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Using Sharp-Tailed Grouse Movement Patterns to Guide Release-Site Selection

PETER S. COATES,[1,2] *Department of Biological Sciences, University of Nevada Reno, Reno, NV 89557, USA*
SAN J. STIVER,[3] *Nevada Department of Wildlife, Reno, NV 89512, USA*
DAVID J. DELEHANTY, *Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007, USA*

Abstract

*Prairie grouse populations are difficult to reestablish after extirpation. Following translocation, distances individuals move from the release site appear to affect restoration success. Previous authors have suggested assessing lek, nest–brood, and winter habitat when selecting release sites. We examined movement of 131 (66 M and 65 F) radiomarked Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) translocated during 1999–2002 as part of management effort to restore populations to historical ranges in northeastern Nevada, USA, an area where sharp-tailed grouse have not been observed in the wild since the 1950s. We released grouse at 2 sites. We chose the initial site based on its physiographic and vegetation similarities to capture sites in Idaho, USA, particularly shrub–steppe at lower elevations and mountain shrub at higher elevations, and used it during 1999 and 2000 (34 M, 18 F in 1999; 42 M, 26 F in 2000). Females released at this site moved greater distances than males through time, with no differences between years. We changed the release site based on nest locations of previously translocated females. The second site was 10 km south of site 1 and we used it in 2001 and 2002 (36 M, 22 F in 2001; 14 M, 5 F in 2002). Grouse released at this site moved substantially shorter distances than did the grouse initially released, and movement distances did not differ by gender or year. During 2004 we observed 23 grouse displaying on a lek near site 2 and observed no grouse near site 1. Our results support the hypothesis that nest-site availability is an important component to release-site selection insofar as sharp-tailed grouse in our study moved less when released into habitat that had been selected for nesting by previously released grouse.* (WILDLIFE SOCIETY BULLETIN 34(5):1376–1382; 2006)

Key words

Columbian sharp-tailed grouse, movement, Nevada, radiotelemetry, reintroduction, translocation, Tympanuchus phasianellus columbianus.

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) populations have declined substantially in numbers and distribution (Connelly et al. 1998) and occupy approximately 10% of their historical range (Miller and Graul 1980). Columbian sharp-tailed grouse were described as the most abundant game bird in the Intermountain West (Bendire 1892) and abundant in Elko County, Nevada, USA (Linsdale 1951), but were extirpated from Nevada by 1952 (Wick 1955).

Translocation of sharp-tailed grouse to reestablish functioning populations has had limited success (reviewed by Snyder et al. 1999). Movement following release appears to have affected the success of restoration efforts (Toepfer et al. 1990). Translocated grouse tend to disperse rapidly from the release sites (Ammann 1957) and move long distances, in some cases up to 45 km (Hamerstrom and Hamerstrom 1951, Gardner 1997). Restoration attempts of greater sage-grouse (*Centrocercus urophasianus*; Patterson 1952) and greater prairie-chicken (*Tympanuchus cupido pinnatus*; Jacobs 1959) also were shown to fail more often if grouse made relatively long movements from the release sites. Robel et al. (1972) reported that sharp-tailed grouse are capable of movement up to 150 km. However, females were shown to nest within 3.2 km of a lek in Idaho, USA (Meints 1991), and seldom moved >1 km from capture sites in their home range in South Dakota, USA (Robel et al. 1972).

Movements from the release sites may have several potential deleterious effects on reestablishing breeding populations. Individuals may become isolated, making it difficult to find mates and reproduce. Also, translocated grouse may be vulnerable to predators as grouse travel across landscapes (Cope 1992).

To reduce distances moved by male grouse from release sites, grouse often are translocated during spring (Hoffman et al. 1992). This promotes males to remain near the release site and engage in breeding displays rather than to wander during the short breeding season. Because translocated males may be more likely to display if other males are displaying, soft-release methods commonly are preferred (Rodgers 1992). Soft release involves the simulation of an active lek with grouse decoys and audio vocalizations of displaying males. Snyder et al. (1999) found spring translocations that use soft-release methods were 3.1 times more likely to succeed in population restoration of North American prairie grouse. Also, habitat suitability index models that identify important seasonal habitat components for successful restoration have been developed for Columbian sharp-tailed grouse (e.g., Meints et al. 1992). These observations suggest that soft spring releases incorporating suitable habitat availability may reduce dispersal by males and increase the probability of successful restoration efforts.

