations was with the Alaska and eMT populations, which is not surprising considering the fact that the Alaska and eMT populations are from different subspecies. However, the coefficients for the Idaho samples appear constant through all pairwise comparisons suggesting an equal distance between these samples and the other four populations (Table 5). This is inexplicable, but may be related to the fact that the sample sizes are grossly unbalanced in each of these calculations (e.g., n= 31 for Idaho and n=3 for Alaska).

Table 5. Two measures of population differentiation. Coancestry coefficent, θ (above the diagonal) measures the degree to which the genotypes have differentiated between each pairwise comparison of populations. A higher coancestry coefficient, the greater the genetic differentiation (θ = 0 indicates no differentiation). Below the diagonal are p-values testing the null hypothesis that the genotypic distribution is idential between each pair of populations (genotypic differentiation test in Genepop). Populations that have significantly different genotypes are shown in bold[a].

	WA	ID	wMT	eMT	AK
WA		0.08	0.05	0.11	0.12
ID	<0.00001		0.07	0.09	0.08
wMT	0.02459	0.00079		0.19	0.21
eMT	<0.00001	<0.00001	0.03529		0.17
AK	0.00014	0.00001	0.60245	0.00496	

[a]$p < 0.05$ is considered significant; however, alpha is adjusted for experimentwise error rate resulting in $p < 0.005$ required to reject null hypothesis.

Fig. 3 is a minimum evolution tree based on the coancestry coefficient in Table 5. A minimum evolution tree is the one tree whose topology out of all possible topologies has the smallest sum of all branch lengths (Nei and Kumar, 2000). The plot is essentially a graphical representation of the coancestry coefficient matrix, and should not be construed as a phylogenetic tree. The tree is unrooted because no outgroup was designated in this analysis. However, from the perspective of the Columbian Sharp-tailed Grouse, the root would be placed at either the AK (Alaska subspecies) or the eMT (Plains subspecies) node. This tree shows the close association between the Washington and wMT samples, and this association is maintained regardless of whether the root for the tree is placed at either the Alaska and eMT node.

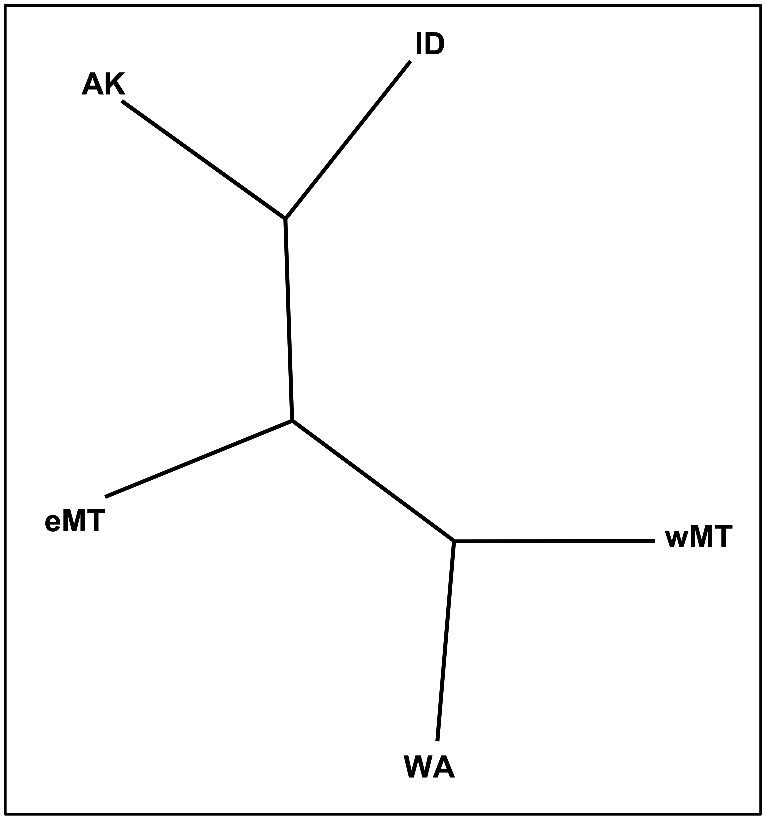

Fig. 3. Unrooted minimum evolution tree derived from the co-ancestry coefficients (Table 5).

The lower part of the matrix in Table 5 are probability values testing the null hypothesis that the genotypic distribution between each pair of populations is identical. That is, small values indicate significant differentiation between the pair of populations. All pairwise comparisons show highly significant population differentiation, except those involving wMT, whose sample size and degree of differentiation provided little power to adequately test for differences (except in wMT's comparison with Idaho, where Idaho large sample size provided sufficient power to adequately test for differences). What this means is that although there may be a significant genetic differentiation between wMT and Washington, Alaska, or eMT, the sample sizes in the analyses are insufficient to test for that differentiation.

CONCLUSIONS

Based on the analyses presented in this report, we reached the following two conclusions. However, we emphasize that although the sample sizes for both the Washington and Idaho samples appear adequate for the types of analyses presented here, they are still relatively small (especially Washington), and the samples were drawn from effectively one population each and during one sampling period. Repeated samples from these populations and neighboring sites from both the Washington and Idaho localities are needed to confirm these conclusions:

(1). The Washington population (Nespelem and Dyre Hill samples) has a reduction in heterozygotes due to inbreeding. Although this population appears to be inbreed, the total number of alleles, representing some measure of genetic diversity, is similar to the outbreed population in Idaho.

(2). The Washington and Idaho populations are significantly differentiated genotypically, which suggests that there is little or no gene flow between these two sites and the populations are currently on different evolutionary trajectories.

In additional to these two conclusions, the following list is a set of tentative conclusions based on the results concerning all five populations in the analysis. Because the sample sizes for the Alaska, Powell County (wMT), and Lewis and Clarke County (eMT) populations are very small, these conclusions should be used with caution, and it is very likely that the conclusions may change with additional samples.

(3). The Powell County, Montana (wMT) samples appear most similar genetically to the Washington samples (and secondarily to the Idaho samples, although this relationship is not entirely clear based on Fig. 3). These wMT samples are not genetically similar to the Lewis and Clark County (eMT) samples which suggest that the wMT samples were drawn from a Columbian Sharp-tailed Grouse population rather than a Plains Sharp-tailed Grouse population.

(4). The current sharp-tailed grouse taxonomy is not reflected in the coancestry coefficients and the minimum evolution tree, based on these coefficients. That is, the Idaho Columbian sharp-tailed grouse appears more similar genetically to either the Alaska sharp-tailed grouse or the plains sharp-tailed grouse, than to the Washington Columbian sharp-tailed grouse. However, the large sample size for the Idaho populations and the small sample sizes for the wMT, eMT, and Alaska samples may be affecting this analysis.

