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Predation by a Regulated Wolf Population on Moose and Caribou

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RESEARCH PROGRESS REPORT

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TITLE: Predation by a Regulated Wolf Population on Moose and Caribou

AUTHORS: Mark E McNay and Jay Ver Hoef

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SUMMARY

We created and simulated a new sampling design to estimate wolf (*Canis lupus*) predation rates on ungulates during winter. Previous estimates of wolf predation rates were drawn from late autumn or early spring surveys, and consequently may be biased by seasonal variation in prey selection, prey vulnerability, wolf pack size, and wolf pack composition. Our sampling method should eliminate that potential seasonal bias. In computer simulations we obtained estimates with a 90% CI of ±24% of the true kill value. Simulations used 11 consecutive 4-day periods that were randomly distributed within 11 2-week periods between late October and early April. We applied the design in the field during winter 1998–1999 and again during winter 2000–2001. During winter 1998–1999 we monitored 12 wolf packs between 8 November and 18 March. We detected 52 kills made by those packs. During winter 2000–2001 we monitored 8 wolf packs between 29 October and 4 April and detected 86 kills. We visited 76% of the kill sites and collected bone marrow samples from killed ungulates. Teeth from killed ungulates older than 2 years of age were extracted and sectioned to estimate cementum age. During the kill-rate study period, we also monitored distribution of the Delta caribou (*Rangifer tarandus*) herd within the study area; however, during both winters moose (*Alces alces*) were the primary prey of all monitored wolf packs and moose comprised an estimated 90% and 98% of the ungulate biomass in the wolf diet during the winters 1998–1999 and 2000–2001, respectively.

Key words: caribou, Dall sheep, moose, predation rates, wolves.

CONTENTS

BACKGROUND

Gasaway et al. (1983) documented the early history of wolf (*Canis lupus*) management in Unit 20A. Between 1954 and 1960, the Unit 20A wolf population was reduced by poisoning and aerial shooting to a density of approximately 4 wolves/1000 km^2. After wolf control ended in 1960, wolves increased and by 1970 had attained densities of 16 wolves/1000 km^2. Moose (*Alces alces*) increased to high densities (≥1300 moose/1000 km^2) by the mid-1960s, then declined to a low density (165 moose/1000 km^2) by 1975. Between 1976 and 1979, wolves were again reduced by aerial shooting to a density of 3 wolves/1000 km^2. Moose, caribou (*Rangifer tarandus*), and wolf populations all increased during the 1980s and wolves reached a density of 16 wolves/1000 km^2 by autumn 1991 (Boertje et al. 1996). Wolves were reduced during a third government wolf control program during winters 1993–1994 and 1994–1995.

Recently, the wolf management controversy in Alaska has focused on 2 issues: whether reducing wolf populations will result in increased moose and caribou populations and, secondly, what socially acceptable methods can be used to reduce wolf predation on moose and caribou.

The debate over the efficacy of wolf control persists because some past wolf control programs have failed to produce measurable increases in moose or caribou, while other programs clearly have increased numbers of these species (Gasaway et al. 1983). Public attitudes toward wolf control methods reflect changes in the values of Alaskan society. Control methods used before statehood are now either considered to be unacceptable (i.e., poisoning and denning) or unpopular (e.g., aerial gunning). "Far greater support exists for ground-based hunting, trapping and snaring to kill wolves. Most Alaskans support wolf and bear control by local hunters rather than by professional wildlife personnel" (National Academy 1997). Consistent with those National Academy of Sciences findings, recent proposals to the Board of Game for wolf predation control have advocated increased harvest by local users, and private organizations have developed monetary incentive programs to encourage local hunters and trappers to kill more wolves. We believe future management of wolf predation on moose and caribou will continue to focus on ground-based hunting and trapping by local hunters and trappers.

Predation rates by wolves on moose and caribou are related to both the number of wolves and to the number of wolf packs within a population. Wolf populations that are harvested by hunting and trapping at moderate levels may be efficiently regulated numerically, but not socially. Conceivably, light to moderately exploited wolf populations could instantaneously increase per capita predation and annually increase finite growth rates so that total predation rates are similar to those of an unregulated wolf population. Therefore, before manipulating wolf populations to reduce predation, managers must be able to estimate predation rates from regulated vs. unregulated wolf populations.

