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Winter Range Expansion by the Northern Yellowstone Elk Herd

Abstract

*We examine and describe changes in northern Yellowstone elk (*Cervus elaphus*) winter distribution, population size and harvests from 1975-1997. Since the late 1970s, northern Yellowstone elk have expanded their winter range by 41 percent to about 152,663 ha. During this period, elk winter range north of Yellowstone National Park (YNP) has more than doubled from 22,179 ha to 53,262 ha. Since 1988-89 the number of elk wintering north of YNP has averaged 5,460 elk/year (1,533-8,626) with 2,000-4,500 elk wintering north of Dome Mountain where few Yellowstone elk wintered prior to 1988-89. Minimum fall elk population estimates increased from 11,149-12,941 animals in the late 1970s to a mean of 17,409 ± 1,377 (SD) elk based on nine annual counts conducted between 1981-82 and 1994-95. Minimum winter (post-hunting) numbers averaged 15,520 ± 2,324 (SD) elk for the same period. With more elk migrating out of YNP, late season elk harvests increased 64 percent from 892 ± 506 (SD) elk/year from 1979-80 to 1987-88 to 1,459 ± 815 (SD) elk/year from 1988-89 to 1996-97. Winter range expansion, elk migration behavior, and increased winter harvests dispelled earlier concerns that winter hunts would prevent elk from using all available winter range. Challenges facing the management of Yellowstone elk north of YNP include harvesting enough elk to maintain the long-term diversity and productivity of winter range vegetation, resolving land use conflicts with elk expanding into Paradise Valley, and addressing growing concerns about the possible transmission of the disease brucellosis from elk to domestic livestock.*

Key words: *Cervus elaphus*, elk, northern Yellowstone elk herd, population trends, winter range, Yellowstone National Park.

Introduction

The northern Yellowstone elk herd is the largest ungulate population in the Yellowstone National Park (YNP), greatly exceeding the combined populations of bison (*Bison bison*), mule deer (*Odocoileus hemionus*), antelope (*Antilocapra americana*), moose (*Alces alces*), bighorn sheep (*Ovis canadensis*), and mountain goat (*Oreamnos americanus*). Elk population management and the effects of large numbers of elk on vegetation are controversial issues (Pengelly 1963, Erickson 1981, Chase 1986, Lemke and Singer 1989, Wagner *et al.* 1995, Yellowstone National Park 1997).

Hunting of migrant Yellowstone elk immediately north of YNP during December-February resumed in 1976 after an 8-year moratorium, prompting concerns that winter hunting would inhibit the natural movement of elk out of YNP and prevent elk from reaching the northernmost available winter range (Houston 1979). Conversely, large elk migrations north of YNP may result in decreasing plant diversity and productivity, reduced ability of winter

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hunts to control elk numbers, and a decline in private landowner tolerance for elk. Since the 1970s, significant changes in winter elk distribution and migration have gone unreported.

Here, we present elk population estimates and annual harvests from 1975-1997, and document changes in the boundaries of occupied winter range. In reviewing elk survey and harvest information for this paper, we discovered minor errors in the numbers reported for some elk surveys and harvests since 1975. We used original survey and harvest data to make appropriate corrections.

Study Area

Many elk in the northern Yellowstone population are migratory. During summer, elk occupy up to 470,000 ha in YNP and 100,000 ha on adjacent lands to the north and east (Houston 1982). From movements of radio-collared elk, Vore (1990) documented migrations of up to 150 km between summer and winter ranges. During winter (mid-November to April) elk occupy a much smaller area known as the "northern Yellowstone winter range," at lower elevations from 1,500-2,500 m along the Yellowstone, Lamar, and Gardiner rivers (Fig. 1). Elk migrate northerly in the winter and southerly in the spring along an extensive system of obvious trails that parallel the rivers.

In winter, elk congregate inside YNP in lower Soda Butte Creek, Slough Creek, Lamar Valley, Specimen Ridge, Hellroaring/Little Buffalo Creek face, Crevice Creek, Blacktail Plateau, Mount Everts, Gardiner Canyon, Stevens Creek, and Reese Creek. North of YNP, elk occupy Deckard Flats, Eagle Creek, Little Trail Creek, Bassett Creek, Cedar Creek, Slip and Slide Creek, Dome Mountain, Dailey Lake, Beattie Gulch, Cinnabar Mountain, and the Cinnabar Basin divide. During winter, elk forage primarily in steppe and steppe shrub habitat types (Despain 1990) where they are readily observed.

