SURVIVAL AND CAUSE-SPECIFIC MORTALITY OF MERRIAM'S TURKEYS IN THE SOUTHERN BLACK HILLS

Chad P. Lehman[1,2]
Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007-1696, USA

Lester D. Flake
Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007-1696, USA

Mark A. Rumble
USDA Forest Service, Rocky Mountain Research Station, 1730 Samco Road, Rapid City, South Dakota 57702, USA

Abstract: Merriam's turkeys (*Meleagris gallopavo merriami*) in the Black Hills feed in ponderosa pine (*Pinus ponderosa*) forest habitats during winter, but some birds centralize winter activities within or near farmsteads that provide waste grain as supplemental food. The objective of our research was to determine if female Merriam's turkeys that wintered in association with supplemental food from livestock feeding had different survival rates than birds that wintered within ponderosa pine forest. We captured and radiomarked 94 females over a 4-year period. Winter (1 Dec–31 Mar) survival of Merriam's females wintering in association with livestock feeding and farmsteads ($\hat{S}$ = 0.94, SE = 0.03) was not different from females wintering in forest habitats ($\hat{S}$ = 0.92, SE = 0.03). Annual survival of adult females (mean $\hat{S}$ = 0.67, SE = 0.09) varied among years (range = 0.54–0.83) from 2001–2003 based on Kaplan-Meier estimates. Lowest seasonal survival occurred during spring (1 Apr–30 Jun) (adult $\hat{S}$ = 0.83, SE = 0.04; yearling $\hat{S}$ = 0.64, SE = 0.13). Mammalian predators accounted for the highest percentage of mortality (47.2%). Primary mammalian predators were coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) based on evidence from infrared camera photos and dorsal guard hair identification. Survival in the southern Black Hills was similar or higher than rates reported for Merriam's turkey from both its indigenous range and introduced range.

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Merriam's turkeys in the Black Hills are nonindigenous. The southern Black Hills population originated with transplants from Colorado and New Mexico in 1950 and 1951 (Peterson and Richardson 1975). The Black Hills population of Merriam's turkeys supports a spring harvest of male turkeys typically ranging from 1,500 to 2,500 birds (Huxoll 2003, 2004). Merriam's turkeys in forested habitats of the Black Hills feed on ponderosa pine seed, kinnikinnick (*Arctostaphylos uva-ursi*) fruits, and grasses during winter (Rumble and Anderson 1996*a,* 1996*b*). However, many Black Hills turkeys have centralized wintering activities (i.e., roosting, feeding, and loafing) within or near cattle feeding operations. This farmstead wintering behavior has developed in other regions of the wild turkey's range (Vander Haegen et al. 1989, Wunz 1992) and may provide some benefits to turkeys in enhanced survival and reproduction (Porter et al. 1983, Vander Hae-

[1] E-mail: Chad.Lehman@state.sd.us
[2] Present address: 13329 US HWY 16A, Custer, SD 57730, USA.

gen et al. 1988, Wunz 1992, Hoffman et al. 1996, Lehman et al. 2001). Farmsteads indirectly provide high-energy foods such as oats and corn for turkeys as waste grain from livestock feeding operations. In addition, farmsteads may provide turkeys some protection from predators during winter and the early part of spring due to the close proximity of humans.

Severe winter weather can limit northern turkey populations (Healy 1992) and food sources can be critical for survival during winter (Porter et al. 1980, Vander Haegen et al. 1988). Within South Dakota, investigators have reported winter survival and causes of mortality for eastern wild turkeys (*M. g. silvestris*) (Leif 1997, Lehman et al. 2001) and Rio Grande wild turkeys (*M. g. intermedia*) (Lehman et al. 2001). In the central Black Hills, annual survival of Merriam's females varied from 33 to 76% (Rumble et al. 2003). In Arizona, annual survival of Merriam's turkeys averaged 57% (Rumble et al. 2003) and in Montana survival averaged 45% (Thompson 1993). Spring is a period of high female mortality for Merriam's turkeys in South Dakota and southeastern Montana (Thompson 1993, Flake and Day 1996, Rumble et al. 2003). Predominant causes of wild turkey mortality in the Midwest are predation, severe weather, starvation, illegal killing, and hunting (Porter 1978, Vangilder 1995, Vangilder and Kurzejeski 1995, Wright et al. 1996, Leif 1997, Lehman et al. 2001). However, survival and cause-specific mortality information is generally lacking for Merriam's turkeys (Rumble et al. 2003). The objectives of this study were to (1) obtain survival and cause-specific mortality information on female Merriam's turkeys in the southern Black Hills, and (2) determine if birds that wintered in association with farmsteads and associated supplemental feeds had different survival rates than birds that wintered within ponderosa pine forest.