Female grouse also can make substantial movements

[1] *E-mail: coatpete@isu.edu*
[2] *Present address: Idaho State University, Department of Biological Sciences, Pocatello, ID 83209-8007, USA*
[3] *Present address: Prescott, AZ 86301, USA*

following release during spring (Toepfer 1988, Musil et al. 1993), a behavior that has been difficult to modify. Females may be searching for established leks, suitable habitat, or potential nest sites (Toepfer 1988, Gardner 1997). Several authors have suggested assessments of nest–brood and winter habitat quality when selecting release sites (Meints et al. 1992, Gardner 1997, Reese and Connelly 1997) to reduce long-distance movements and establish grouse populations. Our objectives were to measure movement patterns of Columbian sharp-tailed grouse over multiple years following reintroduction into northeastern Nevada to guide release-site selection. Our goal was to reduce postrelease movement of females and thereby promote restoration success.

Study Area

During the springs of 1999 and 2000, we captured grouse from 11 leks in the Pocatello and Curlew valleys in southeastern Idaho. Most leks were within Conservation Reserve Program grasslands characterized by crested wheatgrass (*Agropyron cristatum*) and alfalfa (*Medicago sativa*) adjacent to native shrub communities. Historically, shrub–steppe and mountain shrub were the dominant native shrub types in the same area (Ulliman 1995). Shrub–steppe was characterized primarily by big sagebrush (*Artemisia tridentata*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Mountain shrub consisted of primarily bluebunch wheatgrass, antelope bitterbrush (*Purshia tridentata*), sagebrush, and serviceberry (*Amelanchier alnifolia*).

The Nevada Department of Wildlife (NDOW) and Idaho Department of Fish and Game (IDFG) chose site 1 based on their assessment of the site's habitat similarities with the capture area. Also, personnel from NDOW determined the vegetation components of the site. Site 1 was near Dry Creek in the Snake Mountains of Elko County, Nevada (N 0670859, E 4599749; zone 11), and was used during 1999 and 2000. The dominant plant communities were shrub–steppe at lower elevations and mountain shrub at higher elevations. Site 1 was chosen because the shrub–steppe was characterized by mountain big sagebrush (*Artemisia tridentata vaseyana*) and the predominant understory grass was crested wheatgrass, more similar to the capture site than other potential release areas in the grouse's historical range (S. Eaton, NDOW, personal communication). Also, the vegetation components of mountain shrub were more similar to the capture site than other potential release areas, characterized by big sagebrush, serviceberry, and native bunchgrasses. After measuring movements of females from 1999 and 2000 using radiotelemetry, we released grouse at a different site, where 6 female grouse, of the 19 released in 1999 and 2000, nested in a 950-ha area. The other nonnesting and nesting females were broadly scattered across the landscape.

The new release location, site 2, was near Loomis Creek in the Snake Mountains and was 10.2 km south of site 1. The plant communities were similar to site 1, but at site 2 native bunchgrasses were the predominate grasses of the shrub–steppe, with no crested wheatgrass. The vegetation composition was relatively consistent for approximately 5,000 ha and 3,500 ha at sites 1 and 2, respectively. The elevations were 1,980 m and 1,950 m at sites 1 and 2, respectively.

During 1999–2002 the United States Department of Agriculture, Animal Plant Health Inspection Service, Wildlife Services (WS) maintained a removal program directed at coyotes (*Canis latrans*) and ravens (*Corvus corax*) at the release site and the surrounding areas to improve survival and reproduction of translocated grouse (J. O. Spenser Jr., WS, unpublished report). We coordinated with WS personnel to carry out predator-removal activities in all areas where we relocated grouse. Because many grouse moved to the area of site 2 while other grouse remained near the initial release site, both sites were subjected to similar predator-removal activities throughout the duration of the study. Wildlife Services personnel spent approximately 1,150 and 1,300 hours conducting predator removal activities at sites 1 and 2, respectively, and placed 5,173 and 5,550 egg-baits out for raven consumption at sites 1 and 2, respectively (J. O. Spenser Jr., unpublished report). Also, WS personnel used ground methods to remove 26 and 29 coyotes from sites 1 and 2, respectively, and 19 and 9 hours to carry out coyote-removal activities by aircraft at sites 1 and 2, respectively (J. O. Spenser Jr., unpublished report).