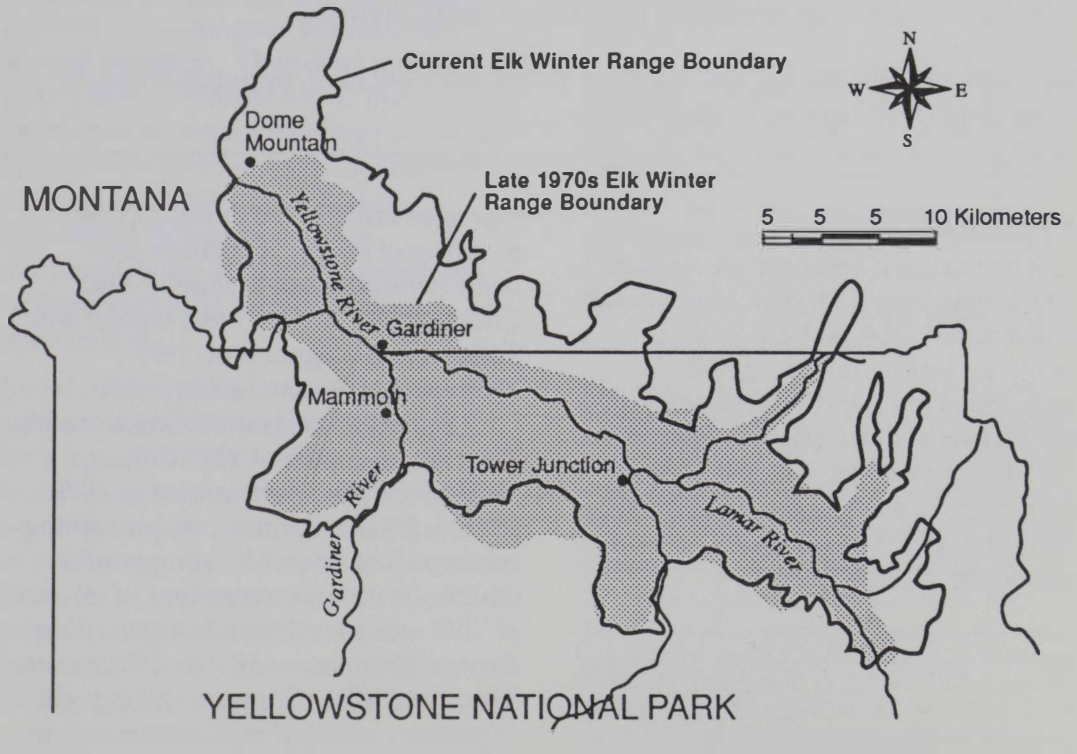

Figure 1. *Location and boundaries of current versus late 1970s northern Yellowstone elk winter range.*

Methods

We determined winter range boundaries and elk distribution from counts of elk obtained with use of a Piper Super Cub aircraft. The presence of elk or elk sign in snow, such as trailing and feeding craters determined the size and location of winter range use. We attempted complete censuses of elk, recognizing that counts invariably fall below actual numbers present (Houston 1982). Four to six winter counts were conducted annually during the 1970s. Two days were required to complete the counts using one aircraft. The highest counts were obtained during December-January when large concentrations of elk first occupied snow covered steppe shrub communities and elk made minimal use of forested habitat.

Montana Fish, Wildlife, and Parks (FWP) and YNP personnel changed survey procedures during the 1980s and 1990s to adjust for increasing elk numbers and the size of the occupied winter range. By 1982, two aircraft typically were used simultaneously. Since 1985, four aircraft have been employed, and five of the last 10 censuses were completed in a single day. Since 1994, the northern Yellowstone winter range has been divided into 68 count units with 50 units primarily inside YNP, 18 units primarily north of YNP, and six units overlapping the YNP boundary. In years when fresh elk tracks were absent, some upper elevation units were not surveyed completely. The areas within the 1970s and the current elk winter range boundaries were measured using Geographic Information System (GIS) technology.