STUDY AREA

The study area was in the southern portion of the Black Hills physiographic region of southwestern South Dakota (Johnson et al. 1995). Elevations range from 930 to 1627 m above mean sea level. Three soil associations (Mathias-Butche-Rockoa, Paunsaugunt-Vanocker, and Tilford-Spearfish) characterize much of the study area's rocky ridges, rolling plateaus, drainages, canyon walls, and mountain valleys (Kalvels 1980). The study area had a continental climate with mean annual precipitation of 44.02 cm and mean annual temperature of 7.78°C (National Climatic Data Center 1971–2000). The woodland habitat was characteristic of xeric conditions, and was dominated by ponderosa pine with an understory composed of western snowberry (*Symphoricarpos occidentalis*), common juniper (*Juniperus communis*), and greater densities of Rocky Mountain juniper (*J. scopulorum*) in the western portion of the study area (Hoffman and Alexander 1987). Dominant grasses on the study area included Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), little bluestem (*Schizachyrium scoparium*), needle and thread (*Stipa comata*), sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), and blue grama (*Bouteloua gracilis*) (Johnson and Larson 1999).

METHODS

Capture and Radiotelemetry

Wild turkeys were captured in winter using cannon nets (Dill and Thornsberry 1950, Austin et al. 1972), rocket nets (Thompson and Delong 1967, Wunz 1984), and drop nets (Glazener et al. 1964) over bait. We classified females as either adult (>1 year old) or yearling (<1 year old) based on barring on the ninth and tenth primary feathers (Williams 1961) and weighed birds to the nearest 0.1 kg. Birds were fitted with 98-g backpack mounted radiotransmitters equipped with activity signals and a mercury switch mortality sensor set to activate after 8 hours of inactivity. Wild turkeys were located by triangulation and visual locations 5–6 days per week using hand-held yagi antennae.

Survival and Cause-specific Mortality

We estimated seasonal and annual survival distributions using the Kaplan-Meier product limit method (Kaplan and Meier 1958) modified for staggered entry (Pollock et al. 1989). Seasonal survival was divided into 4 time periods: (1) winter (1 Dec–31 Mar), (2) spring (1 Apr–30 Jun), (3) summer (1 Jul–31 Aug), and (4) fall (1 Sep–30 Nov). Season intervals were based on a combination of weather (i.e., seasonal variation in temperature and precipitation) and behavior patterns (i.e., nesting and brood-rearing). We estimated annual survival from 1 December–30 November of each year. Yearlings were classified as adults starting the first winter (1 Dec) following capture. Calculating survival distributions we assumed: (1) survival was unique for each radiomarked individual and independent of others, (2) individuals were unbiased and randomly selected, and (3) radiotransmitters did not affect survival.

We defined cause-specific mortality as the probability of a wild turkey dying from a mortality source in the presence of other competing mortality sources (Heisey and Fuller 1985). Necropsy of carcasses determined causes of death, and we classified mortality as mammalian predation, avian predation, weather-related starvation (emaciation or starvation resulting from deep snow cover), hunting, illegal kill, disease, car collision, and unknown. Death was attributed to predation when examination of carcasses revealed hemorrhaging accompanied by puncture wounds. Evidence such as tracks, feces, and caching of the carcass identified the mortality as mammalian predation. Sharp puncture wounds accompanied by removal of the head and neck region from the carcass identified avian predators such as great horned owls (*Bubo virginianus*) (Miller and Leopold 1992). In addition to the aforementioned sign, we used infrared cameras to verify cause of mortality in some instances. Cameras were

Table 1. Kaplan-Meier winter (1 Dec–31 Mar) seasonal survival estimates ($\hat{S}$) for females wintering in farmsteads and females wintering in forest. Estimates are for Merriam's turkey females in the southern Black Hills, South Dakota, 2001–2004.