Methods

The research methods in this study were described and approved in research animal protocol ARP0302438 by the Idaho State University Animal Care Committee. Personnel from IDFG, NDOW, University of Nevada Reno, and Idaho State University captured grouse using modified walk-in funnel traps (Schroeder and Braun 1991) in a "W" wing trap system (Cope 1992) during 3–17 April 1999 and 2002. We translocated a total of 196 grouse to northeastern Nevada (Table 1), of which we marked 66 males (53%) and 65 females (92%) with necklace-style, battery-powered transmitters (Advanced Telemetry Systems, Isanti, Minnesota; Table 1). To prevent transmitter-caused fatality (Carroll 1990), we used collars (<17 g) <3% of grouse body mass, based on the average mass of sharp-tailed grouse in Idaho (596–771 g; Meints 1991, Schneider 1994). We bent the antennae near their bases to limit their interference with flight (Marks and Marks 1987). We classified all grouse by age (Ammann 1944) and gender (Henderson et al. 1967).

We transported all but 2 grouse to the release site on the day of capture and released them within 24 hours of capture to minimize weight loss (Toepfer 1988, Gardner 1997) and potential stress associated with captivity. We held grouse in separate boxes overnight. All releases were at sunrise using a soft-release method (Rodgers 1992) from a large release box with separate compartments for each grouse. Soft-release methods appear to be important in increasing the probability of success of restoration efforts (Snyder et al. 1999) by minimizing immediate dispersal of grouse and promoting display in males (Rodgers 1992). To simulate a lek, we

Table 1. Columbian sharp-tailed grouse translocated to northeastern Nevada, USA, during spring 1999–2002.

	Fitted with transmitters				
	Males		Females		
Year[a]	Yes[b]	No	Yes[b]	No	Totals
1999	21	13	15	3	52
2000	21	20	25	1	67
2001	13	23	20	2	58
2002	11	3	5	0	19
Total	66	59	65	6	196

[a] During 1999 and 2000, sharp-tailed grouse were released near Dry Creek in the Snake Mountains, Elko County, Nevada, USA. During 2001 and 2002 grouse were released 10 km south of the site used in previous years.

[b] Sharp-tailed grouse were fitted with necklace-style, battery-powered transmitters that weighed ≤17 g.

placed 4 decoys (2 M in display posture and 2 F standing upright) approximately 5 m in front of the exit doors of release boxes and played sharp-tailed grouse vocalizations recorded from a natural, active lek. Also, we used 12 pieces of white cardboard cut in triangles and mounted on sticks to simulate the erect tail posture of displaying grouse.

We surveyed the study area for presence of displaying grouse by visiting areas of previous use by grouse and via radiotelemetry from sunrise to 0800 hours during 23 March to 3 April of 2000–2002. We listened and watched for lek activities or other signs of the presence of sharp-tailed grouse and recorded all observations. We continued surveys in 2004 at both release areas as we continued to work in the study area.

We relocated each radiomarked grouse from the ground every 3–7 days. We used an aircraft every 30–60 days to locate missing grouse, followed by ground surveys to verify grouse locations. Throughout the study area, we regularly (approx. every 2–3 days) searched the ground for grouse for which locations were unknown. Searches were directed into areas beyond the last known location of missing grouse. We used the "loudest signal method" (Springer 1979) and circled each grouse at a distance of approximately 30–50 m to reduce location error (Hupp and Ratti 1983, Garrott et al. 1986). We tried to avoid flushing grouse while obtaining their locations.

Statistical Analyses

We entered grouse location data into a geographical information system and used the animal movement analyses extension (Hooge and Eichenlaub 1997) to measure straight-line distances between the release site and all relocation points (White and Dimmick 1978, Gardner 1997). We calculated days elapsed between release and relocation dates for each grouse. We divided the days postrelease into time intervals of 20 days each and calculated the means of distance moved during each time interval. We used repeated-measures analysis of variance (ANOVA) to analyze postrelease movement distances at different time intervals following the release.

During 1999 and 2000, we monitored grouse for 200 days postrelease (10 time intervals) and 100 days postrelease (5 time intervals) in 2001 and 2002. For 200-day postrelease analyses, we used only 1999 and 2000 data. For 100-day analyses across all years we used the first 5 time intervals of 1999 and 2000 and the 100-day data sets from 2001 and 2002. We excluded from analyses data from grouse without consecutive relocations and grouse that did not survive more than 3 days postrelease (Kurzejeski and Root 1988).