We relied on elk counts described above and elk harvest information for the general big game hunting season and the late Gardiner elk hunt (winter harvest) to estimate minimum elk population numbers and trends. Fall elk harvests from 1976-1981 were estimated using mail survey questionnaires. Since 1982, elk harvest estimates were based on telephone harvest surveys for Montana resident license holders and mail surveys for nonresidents (Cada 1985). Annual surveys since 1982 have sampled 42-44 percent of elk licence holders.

The fall harvest for northern Yellowstone elk includes harvest estimates for elk taken in Montana Hunting Districts 313 and 316, located north of YNP. Late season elk removals, legal harvest plus known illegal kills and wounding losses, were determined at FWP check stations. All hunters were required to check in and out of the hunting area at the check stations. Stations were not operated in 1978-79 or 1979-80; harvest estimates were derived from warden field checks in 1978-79 and a mail survey in 1979-80.

A review of harvest records revealed minor discrepancies between field data and what appeared in annual FWP reports (unpublished Pittman-Robertson Survey and Inventory Job Progress Reports 1976-1986). Discrepancies in elk survey data also were found in Singer *et al.* (1989), Mack and Singer (1993), Singer and Mack (1993), and Coughenour and Singer (1996). To reconcile these errors we examined original flight data and elk harvest cards and made the appropriate corrections (Table 1). Houston (1982) derived estimates for minimum fall elk populations by adding fall harvest estimates to the maximum census count. We estimated minimum winter populations by subtracting winter harvest removals from the maximum elk counts for the winters of 1976, 1978 and 1979. These calculations were reported in Houston (1982); however, the minimum winter population estimates were not distinguished from survey counts in his Table 3.1 (Houston 1982).

Since 1990, the beginning of the winter elk season was moved from mid-

Table 1. *Population counts, harvests, and minimum seasonal fall and winter population estimates for the northern Yellowstone elk herd, 1975-1997.*

Winter Period	Maximum Number of Elk Counted	Date of Count	Number of Elk Removed: Fall Hunt[a]	Late Hunt[b]	Total	Minimum Fall Population[c]	Minimun Winter Population[d]
1975-76	12,014	12/17-18	340	1,189	1,529	12,354	10,825
1976-77	8,980[•]	1/23-24	219	No hunt	219	9,199	9,199
1977-78	12,680	12/20-21	261	802	1,063	12,941	11,878
1978-79	10,838	12/29-30	311	31	342	11,149	10,807
1979-80	No count		194	467	661		
1980-81	No count		243	133	367		
1981-82	16,019	1/6-7	344	1,015	1,359	16,473	15,114
1982-83	No count		447	1,434	1,881		
1983-84	No count		404	1,657	2,061		
1984-85	No count		360	1,211	1,571		
1985-86	16,286	12/19-20	456	1,042	1,498	16,885	15,387
1986-87	17,007	12/10	894	845	1,739	17,901	15,268
1987-88	18,913	1/19	359	220	579	19,316	18,737
1988-89	10,265[•]	1/26 & 2/9	487	2,409	2,896	12,328	9,488
1989-90	14,829	1/18-19	815	484	1,299	15,805	14,506
1990-91	9,456[•]	2/6	308	697	1,005	10,287	9,282
1991-92	12,859	12/16	2,728	1,787	4,515	15,587	11,072
1992-93	17,585	11/21 & 12/3	481	1,574	2,055	18,066	16,011
1993-94	19,045	1/20-24	254	273	527	19,359	18,832
1994-95	16,791	12/21	499	2,039	2,538	17,290	14,752
1995-96	No Count		306	1,400	1,706		
1996-97	No Count		855	2,465	3,320		

[a] Combined mid-point elk harvest estimate for Hunting Districts 313 and 316 from FWP Statewide Harvest Survey.

[b] Check station count of late hunt elk harvest plus known illegal kills and wounding loss for all years except 1978-79, 1979-80, and 1981-82. Known annual illegal and wounding loss ranged from 6-106 elk/year ($\bar{x}$ = 45 elk).