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Job Title: Job 4. Evaluate management of ring-necked pheasants in eastern Washington with emphasis on the specific cost-effectiveness of habitat restoration efforts

Period Covered: 01 January 2001 through 31 December 2001

Report Title: Ring-necked pheasants in relation to habitat restoration efforts

Author: Michael A. Schroeder

Personnel: D. John Pierce, Michael A. Schroeder, and Washington Department of Fish and Wildlife

SUMMARY

Nothing was accomplished with this job during the last year.

Job Title:	Job 5. Evaluate Conservation Reserve Program (CRP) with respect to critical species of wildlife including sage grouse, sharp-tailed grouse, and ring-necked pheasants
Period Covered:	01 January 2001 through 31 December 2001
Report Title:	Evaluation of Conservation Reserve Program in eastern Washington
Author:	Michael A. Schroeder and Matthew Vander Haegen
Personnel:	D. John Pierce, Michael A. Schroeder, Matthew Vander Haegen, and Washington Department of Fish and Wildlife

SUMMARY

Although most of eastern Washington was historically dominated by shrub-steppe habitat, the vast majority has been altered by conversion, degradation, and fragmentation. The remaining habitat often appears to be insufficient to support numerous species of wildlife that are dependent on shrub-steppe habitat for all, or a portion, of their life cycle. Consequently, many species dependent on shrub-steppe habitat are faced with declining distributions and populations, and ultimately with an increased risk of extinction. In an effort to slow the decline of the shrub-steppe ecosystem, substantial resources have been dedicated to the acquisition and/or restoration of > 5,000 km^2 in eastern Washington. This include lands enrolled in the federally-administered Conservation Reserve Program (CRP), lands directly administered by federally agencies (Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. Forest Service, Department of Energy, Department of Defense, and Bureau of Reclamation), and wildlife areas owned by the state of Washington.

Unfortunately, because these restoration efforts are being administered by a variety of government agencies and private organizations and individuals, there is no unified goal to address the long-term problems with quantity, quality, and configuration of shrub-steppe habitat. In addition, there is shortage of basic information about the habitat requirements of shrub-steppe wildlife (such as sage grouse and sharp-tailed grouse), the quantity, quality, and configuration of existing shrub-steppe habitat, and the effectiveness of ongoing strategies to restore shrub-steppe habitat. The overall goal of this project is to achieve a basic understanding of the extent and condition of existing and restored shrub-steppe resources in eastern Washington and how human-caused changes in the landscape influence wildlife associated with shrub-steppe. This project is designed to accomplish several specific goals including: 1) augment understanding of relationships between existing shrub-steppe habitat and species of wildlife dependent on shrub-steppe; 2) evaluate the effectiveness of ongoing efforts to restore shrub-steppe; 3) obtain necessary information about species-habitat relationships for species that depend on shrub-steppe; 4) develop cooperative relationships between private, government, and

conservation entities that will help ensure the attainment of conservation objectives; and 5) disseminate information that will facilitate the management, protection, and restoration of the shrub-steppe ecosystem.

Initial plans are being developed to implement this research in Washington. The first step (scheduled for 2002) is to map the Conservation Reserve Program (CRP) habitat in eastern Washington. The new mapping effort will update and expand an earlier database described by Jacobson and Snyder (2000, Shrubsteppe mapping of eastern Washington using Landsat Satellite Thematic Mapper data, Washington Department of Fish and Wildlife). The second effort is to select study areas for an evaluation of habitat quality in 'restored' shrub-steppe habitats. The habitat characteristics to be examined include: 1) landscape configuration in relation to existing shrub-steppe habitat; 2) patch size; 3) type and diversity of vegetation planted in the 'restored' patches; and 4) time since the restoration effort was initiated. The habitat characteristics will be compared with the abundance of wildlife species dependent on shrub-steppe habitat, including sage grouse and sharp-tailed grouse.

Job Title: Job 6. Conduct pilot research to evaluate forest grouse management strategy

Period Covered: 01 January 1992 through 31 December 2001

Report Title: Hunting Pressure and Demography of Forest Grouse in North-central Washington

Author: Michael A. Schroeder and Mick Cope

Personnel: Mick Cope, Daniel J. Peterson, D. John Pierce, Michael A. Schroeder, Matthew Vander Haegen, Dave Ware, and Washington Department of Fish and Wildlife

INTRODUCTION

Ruffed grouse (*Bonasa umbellus*), spruce grouse (*Dendragapus canadensis*), and blue grouse (*D. obscurus*) are important wildlife resources in the forests of north-central Washington, particularly in Region 2. In addition to providing important hunting opportunities, forest-dwelling grouse are integral components of their respective ecosystems. In 1953 surveys were initiated to evaluate the overall demography of forest grouse populations and patterns of hunting pressure. Between 1953 and 2000 surveys consisted of check stations, line transects, wing barrels, hunter questionnaires, and observation and recovery of banded birds. The subsequent analysis of these surveys addresses numerous questions. 1) What is the distribution of grouse harvest with respect to species and age? 2) Does the distribution of harvest vary between area and year? 3) Does hunter success rate (hours/recovered grouse) vary between area and year? 4) Is the proportion of juveniles positively correlated with estimates of harvest? 5) How do the different survey techniques compare with regard to efficiency of data collection and quality of information?

METHODS

Check Stations

Three check stations were operated in north-central Washington to obtain information on grouse harvest at various intervals between 1953 and 2000. The stations included Conconully (1953-1995, 1 km S Conconully), Chumstick (1953-1964, 2 km N Leavenworth), and Eight Mile Creek (1958-1962, 13 km N Winthrop). The check stations were eventually terminated because of the decline in the number of hunters in the respective areas. Check stations typically were conducted on the opening day and/or opening weekend of hunting season. In addition, surveys often were continued on the second, third, and fourth weekends of the hunting season. Check stations for species other than grouse were conducted during variable date periods. Drivers and passengers of most vehicles were interviewed about their hunting results; most recovered grouse were examined. Data collected at check stations included: 1) number of hunters in each group; 2) number of hours hunted; 3) presence of a hunting dog; 4) county of origin for hunters; 5) specific area in which they hunted; and 6) number of birds recovered according to species, sex, and age (Table 1).

Table 1. Documentation of species, age, and sex for blue, spruce, and ruffed grouse.

Species	Age	Sex	Sex and age
General	Dwight 1900, Gower 1939, Petrides 1942, Wright and Hiatt 1943		Larson and Taber 1980
Blue grouse	Van Rossem 1925, Bendell 1955, Smith and Buss 1963, Zwickel and Lance 1966, Schladweiler et al. 1970, Redfield and Zwickel 1976	Caswell 1954, Mussehl and Leik 1963, Zwickel and Dake 1977[a], Hoffman 1983, Zwickel et al. 1991	Boag 1965[a], Braun 1971, Bunnell et al. 1977, Hoffman 1985[a], Zwickel 1992
Spruce grouse	McCourt and Keppie 1975, McKinnon 1983, Szuba et al. 1987	Ellison 1968, Boag and Schroeder 1992	Lumsden and Weeden 1963, Zwickel and Martinsen 1967
Ruffed grouse	Dorney and Holzer 1957, Rodgers 1979	Roussel and Ouellet 1975	Dorney 1966, Hale et al. 1954, Davis 1969

[a]Molt can be use to infer breeding success.