We used PROC MIXED procedures (SAS Institute Inc., Cary, North Carolina) to test for age and gender effects on movement within consecutive time intervals. We also tested for differences in movement between consecutive time intervals for each gender and age. We pooled 1999 and 2000 movements from site 1 because we found no differences within gender between years. Similarly, we also pooled movement from site 2 between 2001 and 2002 due to the lack of differences within gender between years.

Results

Following the releases at site 1, females moved greater linear distances from the release site than males through time (RM ANOVA, Gender*Time, $F_{9,292} = 3.09$, $P = 0.002$; Fig. 1). We found no differences between age classes (adults vs. yearlings). Because there was a significant interaction between gender and time, we analyzed gender differences within each time interval (T1–T10). We did not find a difference in movement between males and females during T1 ($t = -0.35$, $P = 0.730$). However, females move farther than males in all other time intervals (Fig. 1). During T5 females were located a mean distance of 19.5 ± 2.0 km from the release site, which was greater than the mean distance for males of 6.9 ± 2.1 km.

We also considered differences between time intervals by gender following release at site 1. Males stayed in the vicinity of the release site for approximately 40 days (T1–T2) postrelease. However, males moved away from release site in T3 as indicated by greater mean differences (T2–T3; $t = -2.16$, $P = 0.030$). By 60 days postrelease, male dispersal from the release site had ceased insofar as mean male distance from the release site did not differ in serial pairwise comparisons from T3 to T10 ($P > 0.05$).

When grouse were released at site 1, females moved farther and sooner than males (Fig. 1). The longest distance traveled from the release site was 57.6 km by an adult female. Females were located farther from the release site during T2 than T1 ($t = -5.97$, $P \leq 0.001$). The distances females were from the release site also increased from T3 to T4 ($t = -4.61$, $P \leq 0.001$). Eventually, mean distance from release site declined, with females closer to the release site during T9 than T8 ($t = 3.35$, $P \leq 0.001$). However, during the later periods, the distant grouse that died or disappeared were excluded from the analyses, causing mean relocations to be closer to site 1.

Following the change in release sites, sharp-tailed grouse released at site 2 moved shorter distances through time than grouse released at site 1 (RM ANOVA, Gender*Time*

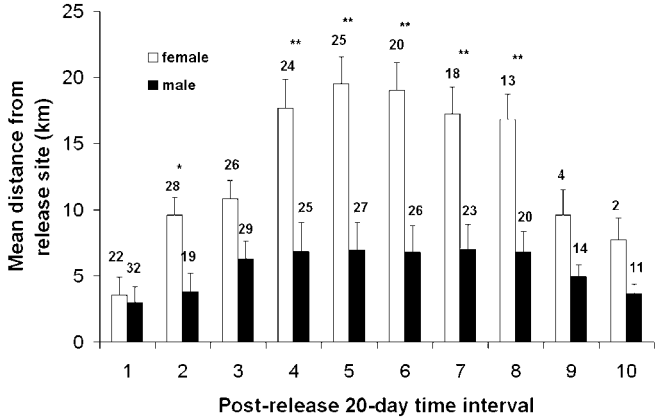

Figure 1. Mean distance from release site of translocated Columbian sharp-tailed grouse released into northeastern Nevada, USA, during 1999 and 2000. Columns represent mean distance from release date at 20-day intervals and bars represent standard error. Sample size is reported above each bar. An asterisk (*) indicates $P \leq 0.010$ and double asterisks (**) indicate $P \leq 0.001$.

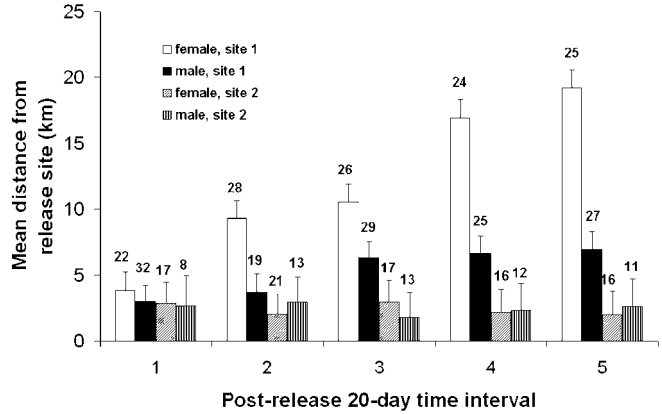

Figure 2. Mean distance from 2 release sites of translocated Columbian sharp-tailed grouse released into northeastern Nevada, USA, during 1999–2002. Columns represent mean distance from release date at 20-day intervals and bars represent standard error. Sample size is reported above each bar.