[c] Minimum fall population estimate = maximum survey count + estimated fall harvest + late hunt removals that occurred prior to survey date, if any.

[d] Minimum winter population estimate = maximum survey count - late hunt removals that occurred after survey date, if any.

[•] Survey conditions were exceptionally poor resulting in inaccurate counts.

December to early January to reduce the incidental harvest of nonmigratory elk north of YNP. Elk counts since the 1980s often occurred after the start of winter hunts due to mild weather or aircraft scheduling problems. The timing of winter hunt removals relative to survey flights affect minimum winter and fall population estimates. Thus, we adjusted the minimum fall and winter population estimates for all years based on date of harvest information.

Results and Discussion

The size of the northern Yellowstone elk winter range has increased by 41 percent over the last 20 years. In the late 1970s, the estimated elk winter range included about 100,000 ha (Houston 1982). As determined more recently from GIS technology on Houston's boundaries, elk occupied a winter range of 108,553 ha in the 1970s. Based on current winter elk distribution, elk

occupy a winter range of 152,663 ha, which extends from the upper Lamar River northwest to Sixmile Creek 32 km north of YNP (Fig. 1).

From the 1970s to the present time, the size of the elk winter range outside YNP more than doubled from 22,179 ha to 53,262 ha. In 1997, 35 percent of the total winter range was located north of YNP compared to 17 percent in the 1970s. Winter elk distribution now includes 9,200 ha between Dome Mountain and Sixmile Creek north of YNP. Since 1988-89, 2,000-4,500 elk have wintered in an area previously occupied by few elk (Fig. 2). In the harsh winters of 1991-92 and 1996-97, elk that migrated from YNP moved further north into Paradise Valley beyond Sixmile Creek. In 1996-97, an estimated 500-1,000 elk moved as far as 10 km beyond Sixmile Creek, the typical northern boundary of their winter range.

Once beyond Sixmile Creek, migratory Yellowstone elk were largely on private agricultural lands and were in direct conflict with agricultural interests. Elk may compete with livestock for standing forage, pose a threat to stored hay crops, damage fences, and mingle with cattle, which raises concerns among livestock producers about transmission of the brucellosis disease bacteria (*Brucella abortus*) from elk to livestock (Thorne *et al.* 1997). Human tolerance for increasing numbers of migrant elk north of Sixmile Creek is low. If migratory elk continue to expand their winter range into Paradise Valley, conflicts between wildlife and livestock producers will increase.

Absent or partial snow cover during 1976-77, 1988-89, and 1990-91 resulted in unrealistically low elk counts. These mild conditions allowed elk to winter at higher elevations in forested habitats,