LINE TRANSECTS

Line transects were surveyed between 1954 and 1974 and between 1996 and 2000 in order to monitor the abundance of forest grouse in north-central Washington (Table 2). Surveys of each transect were initiated at about sunrise during the last half of August and driven at a rate of about 15 km per hour. Information on observed grouse included species, sex (if known), age (if known), group size (particularly for broods), perpendicular distance to the center of the road, and location on the transect.

WING BARRELS

A survey with the aid of wing barrels (Hoffman 1981, Fig. 1) was conducted during 1993-1995 and 1998-2000 to obtain additional information on the harvest of forest grouse in north-central Washington. The locations of the 6 wing barrels included Conconully (1993-1995, 1998-2000), Fish Lake (1993-1995), Loomis (1993-1995), Siwash Creek (1993), Havilla (1993), and Boulder Creek (1995, 1998-2000). Wings usually were gathered at least once a week during September and October and once a month during November and December.

Table 2. Details of specific line transects in north-central Washington, 1954-2000.

General route of line transect	Distance	Survey interval[a]
Nahahum Canyon - Chiwawa River	67 km	1954-1974, 1996-2000
Lake Creek - Slide Ridge	68 km	1954-1974, 1996-2000
Salmon Creek - Boulder Creek	66 km	1954-1971, 1996-2000
Toats Coulee - Cecil Creek	85 km	1954-1971, 1996-2000
Cape LaBelle - Pontiac Ridge	77 km	1955-1971, 1996-2000
Gold Creek - South Navarre Road	86 km	1967-1971, 1974, 1996-2000
Eightmile Creek - Hart Pass	83 km	1997-2000

[a]Some of the original data for 1954-1974 is missing and/or incomplete.

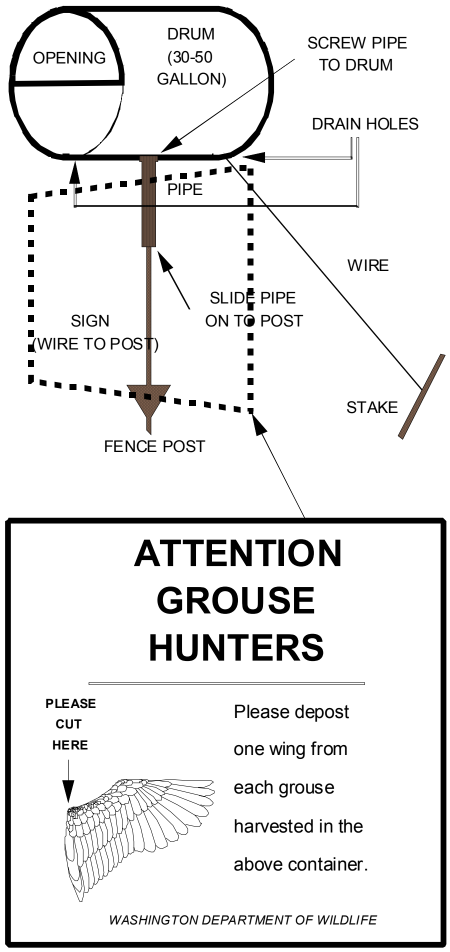

Fig. 1. Sample description of barrel and sign used for wing barrel survey in Washington, 1993-2000.

RESULTS

Check Stations

A total of 13,024 grouse was recovered from 48,411 hunters at all check stations combined (0.27 grouse/hunter). An additional 3,279 grouse were recovered from an unknown number of hunters. Blue grouse comprised about 65.7% of the harvest at all check stations combined. Grouse hunters recovered an average of 0.73 grouse/hunter and mule dear/mountain goat/ring-necked pheasant hunters recovered an average of 0.08 grouse/hunter. Results from check stations illustrated a significant decline in hunting pressure throughout the first month of the hunting season ($F = 42.01$, $P = 0.001$)(Fig. 2). The average number of hours spent hunting also declined throughout the first month of the hunting season ($F = 18.85$, $P = 0.001$)(Fig. 3). The average daily number of hunters declined annually at all check stations that were surveyed ($F = 61.00$, $P = 0.001$); this trend was particularly apparent at the Conconully check station (Fig. 4).