	Farmstead turkeys			Forest turkeys				
Year	*n*	$\hat{S}$	SE	*n*	$\hat{S}$	SE	*Z*-value	*P*
2001	28	0.963	0.036	7	1.000	0.000	1.03	0.303
2002	20	0.950	0.049	20	0.900	0.066	0.61	0.540
2003	22	0.917	0.057	27	0.856	0.065	0.70	0.459
2004	15	0.867	0.088	19	0.947	0.051	0.79	0.430
Pooled	85	0.936	0.026	73	0.922	0.032	0.39	0.734

placed at selected nest sites while females were away from nests. Photos of predators were taken when the predator approached the nest and triggered the infrared sensor. At other mortality sites the infrared cameras were placed near the turkey carcass after the predation event and photos obtained if predators returned to the cache. Dorsal guard hairs collected from shrubs and other vegetation at mortality sites were also used to identify mammalian predators (Moore et al. 1974). We also checked 4 reference sites in cardinal directions 20 m from the nest or other predation site to determine if hair occurrence was random.

Weather-related mortalities, or birds that died from starvation, were classified during winter or early spring when carcasses had emaciated breast muscles without hemorrhaging. If hemorrhaging or emaciation were not present, then carcasses were examined for diseases at the Animal Disease and Diagnostic Laboratory at South Dakota State University by D. H. Zeman, DVM, Ph.D. Otherwise we classified the cause of mortality as unknown.

We tested for differences in survival among years and seasons using chi-square procedures described by Sauer and Williams (1989) using the program CONTRAST (Hines and Sauer 1989). This procedure was also used to compare the 3 most prominent causes of mortality within seasons. We tested the null hypothesis that survival of birds wintering in farmsteads and birds wintering in ponderosa pine forest do not differ using a *Z*-test described by Pollock et al. (1989). We did not compare mortality between adults and yearlings because of small sample sizes within the yearling age class. We censored observations when radiotransmitters failed or if contact was lost. Significant differences occurred at $P \leq 0.05$ and we used a Bonferroni approach to control the Type I experimentwise error rate for multiple comparisons.

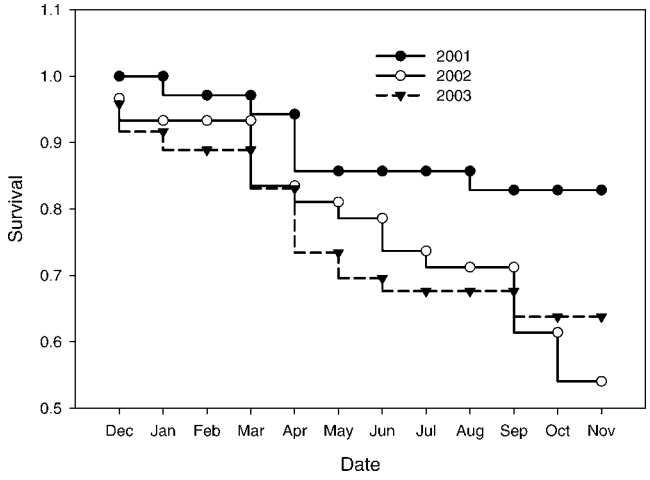

Fig. 1. Kaplan-Meier annual survival distributions (1 Dec–30 Nov) for adult Merriam's turkey females in the southern Black Hills, South Dakota, 2001–2003.

RESULTS

Survival

We captured and radiomarked 94 females during 2001–2004. However, due to capture-related trauma we had to censor 2 females. We used 92 females (n = 76 adults, n = 16 yearlings) for analyses. Within the winter period, we were able to pool years for both farmstead wintering turkeys ($\chi^2 = 1.28$, df = 3, $P = 0.73$) and forest wintering turkeys ($\chi^2 = 3.43$, df = 3, $P = 0.33$) (Table 1). Winter survival was similar between turkeys wintering in farmsteads and turkeys wintering in forest ($Z = 0.39$, $P = 0.73$) (Table 1).