Release Site, $F_{4,261} = 3.74$, $P = 0.006$; Fig. 2). At site 2, we found no differences between age classes of grouse or years or release. Because we found a significant interaction between gender, time interval, and release site, we considered differences between gender and time intervals at each release site (Table 2). We did not find any differences in movement between gender or time intervals at site 2. We also considered differences between release sites within time intervals for each gender (Table 3). We did not find differences in male movements within 4 of the 5 time intervals. During all of the time intervals, females at site 2 moved shorter distances from the release site than females at site 1, except T1 (Table 3). Furthermore, during the nesting period (T3), female movement from the release site was substantially less at site 2 (2.94 ± 1.64 km) than at site 1 (10.54 ± 1.33 km; $t = 3.59$, $P < 0.01$).

At the onset of the breeding season in 2000, prior to translocation, we did not observe any males displaying. During the same period in 2001, we observed 2 small aggregations of 3 ($n = 2$ surveys) and 6 males ($n = 3$ surveys) in the area of sites 1 and 2, respectively. Grouse were displaying but shifted locations between days, indicating a lek had not been established. During 2002 we observed approximately 10 grouse displaying near site 2 ($n = 1$ survey) and no grouse at site 1. No translocation or surveys were carried out during 2003. However, at the onset of breeding season 2004, prior to translocation, we observed 23 grouse ($n = 2$ surveys) displaying as a lek near site 2. We did not observe any grouse displaying near site 1.

Discussion

Our study provided important findings relevant to sharp-tailed grouse restoration efforts. First, postrelease movements differ by gender. At site 1, female sharp-tailed grouse moved sooner and farther than males upon release. Second, differences in release-site location appears to influence postrelease movement by females. Distances moved by females at site 2 were much shorter than at site 1, with no gender difference in movements. We believe that the reduced female movement at site 2 may have been due to the physical environment (i.e., availability of nesting habitat), social environment (i.e., sporadic displaying of males), or a combination of both. Nevertheless, while the relative importance of these 2 factors remain unknown, we show that females were sensitive to release-site location and demonstrated measurably different movement behavior between release sites. We do not believe that predator removal was related to the differences in female movement between sites because each site was subjected to similar duration and intensity of predator-management efforts.

Availability of suitable nesting areas in relation to the release site may best explain patterns of female sharp-tailed grouse postrelease movement. Females released during 1999 and 2000 were relatively more mobile than females released during 2001 and 2002, in that there were greater differences in movement between time intervals and longer distances moved from the release site. In 1999 and 2000, however, 6 of 19 females moved into an approximately 950-ha shrub–steppe area dominated by native bunchgrasses and meadows where they settled and nested. When we released females into this habitat in 2001 and 2002, 14 of 15 females (93%) did not move away from the area but proceeded to settle and nest. In natural populations extensive movements of female grouse within their home ranges have been attributed to searching for suitable nesting areas (Gratson 1988).

At site 1, males stayed near the release site and performed breeding displays, while females moved farther and more immediately upon release. Similar patterns of gender movement differences have been observed in other studies of translocated prairie grouse (Toepfer et al. 1990, Cope 1992, Musil et al. 1993). It is possible that our simulated lek may have prompted males, but not females, to remain nearby even though males ultimately did not establish a lek at site 1. If so, this might reflect reported behavior of sharp-tailed grouse movement during the breeding period. For

Table 2. Post hoc pair-wise comparisons between least-squares means by gender and time intervals of translocated Columbian sharp-tailed grouse in northeastern Nevada, USA, during 1999–2002.