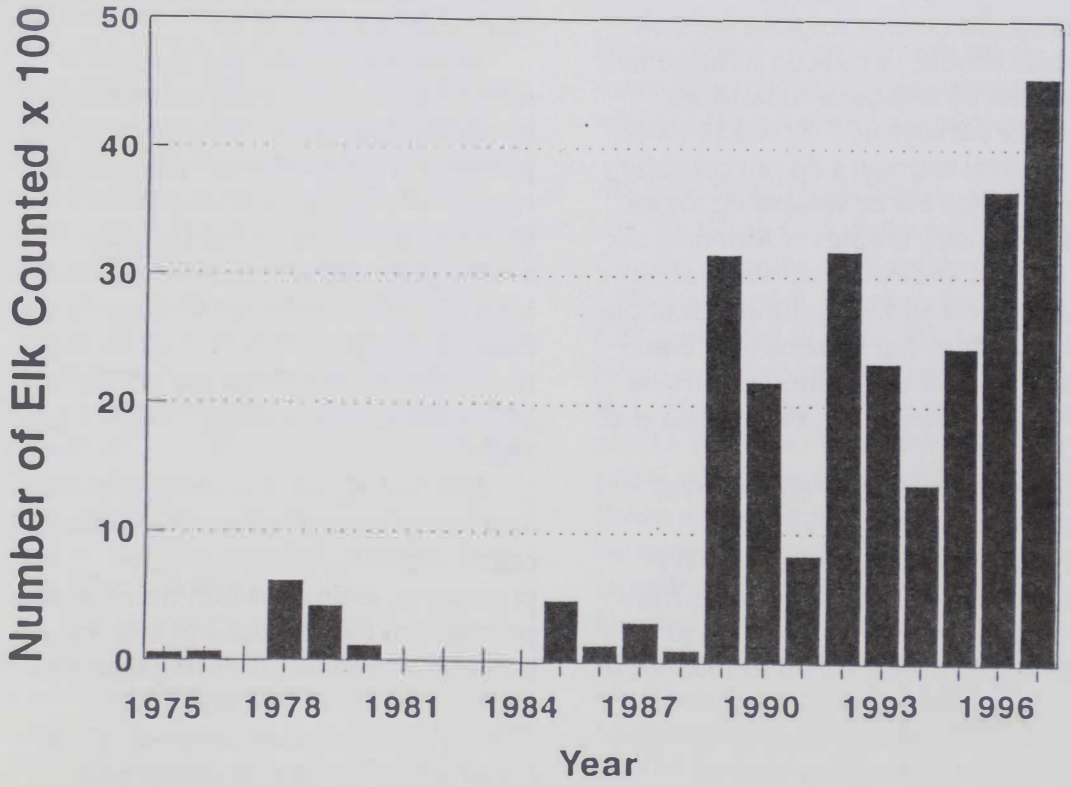

Figure 2. *Number of elk counted during winter north of Dome Mountain, at the northern end of the Yellowstone elk winter range.*

which reduced their observability. Minimum fall populations averaged 17,409 ± 1,377 (SD) elk for nine annual counts conducted from 1981-82 through 1994-95, excluding poor counts of 1988-89 and 1990-91. No total elk counts were conducted in 1995-96 and 1996-97. Annual removals were variable and averaged 1,823 ± 1,022 (SD) elk over the 14 years, including 1,192 ± 661(SD) elk removed annually during the winter hunts. Minimum winter populations averaged 15,520 ± 2,324 (SD) elk for nine annual counts from 1981-82 through 1994-95, excluding 1988-89 and 1990-91. The mean observed rate of increase (r) for minimum winter populations was -0.0012 for the 14-year period and did not differ significantly from zero (regression of l_n elk numbers on time, r = b, $P > 0.08$ (Caughley 1977).

The calculated minimum fall population depended on estimates of fall elk harvests that may have been biased upward from 1976-81. Successful hunters were more likely than unsuccessful ones to respond by mail. This bias should have been reduced or eliminated by changing to random telephone surveys in 1982 (Cada 1985). Fall removal estimates do not consider illegally killed elk or wounding losses. Radio telemetry studies of Montana elk populations indicate that removal by illegal harvest and wounding loss of elk during fall hunting seasons may equal 10-18 percent of the estimated harvest (Hamlin and Ross 1991, Henderson *et al.* 1993).

Estimates of winter elk removal included known illegal kills and wounded animals retrieved by FWP wardens (Table 1). Known losses from these sources averaged 45 elk/year (range 6-106) from 1975-76 to 1996-97, or about 2-7 percent of the legal harvest. Additional illegal and wounding losses surely occurred, but they may be relatively low because of the high density of hunters and wardens in the hunting areas. Wounded animals were quickly killed by other hunters. Winter removals have generally increased since 1988-89, paralleling the increase in elk migrating out of YNP. Winter hunt removals in the last nine years (1988-89 to 1996-97) averaged 1,459 ± 815 (SD) elk/year compared to 892 ± 506 (SD) elk/year removed during the nine years from 1979-80 to 1987-88, a 64 percent increase.

The calculated minimum winter populations assumed that each elk removed during the winter hunts would have been counted in the earlier survey, which is unlikely. The rationale for using the estimated minimum winter population to monitor trends is that this value represents the density of animals subjected to the full rigors of the Yellowstone environment when resources are most limited. Such estimates also are in keeping with a tradition begun in the 1930s, that is, conducting counts after elk removals were completed by the National Park Service within YNP and hunting seasons had closed outside YNP.

Minimum winter population estimates may be subsequently affected by natural late-winter mortality, which probably would influence population trends. Winter elk mortality that followed the counts varied greatly among years (Houston 1982) and has been difficult to monitor accurately. An estimated 3,021-5,757 elk died during the winter of 1988-89 on the northern Yellowstone winter range (Singer *et al.* 1989).