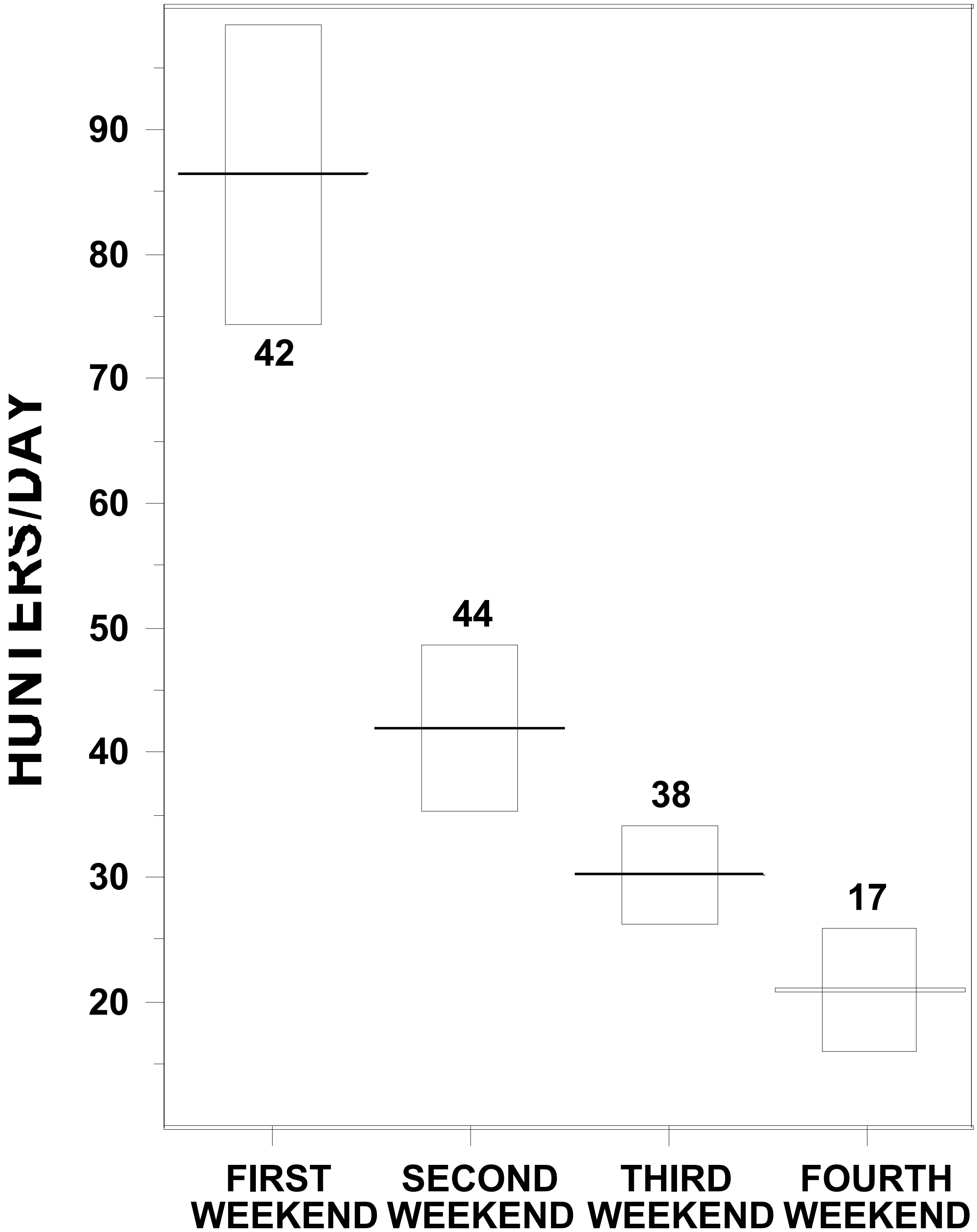

Fig. 2. Average number of hunters (horizontal bar = 0, rectangular box = 95% CI, number above or below box = *n*) recorded at check stations throughout the first month of the hunting season in north-central Washington, 1953-1964.

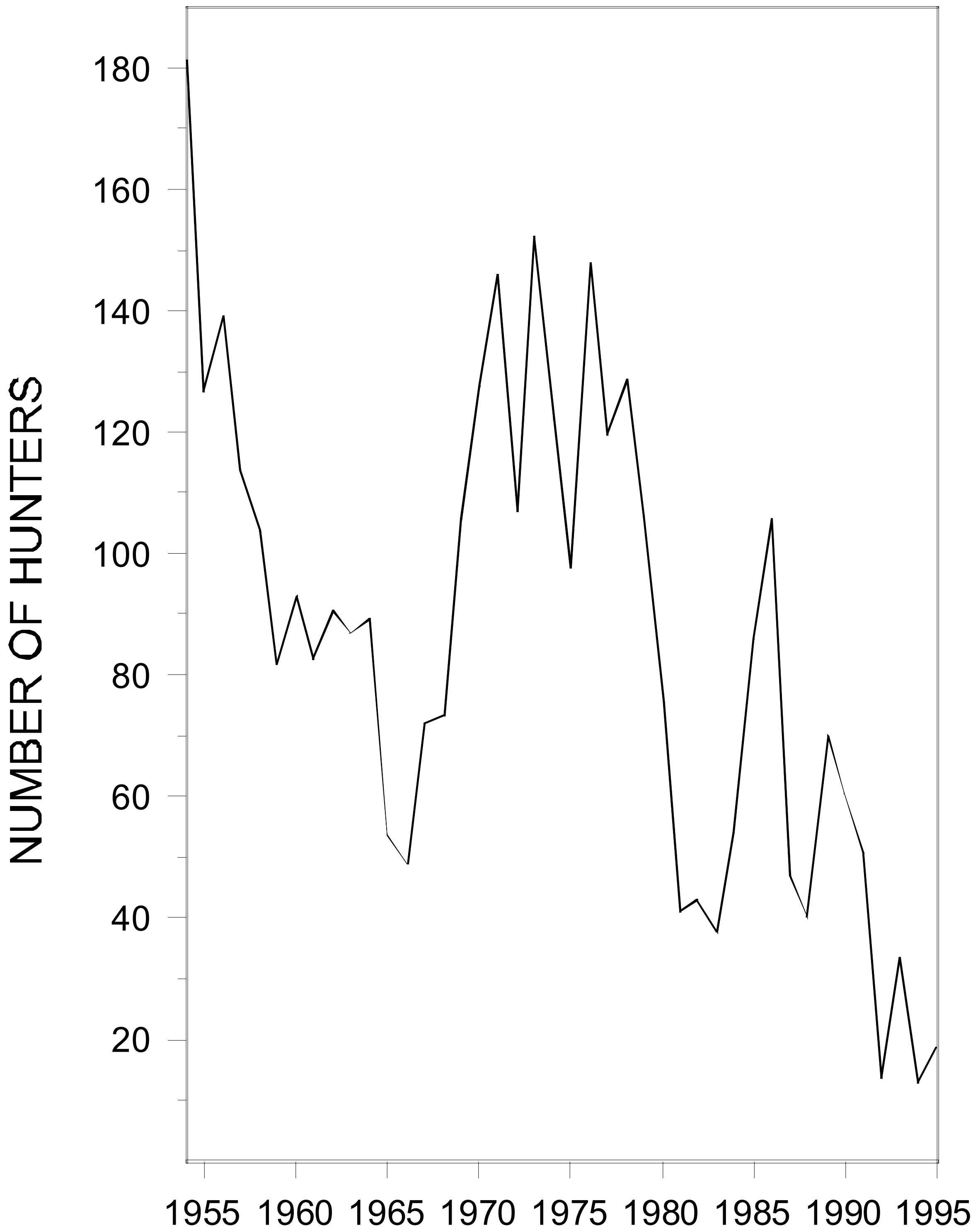

Fig. 3. Average number of hours per day each hunter spent hunting (horizontal bar = 0, rectangular box = 95% CI, number above box = *n*) throughout the first month of the hunting season in north-central Washington, 1953-1964.