Release site[a]	Gender	Time interval[b]	*t*	*P*
1	M, F*	1	−0.44	0.660
	M, F*	2	−2.92	0.004**
	M, F*	3	−2.33	0.020**
	M, F*	4	−5.41	≤0.001**
	M, F*	5	−6.32	≤0.001**
	M	1, 2*	−0.56	0.578
	M	2, 3*	−2.16	0.032**
	M	3, 4*	−0.31	0.758
	M	4, 5*	−0.30	0.767
	F	1, 2*	−4.54	≤0.001**
	F	2, 3*	−1.18	0.240
	F	3, 4*	−5.69	≤0.001**
	F	4, 5*	−1.95	0.050**
2	M, F*	1	−0.06	0.952
	M, F*	2	0.37	0.712
	M, F*	3	−0.46	0.646
	M, F*	4	0.05	0.957
	M, F*	5	0.21	0.832
	M	1, 2*	−0.14	0.889
	M	2, 3*	0.69	0.490
	M	3, 4*	−0.34	0.732
	M	4, 5*	−0.16	0.875
	F	1, 2*	0.52	0.603
	F	2, 3*	−0.67	0.506
	F	3, 4*	0.56	0.575
	F	4, 5*	0.13	0.893

[a] Site 1 was near Dry Creek in the Snake Mountains, Elko County, Nevada, and received grouse in 1999 and 2000. Site 2 was 10 km south of site 1 and received grouse in 2001 and 2002.
[b] Days elapsed following release expressed in 20-day intervals.
* Variables used in post hoc comparisons of the least-squares means, ** Difference between the least-squares means ($\alpha = 0.05$).

Table 3. Post hoc pair-wise comparisons between least-squares means of distances moved from release sites of translocated Columbian sharp-tailed grouse in northeastern Nevada, USA, during 1999–2002.

Release site[a]	Gender	Time interval[b]	*t*	*P*
1, 2	M	1	0.13	0.893
1, 2	M	2	0.32	0.749
1, 2	M	3	1.98	0.049*
1, 2	M	4	1.78	0.076
1, 2	M	5	1.74	0.083
1, 2	F	1	0.46	0.645
1, 2	F	2	3.60	≤0.001*
1, 2	F	3	3.59	≤0.001*
1, 2	F	4	6.66	≤0.001*
1, 2	F	5	7.59	≤0.001*

[a] Site 1 was near Dry Creek in the Snake Mountains, Elko County, Nevada, and received grouse in 1999 and 2000. Site 2 was 10 km south of site 1 and received grouse in 2001 and 2002. Sites 1 and 2 were variables used in post hoc comparisons of the least-squares means.
[b] Days elapsed following release, expressed in 20-day intervals.
* Difference between the least-squares means ($\alpha = 0.05$).

example, in natural populations, males have strong site fidelity to their lek, while females use larger ranges that contain multiple leks (Bergerud 1988).

Following releases at site 1, females may have been searching for appropriate nesting areas, possibly dominated by perennial bunchgrasses. Historically, sharp-tailed grouse were found in "rye-grass meadows" in northeastern Nevada (Linsdale 1936). At site 1, the primary vegetation components were mountain big sagebrush and low sagebrush (*Artemisia arbuscula*) interspersed with crested wheatgrass. However, at site 2, mountain big sagebrush and Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) were found interspersed primarily with perennial bunchgrasses. Many studies describe perennial bunchgrass and sagebrush as important components of nesting habitat for sharp-tailed grouse (Kobriger 1980, Marks and Marks 1987, Meints 1991, McDonald 1998). However, we did not select site 2 on the basis of these vegetation differences. We selected release site 2 solely on the basis that previously released females settled and nested in this location. In other words, we used the behavior of previously released females to identify seemingly preferred nesting habitat.

An alternative but not exclusive explanation involves male lekking behavior. Following releases at site 1, for example, long-distance movements by female grouse may have been a result of the absence of an active lek in the release site. During 2001 we observed an aggregation of approximately 6 males that had successfully overwintered occupying an area in the native bunchgrass habitat used for nesting by females in 1999 and 2000. Shifting locations of these males between days suggested that they had not established a fixed lek. However, the presence of live males could have acted to stabilize female grouse near the release site by eliciting breeding behavior (Jacobs 1959, Rodgers 1992) and dampening the tendency to move (Hoffman et al. 1992). Following the release at site 1, where no live males were observed displaying, males and females settled at approximately 60–80 days, respectively, and these data appear consistent with Columbian sharp-tailed grouse translocated to Shoshone Basin, Idaho, an area that also lacked an established lek (Gardner 1997). However, sharp-tailed grouse translocated to an area with a lek were found to settle in 14–27 days in Montana, USA (Cope 1992), and greater prairie-chickens translocated within 5 km of existing leks in Colorado, USA, generally did not move from the release site (Hoffman et al. 1992). Therefore, translocating grouse to areas with established leks may be important to reducing dispersal.

