TOWER RANGER STATION 1988

THE UNGULATE PREY BASE FOR LARGE PREDATORS IN YELLOWSTONE NATIONAL PARK



Francis J. Singer

Research/Resources

Management Report No. 1

Box 168

Yellowstone National Park

Wyoming 82190

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SUPERINTENDENT'S SUMMARY

A review was made of available information concerning elk, moose, mule deer, and pronghorn antelope populations during the 1980s in Yellowstone National Park. The purpose of this review was to make the data available for an assessment of mountain lion - prey relationships and for predictions concerning a proposed reintroduction of wolves into Yellowstone National Park. Data prior to 1979 is summarized in Houston (1982). This review did not include bison or bighorn sheep. Mountain lion-ungulate relations will be dealt with in a later report prepared by the Wildlife Research Institute, but utilizing the ungulate data from this report. I also provided my own opinion on several biological questions concerning wolf reintroduction.

Conclusions

1. Pronghorn antelope counts on the northern range have increased 226% during the 1980s from 152 in 1979 to 495 in 1988.

2. Mule deer counts on the northern range increased 120% in the 1980s, from 1,007 in 1979 to 2,217 in 1988. Sightability of mule deer in the topographically similar Bridger Mountains of Montana was 66%, suggesting actual mule deer numbers were probably at least 3,000.

3. White-tailed deer are rare on the northern range, but some sightings were made within Yellowstone National Park. Harvest during the 1980s averaged 23 per year in Montana Hunting District 313 on the northern range.

4. Moose apparently declined on the northern range during the latter 1970s, but have apparently recently increased in upper Slough Creek and upper Soda Butte Creek. Fewer moose apparently inhabit some locales such as the Rainbow Lakes - Beaver Ponds area, Blacktail Plateau, Lamar Valley and lower Slough Creek. If 200 moose inhabit the northern range (Houston 1982: 169), then recent harvest levels were 18-24%.

5. Roughly 31,000 elk from 7 or 8 herds summer in Yellowstone National Park. This includes approximately 900 animals from the Gallatin herd, 1,056 from the Sand Creek herd, 2,143 from the Jackson herd, possibly a few from the Carter Mountain herd, 2,020 from the North Fork Shoshone herd, 2,500 from

the Clarks Fork herd, 20,800 from the northern herd, and 800 from the Madison-Firehole herd.

6. About 22,500 elk from 4 herds or groups winter in Yellowstone National Park. This includes 20,800 ± 540 from the northern herd, 800 from the Madison-Firehole herd, 500 from the upper Yellowstone group, and about 500 from the Gallatin herd.

7. The northern elk herd count increased from 10,800 in the winter of 1979-80 to 16,019 in 1981-82, and then to 18,913 in 1987-88. Harvests averaged 9% of the herd during the 1980s.

8. Ungulate numbers increased due to mild winters of the 1980s. Declines for all four species and changes in winter distribution are predicted during winters of normal severity. The fires of 1988 are hypothesized to increase the range carrying capacity, particularly for elk and moose, although some grassland responses to the fire may be fairly brief in duration.

9. Eleven sectors of Yellowstone National Park and boundary areas possess enough space and ungulates to support at least one pack of wolves each under present conditions. In one of these sectors (SW) wolves would likely winter out of the park. More wolves could be supported if at least some packs are migratory, since they would then more efficiently exploit the migratory elk and mule deer. I speculate that the park and its boundary areas would support a minimum of 11-15 non-migratory packs of wolves, and several more packs if at least some packs were migratory. Wolves would rapidly increase because of the enormous prey base, but wolves would likely never reach ecological carrying capacity on the northern range because they would be rapidly delisted (upon reaching 10 pairs) and would then be legally harvested along an extensive boundary area. I speculate that some migratory behavior would be observed, but that migratory behavior would be discouraged by legal harvests, since migratory wolves would be more likely to leave the park. If no or little migratory behavior was observed, then park wolves would not efficiently exploit the strongly migratory elk and deer, and wolf numbers would remain below carrying capacity on a park-wide basis. The pattern of wolf occupation of the park might take 30 or more years to evolve (Dave Mech, pers. corres.). I speculate that a scenario of severe winters would reduce ungulates and wolf packs by about one-third. Four of the eleven sectors presently have marginal numbers of ungulates to sustain wolves year-round. Alternatively, the fires of 1988 may increase elk and moose range capacities and wolf potential.

10. While it would be desirable for wolves to follow the northern elk herd to winter range, it would be more likely for wolves in the SW, SE, NW, and NE sectors to follow elk out of the park in the winter. Wolves should be subjected to legal harvest in these areas on a very expedient basis after reintroduction. While a few wolves in these areas should be acceptable, total protection and high densities of wolves should be unacceptable,

since 4 of the park's migratory elk herds are presently being harvested at or near maximum sustained yield (Jackson, Sand Creek, Gallatin, and Carter Mountain herds). High numbers of wolves in these boundary areas is not essential to either a successful reintroduction to the park or to rapidly delisting the wolves from endangered to game animal status. Computer simulations should be done to predict the number of wolves sustainable without impacting sport hunting, and also to indicate the situations where impacts would most likely occur.

11. Wolves can reduce a less abundant, vulnerable prey species if wolf numbers are determined by a much more abundant species. Elk are 42 times more numerous than pronghorn antelope and bighorn sheep, 104 times more than moose, and 7 times more than mule deer on Yellowstone's northern winter range. The pronghorn population should not be highly vulnerable on their summer ranges since they can outrun wolves on bare ground, and since they occupy open sagebrush areas where they can detect wolves. The park's pronghorns winter near the town of Gardiner where wolves should rarely occur. The park's bighorn sheep already winter on excellent escape terrain where they should not be highly vulnerable to wolves. Mule deer mostly winter north of the park where wolves will most likely be rare. Those few deer that winter in the park could be vulnerable to wolves, as could moose, since moose are currently harvested at high levels (18-24%) and are only 1% as abundant as elk. Elk wintering in the smaller thermal areas which are surrounded by deep snow (Shoshone Lake, Heart Lake, etc.) will be vulnerable to wolves, although it may not be energetically efficient for wolves to move between these distant areas. Some of the smallest groups of elk (<10) might be eliminated.

THE UNGULATE PREY BASE FOR LARGE PREDATORS IN YELLOWSTONE NATIONAL PARK

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INTRODUCTION

This paper presents data on four species of ungulates: elk, mule deer, moose (Alces alces), and pronghorn antelope (Antilocapra americana) in Yellowstone National Park. This will enable analysis of the potential carrying capacity of the area for mountain lions and wolves, so that predictions may be made of the potential effect, if any, of these predators on the ungulates. Bighorn sheep (Ovis canadensis) and bison were excluded from this analysis.

I restricted the analysis only to ungulates wintering or summering within the boundaries of Yellowstone National Park. We also restricted the summary to data collected after 1979, since Meagher (1973), Barmore (1980), and Houston (1982) have summarized pre-1979 data.

A small population of mountain lions winters on the lower elevation areas of Yellowstone National Park's northern range (Koehler and Hornocker 1986). Lions were trapped and shot in Yellowstone National Park until 1928, and they were nearly extirpated (Koehler and Hornocker 1986). Recovery likely came from down the Yellowstone River where lions were more abundant (Koehler and Hornocker 1986). A track survey conducted during the winter of 1985-86 revealed the presence of a minimum of 5 to as many as 20 lions. Apparently, a larger number of lions disperse throughout the park during the summer (Koehler and Hornocker 1986). In 1987, a project was initiated to (1) gather data on the dynamics of the mountain lion population, and (2) evaluate the role of the

mountain lion as a predator, and its effect on prey populations (M. G. Hornocker. 1987. Ecology of the mountain lion in the Yellowstone ecosystem. Proposal, Wildlife Research Institute, Moscow, ID. 7pp.). An important aspect of this 4-year project will be to determine if lions are at some level of ecological carrying capacity. If not, the factors responsible for not allowing full population potential should be identified. As yet, it is too early in the study to determine whether the population may already be at or close to fully occupying the range (K. Murphy, per. corres.). Detailed information is needed on elk (Cervus elaphus) and mule deer (Odocoileus hemionus) numbers, winter and summer distributions, densities, herd growth rates, and any differential distributions of sex and age groups or differential vulnerability of animals.

Yellowstone National Park was identified as one of three potential recovery sites for the northern Rocky Mountain timber wolf (Canis lupus). Many questions surround the prospects of Yellowstone for a recovery site. On the one hand, large, generally unhunted populations of elk and bison (Bison bison) exist in the area, the size of remote park and national forest wilderness areas exceeds three million acres, and the wolf is the only missing element of Yellowstone's fauna. On the other hand, big game hunting is a major industry in the Greater Yellowstone Area and the extent to which wolves will populate areas outside of the park and compete for hunter take of elk and deer is unknown. Contentions range from no effect of wolves on big game at all, to minor impact (Fischer 1986), to significant effects (Zumbo 1987).

Livestock owners are concerned about losses of stock to wolves, slow agency response to any depredating wolves, closing federal lands for wolf protection, and they are concerned about the presence of an endangered species

in areas where coyote (Canis latrans) control is taking place (Owens 1988; Simpson 1988). Other concerns exist about the financial responsibility for wolf recovery, the effects of wolves on ungulates in Yellowstone Park (Simpson 1988), and visitor perceptions of wolves and predation (Fischer 1986).

ACKNOWLEDGMENTS

I thank John Varley and Robert Barbee (Yellowstone National Park) for their strong support and encouragement of this work. Graham Taylor (Montana Fish, Wildlife and Parks), Ruth Gale (Idaho Fish and Game), Garvis Roby, and James Yorgasen (Wyoming Fish and Game) graciously sent us reports and made available data from their surveys and field notes on elk herds that summer in Yellowstone. Cathy Wilson, Dave Albert, Karl Biastoch, and Peggy Tufts assisted with the data collection and map work. Tom France (National Wildlife Federation) and Norman Bishop (Yellowstone National Park) graciously allowed us access to their literature on wolves.

DESCRIPTION OF STUDY AREA

The vegetation and climate of Yellowstone National Park (Fig. 1) are described by Cooper (1975), Despain (1973), Mattson and Despain (1983), Houston (1982), and Despain (in press). Eight elk herds summer within Yellowstone National Park (Houston 1982:33), but only five elk herds winter wholly or partially within the park. Bison exist in three herds within the park (Meagher 1973). Two of these herds, the Pelican Valley and Mary Mountain herds, are severely limited by deep winter snows on the park's Central Plateau (Meagher

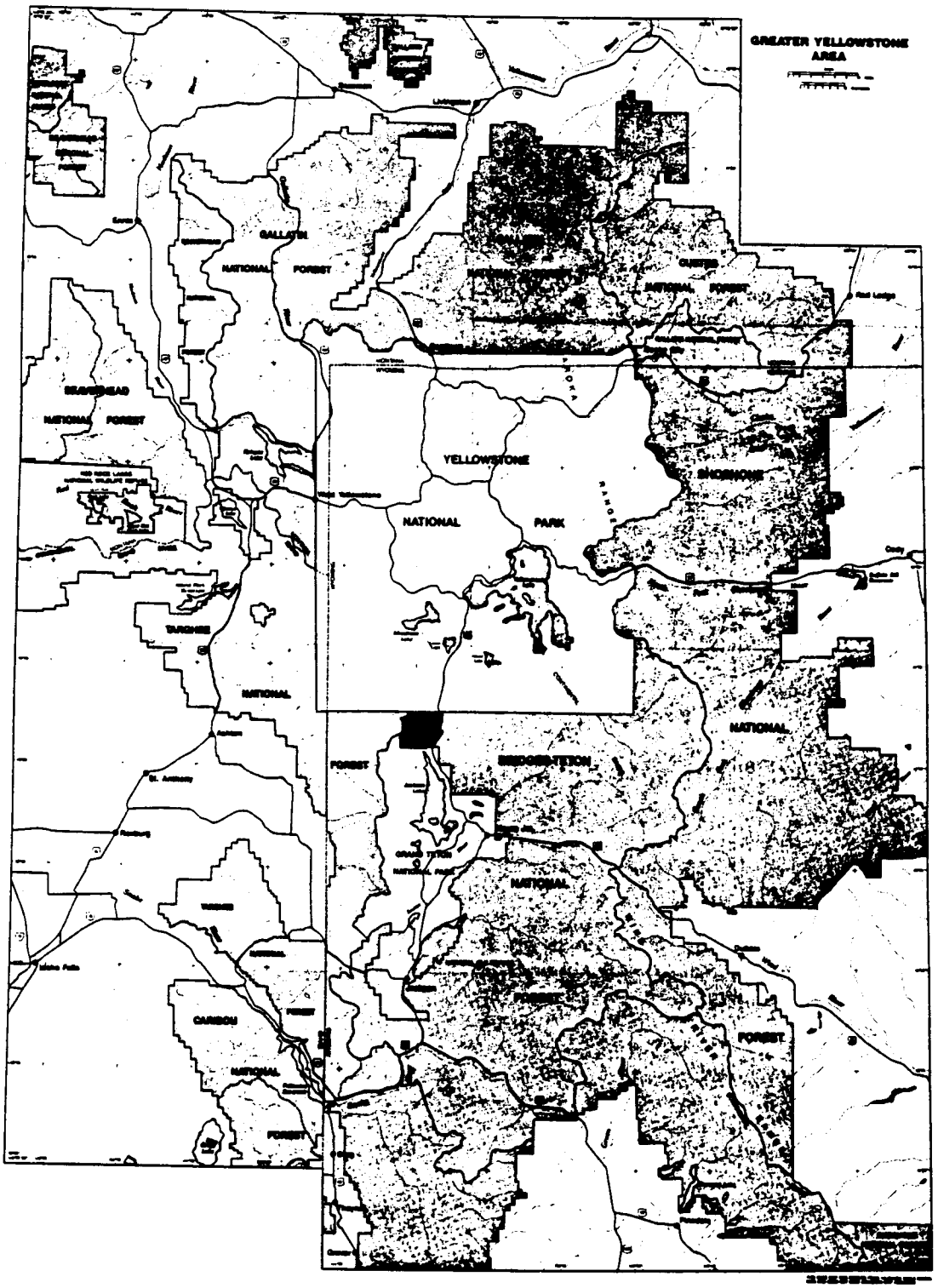


Fig. 1. The Greater Yellowstone Area including the northern elk winter range of Yellowstone National Park and adjacent Montana.

1971). Mule deer summer throughout the park, but they mostly leave the park in winter due to deep snows. Bighorn sheep winter in eight locales on the northern elk winter range (Houston 1982:161). Moose are found in low numbers throughout the park in summer and winter.

The northern elk winter range was defined by Houston (1982) to include 100,000 ha between Silver Gate, Montana, and Dome Mountain. About 82% of the northern range is in Yellowstone National Park, and the remainder is on national forest and private lands.

METHODS

Yellowstone's northern elk winter range was subdivided into 66 ungulate count units using ridgelines and drainages for boundaries (Fig. 2). Maps of mule deer and elk (Fig. 3) and moose (Fig. 4) hunting districts (H.D.) adjacent to the park's northern boundaries in Montana are included for reference.

I contacted state agencies from Idaho, Montana, and Wyoming for data on ungulate herd counts, ungulate movements into the park, and harvest statistics from areas bordering the park. I reviewed park files and survey reports for ungulate counts between 1980-84. From 1985-88, I was responsible for counts and classifications of elk, mule deer, and moose in the park, and I was responsible for pronghorn monitoring from 1985-87.

I searched three sources for published literature on wolves: (a) a bibliography compiled by the National Wildlife Federation (Tucker 1988) for the northern Rocky Mountain area, (b) BIOSIS--a computerized literature reference system, and (c) an extensive literature collection of the author. The computer

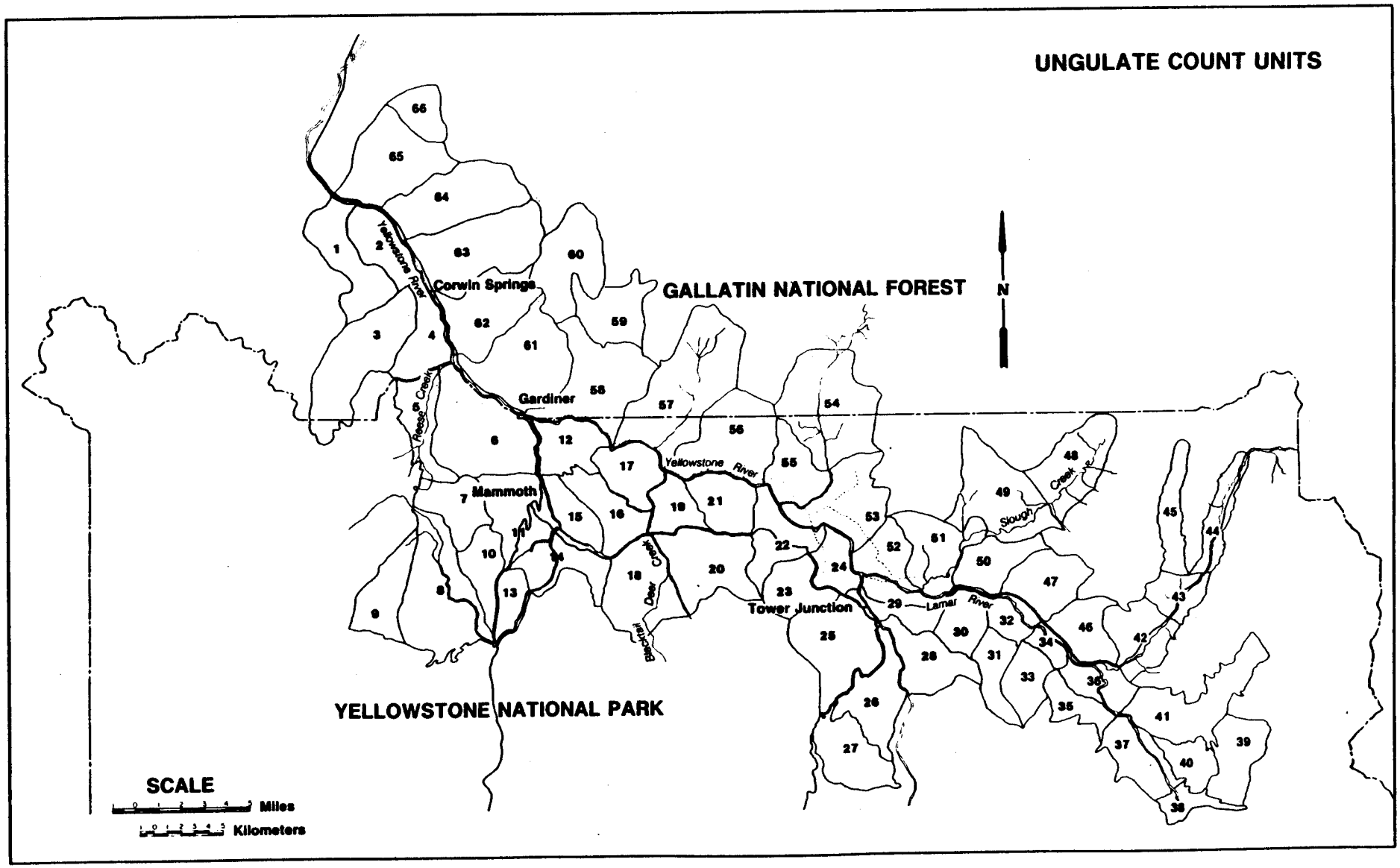


Fig. 2. Count units used in aerial surveys of elk, mule deer, and moose on Yellowstone's northern range, 1985-88.