To estimate winter predation rates by wolves in northern ecosystems, biologists customarily follow wolf packs from the air for a specified number of consecutive days and record the number of kills. It is important that flights be conducted frequently because wolves may consume killed caribou or sheep (*Ovis dalli*) within a few hours. Previous studies contained 1 or 2 sampling periods each of 20–45 days, in either early or late winter (Ballard et al. 1987; Hayes et al. 1991; Valkenburg 1992; Dale et al. 1995). However, prey vulnerability to wolf predation changes throughout winter. Some sex and age classes are inherently more vulnerable in early vs. late winter, and seasonal snow depths and prey distribution change overall prey vulnerability (Mech et al. 1995). Continual daily monitoring of wolf packs throughout the winter is impractical, but surveys flown in only 1 or 2 periods of the winter (e.g., early winter and late winter) are inherently biased. Theoretically, an unbiased estimate of wolf predation, with an estimate of precision, could be obtained by flying frequent, short (3–10 day) sampling periods throughout winter. That method would also be cost-effective and practical.

STUDY OBJECTIVES

1 Develop an unbiased aerial survey method to estimate predation rates on moose and caribou by a wolf population that is regulated by ground-based hunting and trapping.

2 Identify predation-rate characteristics associated with packs of different size and social structure.

3 Integrate these findings with results of a previous study on wolf population responses to trapping and hunting (McNay 1999).

4 Develop recommendations for the use of ground-based hunting and trapping to manage wolf predation on moose and caribou. The findings of the study will be evaluated relative to current wolf-ungulate management practices.

JOB OBJECTIVES

Job 1 Capture and radiocollar approximately 9 wolves in 9 different packs in the Alaska Range foothills in Unit 20A.

Job 2 Estimate wolf predation on moose and caribou by monitoring wolf activities during eleven 4-day aerial surveys conducted between October and April.

Job 3 Visit kill sites of moose and caribou via helicopter to determine age, sex and condition of prey killed by wolves.

Job 4 Monitor distribution of moose and caribou within the kill-rate study area.

Job 5 Purchase wolf carcasses from private trappers who take wolves within the study area.

Job 6 Estimate the proportion of snowshoe hares in the wolf diet.

Job 7 Fly aerial surveys to estimate the wolf population within the study area.

Job 8 Complete data analysis and write reports integrating information on the effects of human harvest on wolves with information on predation rates on moose and caribou by wolves.

Job 9 The principal investigator will present the results of this study at agency workshops, agency meetings, or scientific conferences related to the management of northern wolf-prey systems.

STUDY AREA

The study area lies within Unit 20A (17,601 km^2) of Interior Alaska. Elevations within the study area range from 110 to 4000 m, but most wolves and their prey are at elevations below 2000 m. As the terrain slopes upward from north to south, the habitat changes from poorly drained "flats" of boreal spruce forest underlain by permafrost through a zone of alpine shrubs and into an alpine community of grasses, sedges, and forbs. Elevations above 2000 m are often covered by permanent snow or glacial ice.

Wolves prey primarily on moose, caribou, and Dall sheep. A small herd of approximately 400 bison (*Bison bison*) occupy grass/sedge meadows along the eastern edge of the study area in summer and autumn. Bison are available as prey for only 1 wolf pack within the study area. Other wolf prey include beavers (*Castor canadensis*), snowshoe hares (*Lepus americanus*), and ground squirrels (*Spermophilus undulatus*). Beavers are common in the drainages along the foothills of the Alaska Range. Snowshoe hare numbers increased during the study period as they approached the high of their 10-year cycle. Other potential ungulate predators include black bears (*Ursus americanus*), grizzly bears (*Ursus arctos*), coyotes (*Canis latrans*), wolverine (*Gulo gulo*), and lynx (*Felis lynx*). Golden eagles (*Aquila chrysaetos*) also prey on newborn caribou and Dall sheep.