Depending on objectives, any of the alternative annual values (maximum elk count, estimated minimum fall population, estimated minimum winter population) may be used to monitor elk population trends, providing that the chosen value is used consistently. Mixing survey counts with minimum fall or winter estimates would bias population growth projections.

The number of northern Yellowstone elk currently exceeds the

equilibrium of 12,000 elk predicted in the 1970s (Houston 1982). Current elk numbers equal or slightly exceed the ecological carrying capacity originally estimated at 15,000-17,000 elk (Houston 1982). At current elk population levels, two significant changes have occurred: (1) elk winter distribution has expanded both inside and outside YNP, and (2) larger numbers of elk have consistently migrated to areas north of YNP despite increased winter harvests.

Expanding elk distribution across the winter range may have resulted from a series of exceptionally mild winters during the 1980s that allowed elk to exploit new areas, and/or a simple consequence of higher elk numbers. Other ungulate populations in the greater Yellowstone area also increased during the 1980s, an apparent response to mild winters (Singer 1991, Mack and Singer 1993).

Increased elk use of winter range north of YNP began in the harsh winter of 1988-89 with a migration of over 7,000 elk (Lemke 1997) following wildfires that burned 321,283 ha inside YNP (Despain *et al.* 1989). From 1988-89 to 1996-97, the number of elk wintering north of YNP averaged 5,460 elk/year (1,533-8,626). Large numbers of elk wintering north of Dome Mountain (Fig. 2) have established an important new migratory pattern (Lemke 1997). From 1989 to 1993, a cooperative winter range acquisition project placed 3,500 ha of key privately owned winter range into public ownership (Rocky Mountain Elk Foundation 1993). Livestock grazing was discontinued on this purchased land to increase winter forage for elk and other wildlife.

Maintaining a large annual elk migration with animals distributed to the northern extremes of their winter range while harvesting 1,459 ± 815 (SD) elk/year during winter hunts since 1988-89 dispelled earlier concerns that harvesting large numbers of elk would inhibit migrations north of YNP (Houston 1979). Hunting regulations, which delay the winter hunting season, open hunting areas based on migrant elk distribution, assign hunters to specific 2 or 4-day hunt periods, allow for 3-day rest periods between hunts, and direct the majority of the harvest to antlerless elk, all helped FWP protect and provide high quality winter habitat, reduced game damage conflicts, and provided sustainable public recreation (Lemke 1995a, 1995b).

The greatest issues currently facing management of migratory Yellowstone elk are sustaining a large enough elk harvest to maintain long-term plant diversity and productivity outside YNP, minimizing conflicts between elk and other land uses if elk expand their winter range beyond Sixmile Creek, and addressing concerns about the transmission of brucellosis from elk to domestic livestock. We recommend that consistent monitoring of northern Yellowstone elk be continued to document changes in population size, elk harvests, and winter distribution. Future policy decisions related to managing northern Yellowstone elk will rely heavily on such information.

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Literature Cited

Cada, J. D. 1985. Evaluations of the telephone and mail survey methods of obtaining harvest data from licensed sportsmen in Montana. Pp. 117-128 *in* S. L. Beasom and S. F. Robertson, eds. Game harvest management. Caesar Kleberg Wildl. Res. Inst., Kingsville, TX. 374 pp.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York, NY. 234 pp.

Chase, A. 1986. Playing God in Yellowstone: the destruction of America's first national park. Atlantic Monthly Press, Boston, MA. 446 pp.

Coughenour, M. B., and F. J. Singer. 1996. Elk population processes in Yellowstone National Park under the policy of natural regulation. Ecol. Applications 6:573-593.

Despain, D. 1990. Yellowstone vegetation, consequences of environment and history in a natural setting. Robert Rinehart, Inc., Boulder, C0. 239 pp.

Despain, D., A. Rodman, P. Schullery, and H. Shovic. 1989. Burned area survey of Yellowstone National Park: the fires of 1988. Yellowstone National Park, Mammoth Hot Springs, WY. 14 pp.

Erickson, G. L. 1981. The northern Yellowstone elk herd — a conflict of policies. Proc. Ann. Conf. West. Assoc. Fish and Wildl. Agencies. 62:92-108.