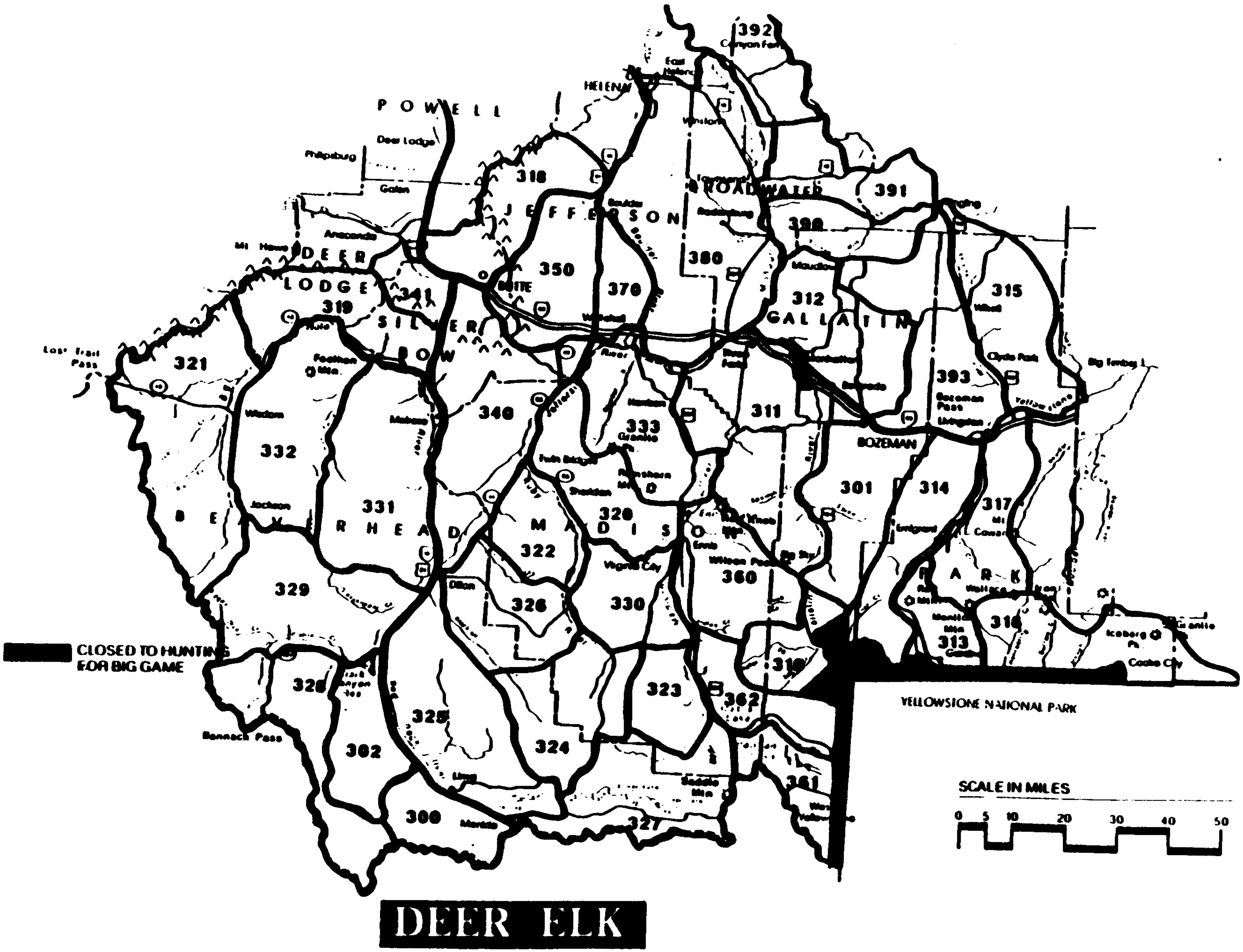


Fig. 3. Elk and mule deer hunting districts (H.D.) in Montana on or adjacent to Yellowstone's northern range.

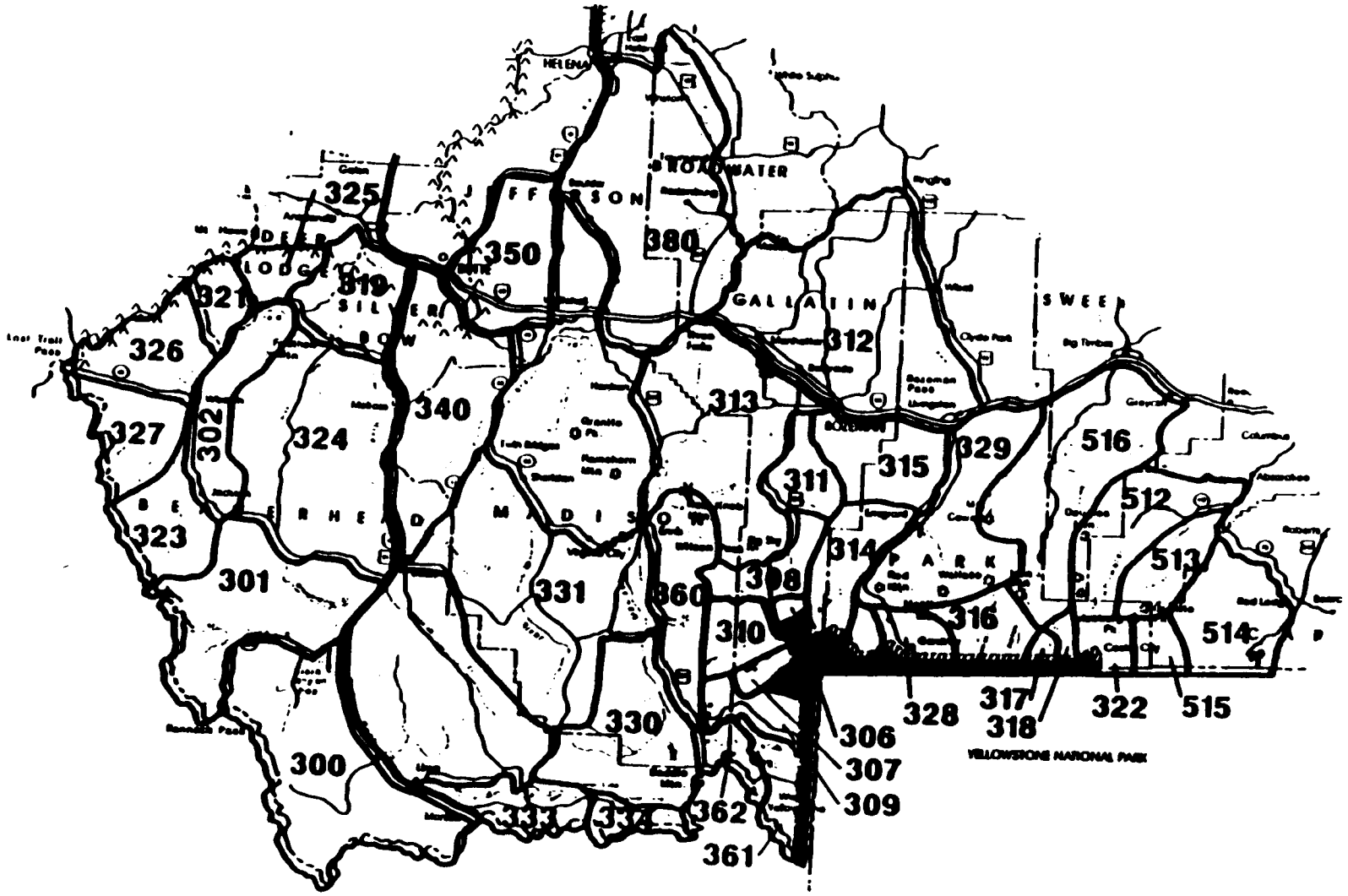


Fig. 4. Moose hunting districts (H.D.) in Montana adjacent to Yellowstone's northern range and the changes in districts that have taken place 1983-87

and manual searches focused on four topics: (1) effects of wolves on other predators and scavengers; (2) effects of wolves on ungulate numbers, behavior, and habitat use; (3) effects of humans on wolves; and (4) wolf territorial strategies.

Pronghorns were counted in the park from a Super Cub during spring green-up following Houston (1982). Since 1985, two to three ground classifications were made each year.

Moose were counted during the course of aerial counts of the northern Yellowstone elk herd, prior to 1980 (Houston 1982). In the winters of 1986-87, seven moose were radiocollared and in 1987-88 another five moose were radiocollared on the northern range both in and adjacent to Yellowstone Park (D. Tyers, unpubl. data). Super Cub surveys for moose were flown during winter and early spring. The success or failure to observe radiocollared moose was recorded during the course of the survey. When a radiocollared moose was not observed, it was then radiolocated and observed if possible. The UTM location, forest habitat type, cover type (Mattson and Despain 1985) and snow cover were recorded for each radiocollared moose and other moose or group of moose observed during the surveys. A sightability model was developed according to the method of Samuel et al. (1987) and applied to the survey data to correct for the numbers of moose not observed. All other known moose concentration areas in the park were also surveyed in 1987-88. Fall horseback surveys of moose were conducted in 1985, 1986, and 1987 (Swenson 1985; Puchlerz 1987).

A total of 47 adult elk were radiocollared on Yellowstone's northern range, 1986-88. These marked elk were also used to generate a correction factor for the elk not observed. Elk were classified by sex and age during

mid-winter ground surveys conducted along the northern park road from 1980-86 (Swenson, in prep.). Additionally, in February of 1987 and 1988, extensive aerial helicopter classifications of elk sex and age were made on the northern range.

Mule deer were counted by one observer in a helicopter in 1979, 1986, and 1988. In 1987 a Jet Ranger II and two observers were employed. In all years, the deer counts were conducted at spring green-up. Fall and spring fawn ratios were sampled from ground classifications (Foss 1985, Singer et al. 1988).

RESULTS

Pronghorn Antelope

Pronghorns increased dramatically on Yellowstone's northern range during the past 10 years (Table 1). Pronghorns are once again approaching the 600-800 population levels that were observed from 1930-1947. The reductions of 1947-1966 lowered the herd size to less than 200 (Houston 1982, Scott 1987). Fawn ratios remained low at 38 ± 15 ($\bar{x}$ ± S.D.) fawns per 100 does from 1967-79 (Houston 1982:443), but fawn crops increased in the 1980s. The 1986 ratio of 80 fawns per 100 does was the highest since 1963 (Table 2).

Pronghorn density increased from 8.4 per $mi.^2$ in 1979 to 26.7 per $mi.^2$ in 1988 over the 41.9 $mi.^2$ winter range (Fig. 5). The area of highest density is count unit 6 between Reese Creek and the Beaver Ponds (Fig. 6). In the winter of 1985-86 and 1986-87 a small group of 13-15 antelope colonized winter range on private land near Cutler Lake. They remained there until April of each year, but they were not observed there in the 1987-88 winter. Pronghorn

Table 1. Highest aerial counts of pronghorn antelope on Yellowstone's northern range, 1979-88.

YEAR	NUMBER OF PRONGHORNS	PRONGHORNS PER SQ.MILE	DATE OF COUNT	OBSERVER/PILOT*
1979	152	8.4	4/16	M.Meagher/D.Stradley
1980	157	8.7	4/08	M.Meagher/D.Stradley
1981	102	5.7	3/21	M.Meagher/D.Stradley
1982	131	7.3	4/17	M.Meagher/D.Stradley
1983	310	17.2	3/08	M.Meagher/D.Stradley
1984	365	20.2	3/23	T.Black/D.Stradley
1985	364	20.2	9/03	F.Singer/B.Ferguson
1986	363	20.1	2/28	F.Singer/B.Ferguson
1987	478	26.5	3/17	C.McClure/D.Stradley
1988	495	26.7	4/16	K.Buechner/B.Ferguson

*All aircraft were Super Cubs.

Table 2. Pronghorn Sex and age ratios on Yellowstone's northern range, 1982-87.

DATE	TOTAL	DOES	FAWNS	BUCKS	UNCLASSIFIED	FAWNS PER 100 DOES	BUCKS PER 100 DOES[3]
8/11/82[1]	50	18	17	12	0	94	83
1/6/83[1]	50	21	13	16	0	62	76
9/3/85	254					50	71
9/13/85[2]	115					63	91
11/21/86	275	81	58	136	0	72	167
12/03/86	329	108	101	78	42	94	72
12/11/86	263	98	74	70	21	76	71
8/24/87	113	49	29	24	11	59	49
9/16/87	138	44	36	54	1	73	123
9/22/87	145	45	27	73	0	60	60
11/11/87	132	49	22	24	37	45	45

[1]From J. Swenson, pers. corres. to M. Meagher, Aug. 31, 1982 and March 10, 1983.

[2]Aerial classification, all others were from the ground with spotting scopes.

[3]In complete sampling of the entire winter range likely contributed to a wide variation in buck ratios.

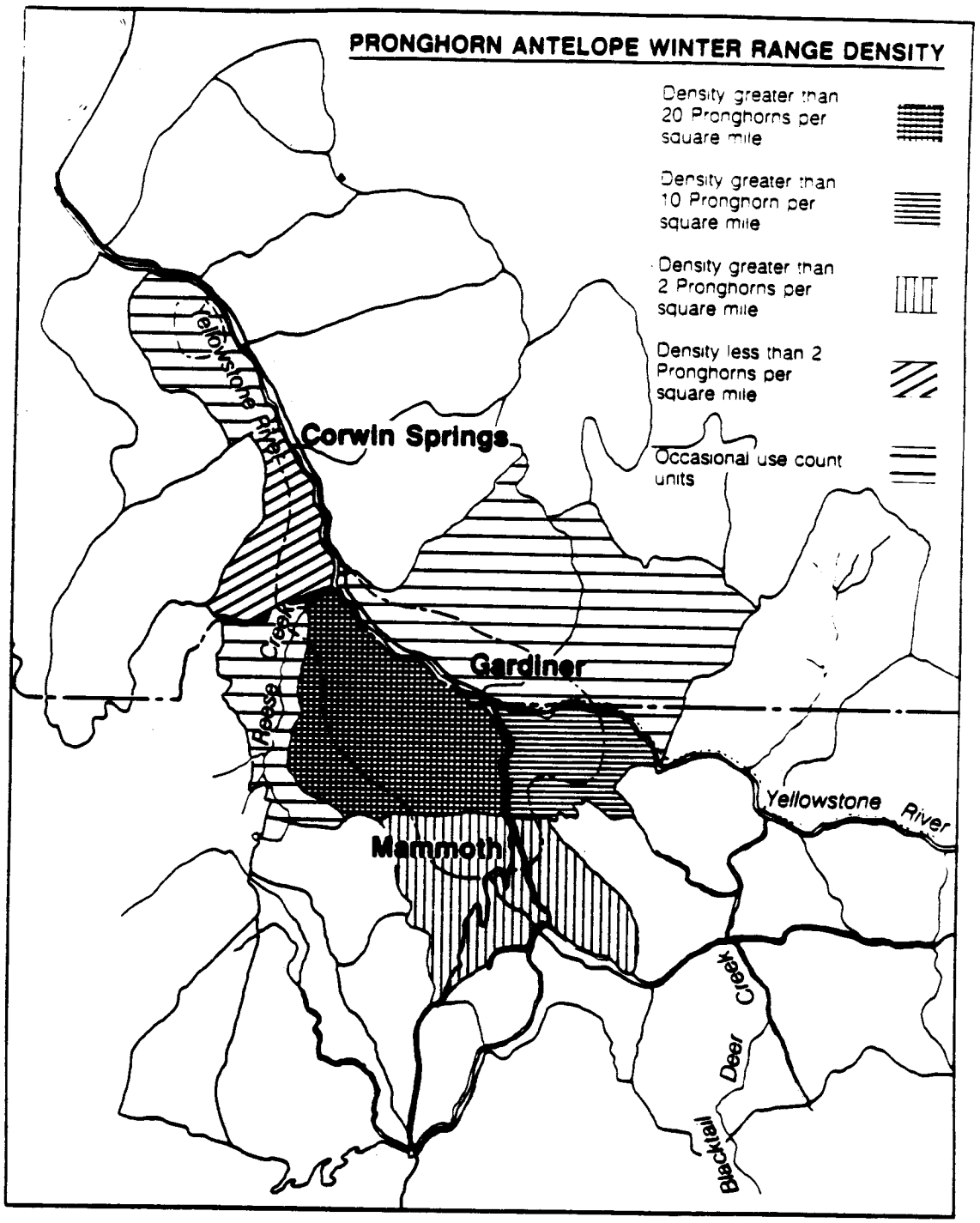


Fig. 5. Primary pronghorn antelope winter range.