The area is roadless except for seasonal mining trails and trails to homestead sites along the western boundary of the area. Two families occupy permanent homestead sites in the center of the study area. The community complexes of Healy/McKinley Park and Delta Junction/Fort Greely lie outside the western and eastern boundaries, respectively. Denali National Park lies adjacent to the study area to the west. Access to the study area is by air via numerous airstrips associated with mining or guiding, or unimproved landing sites along streams and ridges.

METHODS

DESIGNING A PERIODIC SAMPLING SCHEME TO ESTIMATE WOLF PREDATION RATES ON MOOSE AND CARIBOU

Jobs 2 and 8

In 1998 we constructed a computer simulation of a periodic sampling design to estimate kill rates of moose and caribou by wolves. Our goal was to develop a method with acceptable accuracy and precision that involved no more than 45 total flying days distributed among short survey periods throughout the winter. We envisioned each survey period occurring over as few days as possible to avoid weather interruptions and hoped that by distributing survey periods throughout the winter, we would avoid bias associated with sampling during only 1 season (i.e., typically Nov or Mar).

Using empirical wolf kill rates (Ballard et al. 1997) and prey sex-age composition data (Mech et al. 1995), we built a table of expected intervals between wolf kills. To provide random variation, we assumed a Poisson distribution (i.e., variance = mean) for the empirical wolf kill rates. The table included expected intervals (in days) following a caribou kill and following a moose kill for wolf pack sizes of 2–15. The mean interval following moose kills was longer

(2.49×) than that following caribou kills because moose provided more food biomass per kill. We then constructed 2 transition matrices that described the probabilities that wolves would kill either a moose or a caribou in our simulated ecosystem following the kill of either a moose or a caribou. In the first case, we assumed that wolves preyed primarily on moose because moose were evenly distributed and more abundant in the study area than caribou (moose prey matrix). For the second case, we assumed that once a pack killed a caribou, the probability increased that the pack would kill another caribou. That transition matrix simulated the clumped distribution of caribou and reflected a preferred preference by wolves for caribou when available (caribou/moose matrix).

Then for each pack size of 2, 5, 7, 10, and 14, we constructed a "true" kill sequence for each transition matrix. Once the true kill sequences were established, we applied 5 periodic sampling designs to kill sequences for each of the 5 pack sizes among each of the 2 transition matrices. All sample designs consisted of 42 to 45 total flying days, but they were divided into randomly distributed sequences of 2-, 3-, 4-, 5-, or 6-day periods. For example, one sample design called for 22 2-day flying periods randomly distributed throughout the winter, another called for 7 6-day periods.

Estimated kill for each simulation was calculated as $(K/N) * D$, where K = # of kills detected, N = number of sample days, and D = number of days in winter. N, the number of sample days, was defined as $F–P$, where F = total flying days (i.e., 42–45) and P = number of random periods, because the first day of each period was not included as a sample day. K was calculated for caribou, moose, and total ungulates for each of the simulations. We simulated 100 winters of sampling for each of the 50 combinations of pack size, sample design, and transition matrix.

Wolf Capture and Handling

Job 1

We darted wolves from helicopters, using 3cc Palmer Cap-Chur® darts (Douglasville, Georgia, USA) loaded with 500–560 mg of Telazol® (tiletamine HCl and zolazepam HCl, Fort Dodge Lab, Fort Dodge, Iowa, USA) and propelled by low-velocity (brown) charges. Wolves were either eartagged or fitted with radio collars containing a mortality-sensing device (Telonics, Inc. Mesa, Arizona USA).