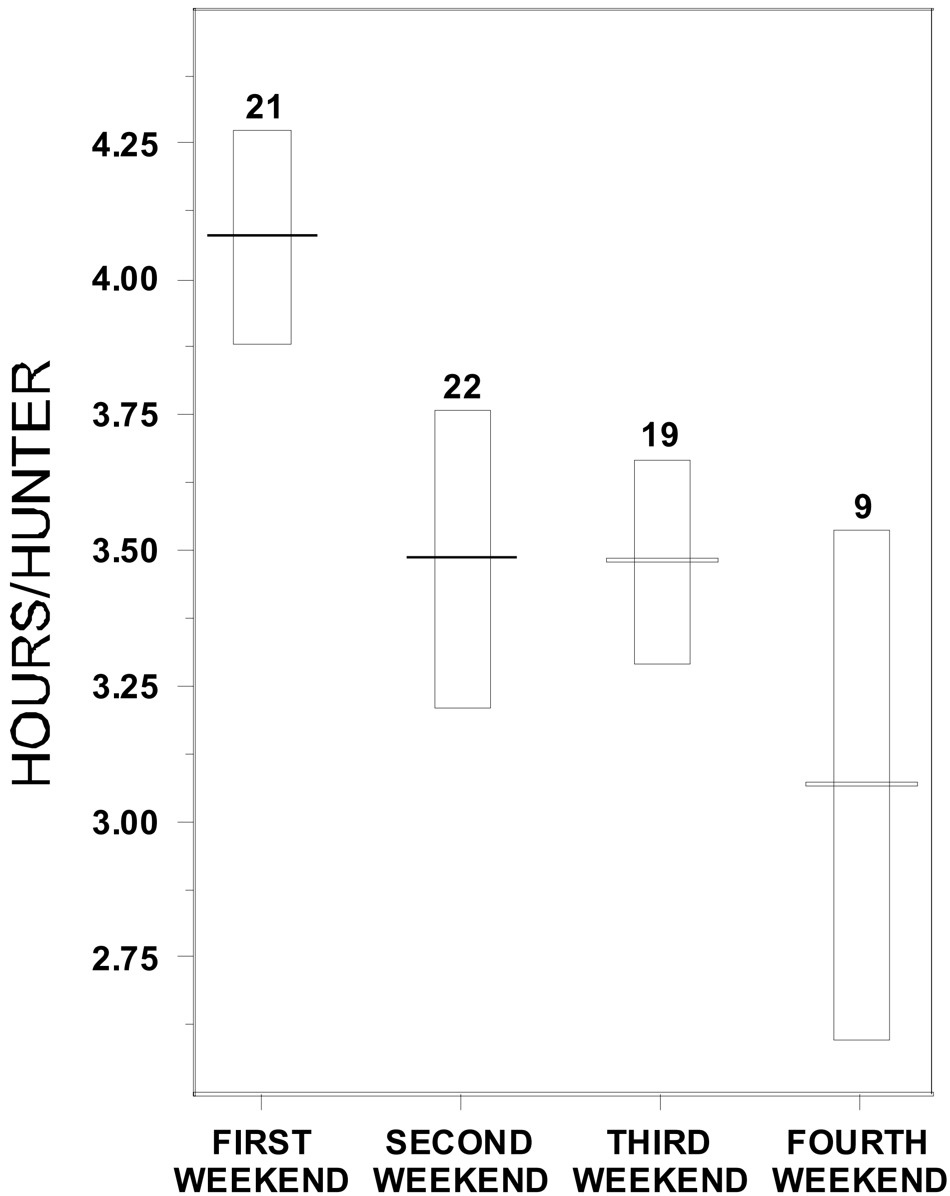

Fig. 4. Average daily number of hunters recorded during the opening week of the hunting season at the Conconully check station in north-central Washington, 1954-1995.

Declines in hunting pressure appeared to be reflected in annual numbers of recovered birds. Number of recovered birds appear to decline annually ($F = 11.21$, $P = 0.001$), even when differences between area ($F = 6.68$, $P = 0.002$) and weekend ($F = 16.93$, $P = 0.001$) were considered. Although it was clear that most of the decline in harvest was due to declining hunting pressure, some of the decline may have be due to declining numbers of grouse.

Check stations presumably are designed to provide more than basic information on proportions of species in the harvest and distribution of hunting pressure. Ideally, surveys should provide a methodology for monitoring the 'health' of populations. The average number of hours per recovered bird was considered as a technique for evaluating the population. Hours per bird varied by checking station ($F = 20.70$, $P = 0.001$) and weekend ($F = 5.24$, $P = 0.025$). Differences in hunting success were especially dramatic between the Chumstick and Conconully checking stations (Fig. 5). When 'hours per bird' was controlled for area and weekend, significant annual differences were detected ($F = 9.55$, $P = 0.004$); hours per bird appeared to increase slightly throughout the survey interval (Fig. 6).

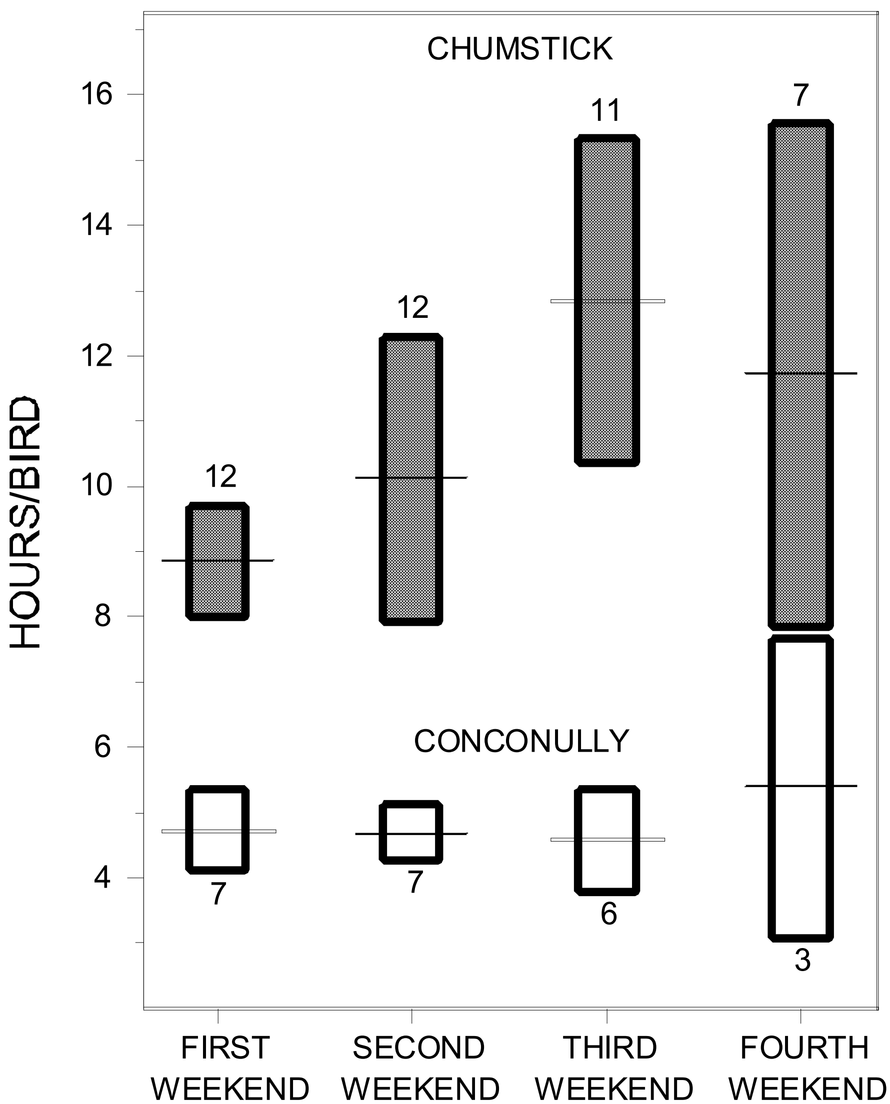

Fig. 5. Average number of hours for each recovered bird (horizontal bar = 0, rectangular box = 95% CI, number above or below box = *n*) recorded at Chumstick and Conconully check stations throughout the first month of the hunting season in north-central Washington, 1953-1964.