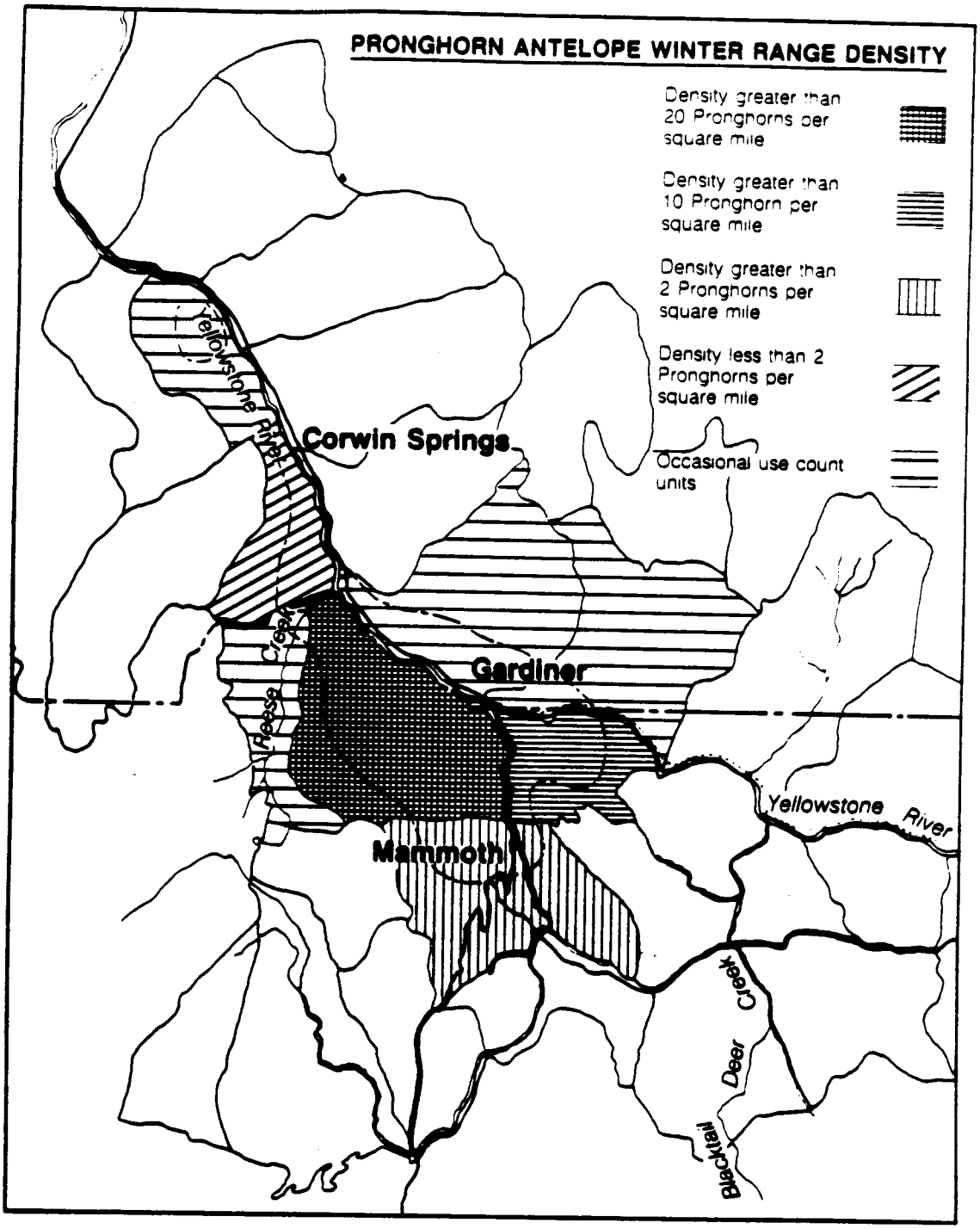


Fig. 6. Winter densities of pronghorn antelope on 11 count units that they occurred on in 1985-88 on Yellowstone's northern range.

migrated each summer to the higher elevations in the northern one-third of the park, while a portion of the herd remained on the winter range (Houston 1982:167-169; Scott 1987).

During three autumns, 1985-87, a damage-control hunt was instituted on the Royal Teton Ranch after complaints from the Church Universal and Triumphant about crop depredations. In 1983, the landowner plowed and reseeded two fields near Spring Creek, to which 20-25 antelope were attracted each summer. About 3% of the total herd was harvested each year (Table 3). In November-December of 1985, about 90% of the pronghorn herd migrated north of Yellowstone National Park due to heavy snows. Antelope remained out of the park for about three weeks until the snows began to melt. These migrations out of the park have occurred at periodic intervals (Scott 1987), and the movements may be critical to the herd's long-term survival (Barmore 1980; Houston 1982:168). Threats to pronghorns when they leave the park now include: (1) fences which may hinder movements, (2) increased development and disturbance on private lands both east and west of the river, and (3) the possibility that a winter damage hunt underway could interfere with migration. Barmore (1980) reported aconsiderable decline of antelope March-May, 1968, when at least 53% of the pronghorn herd moved north of the park.

Table 3. Pronghorn damage control hunt statistics on Yellowstone's northern range, 1985-88. Data obtained from K. Alt, Montana Department of Fish, Wildlife, and Parks.

YEAR	NO. PERMITS ISSUED	NO. ANIMALS KILLED	APPROXIMATE PERCENT OF HERD
1985-86	15	10-12	3
1986-87	50	12-15	2
1987-88	39	16	3

Mule Deer

Mule deer have dramatically increased from 1,007 observed in 1979 (Erickson 1979) to 1,863 (+ 85%) in 1986, 2,134 (+ 15%) in 1987, and 2,217 (+ 4%) in 1988 (Table 4). Helicopter surveys proved 43-62% more efficient than Super Cubs (Table 4). Time devoted to the count increased 75% from the 1979 and 1986 counts to the 1987 and 1988 counts. The increase in search effort is partially a product of counting more deer. However, such a large increase in search time may also have resulted in greater counting efficiency. Additionally, the winters of 1986-87 and 1987-88 were mild. Snowpacks averaged 70-80% and 50-70% of the average, respectively. The snowline in the count areas was 300-500 feet higher during the 1987 count than during the 1986 count, and it was 200-500 feet higher during the 1988 count than during the 1987 count. Each year, we flew just up to snowline since all of the deer were concentrated below snowline on green-up. As a result, the size of the area counted increased greatly in 1987 and 1988. Helicopter surveys of mule deer in the Bridger Mountains with similar terrain and vegetation yield about 66% sightability of mule deer (Mackie et al. 1980), suggesting the herd on the northern range might number at least 3,000 deer.

Highest densities of mule deer were in count units 2 and 4 west of the Yellowstone River and north of Yellowstone National Park (Fig. 7, Table 5). These count units include most of the irrigated hay fields of Royal Teton Ranch, which provides additional available deer habitat. Mule deer numbers increased both east of the Yellowstone River (+ 26%) and west of the river in Yellowstone National Park (+ 32%), but numbers declined dramatically west of the river north of the park (- 25%). Fawns per 100 adult deer ratios in the

Table 4. Mule deer aerial counts on Yellowstone's northern range, 1979-88.

YEAR	DATE OF COUNT	DEER COUNTED	PILOT	OBSERVER(S)	AIRCRAFT
1979	?	572	D.Stradley	Houston	Super Cub
1979	4/3	1,007	M.Duffy	Erickson	Jet Ranger II
1986	3/4	706	B.Ferguson	Singer	Super Cub
1986	3/14-15	1,863	C.Rogers	Singer	Bell-206
1987	3/31-4/1	2,134	M.Duffy	Alt/Hoppe/Singer	Jet Ranger II
1988	4/11-12	2,274	G.Ewen	Singer/McClure	Helier 12-E

Sources include:

(1) Erickson. 1979. Game production count, mule deer. Hunting District 313 and Yellowstone National Park. Montana Fish, Wildlife and Parks file. 7pp.

(2) Singer, F. 1986. Northern Yellowstone mule deer count. Interagency Count. Yellowstone Park, Gallatin Forest, and Montana Fish, Wildlife and Park files. 2pp.

(3) Alt K., P. Hoppe and F. Singer. 1987. Northern Yellowstone spring mule deer count. Interagency Count. Yellowstone Park, Gallatin Forest, and Montana Fish, Wildlife, and Parks files. 7pp.

(4) Singer F., C. McClure, S. Consolo and K. Alt. 1988. Northern Yellowstone spring green-up mule deer count. Interagency count. Yellowstone Park, Gallatin Forest and Montana Fish, Wildlife, and Park files. 4pp.

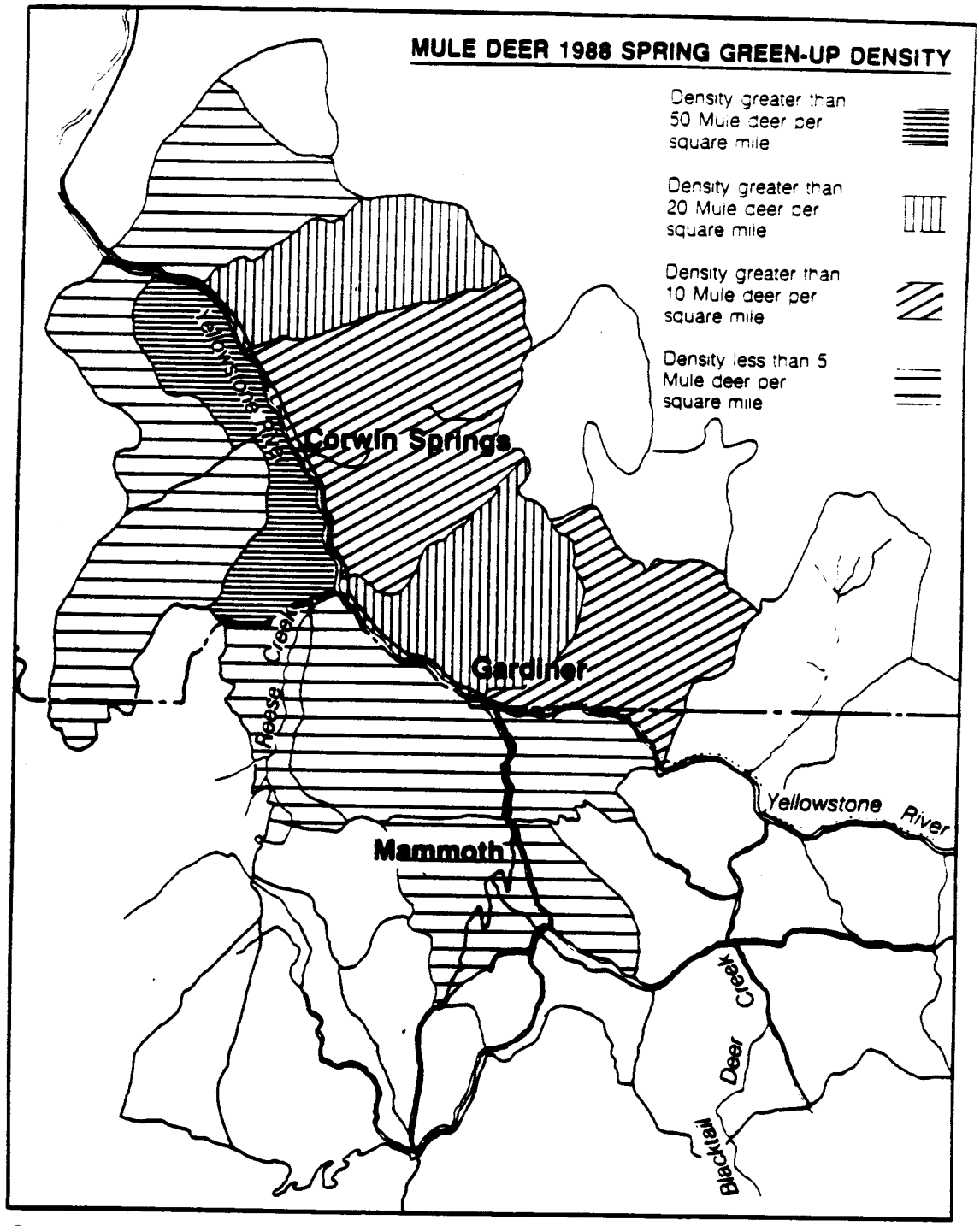


Fig. 7. Mule deer densities at spring green-up time on Yellowstone's northern range.

Table 5. Spring green-up counts of mule deer on Yellowstone's northern range in 1986-88.

	Count Unit	Count Unit Name	Deer seen in 1986	Deer seen in 1987	Deer seen in 1988	Percent Change (%)
West of the	1	Cinnabar	0	47	46	-2
Yellowstone	2	Cutler Lake	230	326	350	+7
River:	3	Aldridge Lake	70	154	5	-97
	4	Beattie Gulch	432	399	295	-26
Subtotal North of park			732	926	696	-25
	5	Reese Creek	35	26	7	-73
	6	Stephens Creek	47	20	49	+145
	11	Mammoth	23	7	17	+143
	12	Rattlesnake	0	0	10	+
	15	Gardner Canyon	6	26	21	-19
Subtotal park only			111	79	104	+32
Subtotal all areas West of river			843	1005	800	-20
East of the	58	Deckard Flats	127	142	203	+43
Yellowstone	61	Eagle Creek	335	286	481	+68
River:	62	Maiden Basin	43	163	193	+18
	63	Basset-Cedar Creeks	114	140	181	+29
	64	Cedar Slip and Slide	265	329	305	-7
	65	Joe Brown Creek	136	69	54	-22
Subtotal all areas East of River			1020	1129	1417	+26
Total			1863	2134	2217	+3

spring have been very high (except for 1983) corresponding to the dramatic increase in deer numbers since 1979 (Table 6). Fawn ratios per 100 adults in 1988 were 44 east of the river, but were 53 west of the river where the decline occurred, suggesting decreased recruitment was not the cause for the decline.

Harvests of mule deer in the area have steadily increased during the 1980s (see Appendix I) with 1983 the highest reported harvest on record for Hunting Districts 313 and 314 (Foss 1985). Only H. D. 313 contains mule deer from just the northern range. H. D. 314 and 316 include deer from other areas. The actual count of mule deer in H. D. 313 averaged 1,187 from 1986-1988, but actual numbers were higher, probably at least 1,600. Harvests of deer in H. D. 313 averaged 567 from 1983-86, or about 35% of the estimated population. Harvests of these levels are unlikely to stop herd growth (K. Alt, pers. corres.). However, the Church Universal and Triumphant has encouraged the hunting of does on their lands during the fall of 1986 and 1987 hunting seasons. It is likely that due to ease of road access on their lands, some concentration of doe harvest for Hunting Districts 313 and 314 might have occurred on their lands. The harvest and/or avoidance of the area could explain the decline in deer numbers seen on those areas in 1988. Several alternate explanations are also possible, e.g., a change in distribution of deer from west of the river to east of the river. Such a shift, however, is unsubstantiated by the deer count west of the river in Yellowstone Park which increased in 1988. Despite this localized decline, the Royal Teton Ranch lands (Count units 2, 4) still support the highest mule deer densities on the northern range.

Table 6. Deer harvest and classification data for Yellowstone's northern range north of the park line and east of the Yellowstone River (H.D. 313).

	POST HUNTING SEASON (DEC.) RATIOS				SPRING RATIOS				HARVESTS	
YEAR	Bucks: 100 Does	Fawns: 100 Does	Fawns: 100 Ads.	Sample Size	Fawns: 100 ads.	Sample Size	FAWN MORTALITY(%)	RECRUIT-MENT	Mule Deer	White-tails
1979	17	67	52	345	32	1,108	23	29	234	9
1980	-	-	61	286	-	-	-	-	256	11
1981	15	65	56	97	40	300	29	29	504	27
1982	-	-	55	381	48	727	13	32	571	44
1983	7	65	60	303	29	420	52	23	746	11
1984	21	88	73	159	47	508	36	32	580	12
1985	0	42	42	68	44	562	0	31	404	33
1986					50	624				
1987					47	2,134				
1988					52	1,936				

Sources include:

(1) Foss, A.J. 1985. Montana big game survey and inventory--Region III. Job Progress Report, Job No. I-3A (Deer). Project No.: W-130-R-16.

(2) Alt, K., F. Singer and P. Hoppe. 1987. Northern Yellowstone spring mule deer count. Interagency Count. Yellowstone National Park, Gallatin Forest and MT Fish, Wildlife, and Parks Files.

(3) Singer, F.J., C. McClure, S. Consolo and K. Alt. 1988. Northern Yellowstone spring green-up mule deer count. Interagency Count. Yellowstone Park files. 4pp.

White-Tailed Deer

White-tailed deer (Odocoileus virginianus) are rare on Yellowstone's northern range. Skinner (1929) reported that whitetails were present although not numerous and probably numbered about 100 prior to 1916. Skinner (1929) reported a decline 1914-21, and he reported the deer were gone altogether by 1924. Harvests of deer in Hunting Districts 313 and 314 suggest that whitetails have increased substantially on the northern range just north of Yellowstone National Park during the 1980s (Table 6).

A considerable amount of debate surrounds the historical status of whitetails within Yellowstone National Park. Whitetails were likely never common anywhere in the park. The area lacks the extensive riverine deciduous shrub and deciduous forest that are typical white-tailed deer habitat in Montana (Martinka 1968; Allen 1968; Dusek 1981), and snow depths above the Mammoth-Gardiner area appear excessive for whitetails. Wildlife report cards (YNP files), however, include 18 recent sightings of whitetails within the boundaries of Yellowstone National Park. The locations of recent reported white-tailed deer sightings is provided in Fig. 8.