Estimating Wolf Predation on Moose, Caribou, and Dall Sheep

Job 2

The winter period was divided into 12 2-week periods beginning 29 October and ending 16 April. During each period a random date was selected and beginning on that date we attempted to monitor the movements and predation activities of 8–9 wolf packs for 4 consecutive days. We flew in small aircraft (Piper PA-18 or Bellanca 8GCBC) and located radiocollared wolves from the air. The location and activity data from the first day of each period was used to establish a starting point for the estimation procedure. On subsequent flights (i.e., days 2–4) we attempted to backtrack each pack to their previous day's location by following their tracks in the snow. We attempted to fly at least 4 consecutive days during each sampling period, but weather prevented us from completing 2 sampling periods in 1998. On 4 occasions in 1998 and on 3 occasions in 2000 weather interrupted a sampling period, and we did not fly on 1 or 2 days. One complete sampling period was canceled in late January 1999 because of extreme cold.

Fresh ungulate kills detected on days 2–4 were used in calculating the kill rate. The number of kills made by each pack during 29 October–4 April will be estimated as $(K/N) * D$, where K was the number of kills detected on sampling days, N was the number of total sample days and D represents the total days during the winter study period (i.e., 8 Nov–18 Mar in 1998–1999; 29 Oct–4 Apr in 2000–2001).

To enable calculation of per capita consumption rates, we monitored changes in pack size as well as kill rate. Determining pack sizes in packs with only 1 or 2 radio collars can be difficult because a) wolves are often concealed in dense cover and b) some proportion of unmarked pack members are often temporarily disassociated from the radiocollared animals. Therefore, in most cases we defined pack size during each 4-day sampling period as the largest number of wolves observed during or subsequent to that sampling period. Defined in that way, pack size normally remains stable or declines over time. However, in one instance we observed an increase in pack size that resulted from recruitment of a new pack member during midwinter. In that case, pack size increased above previous levels.

VISIT KILL SITES OF MOOSE AND CARIBOU VIA HELICOPTER TO DETERMINE AGE, SEX, AND CONDITION OF PREY KILLED BY WOLVES

Job 3

Using a helicopter, we visited kill sites identified during sampling periods. Generally, we conducted site visits after even-numbered sampling periods (i.e., period 2, 4, 6, etc.) and conducted a final site visit in early summer after snowmelt. At each kill site we attempted to determine the species, sex, age, and body condition of the prey. When available we collected a lower jaw and extracted an incisor for cementum aging. We also extracted bone marrow from long bones and estimated the proportion of fat in the marrow using the dry weight method (Neiland 1970). We did not apply a correction for nonfat residue in the dried sample because no correction has been derived specifically for moose. However, based on the corrections derived from caribou marrow fat, any correction would likely be insignificant (Neiland 1970).

MONITOR DISTRIBUTION OF MOOSE AND CARIBOU WITHIN THE KILL-RATE STUDY AREA

Job 4

During autumn 1998 and autumn 2000 at least 70 caribou wore radio collars within the wolf study area. Some of those caribou spend portions of the winter on the north side of the Alaska Range within the kill-rate study area, but they move frequently between wolf home ranges. On the first day of each 4-day sampling period, we located all radiocollared caribou within the predation rate study area. The study area was defined by a perimeter that included territories of the wolf packs that were monitored during the sampling periods. All wolf pack territories in the study area were contiguous. We used the proportion of radiocollared caribou within vs.

outside the study area as an estimate of the proportion of the caribou population that was within the study area. Minimum population estimates of the Delta caribou herd were derived from aerial photographs of caribou groups surrounding radiocollared animals during postcalving aggregations in summer (Valkenburg et al. 1985).

MORTALITY AND POSTMORTEM EXAMINATIONS

Job 5

We purchased wolf carcasses from private trappers. During postmortem examinations we recorded location, method and date of take, and body measurements. Female reproductive tracts were removed and dissected. We counted placental scars, excised and weighed xiphoid fat, collected tissue and noted injuries. Skulls were cleaned and an upper premolar was extracted for cementum aging from animals more than 1 year of age. First year animals were aged on evidence of incomplete epiphysal closure in the radius and ulna. When possible we assigned a pack affiliation to each harvested wolf.

ESTIMATE THE PROPORTION OF SNOWSHOE HARES IN THE WOLF DIET

Job 6

Wolf scats not associated with ungulate kills were collected along trails and frozen river travel corridors during winter 2000–2001. The scats were placed in plastic whirl packs, labeled, and shipped to Big Sky Laboratory in Florence, Montana for analysis.