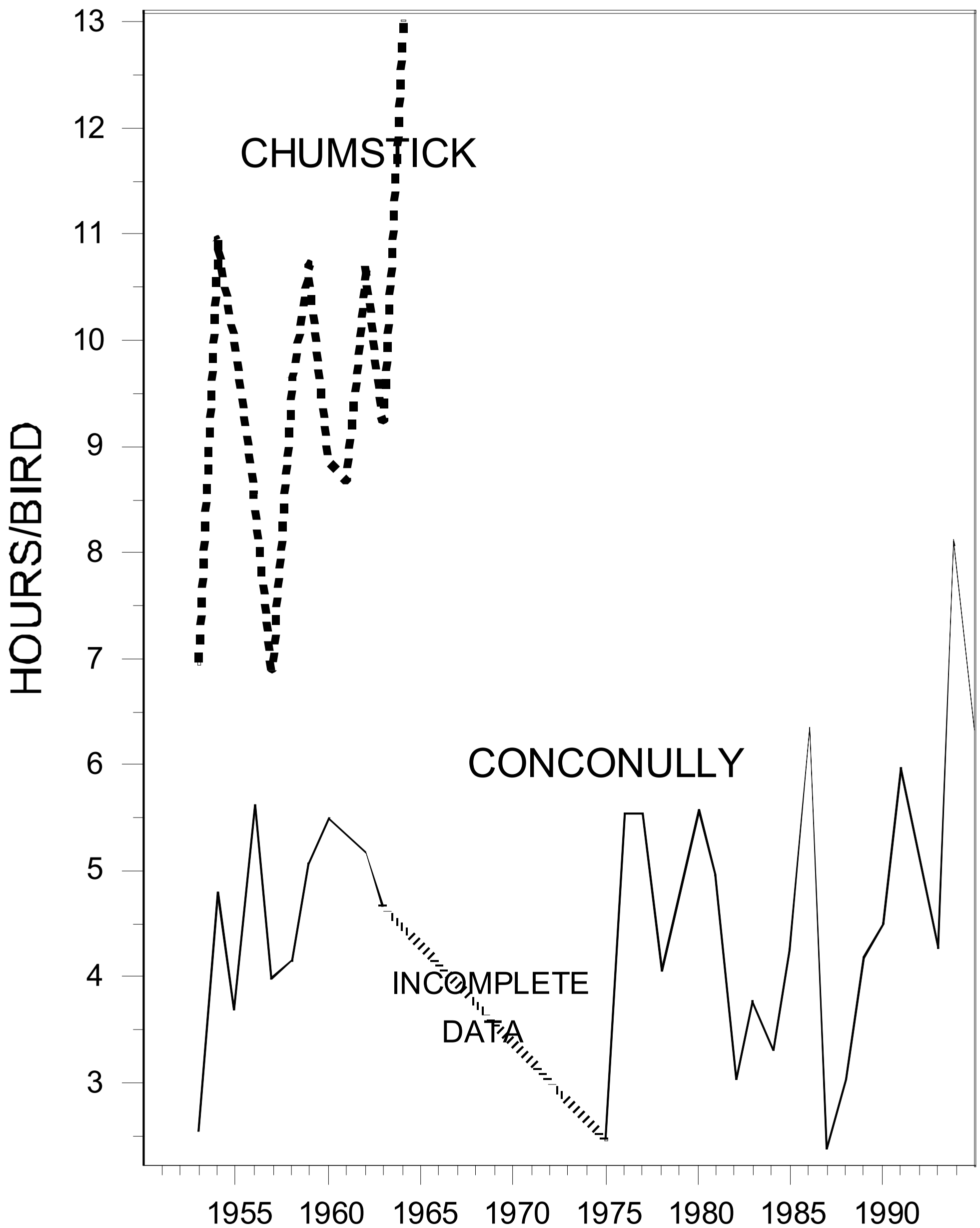

Fig. 6. Average number of hours for each recovered bird recorded at the Chumstick and Conconully check stations in north-central Washington, 1953-1995.

The proportion of juveniles in the population was also considered as a technique for monitoring the health of the population. Presumably a declining proportion of juveniles would be consistent with a declining population. The proportion of juveniles examined at check stations appeared to fluctuate dramatically on an annual basis with no significant trends overall ($F = 1.18$, $P = 0.295$)(Fig. 7). Nevertheless, the proportion of juveniles in the harvest tended to be lower in recent years. There was no correlation in the proportion of juveniles examined at check stations with the total number of birds recovered ($F = 0.41$, $P = 0.684$) or the average number of hours for each recovered bird ($F = 0.49$, $P = 0.629$).