Moose

Moose moved into the Jackson Hole area and the area south of Yellowstone Lake by the 1870s (Houston 1982:158). Moose apparently did not occur on the northern range until around 1913 (Houston 1982:158), and they did not occur in adjacent south-central Montana until about the same time period (Stevens 1971; Walcheck 1976). Moose increased on the northern range and were abundant in Slough Creek 1930-1940 (McDowell and Moy 1942). The subsequent status of moose

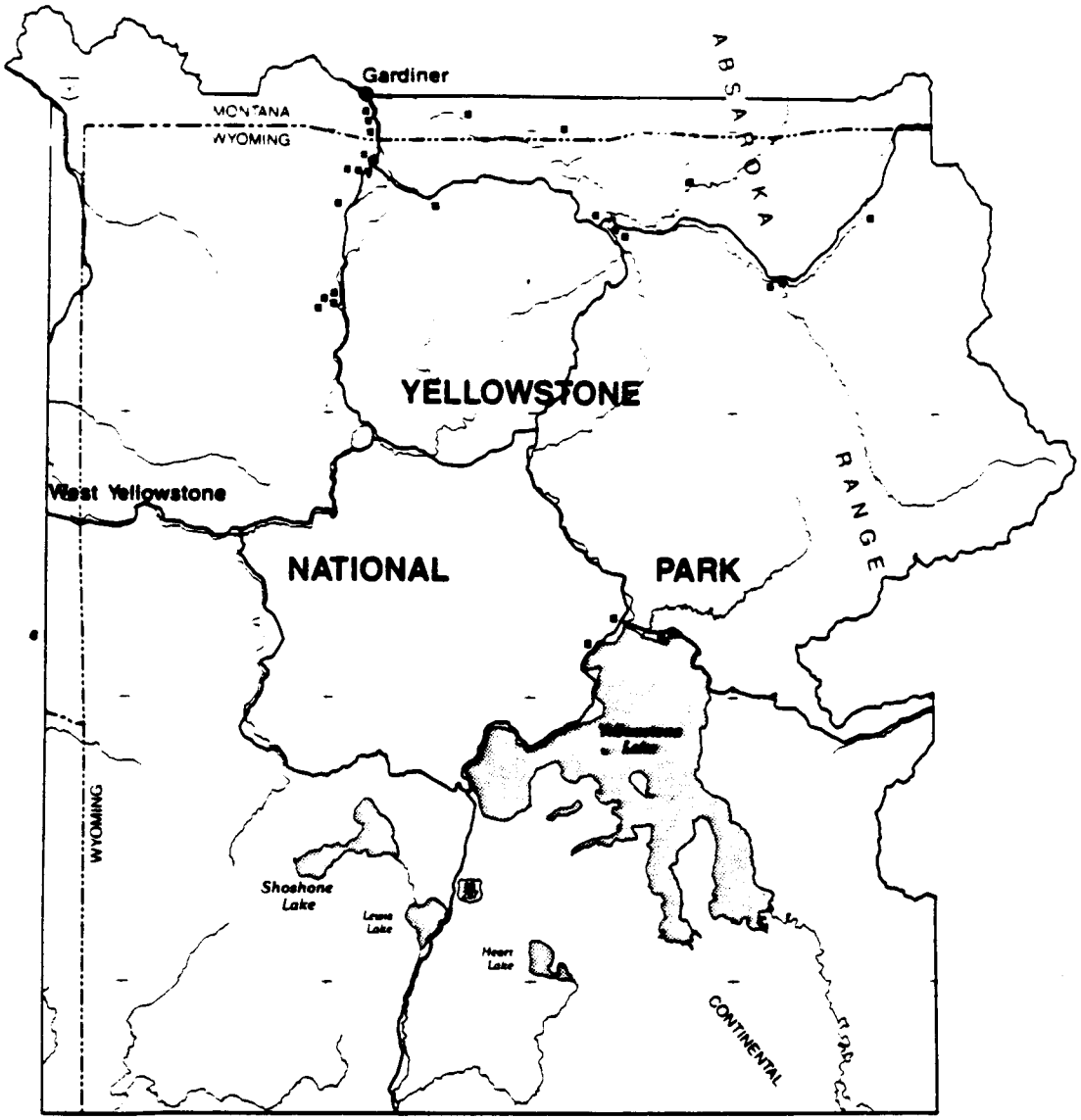


Fig. 8. Recorded observations of white-tailed deer within Yellowstone National Park, 1980-88.

on the northern range is unclear. Chadde and Kay (1987), citing unpublished Gallatin National Forest files, felt that moose declined between 1940 and the early 1960s. Erickson (1979) felt moose numbers were relatively stable from 1961 to the late 1970s. Swenson (1985) felt that moose had declined 1949 onward, but that the 1978-85 trend was upwards due to conservative harvests.

A horseback index to moose abundance in the upper Hellroaring-Buffalo Fork-Slough Creek drainages suggests that moose declined from the 1940s to 1980s (Table 7). The validity of the index data, however, has not been tested.

The numbers of moose seen on elk distribution flights in 1969-1973 (Fig. 9) averaged 32 ± 16 ($\bar{x}$ ± S.D.) in December and 45 ± 20 in May, but these counts declined to 17 ± 9 in December and 27 ± 10 in May for the years 1974-77, for mean declines of 47% and 40%, respectively ($t = 3.68$, d.f. = 4, $P = 0.05$ for December; $t = 1.67$, d.f. = 7, $P < 0.15$ for May).

The 1986-87 and 1987-88 winter moose counts were not comparable to the earlier counts, since they were conducted just in the Hellroaring, Buffalo Fork, Slough, Pebble and Soda Butte Creek drainages in and out of the park. Only one area, upper Slough Creek, was consistently flown all years. Counts in this area declined during the mid-1970s and then recovered to 1988 (Table 8).

Data presented in Table 8, combined with my own observations, 1985-88, suggests local declines have occurred below Mammoth, in the Lamar Valley, on Blacktail Plateau, and in lower Slough Creek.

The Soda Butte drainage has likely experienced a recent increase in moose. Calf ratios in the drainage were 80 calves per 100 cows in December of 1987.

Table 7. Summary of fall moose horseback counts in the upper Hellroaring, Buffalo Fork and Slough Creek drainages, Gallatin National Forest.

YEAR	PERIOD	PARTY DAYS	MOOSE OBSERVED PER OBSERVER-DAY	
			Different	New Moose
1942	June-Oct.	~100	194	1.94
1947	9/5-10/3	29	78	2.69
1948	9/4-9/29	26	53	2.04
1949	9/8-9/27	20	24	1.20
1985	9/11-9/20	23	12	0.52
1986	9/11-9/17	16	13	0.81

Sources: (1) Swenson, J. Nov. 12, 1985. Moose Survey in the Absaroka high country, memo to LeRoy Ellig, Mont. Dept. Fish, Wildl. and Parks, Bozeman. 8pp.

(2) T. Puchlerz, memo to District Ranger, Gardiner Ranger District, Gallatin National Forest, dated Oct. 2, 1986. 5pp.

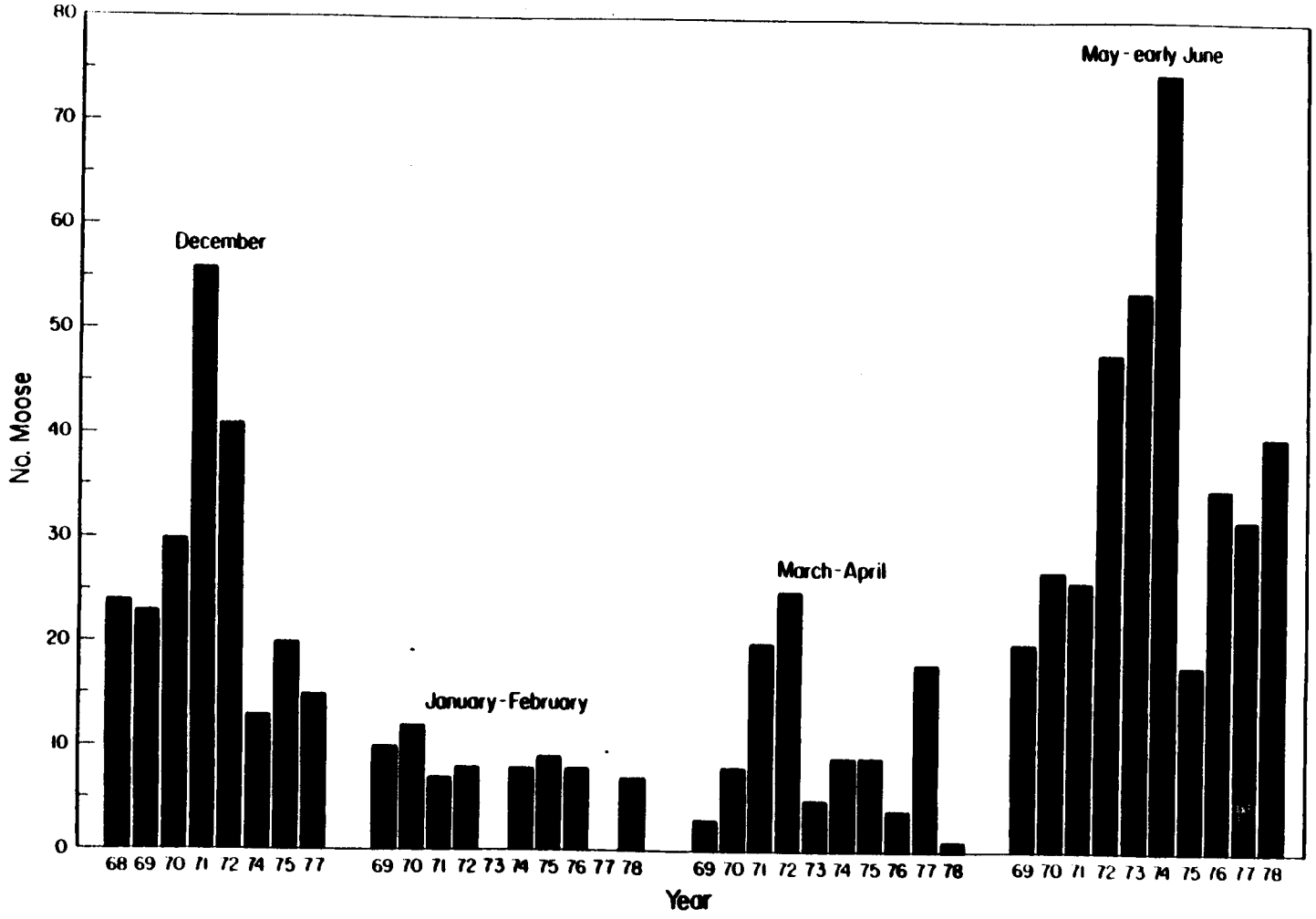


Fig. 9. Number of moose observed incidentally during elk distribution flights on Yellowstone's northern range from December to May of each year 1969-73 (Barmore 1980; Houston 1982). Upper Soda Butte and upper Wallrearing drainages

Table 8. Highest counts of moose during 10 winters, 1968-78, seen in specific locales incidental to elk counts on Yellowstone's northern range. Data from Barmore (1980) and Houston (1982).

	Below Mammoth	Gardner River-Mt. Everts	Above Mammoth-Gardners Hole	Black-Tail Plateau	Tower Area	Lower Slough Creek	Upper Slough Creek	Lamar Valley
1968-69	4	3	4	1	4	1	14	6
1969-70	5	2	11	2	5	3	10	3
1970-71	2	1	5	7	9	10	13	5
1971-72	3	1	16	8	14	25	27	6
1972-73	1	3	6	0	13	14	14	1
1973-74	3	3	4	3	14	14	23	11
1974-75	3	3	7	1	4	7	6	2
1975-76	5	4	6	2	13	15	3	2
1976-77	1	1	3	3	12	6	9	3
1977-78	1	3	4	2	8	2	11	7
1985-86*							4	
1986-87*							14	
1987-88*							28	
1988-89*							29	

* Locales other than Upper Slough Creek were not available for comparison 1985-89.

No previous counts, however, were made in upper Soda Butte Creek.

We did not compare moose seen on the 1985-88 elk census flights since: (1) 2-4 times as many elk were counted per hour when compared to the earlier counts, and, therefore, the observers were less likely to observe or record moose; and (2) observers varied more. A total of seven observers were used 1985-88, versus only two observers (W. Barmore and D. Houston) during 1969-79.

Houston (1982:169) conservatively estimated that there were 200 moose on the northern range and another 200 outside of the northern range in Yellowstone Park. In 1987, I counted 67 in the upper Yellowstone River and 11 on the lower Madison River in Yellowstone Park. Very little is known of moose abundance elsewhere in the park.

Moose harvests increased from 35 in 1979 to 47 in 1986 on areas bordering the northern range (Table 9). If 200 moose exist on the northern range pre-hunting season (Houston 1982:169), then these harvests correspond to 18% and 24% of the population, respectively. Montana hunting districts were realigned to better distribute the harvest, and beginning in 1986, the number of permits were increased. The rationale for the increase was to lower the population due to reduced habitat carrying-capacity and to increase the low calf ratios (Swenson 1985).

Elk

Summer

A total of seven different elk herds and possibly a few animals from an eighth herd, the Carter Mountain herd, summer within Yellowstone National Park

Table 9. Average annual harvest of moose in Montana adjacent to the northern and northeastern boundaries of Yellowstone National Park, 1979-87 (also see APPENDIX II).

Hunting District	Mean Annual Harvest		
	Mean	Standard Deviation	Years
Northern Range:			
306	10	1.6	1979-87
307	5	0.5	1984-86
328	2	0	1986-87
313	5	0.5	1979-87
317	5	0	1986-87
318	6	0	1985-87
322	13	0.5	1985-87
316	7	1	1979-87
Gallatin Drainage			
309	16	3	1979-87
310	19	6	1979-87
Hebgen Lake			
361	18	9	1983-86
362	6	0.9	1984-87

(Fig. 10). The relative proportion of each elk herd summering in the park was crudely estimated from the proportion of radiocollared animals caught on winter ranges that then migrated to Yellowstone. An estimated 31,000 elk summer in Yellowstone and about 22,000 winter within the park boundaries (Table 10). This assumes that the original marked sample was unbiased with respect to sex or area of capture. This assumption is more closely approached for the Gallatin, Sand Creek, and Jackson herds, where the sampling of elk was extensive and conducted over a period of years. The North Fork Shoshone, Clarks Fork, and Madison-Firehole captures, however, emphasized adult cows (Rudd 1982; Craighead et al. 1972).

Some differences in elk migrations were noted when compared to historical data. Craighead et al. (1972) observed marked elk from the Clarks Fork, North Fork Shoshone, and northern herds to occupy slightly more extensive summer ranges than the more recent radiotelemetry suggests (Rudd 1982; D. Vales, A. Harting unpublished data). Other changes in distribution have occurred. A segment of the Jackson elk herd once migrated east and north of Jackson Lake to summer on the Pitchstone Plateau (J. Yorgason, pers. corres.). This segment may have been eliminated due to extensive hunting on Uhl Hill of elk that had traveled across Burned Ridge and Antelope Flats towards the National Elk Refuge. Alternatively, there may have been a natural shift in migration patterns (M. Boyce, pers. corres.) The Pitchstone is now occupied primarily by the Sand Creek elk herd (Brown 1985).

The northern herd shares about half of its summer ranges with at least one of the six or seven other herds. Two summer ranges are shared by three herds: (1) the Madison Plateau (Sand Creek, northern, and a few animals from the

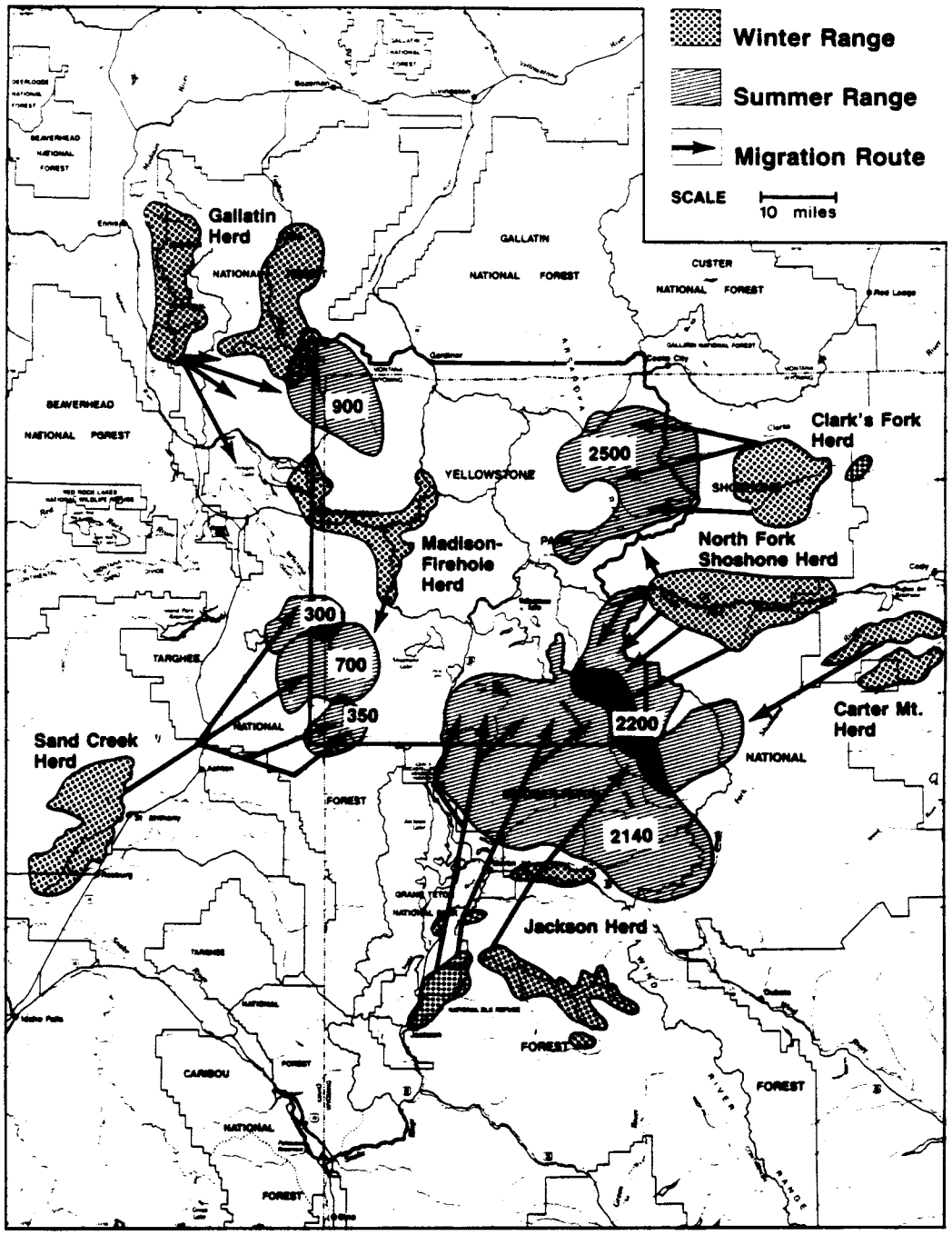


Fig. 10. Map showing the approximate winter ranges and just those portions of summering areas within Yellowstone National Park for 7 elk herds other than the northern herd. Explanation for the summer estimates is provided in Table 10.

Table 10. Estimates of elk summering in Yellowstone National Park.

Name of Herd	Herd Size	Proportion of radio-collared elk summering in Yellowstone	Sample size of collared Elk	Est. no. elk summering in Yellowstone	Mean no. wintering in Yellowstone	Years of Radiolocation Data
Gallatin	1,850(c)	.48	72	900	580(c)	1969-86
Sand Creek	4,900(e)	.21	84	1,056(e)	0	1981-87
Jackson	7,600(e)	.28	85	2,143	0	1978-82
Carter Mtn.	1,200(e)	Tr	--	Tr	0	1986-88
N.Fork Shoshone	2,600(e)	.78	18	2,020	0-500	1979-80
Clarks Fork	3,000(c)	.83	18	2,500	0	1979-80
Northern	21,000(e)	.98	68	20,580	17,000-19,000(c)	1985-88
Madison-Firehole	800(c)	1.00	6	800	800	1965-66
TOTAL				30,899	20,880	

(c) = count
(e) = estimate

Table 10, Continued.