RESULTS AND DISCUSSION

DESIGNING A PERIODIC SAMPLING SCHEME TO ESTIMATE WOLF PREDATION RATES ON MOOSE AND CARIBOU

Results of the simulations were evaluated in terms of the mean square error value resulting from the 100 simulations for each sample design/pack/matrix combination. Based on those values, we chose a sample design that called for 11 4-day sampling periods. Predicted 90% confidence limits around the true kill for all pack sizes pooled were ±24% for the moose prey matrix and ±22% for the caribou/moose prey matrix. Increasing the length of sampling periods to 6 days marginally increased precision, but we believed that weather constraints would have prevented us from completing most 6-day sampling periods.

We applied our computer simulation as a field test in 1998 and monitored 12 wolf packs varying in size from 1 to 15 wolves during 10 sampling periods between 8 November 1998 and 18 March 1999. During winter 2000–2001 we monitored 8 packs of 2–16 wolves during 12 sampling periods between 29 October and 4 April.

WOLF CAPTURE AND HANDLING

Dispersal and mortality of radiocollared wolves continually reduced the number of radio collars within study packs. In October 2000 we captured 5 wolves in 3 packs within the kill-rate study area to supplement our radiocollared sample. Similarly, we captured an additional 7 wolves in 4 packs within the study area during February 2001.

Estimating Wolf Predation on Moose, Caribou and Dall Sheep

We surveyed 38 total days with 28 sample days during winter 1998–1999 and 43 total days with 33 sample days during 2000–2001. However, because of localized weather conditions, not all packs were surveyed on each survey day. During winter 1998–1999 we detected 62 sites where wolves had killed ungulates or wolves were scavenging prey remains; 25 of those kills were fresh kills detected on sample days and were used in kill-rate calculations. During winter 2000–2001 we detected 45 fresh kills on sample days among a total of 86 kill or scavenging sites detected during survey flights.

In studying predation we must keep in mind that percentages between numbers of kills ("numerical" kills) often vary widely from percentages of biomass in wolf diets. For example, moose were the most common prey item for all packs during both winters accounting for 72% of the ungulates killed during 1998–1999 and 91% of the ungulates killed on sample days during winter 2000–2001 (Tables 1 and 2). Caribou accounted for 20% of the numerical kill in 1998 but only 2% of the numerical kill in 2000–2001; 8% of the 1998–1999 kills were Dall sheep and 7% of the 2000–2001 kill were Dall sheep. Based on common weights among all sex and age classes of sheep, caribou and moose ungulates have a relative biomass ratio of 0.17:0.32:1.00, respectively (McNay 1998, p. 181). Therefore, among wolves within the study area, moose biomass represented 90% of the wolf population's ungulate diet in 1998–1999 and 98% in 2000–2001.

Because large packs kill more ungulates than small packs (Ballard et al. 1987; Dale et al. 1995), pack size is an important aspect of wolf-prey interactions. During the kill-rate surveys, pack sizes changed as wolves within the study area were harvested; others died of natural mortality or dispersed from the study area. Therefore, kill rates based upon spring surveys alone may be biased not only because of seasonal differences in per capita kill rates but also because wolf packs tend to become progressively smaller toward late winter. Mean pack size among monitored wolf packs within the study area declined from 7.3 ($n = 8$) in autumn 1998 to 4.4 ($n = 5$) in spring 1999, and 2 packs were eliminated by hunters and trappers before the end of winter. Similarly, mean pack size declined from 8.1 in autumn 2000 ($n = 8$) to 3.9 in spring 2001 ($n = 7$), and 1 pack was eliminated during that winter (Tables 3 and 4).

Visit Kill Sites of Moose and Caribou Via Helicopter to Determine Age, Sex and Condition of Prey Killed by Wolves

We examined the remains from 39 of the 52 kills identified during winter 1998–1999 and 66 of 86 kills identified during winter 2000–2001. Among the 138 ungulate kills identified, 70 were killed on sample days and were included in kill-rate calculations. Twenty-five ungulates were killed on sample days during winter 1998–1999; 45 were killed on sample days during winter 2000–2001. Marrow was collected from 17 ungulate kills in winter 1998–1999 and from 68 kills in 2000–2001 (Table 5).