Annual survival for adult females differed among years ($\chi^2 = 9.43$, df = 2, $P = 0.009$). Survival in 2001 ($\hat{S} = 0.83$, SE = 0.06) was significantly higher than 2003 ($\hat{S} = 0.64$, SE = 0.07) and 2002 ($\hat{S} = 0.54$, SE = 0.08) (Figure 1). Average annual survival for adults for the study period was 0.67 (SE = 0.09). Average annual survival for yearlings for the study period was 0.49 (SE = 0.11). Adult seasonal survival was similar ($\chi^2 \leq 5.66$, $P \geq 0.06$) among years and we pooled seasons for the analysis (Table 2). Spring survival was the lowest among all seasons for both adult (Table 2) and yearling females (Table 3). A high percentage (53%) of spring mortality occurred while females were laying eggs or incubating nests. Seasonal survival distributions for adults differed ($\chi^2 = 11.13$, df = 3, $P = 0.01$). Spring and fall were periods of lower survival, and winter and summer periods were periods of higher survival (Table 2).

Table 2. Kaplan-Meier seasonal survival estimates ($\hat{S}$) during winter (1 Dec–31 Mar), spring (1 Apr–30 Jun), summer (1 Jul–31 Aug), and fall (1 Sep–30 Nov) for adult Merriam's turkey females in the southern Black Hills, South Dakota, 2001–2004.

Interval	*n*	$\hat{S}$	SE
Winter	158	0.932	0.020
Spring	118	0.831	0.035
Summer	91	0.956	0.022
Fall	58	0.860	0.047

Table 3. Kaplan-Meier seasonal survival estimates ($\hat{S}$) during winter (1 Dec–31 Mar), spring (1 Apr–30 Jun), summer (1 Jul–31 Aug), and fall (1 Sep–30 Nov) for yearling Merriam's turkey females in the southern Black Hills, South Dakota, 2001–2003.

Interval[a]	*n*	$\hat{S}$	SE
Winter 2001	6	1.000	0.000
Winter 2002	7	0.857	0.132
Winter 2003	3	0.500	0.250
Winter pooled	16	0.871	0.084
Spring 2001	6	0.667	0.192
Spring 2002	6	0.500	0.204
Spring 2003	2	1.000	0.000
Spring pooled	14	0.643	0.128
Summer 2001	4	1.000	0.000
Summer 2002	3	1.000	0.000
Summer 2003	2	1.000	0.000
Summer pooled	9	1.000	0.000
Fall 2001	4	1.000	0.000
Fall 2002	4	0.667	0.272
Fall 2003	2	1.000	0.000
Fall pooled	10	0.889	0.112

[a] Due to small sample size years were not compared and thus not pooled.

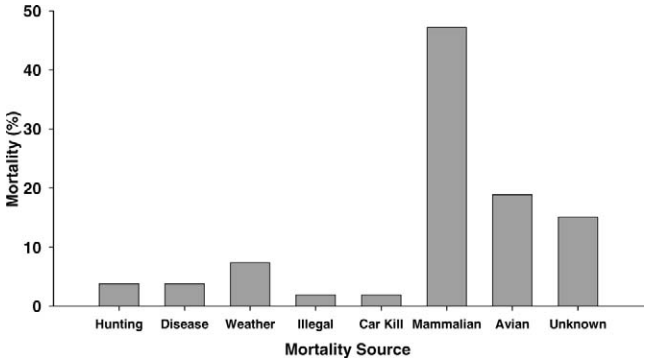

Fig. 2. Causes (%) of mortality for Merriam's turkey females (n = 53) in the southern Black Hills, South Dakota, 2001–2004.

Cause-specific Mortality

Mammalian predators, primarily coyotes and bobcats, caused 47.2% of mortality to female Merriam's turkeys (Figure 2). Guard hairs found on shrubs and debris at predation sites were used to identify cause of predation at 17 sites and guard hairs were not found at reference sites. Infrared cameras were used to positively identify predators in some instances (n = 6). Avian predators, mostly great horned owls, caused 18.9% of mortality and weather-related starvation accounted for 7.4% (Figure 2). Other causes of mortality included fall hunting (3.8%), illegal kill (1.9%), disease (3.8%), car collisions (1.9%), and unknown (15.1%) (Figure 2). Deep snow cover in late winter of 2002 resulted in starvation of 4 females wintering in forest. Multisystemic inflammatory disease compatible with bacteria septicemia (*Escherichia coli*) caused one death, and cloacal impaction caused another death (D. H. Zeman, DVM, Animal Disease and Diagnostics Laboratory, South Dakota State University). Across seasons, most mortality factors were evenly distributed with the exception during spring when mammalian predation was noticeably higher than other seasons (Table 4). Within winter, summer, and fall seasons cause-specific mortality rates did not differ ($\chi^2 \leq 1.22$, $P \geq 0.40$). However, during spring rates differed ($\chi^2 = 8.72$, df = 2, $P = 0.01$), as mammalian predation was higher than avian predation and weather-related mortality (Table 4).