Name of Herd	Days spent on summer Range	Summer Locations	Source
Gallatin	150	Gallatin Range, Specimen Cr.,	Cada (1970-77); Taylor (1978-86)
Sand Creek	138	Bechler Meadows, Madison Plateau, Chick Cr.	Davidson et al. (1985,1986); Brown (1985)
Jackson	150	Thorofare, Two-Ocean, Big Game, Chicken Ridges	Boyce (in press); B. Smith (in prep.)
Carter Mtn.	-	South Fork Shoshone	Yorgason et al. (1986)
N. Fork Shoshone	160	Signal Hills, Thorofare	Rudd (1982); Yorgason et al. (1986)
Clarks Fork	160	Upper Lamar, Pelican, Mist Cr.	Rudd (1982); Yorgason et al. (1986)
Northern	140	All of Yellowstone Park	Vore (in prep.);D.Vales (unpubl.)
Madison-Firehole	-	Madison drainage, Madison Plateau	Craighead et al. (1973)

Madison-Firehole herd); and (2) the Madison-Firehole area (Madison-Firehole herd, Gallatin herd, and northern herd). In the Thorofare area, as many as four elk herds may share a common summer range (the Jackson, North Fork Shoshone, northern, and possibly a few individuals from the Carter Mt. herd). Summer ranges in the central and north-central portions of the park are apparently only occupied by the northern herd.

Production and herd growth vary considerably among the various herds (Table 11). The Sand Creek herd increased 5-fold 1959-83, but has been relatively stable 1983-86 (Davidson et al. 1986). The Gallatin herd was reduced almost to half of the 1960s levels to meet objectives of range carrying capacity (A.Foss, pers. corres., Aug. 1987). The Madison portion of the Gallatin herd, however, has grown to about 650 in the 1980s (Taylor 1984). The Madison-Firehole elk herd is suspected to have declined about 21% during the 1980s (F. Singer, G. Bowser unpublished data). Six aerial counts conducted from 1965-80 averaged 763 (range 593-959), whereas eight counts conducted 1985-88 averaged 601 (range 487-736).

Harvest levels on the seven or eight elk herds varied considerably. The Jackson, Sand Creek, Gallatin, and Carter Mountain herds were being harvested at or near maximum sustained yield (Boyce in press) (Table 12). Boyce (in press) calculated that the Jackson herd harvest averaged 86% of maximum sustained yield. Harvests of the North Fork Shoshone and Clarks Fork herds were more moderate, while harvests of the northern and Madison-Firehole herds were low.

Table 11. Sex and age classifications of the eight elk herds residing in or migrating into or immediately adjacent to Yellowstone National Park.

ELK HERD	Years of Data	% Calves	% Cows	% Spikes	% Mature Bulls	Time of Classification	Source
Jackson	1950-86	25	55	6	14	winter	Boyce (in press)
Sand Creek	1980-87	31	57	6	6	early winter	Brown (1985); Davidson et al. (1987)
Gallatin	a)1969-86	28	58	-	13	July-August	Cada (1970-1975); Taylor (1979-1986)
	b)1975	36	55	6	3	Winter	Cada (1975)
North Fork Shoshone	1982-86	25	68	3	4	post-hunt	Yorgason (1986)
Clarks Fork	1983-86	24	68	2	5	post-hunt	Yorgason (1986)
Carter Mtn.	1982-86	28	67	4	1	post-hunt	Yorgason (1986)
Madison-Firehole	a)1967-76, 1988	28	54	6	12	December	Cole (1983); this report
	b)1967-76, 1988	14	73	4	9	Late winter	Cole (1983); this report
Northern	1986-88	16	73	4	7	February	This report

Table 12. Harvests of eight elk herds inhabiting Yellowstone National Park.

ELK HERD	Population Size	Mean Harvest	% Harvest[3]	Period	Sex and Age Classes Harvested: Spikes	Mature Bulls	Cow	Calves	Source
Jackson	8,325(c)[1]	2,913	35	1950-85					Boyce (in press)
Sand Cr.	2,269(c)	966	20-43	1981-86	310	297	359		Davidson et al. (1987)
Gallatin[2]	2,500(c)	912	36	1980-85	320	342	219	31	Taylor (1981-86)
N. Fork Shoshone	2,800(e)	570	20	1982-86	122	245	180	23	Yorgason (1987)
Clarks Fork	3,000(e)	713	24	1982-86	103	236	313	61	Yorgason (1987)
Carter Mtn.	1,200(e)	658	55	1982-86	162	170	262	64	Yorgason (1987)
Madison-Firehole	800(c)	<20	2	1980-88	-	-	-	-	This report
Northern	18,986(se)	735	8	a) 1980-86, reg.	87	132	73	106	Mont.Fish, Wildl. and
				b) 1980-87, late	59	198	574	207	Parks (1987)

[1]Winter feedground count only.

[2]In this case elk numbers and harvests on the southeast side of the Madison Valley are included (e.g., H.D. 360).

[3]Several % harvest rates may be overestimated, since population sizes are likely underestimated.

c = count, e = estimate, se = sightability estimate.

Winter

During the 1980s, nearly all of the Madison-Firehole, most of the northern herd, and about 31% of the Gallatin herd wintered within Yellowstone National Park (Table 1). In addition, a fourth small group of elk has wintered since at least 1975 in the Thorofare area south of Yellowstone Lake (G. Roby, J. Yorgason pers. corres.; D. Houston unpublished data) (Table 13). This upper Yellowstone River wintering group apparently consists of both year-round resident elk and migratory elk with strong affinities to the North Fork Shoshone elk herd. Winter counts in the area varied, from 800 in the mild winter of 1977-78 (G. Roby, pers. corres.), to as few as 245 elk in more severe winters (J. Yorgason, pers. corres.). The transient elk included radiocollared animals from the North Fork Shoshone herd (Rudd 1982). None of 85 radiocollared elk from the Jackson herd attempted to winter in the area (B. Smith, in prep.). About 500 were seen on early winter counts, 1976-87 (Table 13). An additional 31 elk were observed in 1987-88 in or near small thermal areas scattered throughout the park (Bechler Meadows, Heart Lake, Shoshone Lake, West Thumb, Hot Springs Basin).

The Northern Elk Herd

Total Counts and Harvests

The actual counts of elk increased during the 1980s to 18,913 elk in 1988 (Table 14). A sightability correction (Singer et al. 1988) suggested that the increase in elk between 1986-87 and 1987-88 was about 1,500. Sightability was 91% in 1987-88 and 86% in 1986-87. The approximate percent of the herd harvested increased during the 1980s from <5 to 9% of the counted herd

Table 13. Winter counts of elk and moose in the upper Yellowstone River area, south of Yellowstone Lake. The survey area also includes the upper tributary areas of Thorofare Creek, Open Creek, Atlantic Creek, and the upper Yellowstone. About 1/3 of this survey area is outside of Yellowstone National Park.

Year	Date	Upper Yellowstone Elk	Upper Yellowstone Moose	Signal Hills Elk	S. Arm Elk	Observer/Pilot
1974	4/17-18	9	1	14	---	Houston/Stradley
1975	2/24	226	27	---	---	Houston/Stradley
1975	3/14	98	15	---	---	Houston/Stradley
1975	4/21	90	8	---	---	Houston/Stradley
1976	1/21	585	59	---	---	Roby
1977	1/20	492	21	---	32	Houston/Stradley
1977	2/13	571	61	---	---	Roby
1978	1/21	489	51	---	---	Roby
1979	2/16	414	50	---	---	Roby
1981	12/21	450	92	---	---	Roby
1982	1/20	499	77	---	---	Roby
1986	12/11	119	38	---	---	Singer/Ferguson
1987	12/29	431	67	---	---	Singer/Ferguson
1988	2/27	157	33	6	---	Singer/Ferguson

Table 14. Aerial counts of elk and total harvests of elk on Yellowstone's northern elk winter range, 1978-88.

COUNT	TOTAL COUNT	NO. COUNTED IN PARK	NO. COUNTED NORTH OF PARK	TOTAL HARVEST SUBSEQUENT FALL[1]	APPROXIMATE % OF HERD HARVESTED	PERCENT OF BULLS IN LATE HARVEST
1978-79	11,900			585	5	61
1979-80	10,800			247	2	56
1980-81				1,234	9	48
1981-82	16,019	14,922	1,097	1,804[1]	10	33
1982-83				1,955	11	24
1983-84				1,419	8	14
1984-85				1,371	8	12
1985-86	16,286	13,288	2,998	1,595	9	8
1986-87	17,007	15,284	1,723			
1987-88	18,913	18,430	483			

[1]Includes nearly all the elk harvest except that a small percent of the regular season harvest from Hunting District 314 could not be separated from the rest of that unit and is not included.

Sources: (1) Yellowstone National Park survey reports

(2) Montana Dept. Fish, Wildl., and Parks. 1987. Big Game Survey and Inventory, Region 3. Proj. W-130-R-18. Helena. 55pp.

(Table 14) largely due to increased migration. Beginning in 1980, Montana Department of Fish, Wildlife, and Parks initiated a series of changes in the late season hunt that coincided with elk leaving the park on a more regular basis (Swenson in prep.). Herd growth also likely contributed to the reoccupation of the portion of the northern winter range outside the park boundary. Harvests have subsequently increased, except for 1987-88. Fewer bull permits were issued during the 1980s (Table 14) to increase the proportion of bulls leaving the park. Coincident with fewer bull permits, the percent of bulls in the harvest declined from 61% to 8% from 1978-88 (Table 14).

Northern Herd--Sex and Age Ratios

The northern herd is characterized by low calf ratios in late winter and by a relatively low ratio of mature bulls to cows (Table 15). Ground classification work conducted prior to the helicopter work of 1986-88 likely overestimated calf to cow ratios [Table 15, 1986-87, (a) and (b)] and undoubtedly underestimated bull to cow ratios (Houston 1982). There were proportionately more calves and fewer bulls near the park road (Figs. 11, 12, 13). In general, calf to cow ratios were higher near the park boundary, e.g., Stephens Creek, Crevice Creek; and also in accessible hunted areas north of the park, e.g., Sphinx Creek, Cedar Creek-North, Little Trail Creek, Dome Mountain, and Cinnabar Mountain (Fig. 11). The Stephens Creek group had high calf ratios but this group was largely resident and non-migratory during the mild winters of 1986-88 (J. Vore, F. Cassirer, unpubl. data). Perhaps this group would be more migratory in normal or severe winters. Shallow snow depths here probably contributed to higher calf survival. Secondarily, hunter selection for cows over calves may elevate calf ratios in the most accessible hunted areas. High

Table 15. Calf, spike bull, and mature bull ratios of northern Yellowstone elk, 1982-88. (g) = ground, (h) = helicopter, (Sc) = Super Cub.

			Calves / 100 Cows				Spikes / 100 Cows			
	DATE OF		YELLOWSTONE PARK			NORTH OF	YELLOWSTONE PARK			NORTH OF
WINTER	CLASSIFICATION	METHOD	Upper	Middle	Lower	PARK	Upper	Middle	Lower	PARK
1982-83		(g)	27	-	46	-	-	-	-	-
1983-84		(g)	25	-	47	-	-	-	-	-
1984-85	1/4-25/85	(g)	24	-	48	-	9	-	4	-
1985-86										
(a)	10/85-12/16/85	(g)	32	52	66	-	3	-	-	-
(b)	1/4-9/86	(g)	27	-	42	-	6	-	4	-
(c)	1/3-2/12/86	(g,Sc)	31	24	34	23	4	3	4	3
(d)	3/26-28,4/6	(g)	-	25	57	20	-	2	0	<1
1986-87										
(a)	12/12-3/12	(g)	21	-	44	63	-	-	-	4
(b)	2/87	(h)	19	18	23	30	3	-	6	6
1987-88										
(a)	2/88	(h)	16	21	31	21	5	3	4	5

Table 15 Con't.

			Mature Bulls / 100 Cows					
			YELLOWSTONE PARK			NORTH OF	SAMPLE	
WINTER		METHOD	Upper	Middle	Lower	PARK	SIZE	SOURCE
1982-83		(g)	-	-	-	-	988+	Swenson (in prep.)
1983-84		(g)	-	-	-	-	1,101+	" "
1984-85		(g)	2	-	-	-	923+	" "
1985-86	(a)	(g)	1	-	-	-	2,706	E.Ables (unpubl.data)
	(b)	(g)	7	-	-	-	1,398	Fish,Wildl.,Parks(1986)
1985-86	(c)	(g,Sc)[1]	2	45	2	1	3,851	F. Singer (unpubl.data)
	(d)	(g)	-	3	2	<1	2,753	F. Singer (unpubl.data)
1986-87	(a)	(g)	-	-	-	2	1,523 and 1,625+	Mont.Fish,Wildl. and Parks (1987)
	(b)	(h)[1]	3	10	16	24		F. Singer (unpubl.data)
1987-88	(a)	(h)[1]	2	3	20	19		F. Singer (unpubl.data)

[1]Higher mature bull ratios are likely a result of more random aerial surveys than a demographic change.

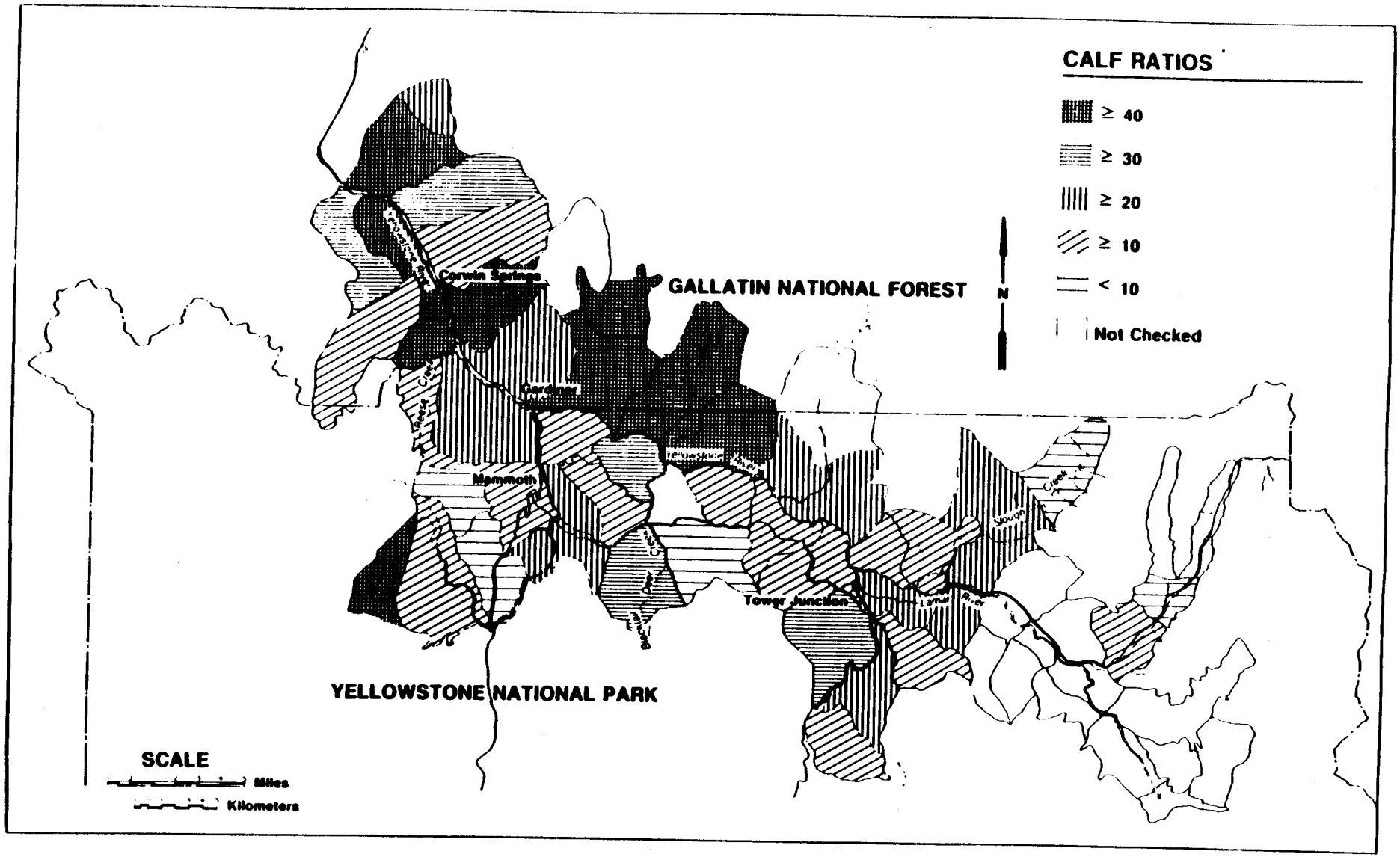


Fig. 11. Map of elk calf ratios (calves:100 cows) on 66 count units on Yellowstone's northern range as determined by helicopter survey, Feb. 1987.

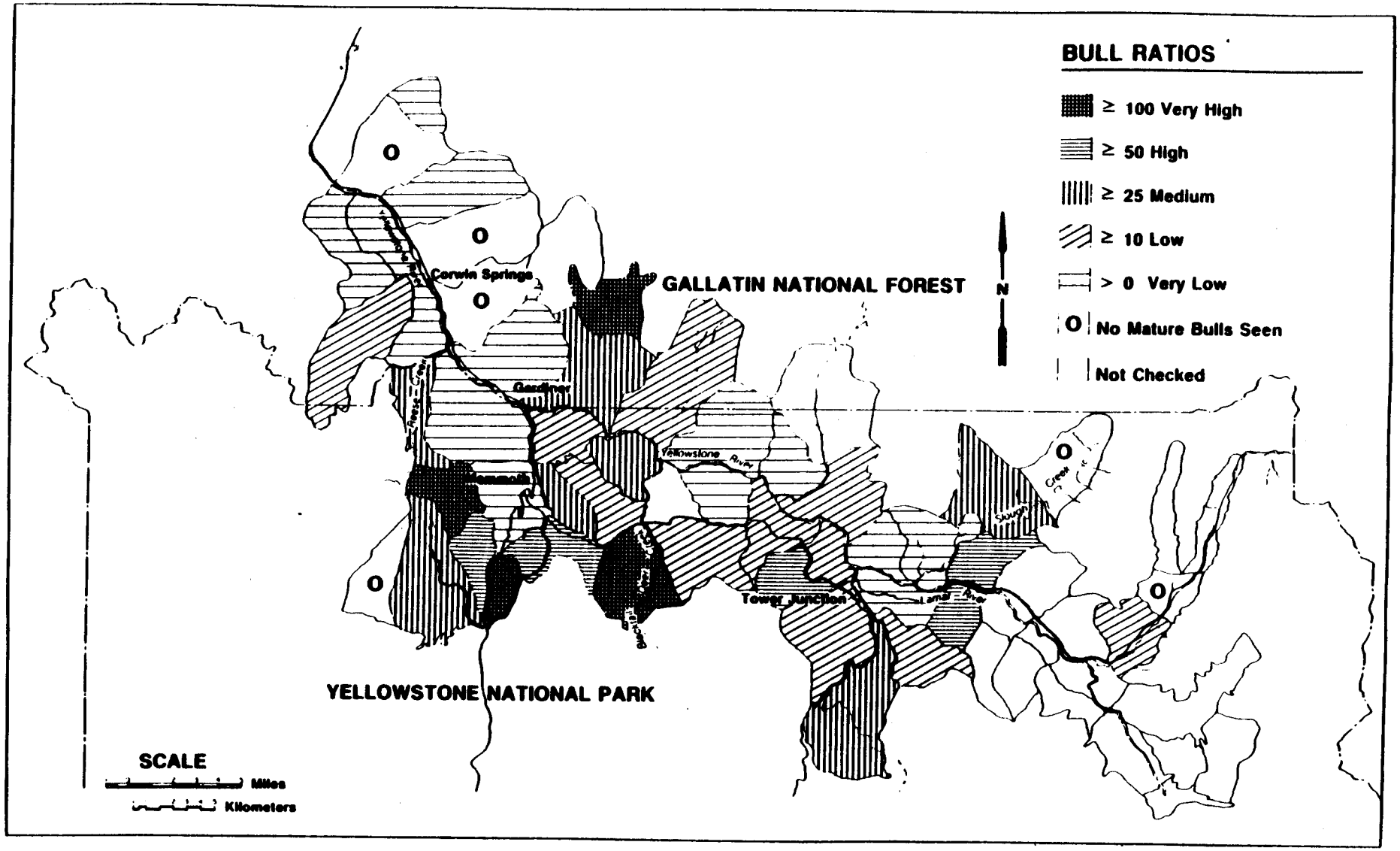


Fig. 12. Map of mature bulls:100 cows on 66 count units on Yellowstone's northern range as determined by helicopter survey, February, 1987.