Monitor Distribution of Moose and Caribou Within the Kill-Rate Study Area

Stratified random population estimates of moose were completed within the study area in autumn 1998 and 2000 (Don Young, ADF&G, personal communication). Radiocollared caribou were also monitored within the study area during both years. Among an estimated 71 radiocollared caribou in the Delta Herd in autumn 1998 and 77 radiocollared caribou in the herd in autumn 2000, 13–32% spent a portion of the winter within the kill-rate study area. Occupation of the study area was highest in the early autumn and early spring. During winter most of the Delta caribou herd remained outside of the study area. The Delta caribou herd was estimated to contain 3829 and 3227 caribou during 1998 and 2000, respectively (Don Young, ADF&G, personal communication).

MORTALITY AND POSTMORTEM EXAMINATIONS

We conducted postmortem examination of 12 radiocollared wolves that were members of study packs and killed during the kill-rate periods; 8 were killed from 5 packs in 1998 and 4 radiomarked wolves were killed from 4 packs. Other wolves killed 2 of these wolves; trappers killed the remaining 10.

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LITERATURE CITED

BALLARD WB, JS WHITMAN, AND CL GARDNER. 1987. Ecology of an exploited wolf population in southcentral Alaska. *Wildlife Monographs* 98.

———, LEE ANNE AYRES, PAUL R. KRAUSMAN, DANIEL J. REED AND STEVEN G. FANCY. 1997. Ecology of wolves in relation to a migratory caribou herd in Northwest Alaska. *Wildlife Monographs* 135.

BOERTJE RD, P VALKENBURG, AND ME MCNAY. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. *Journal of Wildlife Management* 60(3):474–489

DALE BW, LG ADAMS, AND RT BOWYER. 1995. Winter wolf predation in a multiple prey system, Gates of the Arctic National Park, Alaska. Pages 223–230 *in* LN Carbyn, SH Fritts, and D Seip, editors. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication 35.

GASAWAY WC, RO STEPHENSON, JL DAVIS, PEK SHEPHERD, AND OE BURRIS. 1983. Interrelationships of wolves, prey, and man in interior Alaska. *Wildlife Monographs* 84.

HAYES RD, AM BAYER, AND DG LARSON. 1991. Population dynamics and prey relationships of an exploited and recovering wolf population in the southern Yukon. Yukon Fish and Wildlife Branch Final Rep. TR-91-1.

MCNAY ME. 1999. Investigation of wolf population response to intensive trapping in the presence of high ungulate biomass. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Progress report. Grant 27-1. Study 14.17. Juneau, Alaska.

———. 1998. Development and Testing of a General Predator-Prey Computer Model for Use in Making Management Decisions. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research Final Report. Grant W-24-1 and W-24-5. Study 1.46. Juneau, Alaska.

MECH LD, TJ MEIR, JW BURCH, AND LG ADAMS. 1995. Patterns of prey selection by wolves in Denali National Park, Alaska. Pages 231–244 *in* LN Carbyn, SH Fritts, and D Seip, editors. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute. Occasional Publication 35.

NEILAND KA. 1970. Weight of dried marrow as indicator of fat in caribou femurs. *Journal Wildlife Management* 34(4):904-907.

NATIONAL ACADEMY OF SCIENCES. 1997. Wolves Bears, and their Prey in Alaska.

VALKENBURG P. 1992. Investigation of limiting and regulating factors in the Delta caribou herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research Final Report. Grant W-23-5. Study 3.37. Juneau, Alaska.

———, DA ANDERSON, JL DAVIS, AND DJ REED. 1985. Evaluation of an aerial photocensus technique for caribou based on radiotelemetry. Proceedings of second North American caribou workshop, Val Morin, Quebec. McGill Subarctic Research Paper 40.