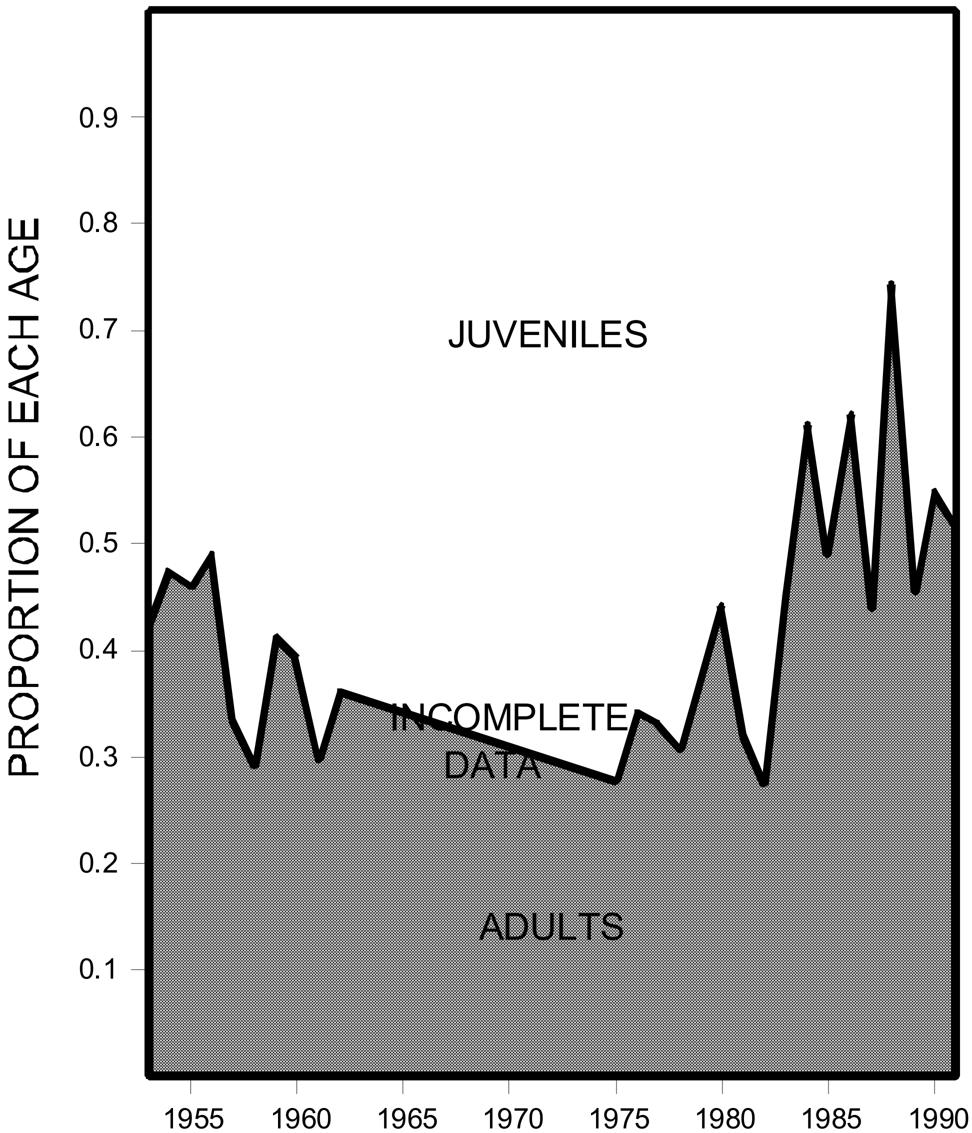

Fig. 7. The proportion of juvenile and adult blue grouse recorded at the Conconully check station in north-central Washington between 1953 and 1991.

LINE TRANSECTS

A total of 740 grouse was observed on transects between 1954 and 2000 (excluding 1975-1995). Blue grouse comprised 73.5% of the observations on line transects. Spruce grouse were also common (16.5%), perhaps because most transects were placed on relatively high elevation roads. There was a substantial downward trend in number of grouse observed per km between 1954 and 2000 (Fig. 8). The lack of an appropriate line transect protocol made estimates of density impossible to obtain. There also appeared to be a slight increase in the relative number of blue grouse observed on the transects (Fig. 9); the difference appeared to be related to a decline in the number of spruce grouse observed.

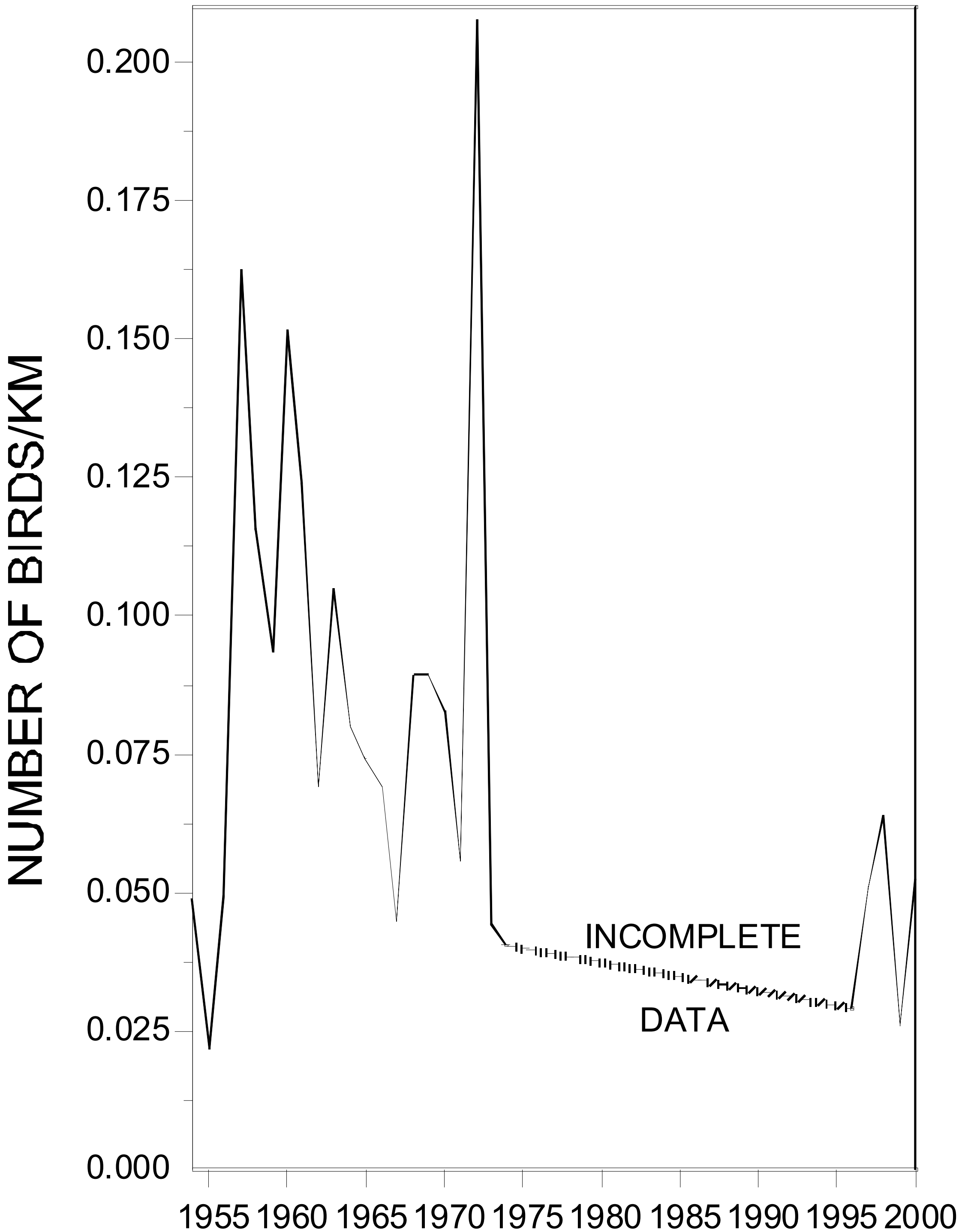

Fig. 8. The number grouse (grouse/km) observed on transects in north-central Washington, 1954-2000.