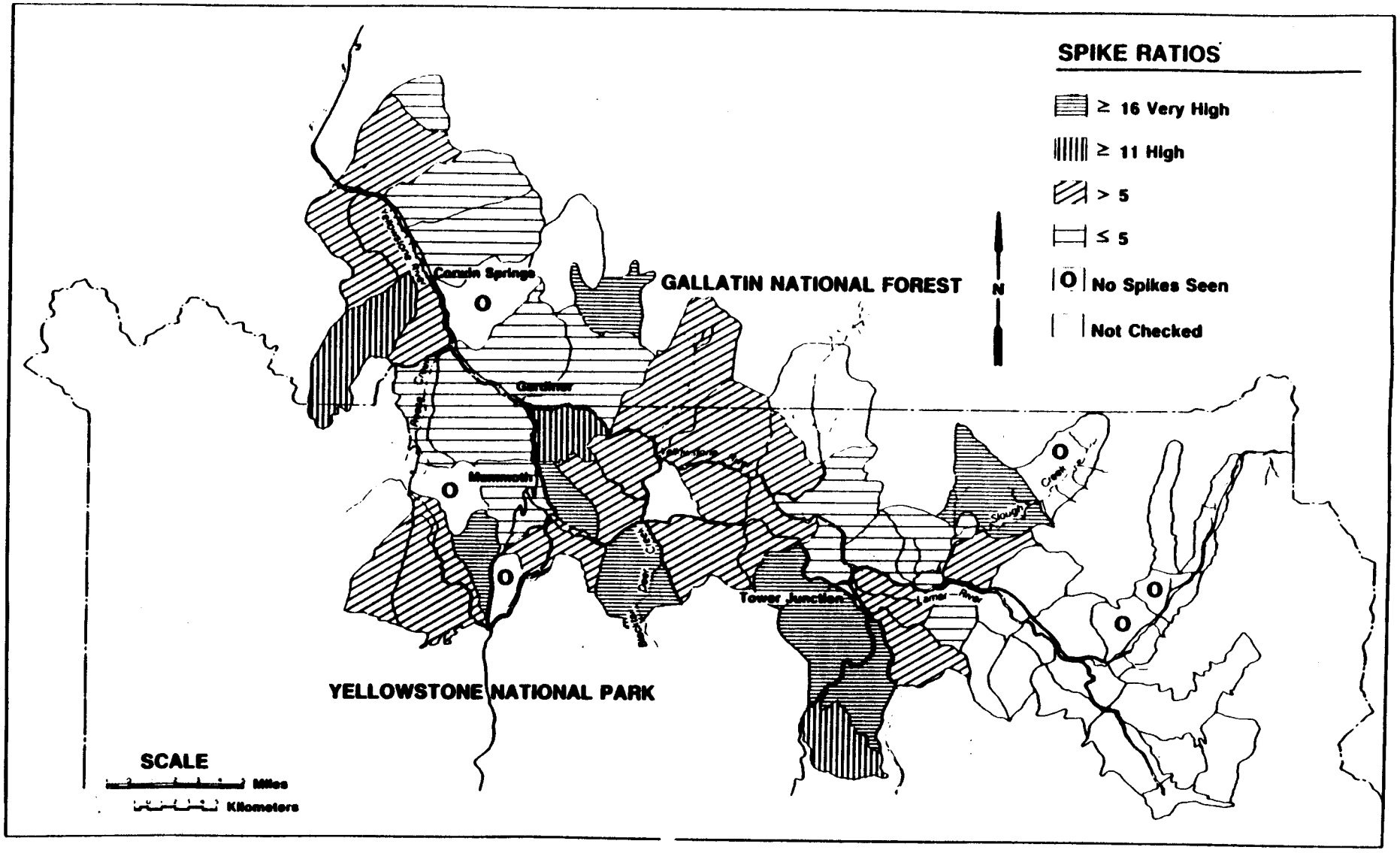


Fig. 13. Map of spike bulls:100 cows on 66 count units on Yellowstone's northern range as determined by helicopter survey, February, 1987.

High densities of elk coincided with high calf to cow ratios in several boundary areas (Figs. 14, 15, 16), but in deeper snow areas, e.g., Upper Slough Creek, Blacktail Deer Plateau, high densities of elk occurred with low calf to cow ratios.

Mountain Lions

The relationship of mountain lions to the ungulate prey base on Yellowstone's northern range will be detailed in a later report by the Wildlife Research Institute (Hornocker 1987).

Wolves

Potential Population

Yellowstone National Park and its northern boundary areas were divided into 11 sectors to compare ungulate distributions (Fig. 17). Highly provisional estimates of six species of ungulates summering and wintering in these sectors are provided in Table 16. I speculate that each of these sectors might support at least one pack or pair of wolves on a year-round basis under the mild climatic conditions and peak numbers of ungulates that prevailed during the 1980s. In one area (SW) wolves would likely leave the park during the winter. After a period of more severe winters, year-round occupancy of four of the areas by wolves would be less likely. I speculate Yellowstone National Park might support a minimum of 11-15 wolf packs if they are totally non-migratory and several more if they were partially migratory, depending upon winter weather patterns. I predict that some of the wolves would be migratory because of the very large seasonal differences in ungulate densities, in

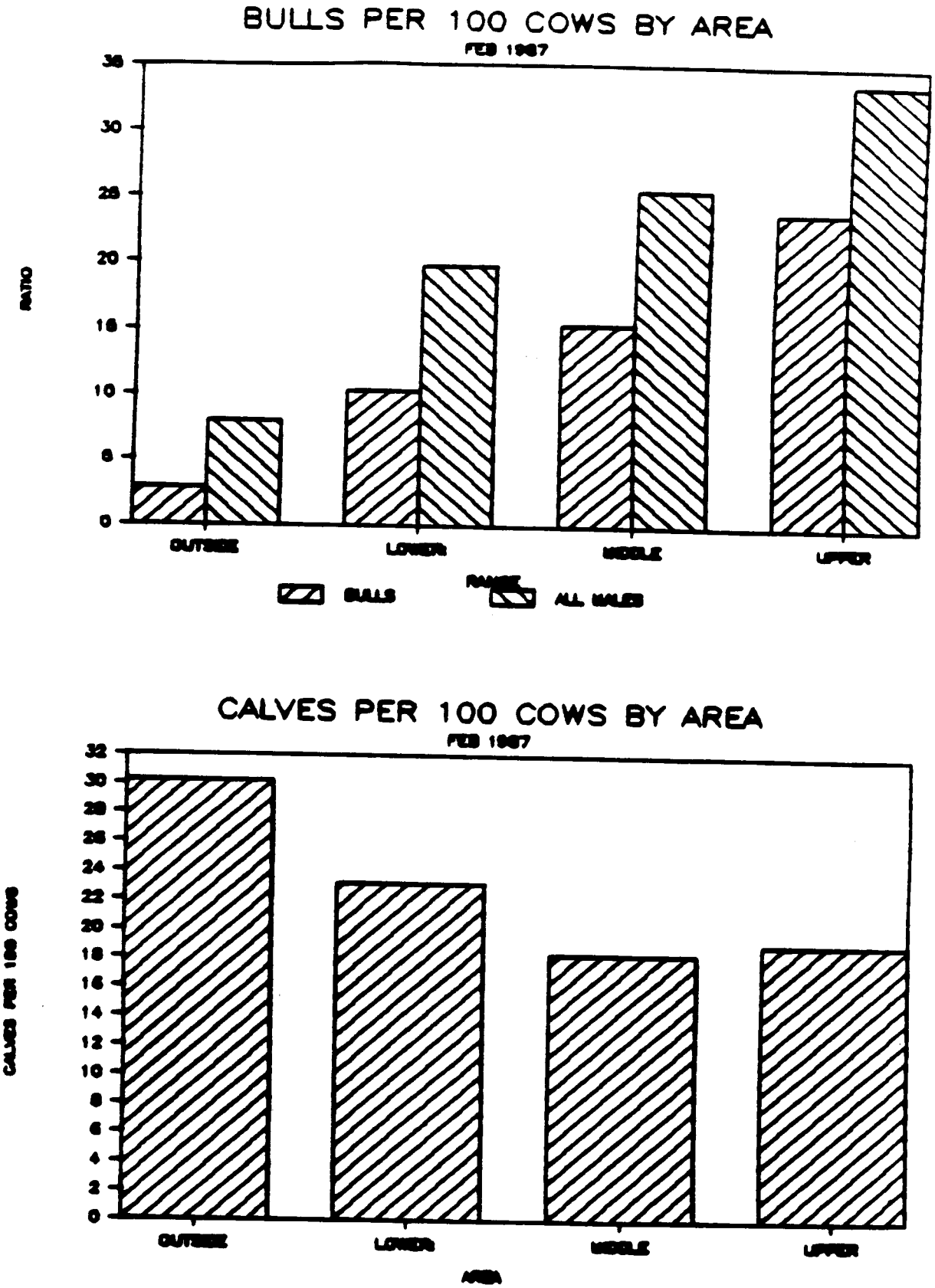


Fig. 14. Summary of bull and calf ratios on the upper, middle, lower, and outside the park on Yellowstone's northern range. Upper = Lamar Valley; Middle = Lamar Canyon to Undine Falls; Lower = Undine Falls to park boundary; and Outside = north of park.

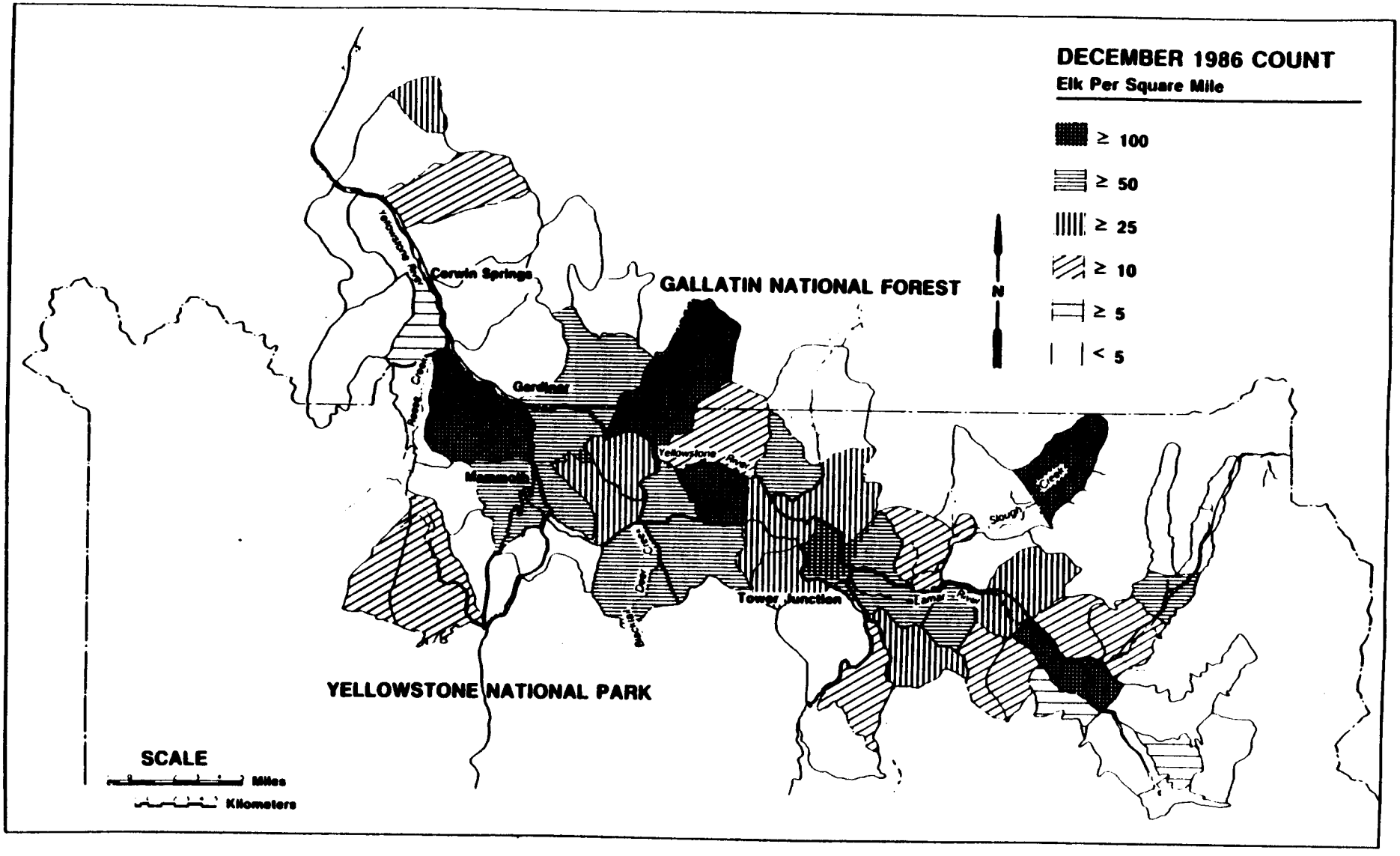


Fig. 15. Densities of elk in 66 count units on Yellowstone's northern range, December, 1986.

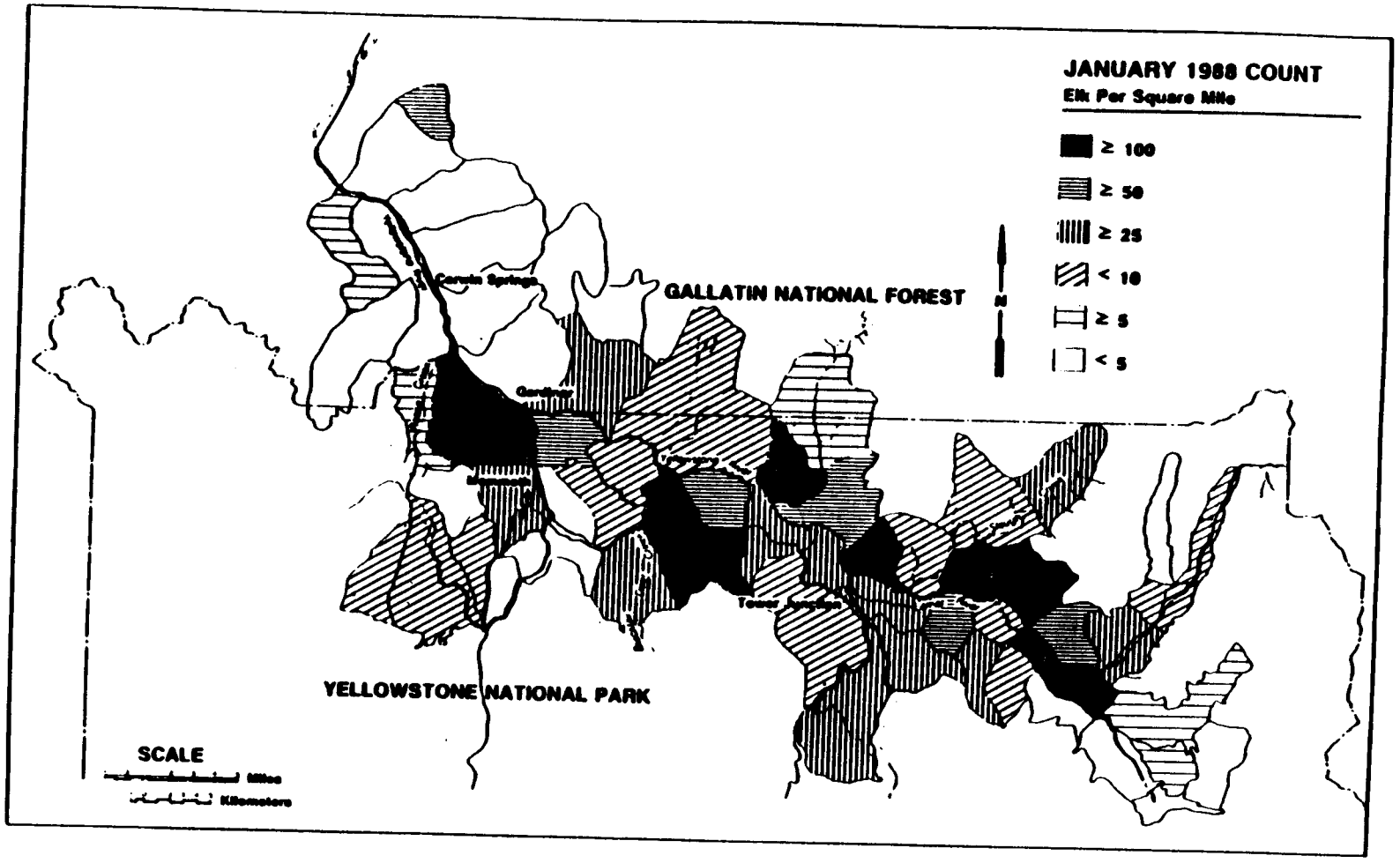


Fig. 16. Densities of elk in 66 count units on Yellowstone's northern range, January, 1988.