Hamlin, K. L., and M. S. Ross. 1991. Varying definitions of the legal bull — the effects on hunters, hunting, and elk populations. Pp. 247-254 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, comps. Proc. Elk Vulnerability Symp., Montana State Univ., Bozeman. 330 pp.

Henderson, R. E., B. A. Sterling, and T. O. Lemke. 1993. The lower Clark Fork elk study: final report 1985-1990. Montana Fish, Wildlife & Parks, Unpubl. Rept., Helena, MT. 141 pp.

Houston, D. B. 1979. The northern Yellowstone elk — winter distribution and management. Pp. 263-273 *in* M. S. Boyce and L. D. Hayden-Wing, eds., North American elk: ecology, behavior, and management. Univ. of Wyoming, Laramie. 294 pp.

Houston, D. B. 1982. The northern Yellowstone elk: ecology and management. Macmillan Publishing Co., New York, NY. 474 pp.

Lemke, T. O. 1995a. A Montana tradition. Montana Outdoors 26(2):1-9 .

Lemke, T. O. 1995b. Yellowstone Park elk management review, Gardiner late hunt. Montana Fish, Wildlife and Parks, Bozeman, MT. 8 pp.

Lemke, T. O. 1997. Late winter 1996-97 northern Yellowstone elk survey; trends in Yellowstone elk migrations and distribution; bison counts and brucellosis monitoring update. Montana Fish, Wildlife and Parks, Bozeman, MT. 6 pp.

Lemke, T. O., and F. J. Singer. 1989. Northern Yellowstone elk: the big herd, a management challenge. Rocky Mtn. Elk Foundation, Bugle 6:113-121.

Mack, J. A., and F. J. Singer. 1993. Population models for elk, mule deer, and moose on Yellowstone's northern winter range. Pp. 270-305 *in* R. S. Cook, ed., Ecological issues on reintroducing wolves into Yellowstone National Park. Natl. Park Ser. Scientific Monog. 93:22. 328 pp.

Pengelly, W. L. 1963. Thunder on the Yellowstone. Naturalist 14:18-25.

Rocky Mountain Elk Foundation. 1993. Preserving a legacy through partnerships—northern Yellowstone elk herd project. Missoula, MT. 12 pp.

Singer, F. J. 1991. Ungulate prey base for wolves in Yellowstone National Park. Pp. 323-348 *in* R. B. Keiter, and M. S. Boyce, eds. The greater Yellowstone ecosystem: redefining America's wilderness heritage. Yale Univ. Press, New Haven, CT. 428 pp.

Singer, F. J., and J. A. Mack. 1993. Potential ungulate prey for gray wolves. Pp. 75-117 *in* R. S. Cook, ed., Ecological issues on reintroducing wolves into Yellowstone National Park. Natl. Park Ser. Scientific Monogr. 93:22. 328 pp.

Singer, F. J., W. Schreier, J. Oppeheim, and E. O. Garton. 1989. Drought, fires, and large mammals. BioScience 39:716-722.

Thorne, E. T., S. G. Smith, K. Aune, D. Hunter, and T. J. Roffe. 1997. Brucellosis: the disease in elk. Pp. 33-44 *in* E. T. Thorne, M. S. Boyce, P. Nicoletti, and T. J. Kreeger, eds., Brucellosis, bison, elk, and cattle in the greater Yellowstone area: defining the problems, exploring solutions. Wyoming Game and Fish Dept., and Greater Yellowstone Interagency Brucellosis Committee, Cheyenne, WY. 219 pp.

Vore, J. M. 1990. Movements and distribution of some northern Yellowstone elk. Unpubl. M.S. Thesis, Montana State Univ., Bozeman. 80 pp.

Wagner, F. H., R. Foresta, R. B. Gill, D. R. McCullough, M. R. Pelton, W. F. Porter, and H. Salwasser. 1995. Wildlife policies in the U.S. National Parks. Island Press, Washington, DC. 242 pp.

Yellowstone National Park. 1997. Yellowstone's northern range: complexity and change in a wildland ecosystem. National Park Service, Mammoth Hot Springs, WY. 148 pp.