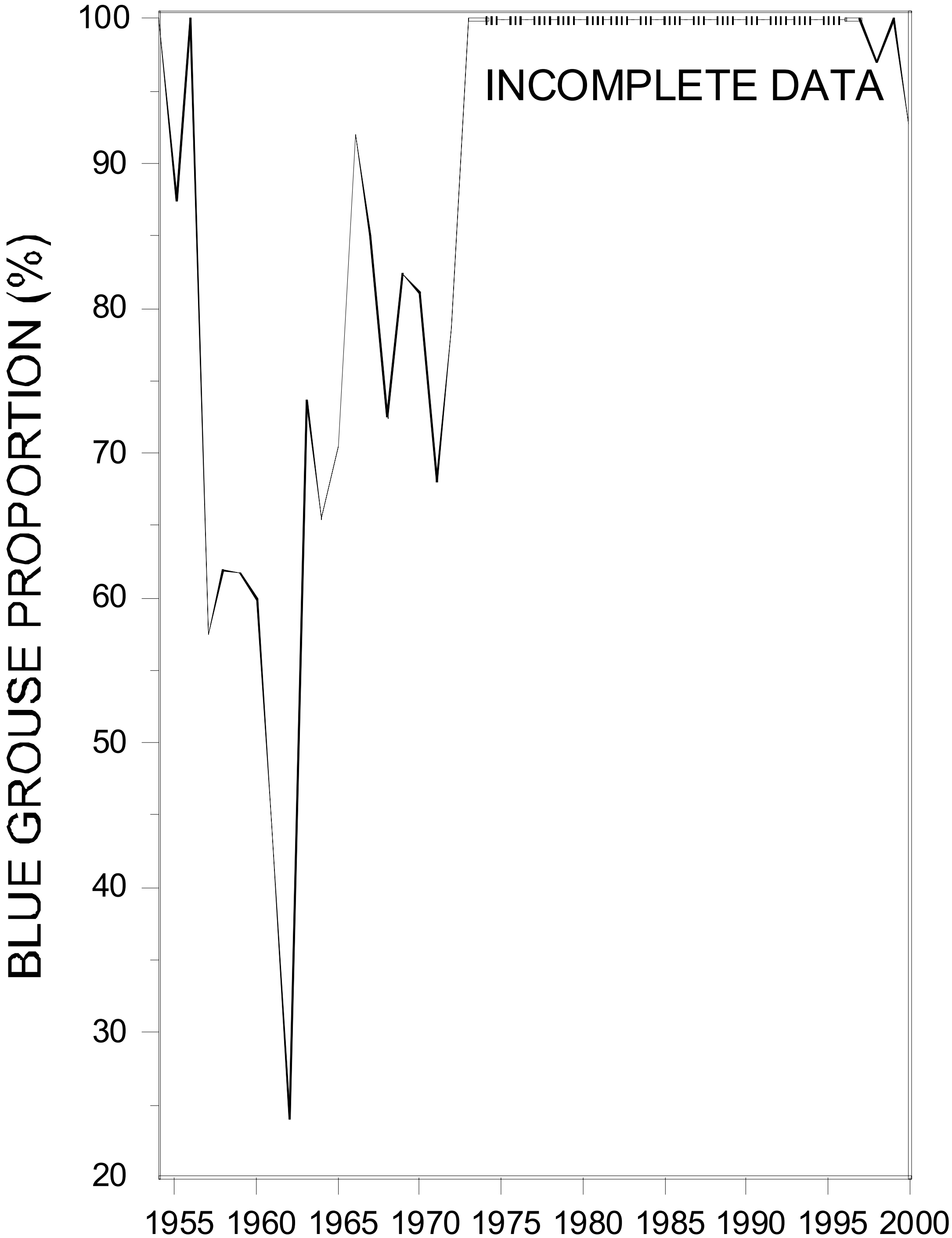

Fig. 9. Proportions of forest grouse species observed on transects in north-central Washington, 1954-2000.

WING BARRELS

A total of 3,405 grouse wings was examined from wing barrels in 1993-1995 and 1998-2000. Declines in harvest throughout the hunting season were clear; 46.2% of wings were collected during the first half of September and only 6.8% of wings were collected during November and December combined. Consequently, wing barrels were not continued past October after 1994.

Blue grouse comprised 64.1% of the wings at all wing barrels; the proportion of blue grouse in the harvest apparently declined throughout the hunting season and between 1993 and 2000 (Fig. 10). The majority (68.0%) of the harvested blue grouse were juveniles. Most (58.4%) of the remaining breeding-aged birds were females. Patterns of molt were used to evaluate breeding success among female blue grouse (successful females molt later than unsuccessful females). Estimated breeding success for harvested females was 62.1%.

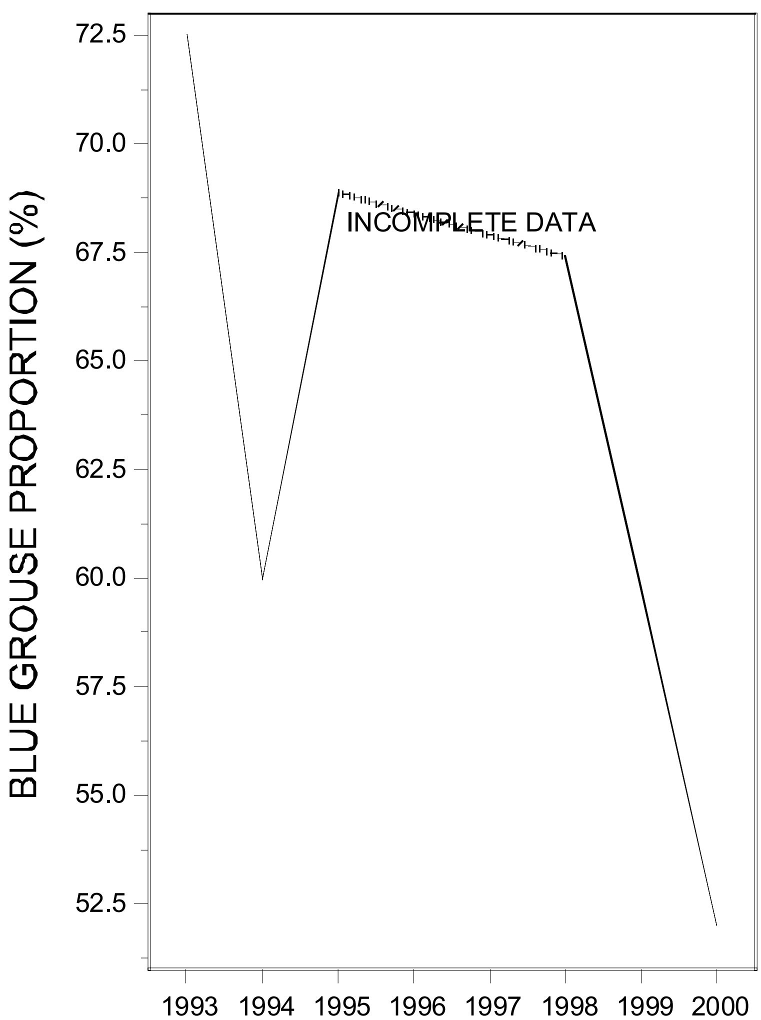

Fig. 10. Proportions of blue grouse deposited in wing barrels in north-central Washington, 1993-2000.

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