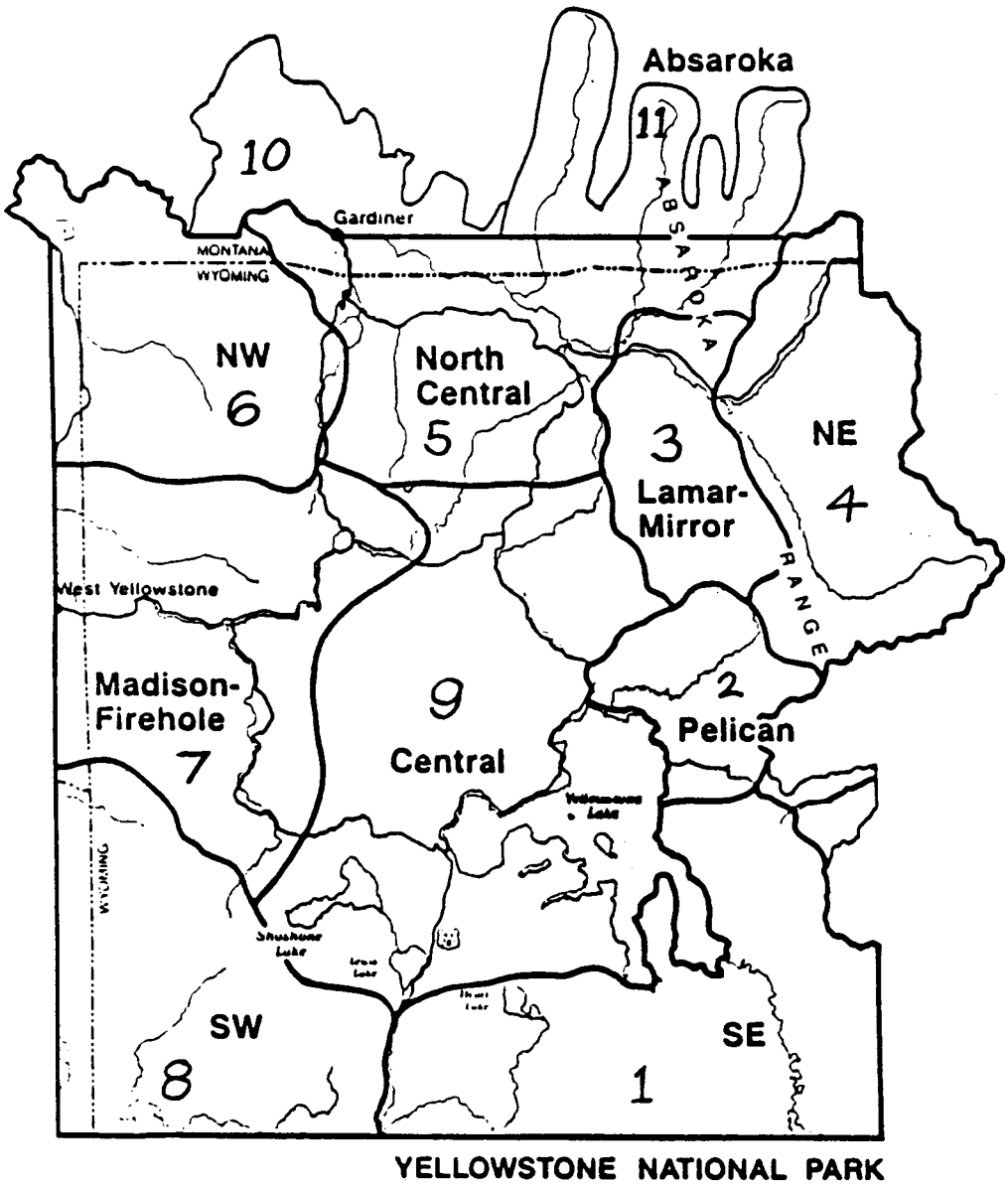


Fig. 17. Eleven sectors of Yellowstone National Park designated for purposes of comparing seasonal numbers of ungulates.

Table 16. Summary of estimated ungulate numbers in 11 sectors in and near Yellowstone National Park. Northern elk herd summer distribution estimates are highly provisional.

	Ungulates-Summer						Ungulates-winter	
Sector	Mule Deer	Moose	Elk(Herd)	Bighorns	Prong-horns	Bison	Mule Deer	Moose
IN PARK:								
1)SE	Common	Common	2,200(NFS) 2,140(J) tr (CM) 900(N)	Present	0	0	0	67+
2)Pelican Valley	Present	A few	150(CF) 1,500(N)	0	0	<50	0	A few
3)Lamar Valley--Mirror Plateau	A few	tr	<50(CF) 2,500(N)	~40	50-100	200-400	0	tr
4)NE	Common	tr	2,500(CF) 3,000(N)	200+	0	200-600	0	~100
5)NC	Common	A few	2,000(N)	~100	300	<100	~150	<50
6)NW	Common	300+	3,000(N) 900(G)	100-200+	0	5	A few	100-200+
7)Madison Firehole	Common	50+	800(MF) A few(G)	0	0	500	5	50+
8)SW	A few	100-200+	1,056(SC) ~300(N) ~70(MF)	0	0	<50	0	100+
9)Central	A few	<50	5,000(N)	0	0	1,000	<20	<50
OUT OF PARK:								
10)Northern Range	1,000	tr	500(N)	<50	25	0	2,000	tr
11)Absaroka Wilderness	Common	200-300	2,000(N)	100+	0	0	0	~100

Table 16, continued.

	Ungulates-Winter			
Sector	Elk	Bighorns	Pronghorns	Bison
IN PARK:				
SE	250-500	A few	0	0
Pelican Valley	0	0	0	600
Lamar Valley-Mirror Plateau	200	~60	0	0
NE	200	~60	0	0
NC	7-11,000	~50	450	200-300
NW	1,500	A few	0	5
Madison-Firehole	800	0	0	1,500
SW	<20	0	0	<20
Central	<25	0	0	50-200
OUT OF PARK:				
Northern Range	1,000-4,500	300	50	0
Absaroka 2(s)Wilderness	300	~30	0	0

tr = trace

Elk herds: N = northern, J = Jackson, CF = Clarks Fork, NFS = North Fork Shoshone, G = Gallatin, CM = Carter Mt., MF = Madison-Firehole, SC = Sand Creek.

particular the SE, SW, and Central sectors (Table 16). Migratory wolves using these areas in summer would possibly migrate to the NC winter range; however, wolves in the SW and SE sectors could winter outside the park. Since elk migrate to summer ranges in late May and wolves den in March, wolves could only follow elk after the pups are old enough to be moved (about July).

These estimates are conservative. They are based upon the assumption that wolves in the Greater Yellowstone Area would be promptly delisted and harvest seasons would be opened for them in Montana, Wyoming, and Idaho. If so, wolves would never fully exploit the ungulate herds that summer or winter in close proximity to the park boundary, particularly in the NW, SW, SE, NE, and NC, sectors. Accordingly, wolves would likely not reach full population potential. Harvesting wolves leaving the park would discourage migratory behavior. Suppression of wolf numbers in park boundary areas would be desirable, since three of the migratory elk herds summering in these areas are being harvested at or near levels of maximum sustained yield.

DISCUSSION

Literature Review - Wolves

In this section I present my personal views based upon the literature and my experiences with wolves in Glacier National Park and Alaska.

Would Yellowstone's wolves be migratory?

Possibly. Wolves are known to migrate 50 to 100 miles each year to follow the western arctic caribou herd (Stephenson and James 1982), and as much as 225 miles to follow the Kaminuriak caribou herd. Wolves concentrate as densely as

one wolf per 6.9 miles^2 on caribou winter ranges (Kuyt 1972) and defend very small, flexible territories from adjacent packs largely by howling (D. Mech, pers. corres.). No other instance of migratory wolves south of the arctic or boreal forest are known, though many wolf populations exist where migratory ungulates occur (Carbyn 1974; Mech 1970).

Nevertheless, I predict that some wolves in Yellowstone could be migratory because of the great summer abundance of prey in the park's interior plateaus, where essentially no prey would be available in the winter, and differences in the prey base between summer and winter are striking in parts of the park's interior. Migratory wolves will be more efficient at utilizing the park's migratory elk, whereas strictly territorial wolves would have to inhabit territories large enough to meet their year-round food requirements.

Would wolves affect ungulate distributions or use of habitats?

Yes; depending upon the intensity of predation pressure there could be some minor changes in habitat use or distributions, especially by females with young. If predator pressure remains only low to moderate, however, I predict no significant differences.

Adult females with vulnerable young are more likely to alter their habits because of wolves. Cow moose with calves on Isle Royale frequent wolf-free islands and have a poorer quality diet than cows without calves and yearlings (Edwards 1983). Similarly, cow caribou seek high, south facing slopes with a lower quality forage base as an anti-predator tactic (Kelsall 1968; Bergerud et al. 1984). These slopes are more likely bare of snow than lowlands, thus enabling brown caribou calves to be cryptic. Also, the isolation of single

cows and their calves from nursery bands increases the search effort of wolves (Bergerud et al. 1984). Caribou cows with calves typically skirt willow patches in Alaska apparently to avoid ambushes by wolves or grizzlies (Roby 1978). Caribou use of a distinct calving ground removed from their winter and summer ranges may be a strategy to confuse wolves tied to a fixed den site (Bergerud 1980). Bison calves are safest from wolf predation when bunched as a unit near the center of a group, yet persistent wolf attacks tended to break up and discourage pod formation (Oosenbrug and Carbyn 1983). Carbyn and Trottier (1988) felt that calf bison were safest in open areas, but that when herds of cows with calves entered forests, vulnerability probably increased since calves were more obstructed by vegetation, and separation of young from adults was more likely. Both muskox (Gray 1983) and bison (Carbyn and Trottier 1988) that stand their ground are more likely to survive an attack by wolves. The strategy of isolating and hiding elk calves at birth is an anti-predator tactic (Carbyn 1974) that will be successful with wolves. In addition, elk calving is not as synchronized as caribou calving, which should increase the search time for wolves. However, after initially hiding calves, elk cows later bring their calves to nursery groups where they are then visible and vulnerable to wolves, and where the clumping of vulnerable-aged calves could result in excess or surplus kills in some cases (Miller et al. 1985).

Yellowstone's ungulates might alter their winter distributions in response to wolf predation. Elk are less vulnerable to wolves in deep powder snow, as is typical of Yellowstone in early winter, and I suspect the early-winter use of open areas by elk would continue. However, as snows deepen or crusts form, wolves would have an advantage in the open, and elk may prefer forests with shallower snows for escape. Moose apparently can outrun wolves in the sedge-

tussock communities of Alaska and in heavy downfall in mature forests where their long legs are an advantage (Peterson and Allen 1974). Both elk and moose may run into water to escape wolves, moose may successfully back up to cliffs and fend off wolves, and elk may get onto cliffs to escape wolves (Peterson and Allen 1974; Gunson 1986). Elk on Vancouver Island, where there are high wolf densities, prefer forest habitats in winter (Hatter 1982). Wolves contributed to increased summer range movements of elk cow-calf groups and caused black-tailed deer to bypass spring ranges where wolf predation was intense (Hatter 1982). Moose frequent the Denali National Park, Alaska, headquarters and hotel areas apparently to avoid predators (F. Singer and J. Dalle-Molle, personal observations). For the same reasons, high use by elk of the Yellowstone headquarters and Gardiner townsite areas will continue or even increase after wolf reoccupation.

Wolves will often kill ungulates in disproportionate numbers in peripheral situations where more vulnerable individuals occur or snows are deeper. For example, two-third of deer kills in northeastern Minnesota occurred in low density deer areas (Fritts and Mech 1981). Many deer, especially males, were killed on the periphery of deer yards (Fritts and Mech 1981). Barren cows and adult bull elk typically occupy the peripheral areas of Yellowstone's northern range; therefore, they may be more vulnerable to wolf predation.

Which of Yellowstone's ungulates will wolves prefer?

Reintroduced wolves in Yellowstone National Park would likely prefer mule deer > elk > bison > moose > bighorn sheep > pronghorn antelope. Because of prey abundance, diets of wolves parkwide would most likely be elk > bison >

mule deer > moose > pronghorn antelope > bighorn sheep. The ratios of ungulates on Yellowstone's northern range are 100 elk : 14 mule deer : 3 bison : 2 pronghorn antelope : 2 bighorn sheep : 1 moose. I predict that Yellowstone's bighorn sheep will not be particularly vulnerable to wolves because they already occupy excellent escape terrain. Bighorn sheep were 1.3 times as numerous as elk, but were eaten only 0.17 times as often in the Rocky Mountain National Parks of Canada (Cowan 1947). Pronghorn antelope could be vulnerable to wolves in deep snow, but Yellowstone's pronghorns winter near the town of Gardiner where wolves will rarely occur. In the summer, the pronghorn antelope migrate into potential wolf range, but they usually occupy open sagebrush habitats where they could easily detect and outrun wolves.

Mule deer are slightly to greatly preferred over elk where they occur together, and elk are more readily killed than moose. For example, Cowan (1947) reported mule deer were taken 1.3 times more than elk, and Carbyn (1974) reported they were taken 1.8 times more than elk, when corrected for relative abundance. Mule deer, however, will be less available in Yellowstone in the winter because they occur mostly north of the park's boundaries, where wolves will be harvested and most likely be rare.

In Riding Mountain National Park, Manitoba, there was 1 moose/10.5 elk, but wolves killed only 1 moose/15 elk. Elk are nearly as big as moose, but in Riding Mountain National Park, elk were cornered in 1/6 the distance of moose and once cornered, were easier to kill (Carbyn et al. 1987). Both moose and bison can fend off wolves and defend calves, making them less vulnerable than deer or elk. However, wolves can kill adult bison and moose, and wolves can exist where either species is their primary food resource (Oosenbrug and Carbyn

1983; Messier and Crete 1985; Gasaway et al. 1983). Bison and moose are probably roughly equivalent in their vulnerability to wolves, although Telfer and Kelsall (1984) felt that bison were easier prey than moose during winter.

Would wolves be hampered or benefited by the deep, soft snows of Yellowstone?

Snow density of less than 0.21 g/cm^3 hampers movements of wolves; 40 cm of soft snow made it difficult for wolves to pursue prey, and in 50-60 cm of snow, pursuits through untracked snow were almost impossible (Peterson and Allen 1974). However, a density of 0.33-0.35 g/cm^3 in the upper layers of the snow profile supports wolves and provides them great advantage in the pursuit of prey. In general, wolves may be at a disadvantage in Yellowstone in the deep, soft snows of early winter, but ungulates become more vulnerable when crusts form in later winter, and wolves are then supported better than their prey (Formosov 1946; Nasimovitch 1955; Mech et al. 1971; Kolenosky 1972).

If wolves are reintroduced to Yellowstone they will undoubtedly prefer to travel in shallower snows, on wind-swept ridges, along the frozen shorelines of Yellowstone Lake, along snow-free watercourses, and possibly on snowmachine trails. Wolves will probably not push through snow over the park's large, interior plateaus (e.g., Madison, Two Ocean). Wolves can move through deep snow by traveling single file (Mech 1971; Peterson and Allen 1974) where the movement is limited to a few miles and where the movement route is known.

Telfer and Kelsall (1984) calculated morphological indices rating from the least to the most difficulty in snow as follows: moose - 140, wolf - 135, elk - 118, bighorn sheep - 114, white-tailed deer - 112, bison - 95, and pronghorn antelope - 81. Therefore, they felt that elk, deer, bison, and antelope should

be relatively easy prey for wolves in winter and sheep in the rare situations away from escape terrain.

Would less abundant ungulates be severely impacted by wolves?

Less abundant and more vulnerable prey may be severely limited by wolves when the wolf density is determined by the more abundant ungulate prey species. Several cases of declining caribou populations have been observed in northern British Columbia, where wolves have increased as a result of newly-invading moose populations (Bergerud et al. 1983). Caribou are more vulnerable to wolves than are moose (Haber 1977). Bergerud et al. (1983) felt caribou may exist "...only at densities sufficiently low that wolves hunt mostly moose...As long as wolves can maintain high numbers because of the new food base provided by moose, caribou will not be able to reach their former abundance."

Elk are considerably more abundant than the other ungulates on Yellowstone's northern range. Elk are 7 times more abundant than mule deer, 30 times more than bison, 42 times more than pronghorn antelope and bighorn sheep, and 104 times more than moose, suggesting severe pressure could occur on one of the less abundant ungulates. However, I hypothesize that mule deer, bighorn sheep, and pronghorn antelope would most likely be largely unavailable to wolves during winter. Bison and moose are less vulnerable than elk, but moose are of special concern since current harvest levels are high. Moose might decline under present sport harvest levels outside the park on the northern range if wolves were reintroduced.

Would reintroduced wolves impact sport harvest levels of big game that migrate out of Yellowstone National Park?

Yes, if wolves were protected and were allowed to reach high densities in the areas bordering Yellowstone National Park. Wolf recovery can clearly be sustained within the boundaries of the park, and wolves in bordering areas could be kept at low levels where impact upon sport harvests was or minimal. Harvest of wolves alone could "trim" wolf levels in those areas with road and trail access and high recreational use, but direct control of wolves should also be retained as an option, where necessary, for inaccessible wilderness areas.

The published literature as a whole suggests that wolves can compete with hunter harvests of big game, particularly under situations of severe winters, high hunter harvests, and high wolf densities (Pimlott 1967; Mech and Karns 1977; Fuller and Keith 1980; Gunson 1986; Keith 1983; Gasaway et al. 1983; Gunson 1986). However, none of these situations included relatively small protected wolf populations surrounded by extensive human developments. For example, in Glacier National Park, Montana, (R. Ream, pers. corres.) and Riding Mountain National Park, Manitoba, (Carbyn et al. 1987) wolves have not achieved their full population potential due to extensive removals by humans along the boundaries.

Can the findings concerning predator-prey relations from Alaska, Yukon, and northern British Columbia be applied directly to Yellowstone?

Not entirely, although some applications are possible. Those studies were conducted on very large contiguous areas where wolf immigration was a very

significant factor (Gasaway et al. 1983; Ballard et al. 1987) and where the prey populations were harvested by man. Yellowstone is a habitat island with a proportionately higher boundary influence from human developments and human exploitation and some prey populations are essentially unharvested. Probably 2/3 of all wolf packs would be subjected to some boundary influence.

Will wolves affect the demography of Yellowstone's ungulates?