DISCUSSION

In winter, female Merriam's turkeys primarily fed on ponderosa pine seeds or farmstead grains and survival was high. Although turkeys wintering in association with farmsteads have increased survival in some areas (Lehman et al. 2001), this was not evident in our study as survival rates of females that wintered in farmsteads were not higher than rates of females wintering in ponderosa pine forest. Several studies have shown a link between habitat and foods for Merriam's turkeys (Rumble and Anderson 1996*a,* 1996*b*), and this may affect their winter survival (Wakeling and Rogers 1996, Wakeling and Goodwin 1999). Merriam's females in Arizona experienced low winter survival, possibly due to lack of winter food availability (Wakeling 1991, Wakeling and Goodwin 1999). Merriam's turkeys in the central Black Hills also fed upon pine seeds in winter (Rumble and Anderson 1996*a*) and used pine stands with high canopy coverage (Rumble and Anderson 1996*b*). Turkeys in the central Black Hills also had high winter survival except for yearling females following deep snowfall events

Table 4. Seasonal cause-specific mortality rates (SE) and deaths (*n*) during winter (1 Dec–31 Mar), spring (1 Apr–30 Jun), summer (1 Jul–31 Aug), and fall (1 Sep–30 Nov) for Merriam's turkey females in the southern Black Hills, South Dakota, 2001–2004. Rates were calculated using the Kaplan-Meier method.

Mortality source	Season							
	Winter		Spring		Summer		Fall	
	Rate (SE)	*n*	Rate (SE)	*n*	Rate (SE)	*n*	Rate (SE)	*n*
Mammalian	0.027 (0.01)	4	0.114 (0.03)	15	0.029 (0.02)	3	0.031 (0.02)	3
Avian	0.028 (0.01)	4	0.023 (0.01)	3	0.000 (0.00)	0	0.031 (0.02)	3
Weather	0.008 (0.01)	1	0.023 (0.01)	3	0.000 (0.00)	0	0.000 (0.00)	0
Hunting	0.000 (0.00)	0	0.000 (0.00)	0	0.000 (0.00)	0	0.020 (0.01)	2
Illegal kill	0.000 (0.00)	0	0.008 (0.01)	1	0.000 (0.00)	0	0.000 (0.00)	0
Disease	0.000 (0.00)	0	0.015 (0.01)	2	0.000 (0.00)	0	0.000 (0.00)	0
Car kill	0.000 (0.00)	0	0.000 (0.00)	0	0.000 (0.00)	0	0.010 (0.01)	1
Unknown	0.014 (0.01)	2	0.015 (0.01)	2	0.010 (0.01)	1	0.031 (0.02)	3

(Rumble et al. 2003). In 2002, 3 yearlings and 1 adult wintering in forest died of starvation shortly after deep snowfall covered food resources. During this period snow cover ≥20 cm lasted about 14 days. Emaciated birds had lost 40–41% of their original body weight.

Annual survival of adult female Merriam's turkeys in the southern Black Hills averaged 67%, which is similar to that for Merriam's females in the central Black Hills ($\bar{x}$ = 68%, Rumble et al. 2003). Age-classes combined, average annual survival of Merriam's turkey females in Arizona was 57% (Rumble et al. 2003) and 45% in Montana (Thompson 1993). In Arizona, annual survival for adult females averaged 67% for the Mogollon Rim (Wakeling 1991) but reached 84% or above at some sites (Rumble et al. 2003). Adult female Merriam's turkey survival in Oregon averaged 62% but yearling female survival was only 42% (Crawford and Lutz 1984). Annual yearling female survival averaged 49% in the southern Black Hills, but sample sizes were small during this study (n = 16). In comparison, yearling female survival in New Mexico and Arizona was higher at 65% (Lockwood and Sutcliffe 1985) and 69% (Wakeling 1991).