We found no established sharp-tailed grouse leks within the surveyed area at sites 1 and 2 during 1999–2002. However, during 2004, we found 23 displaying males within 200 m of the release point at site 2 and observed no grouse at site 1. At site 2 we observed lekking activity for several consecutive days at the same location, indicating that a lek had become established near the center of the area where females consistently settled and nested.

Previous authors have hypothesized that nesting and lekking habitat should be considered in release-site selection, which suggests male and female grouse may benefit from different release-site characteristics (Robel et

al. 1972, Gardner 1997, Meints et al. 1992, Reese and Connelly 1997). Our results provide support for these hypotheses by showing male and female differences in postrelease movement and sensitivity in female response. In particular, female movement was dampened after selecting a release area used previously for nesting by females.

Management Implications

Wildlife managers have focused on establishing functioning populations of prairie grouse by identifying release areas that appear appropriate for winter survival, lekking, and nesting (Meints et al. 1992, Gardner 1997, Reese and Connelly 1997). In our study NDOW followed recommendations in considering appropriate sharp-tailed grouse habitat while selecting the initial release site based on literature (Meints et al. 1992, Gardner 1997). Also, we followed recommendations by Snyder et al. (1999) to increase the probability of a successful restoration by using a soft-release method (Rodgers 1992), translocating >100 grouse, and carrying out the translocation for multiple years (Griffith et al. 1989). We make a further recommendation to wildlife managers to closely monitor released grouse, particularly in the initial years of a translocation, and to use movement patterns of released grouse to fine-tune subsequent release-site selection. Using the movement patterns of released grouse to identify future release sites is merited scientifically and has intuitive appeal in that grouse should be expert at recognizing habitat that is suitable to them when they encounter it. In our study changing the location of release sites based on movement patterns substantially reduced postrelease movement by females and promoted nesting near the release area and population establishment. Identifying other behavioral responses of translocated sharp-tailed grouse may be helpful in identifying areas suitable for establishing populations as well.

Changing release sites to areas preferred by females does not preclude taking actions to promote male lekking behavior. For example, artificial leks can be simulated during releases and males may lek near suitable nesting areas, as demonstrated in our study. Thus, when releasing grouse over multiple years, managers should consider using methods to induce lekking behavior while closely monitoring movement to guide release-site selection.

Predator-removal activities were carried out similarly among sites in duration and extent, and we do not believe these activities influenced the difference in movement dynamics between sites. However, we are uncertain of the effects of removing predators on sharp-tailed grouse population dynamics and contributions to establishing a successful population. The role of predator management for reintroduced populations needs further research.

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Peter S. Coates (photo) is a Ph.D. candidate in biology and a National Science Foundation Gk-12 Fellow at Idaho State University. He currently is performing research on incubation time budgets, incubation behavior, and nest predation of greater sage-grouse in northeastern Nevada. He is an Associate Biologist through The Wildlife Society and he is interested in wildlife population restoration, human–wildlife conflict management, and predator ecology. He received an M.S. in biology and a B.S. in conservation biology at University of Nevada Reno. ***San J. Stiver*** retired after 30 years as a biologist for the Nevada Division of Wildlife. He currently is employed by the Western Association of Fish and Wildlife Agencies as the wildlife coordinator on the sage-grouse framework team. San received his B.S. (1974) from the University of Montana. He has been a member of The Wildlife Society since 1971 and was a member of the Western Sage and Columbian Sharp-tailed Grouse Technical Committee from 1981 to 2003. San has been involved in national and international wildlife conservation issues since 1985. He has worked on grouse as a field biologist, researcher, staff biologist, and consultant for nearly 30 years. ***David J. (Dave) Delehanty*** is an associate professor in the Department of Biology at Idaho State University where he teaches ornithology, animal behavior, and conservation biology and also is Curator of Birds for the Idaho Museum of Natural History. He and his graduate and undergraduate students perform research on the restoration, conservation, and breeding biology of North American game birds. He received his Ph.D. in Ecology, Evolution, and Conservation Biology from the University of Nevada Reno, an M.S. from the University of North Dakota, and a B.S. from the University of Minnesota.

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