Yes. Wolves killed mostly young of the year and older animals in studied populations of elk (Carbyn 1983), moose (Mech 1966; Pimlott et al. 1969; Peterson 1977), Dall sheep (Murie 1944), white-tailed deer (Pimlott 1969; Mech and Frenzel 1971), caribou (Kuyt 1972). Additionally, wolves killed proportionately more male white-tailed deer (Pimlott 1967; Mech and Frenzel 1971). Wolves selectively prey on mature bull elk and mature bull caribou during summer (Carbyn et al. 1987; Haber 1971; Mech et al. 1988). Wolves killed proportionately more bull bison in one study (Oosenbrug and Carbyn 1983), but mostly cows and calves in another study (Van Camp in prep.). Wolves would undoubtedly greatly influence the timing of and proximate cause of death for the northern Yellowstone elk herd, and as Mech (1970) stated, "...starvation seems to be a very unnatural type of control on any (ungulate) population."

Will wolves limit ungulates within the boundaries of Yellowstone where sport hunting removals don't occur?

Unknown. Several examples exist where wolves did apparently limit unhunted herds of ungulates. Wolves were believed to limit the growth of a

moose population in unhunted Pukaskwa National Park, Ontario, (Bergerud et al. 1983). Pimlott (1967) and Keith (1974) felt that wolves were important limiting factors upon ungulates under pristine conditions. Wolves apparently held moose below ecological carrying capacity even in an unhunted situation (e.g., La Verendry Game Reserve) in Quebec (Crete and Messier 1984). Additional contributing factors in Yellowstone include predation upon ungulates by grizzly bears, black bears, coyotes, and mountain lions, plus wolves and grizzlies may occasionally kill surplus numbers of calves (Miller et al. 1985; Singer 1986), and wolves engage in surplus or excess killing of adult ungulates under severe winter conditions (Bjarvall and Nilsson 1976; Mech et al. 1971; Eide and Ballard 1982). Fowler and Barmore (1979) felt that wolf predation on northern Yellowstone elk, in combination with hunting of the migratory portion, might limit the herd. Both Dave Mech and Vic Van Ballenberghe (in verbal presentations) have predicted that fewer elk will exist on the northern range after a wolf reintroduction.

A number of counter-arguments exist, however, that suggest wolves might not limit elk on the northern range. These include:

1. Wolves might stimulate reproductive rates in elk by changing age structure or by lowering elk densities and increasing relative food availability for elk (= compensatory reproduction). The twining rates and production of moose on Isle Royale apparently increased after wolves reoccupied the island (Mech 1970). Peterson (1977) predicted "Long-term population levels of moose might be lower without predation..." on Isle Royale;

2. The social constraints of wolves put an upper limit on their density such that wolves have significantly less effect upon very high densities of ungulates (Pimlott 1967; Mech 1970; Walters et al. 1981; Gasaway et al. 1983). Mech (1970) suggested that when prey per wolf exceeds 11,000 kg, wolves are not able to limit the prey. Wolves did not influence the abundant elk of Riding Mountain National Park (Carbyn et al. 1987). The elk of Yellowstone's northern range may presently be too numerous for wolves to influence them;

3. If reintroduced wolves did not migrate with Yellowstone's elk, then they would be less able to fully exploit elk because their home ranges would have to be large enough to contain adequate year-round prey;

4. The park boundary on Yellowstone's northern range is extensive; therefore, harvest of wolves could be considerable (Carbyn et al. 1987), suggesting wolves would be held below ecological carrying capacity; and

5. Peterson (1977) stated that, "Wolves did not hold the moose population on Isle Royale below the level at which food supply and environmental conditions affected the welfare of moose." Peterson (1977) further concluded, "There appears to be no adequately documented cases of wolf predation imposing long-term limit on ungulate populations independent of environmental influences."

Clearly, whether or not wolves would limit the park's ungulates is a complex and open question.

Would wolf predation be largely additive or largely compensatory to that of grizzlies (or black bears, coyotes, or mountain lions) on Yellowstone's northern range?

Apparently, wolves would significantly reduce the numbers of coyotes on the northern range (Krefting 1969; Mech 1970; Carbyn et al. 1987); therefore, predation on ungulates would be compensatory to some extent.

The case for grizzly bears and wolves is more complex. Grizzly bears and black bears have been shown to be significant predators on neonatal calves of moose (Ballard et al. 1981; Franzmann et al. 1980), caribou (R. Page, unpublished data; Singer 1986), and elk (Schlegel 1973; K. Gunther unpublished data; Singer and Harting 1988). Predation upon adult elk is occasionally significant in Yellowstone (Cole 1972). Filonov (1980) and Haber (1987) reported that predation by wolves and grizzlies upon moose compensated each other. However, Weaver (1986) felt that wolves would benefit grizzlies in

Yellowstone Park by providing ungulate carcasses on a more year-round basis for bears to scavenge. Haber (1987), however, felt that large packs of wolves dominanted grizzly bears at carcasses, and possibly limited bear's use of key locales such as moose calving areas.

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APPENDIX I. Harvests of mule deer and white-tailed deer in the state of Montana in Hunting Districts on the northern range (H.D. 313), partially on the northern range (H.D. 316, 314), or adjacent to Yellowstone National Park (H.D. 310, 361, 362).

H.D.	Year	Antlered	Antlerless	Mule deer	Whitetails	Total Harvest
310	1979	58	-	53	5	58
310	1980	91	-	83	8	92
310	1981	85	-	89	-	89
310	1982	83	-	83	5	88
310	1983	87	6	84	9	93
310	1984	71	-	59	12	71
310	1985	14	-	100	14	114
310	1986	53	8	49	12	61
313	1979	216	26	234	9	243
313	1980	233	29	256	11	267
313	1981	464	59	504	27	531
313	1982	506	103	571	44	615
313	1983	555	202	746	11	757
313	1984	347	245	580	12	592
313	1985	247	350	457	40	497
313	1986	353	166	488	31	519
314	1979	468	21	469	29	498
314	1980	621	58	627	65	692
314	1981	715	100	778	43	821
314	1982	552	107	614	49	663
314	1983	724	251	841	134	975
314	1984	700	377	948	134	1082
314	1985	771	402	992	181	1173
314	1986	582	384	833	133	970
316	1979	78	-	74	4	78
316	1980	92	-	-	-	92
316	1981	83	-	89	-	-
316	1982	52	-	47	5	52
316	1983	55	-	40	15	55
316	1984	42	-	42	-	42
316	1986	44	12	48	8	56

Appendix I, Continued

H.D.	Year	Antlered	Antlerless	Mule deer	Whitetails	Total Harvest
361	1979	39	-	39	-	39
361	1980	39	-	39	-	39
361	1981	85	-	85	-	85
361	1982	56	-	57	8	-
361	1983	34	-	25	9	34
361	1984	32	-	26	6	32
361	1985	17	-	17	-	17
361	1986	24	-	20	4	24
362	1982	90	28	119	5	-
362	1983	38	70	96	12	108
362	1984	61	33	81	13	94
362	1985	99	50	137	12	149
362	1986	48	56	88	16	104

Data taken from the following Progress Reports:

Foss, A.J. 1981. Montana Big Game Survey and Inventory, Region Three. Job Progress Report. Job No.: I-e segment A (Deer). Project No. : W-130-R-12. Table No. 3. pp.36-40.

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APPENDIX II. Moose harvest statistics in hunting districts in Montana adjacent to the northern boundary of Yellowstone National Park.

HUNTING DISTRICT	YEAR	MOOSE HARVESTED				
		BULL	COW	CALF	UNKNOWN	TOTAL
306	1979	6	1	1	-	8
306	1980	7	-	1	-	8
306	1981	9	1	-	-	10
306	1982	9	1	-	-	11
306	1983	11	-	-	-	11
306	1984	9	3	1	-	13
306	1985	8	1	-	-	9
306	1986	7	3	1	-	11
306	1987					
307	1984	5	-	-	-	5
307	1985	6	-	-	-	6
307	1986	4	1	-	-	5
309	1979	13	1	-	-	14
309	1980	11	2	2	-	15
309	1981	14	4	1	-	19
309	1982	19	-	1	-	20
309	1983	16	2	-	-	18
309	1984	13	-	1	-	14
309	1985	14	2	-	-	16
309	1986	8	3	-	-	11
309	1987					
310	1979	6	3	-	-	9
310	1980	13	2	-	-	15
310	1981	12	5	-	-	17
310	1982	26	4	-	-	30
310	1983	15	6	1	-	22
310	1984	18	3	-	-	21
310	1985	13	3	4	-	20
310	1986	11	6	2	-	19
310	1987					
313	1979	6	4	-	-	10
313	1980	6	3	-	-	9
313	1981	4	-	-	-	4
313	1982	11	3	-	-	14
313	1983	6	3	2	-	11
313	1984	8	-	-	-	8
313	1985	7	-	-	-	7

APPENDIX II, Continued.

HUNTING DISTRICT	YEAR	MOOSE HARVESTED BULL	COW	CALF	UNKNOWN	TOTAL
318	1985	3	1	2	-	6
318	1986	3	3	-	-	6
322	1985	9	3	-	-	12
322	1986	8	5	-	-	13
328	1986	2	-	-	-	2
361	1979	20	4	-	-	24
361	1980	18	3	3	-	22
361	1981	17	6	1	-	24
361	1982	15	7	1	1	24
361	1983	17	5	-	2	24
361	1984	16	2	4	-	22
361	1985	17	5	-	-	22
361	1986	18	3	3	-	25
361	1987					
362	1984	5	2	-	-	7
362	1985	5	-	-	-	5
362	1986	7	-	-	-	7
362	1987					
316	1979	3	3	-	-	6
316	1980	3	2	-	-	5
316	1981	5	1	-	-	6
316	1982	5	1	-	-	6
316	1983	3	-	-	-	3
316	1984	-	-	1	-	1
316	1985	3	0	-	-	3
316	1986	3	-	-	-	3
316	1987					

Sources include:

(1) Alt, K.L. and A.J. Foss. 1987. Montana Big Game Survey and Inventory, Region Three. Job. No. I-3(c). Project No.:W-130-R-18, Montana Department of Fish, Wildlife and Parks, Helena.

(2) Taylor, G. 1986. Montana Big Game Survey and Inventory, Region Three. Job No.:I-3(c). Project No.:W-130-R-17. Montana Department of Fish, Wildlife and Parks, Helena.

(3) Swenson, J.E. and A.J. Foss. 1986. Montana Big Game survey and Inventory, Region Three. Job No.:I-3(c). Project No. W-130-R-17, Montana Department of Wildlife and Parks, Helena. Table 39. pp.56-63.

(4) Erickson, G.L. 1981. Montana Big Game survey and Inventory, Region three. Job No.:I-3(c). Project No.:W-130-R-12. Montana Department of Fish, Wildlife and Parks, Helena. Table 48. pp.44-48.

APPENDIX III. Sex and age ratios of bighorn sheep in the Deckard Flats-McMinn Bench herd on the northeastern corner of Yellowstone National Park, 1979-88. Source: Annual Interagency classification (Swenson 1979-85; Puchlerz 1986, 1987).

Year	n=	Ewes	Lambs	Lambs per 100 ♀	Rams per 100 ♀
1979	89	36	21	58	86
1980	265	127	50	39	66
1981	156	74	33	45	57
1982	72	26	7	27	138
1983	38	15	2	13	140
1984	46	19	6	32	111
1985	59	24	10	42	104
1986	93	33	12	36	145
1987	108	45	33	73	89

APPENDIX IV. Elk harvest statistics for hunting districts on the northern and northeastern boundaries of Yellowstone National Park, 1979-87.

HUNTING DISTRICT	YEAR	BULL	SPIKE	COW	CALF	UNKNOWN	TOTAL
310	1979	72	42	-	-	-	114
310	1980	87	67	19	5	6	184
310	1981	105	105	27	7	-	244
310	1982	143	96	15	2	-	343
310	1983	62	101	14	15	-	192
310	1984	53	70	12	-	-	135
310	1985	75	71	30	3	-	179
310	1986	99	NC	78	10	-	187
310	1987						
313	1979	36	56	22	2	2	118
313	1980	35	84	21	1	-	141
313	1981	140	58	21	1	-	220
313	1982	226	100	17	-	-	343
313	1983	118	120	38	28	-	304
313	1984	102	57	51	4	-	214
313	1985	132	101	61	10	-	304
313	1986	397	NC	305	64	-	766
316	1979	37	17	17	-	5	76
316	1980	60	13	19	-	-	92
316	1981	60	23	31	10	-	124
316	1982	52	25	22	4	1	203
316	1983	85	15	-	-	-	100
316	1984	107	15	24	-	-	146
316	1985	86	17	36	6	-	145
316	1986	97	NC	23	8	-	128
361	1979	9	16	7	-	-	32
361	1980	26	9	15	2	-	52
361	1981	49	17	17	5	-	88
361	1982	43	21	13	2	-	79
361	1983	39	17	19	5	-	80
361	1984	16	28	25	1	-	70
361	1985	21	5	22	3	-	51
361	1986	18	NC	20	6	-	44
361	1987						
362	1979	No Data					
362	1980	No data					
362	1981	No data					
362	1982	No data					
362	1983	31	84	90	22	-	227
362	1984	48	26	161	4	-	239

APPENDIX IV, Con't.

HUNTING DISTRICT	YEAR	BULL	SPIKE	COW	CALF	UNKNOWN	TOTAL
362	1985	59	17	127	24	-	227
362	1986	65	NC	160	21	-	246
362	1987						

NC = Not separated (classified) into bulls and spikes.

Data taken from:

(1) Chrest, H. 1979. Montana Big Game Survey and Inventory, Region Three. Project No.:I-3 (segment B) Elk. Project No.:W-130-R-11. Montana Department of Fish, Wildlife, and Parks, Helena. Table 3. pp.36-39.

(2) _____. 1981 Montana Big Game Survey and Inventory, Region Three. Project NO.:I-3 (segment B) Elk. Project No.:W-130-R-12. Montana Department of Fish, Wildlife, and Parks, Helena. Table 3, pp.23.

(3) _____. 1982. Montana Big Game Survey and Inventory, Region Three. Project No.:I-3 (segment B) Elk. Project No.:W-130-R-13. Montana Department of Fish, Wildlife, and Parks, Helena. Table 4. pp.32.

(4) _____. 1983. Montana Big Game Survey and Inventory, Region Three, Project No.I-3(segment B) Elk. Project No.:W-130-R-14. Montana Department of Fish, Wildlife, and Parks, Helena. Table 4. pp.41.

(5) _____. 1984. Montana Big Game Survey and Inventory,Region Three. Job N.:I-3 (segment B) Elk. Project No.:W-130-R-15. Montana Department of Fish, Wildlife, and Parks, Helena. Table 4. pp.47.

(6) _____, and J. Herbert. 1985. Montana Big Game Survey and Inventory,Region Three. Project NO.:I-3 (segment B) Elk. Project No.:W-130-R-16. Montana Department of Fish, Wildlife, and Parks, Helena. Table 4. pp.53.

(7) _____. 1986. Montana Big Game Survey and Inventory, Region Three. Job No.:1-3 (segment B) Elk. Project No.:W-130-R-17. Montana Department of Fish, Wildlife, and Parks, Helena. Table 4. pp.28.

(8) _____. 1987. Montana Big Game Survey and Inventory, Region Three. Job No. 1-3 (segment B) Elk. Project No.:W-130-R-18. Montana Department of Fish, Wildlife, and Parks, Helena. Table 4. pp.27.

APPENDIX V. Harvest statistics for elk on Yellowstone's northern elk winter range[1], 1979-87.

	REGULAR SEASON H.D. 313					LATE HUNT HARVEST			
YEAR	TOTAL	ADULT BULLS	SPIKE BULLS	COWS	CALVES	TOTAL	BULLS	COWS	CALVES
1979	118	36	56	22	2	467	285	157	25
1980	114	35	84	21	1	133	75	42	16
1981	219	140	58	21	1	1,015	491	422	100
1982	342	226	100	17	0	1,462	470	712	241
1983	303	118	120	38	28	1,652	396	816	396
1984	213	102	57	51	3	1,206	173	742	291
1985	313	146	103	53	9	1,058	126	728	204
1986	766	-397-		305	64	829	68	557	204
1987									

[1]Data include all of northern range except a small portion of hunting district 314 between Mol Heron Creek and Sphinx Creek, which is part of the northern range, but the harvest there was impossible to separate from the rest of the hunting district.

Source: (1) Chrest, H. 1986. Montana Big Game Survey and Inventory, Region III, Elk, Job No.:I-3, Project No.:W-130-R-17. Montana Department of Fish, Wildlife, and Parks, Helena. Table 13, pp.35.

APPENDIX VI. Elk counted per count unit on Yellowstone's northern winter range.

COUNT UNIT	Feb. 1988	Feb. 1988	Jan. 1988	Feb. 1987	Dec. 1986
1	45	5	57	146	19
2	--	--	0	256	32
3	--	--	68	103	49
4	43	15	16	88	34
5	--	--	60	31	16
6	1206	1056	1621	648	1625
7	--	--	4	35	31
8	--	--	288	180	177
9	--	--	170	201	153
10	13	7	52	15	0
11	--	--	273	582	508
12	--	--	483	349	604
13	0	0	15	2	0
14	--	--	28	40	0
15	--	--	19	108	297
16	349	--	117	290	229
17	--	--	85	337	169
18	200	174	419	132	763
19	--	--	557	--	328
20	--	--	1415	904	536
21	514	--	493	848	702
22	267	119	344	210	314
23	121	--	98	70	185
24	295	165	166	129	338
25	--	--	278	104	43
26	113	52	356	38	171
27	--	--	213	11	11
28	--	--	285	300	360
29	--	--	309	41	321
30	372	209	331	90	403
31	95	141	139	--	47
32	--	--	64	--	116
33	--	--	104	--	91
34	--	--	959	--	430
35	--	--	0	--	24
36	--	--	1299	--	592
37	--	--	1	--	2
38	--	--	0	--	0
39	--	--	5	--	13
40	--	--	31	--	34
41	--	--	121	--	21
42	237	28	284	161	115
43	--	--	70	16	295
44	--	--	50	--	0
45	--	--	14	--	0

Continued:

APPENDIX VI. Elk counted per count unit on Yellowstone's northern winter range.

COUNT UNIT	Feb. 1988	Feb. 1988	Jan. 1988	Feb. 1987	Dec. 1986
46	--	--	301	--	100
47	--	--	1167	--	324
48	40	--	522	2	1134
49	--	--	129	159	34
50	--	--	720	207	--
51	348	158	163	336	157
52	--	--	1000	944	368
53	--	--	732	342	432
54	--	--	161	--	37
55	478	--	764	632	445
56	301	--	310	118	165
57	--	--	325	357	2024
58	382	237	516	48	964
59	--	--	0	8	0
60	--	--	0	0	0
61	--	--	0	353	21
62	--	--	1	152	0
63	281	180	12	411	62
64	--	--	70	381	337
65	--	--	2	19	23
66	95	100	257	679	182



Illustration by Charles W. Schwartz

Courtesy of Big Game of North America,

Ecology & Management