In the southern Black Hills, adult survival was lowest during spring and fall, and highest during winter and summer. Spring has been a period of high female mortality apparently because of vulnerability of females nesting on the ground during the long incubation period (Speake 1980). Survival in the spring was similar to other studies of Merriam's turkeys that also showed the apparent vulnerability of females during nesting (Rumble and Hodorff 1993, Thompson 1993, Rumble et al. 2003). Mammalian predators caused most of the mortality during the spring period, and much of the mortality occurred while females were laying eggs or incubating clutches. Thompson (1993) reported 50% of all mortality of females occurred during the nesting period. In Arizona, Merriam's turkeys experienced low predation during nesting, but high predation rates during brood rearing (Wakeling 1991). Avian predators were the primary cause of mortality during brood-rearing (Wakeling 1991). We found no evidence of high female mortality in the southern Black Hills during brood-rearing. Fall survival was similar to spring survival in our study but had an even distribution of mortality factors, including predation, hunting, and unknown.

In our study, coyote and bobcat predation accounted for the highest percentage of mortality, followed by great horned owl predation. Across the Merriam's range predation by mammalian and avian predators accounts for the majority of mortality events in Merriam's turkeys (Rumble et al. 2003). Starvation associated with deep snowfall was not common in the southern Black Hills. However, in northeastern South Dakota severe winter weather caused 14% of mortality (Lehman et al. 2001). Deep snow cover on food sources in late winter and early spring can have negative cumulative effects on the physiological condition of birds (Rumble and Anderson 1996*a,* Wakeling and Rogers 1996). Fall harvest of females is slight, accounting for about 4%, and does not affect turkey populations in the southern Black Hills. Similarly, fall hunting caused 2.6% of annual mortality in Arizona and had little affect on Arizona turkey populations (Wakeling 1991). One female (1.9%) was illegally killed by spring turkey hunters, which is a lower rate than in heavily hunted areas in the eastern United States (Healy and Powell 1999). In the southern Black Hills, cause-specific mortality rates typically did not differ within seasons with the exception of spring when mammalian predation exceeded other mortality factors. Mammalian predators were more successful in finding nesting females than avian predators and may account for the differential predation rate.

MANAGEMENT IMPLICATIONS

With the exception of adult females from some areas in Arizona (Rumble et al. 2003), survival in the southern Black Hills was similar or higher than rates reported for Merriam's turkeys from both its indigenous range (Lockwood and Sutcliffe 1985) and its introduced range (Crawford and Lutz 1984, Thompson 1993, Rumble et al. 2003). Survival was excellent for both turkeys that wintered near farmsteads and turkeys that wintered in forest. Farmstead habitats were highly utilized by Merriam's turkeys in the southern Black Hills (Lehman 2005). Farmsteads were particularly important during the winter of 2003 when there was less pine seed production. Farmsteads could be important in sustaining population levels during years of severe winter weather. Although only a small percentage (1.9%) of females were illegally killed by spring turkey hunters in this study, we recommend that illegal female harvest continue to be monitored as the number of hunters increases in the Black Hills.

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Chad P. Lehman received a B.S. in Biological Science from the University of Minnesota-Duluth (1994) and M.S. in Wildlife Science from South Dakota State University (1998). He received a Ph.D. in Biological Science from South Dakota State University (2005) and his research focused on Merriam's turkey ecology, particularly the influence of weather and habitat selection/availability on survival and reproduction. As a wildlife biologist for Custer State Park, Chad conducts research and manages habitats for game and nongame wildlife species. For hobbies, Chad enjoys hiking with his wife Michelle and son Drew, and hunting birds with his yellow Labrador Retrievers.

Les Flake retired from South Dakota State University in August of 2002 after 31 years on the faculty and was appointed Distinguished Professor Emeritus. He is still advising graduate students and remains involved with several projects in South Dakota. In his free time Les enjoys visiting grandchildren, hiking in the mountains of Utah, reading, fly fishing, bow hunting, and chasing pheasants with old friends in South Dakota. Les has a Ph.D. in Zoology from Washington State University (1971) and an M.S. in Zoology from Brigham Young University (1966).

Mark A. Rumble received a B.S. in wildlife biology from Washington State University, an M.S. in Wildlife Science from South Dakota State University, and a Ph.D. in Zoology from the University of Wyoming. Mark has worked for the U.S. Forest Service for 27 years, and 26 years for the Rocky Mountain Research Station in Rapid City, South Dakota. His professional interest includes understanding the effects of land management on wildlife habitat with an emphasis on developing information in formats that are usable by forest and range managers.