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Table 1 Number and type of prey killed on sample days by monitored wolf packs between 9 November 1998 and 18 March 1999

	Number of prey killed on sample days											
	Moose				Caribou			Sheep			Total	No. of sample
Pack name	Calf	Adult	Yrlg	Unk	Calf	Adult	Unk	Lamb	Adult	Unk	kills	days
Westfork	3	3				2	2		1		11	24
Dry Creek											0	3
Dry Flat	3	4	1								8	27
Buzzard		1									1	27
Slide											0	18
Rockstad							1				1	23
Sheep										1	1	15
Paradise	1		2								3	18
Boulder											0	16
3-Mile											0	6
Rogers											0	8
Bonnifield											0	8
Totals	7	8	3	0	0	2	3	0	1	1	25	

Table 2 Number and type of prey killed on sample days by monitored wolf packs between 30 October 2000 and 4 April 2001

	Number of prey killed on sample days											
	Moose				Caribou			Sheep			Total	No. of sample
Pack name	Calf	Adult	Yrlg	Unk	Calf	Adult	Unk	Lamb	Adult	Unk	kills	days
Dry Flat	6	5	1								12	31
Buzzard		3	2	2							7	29
Rockstad	1	1	1			1					4	29
Sheep		2	1	1					1		5	29
Boulder		1	2								3	28
Benches	3	2									5	31
Red Mountain	2	1	2							1	6	30
Grubstake	1		1							1	3	22
Totals	13	15	10	3	0	1	0	0	1	2	45	

Table 3 Maximum pack sizes recorded during each sampling period for packs that killed ungulate prey on sample days, winter 1998–1999

	Sampling period										Mean pack
Pack name	1	2	3	4	5	6	7	8	9	10	size
Westfork	15	15	15	15	15	15	15	13	13	12	14.3
Dry Flat	14	14	14	14	14	14	13	13	9	8	12.7
Buzzard	5	5	5	5	5	5	5	5	5	5	5.0
Rockstad	2	2	2	2	2	2	2	2	2	2	2.0
Sheep	2	2	2	2	1	1	1	1	2	2	1.6
Paradise	5	6	6	5	5	5	5	2	0	0	3.9
Slide	2	2	2	2	1	1	1	1	1	0	1.3
Boulder[a]	13	13	13	8	7	6	6	6	6	6	8.4
Mean pack size	7.3	7.4	7.4	6.6	6.3	6.1	6.0	5.4	4.8	4.4	6.2

[a] The Boulder pack was not collared and did not become a part of the study until period 3.

Table 4 Maximum pack sizes recorded during each sampling period for packs that killed ungulate prey on sample days, winter 2000–2001

Pack name	Sampling period												Mean pack size
	11	12	13	14	15	16	17	18	19	20	21	22	
Dry Flat	16	16	16	15	15	15	15	15	14	11	11	10	14.1
Buzzard	8	8	8	8	7	7	7	7	7	6	6	3	6.8
Rockstad	5	5	5	5	5	5	5	5	5	5	5	5	5.0
Sheep	12	12	12	12	12	7	6	6	6	6	6	2	8.3
Boulder	3	3	3	3	3	3	3	2	2	2	2	0	2.4
Benches	3	3	3	3	3	3	3	3	3	3	3	2	2.9
Red Mountain	11	11	9	9	9	9	9	9	8	4	4	3	7.9
Grubstake	7	7	7	7	7	7	7	7	7	7	7	6	6.9
Mean pack size	8.1	8.1	7.9	7.8	7.6	7.0	6.9	6.8	6.5	5.5	5.5	3.9	6.8

Table 5 Percent fat in bone marrow of ungulates killed by monitored wolf packs during winters 1998–1999 and 2000–2001

Winter	Prey ID #	Killed on sample day?	Prey species	Sex	Age	Date of kill	% Fat[a]	Bone type
1998–1999	04-9801	N	Moose	Unknown	Unknown	11/8/98	N/A	N/A
1998–1999	04-9802	Y	Moose	Unknown	Calf	11/10/98	N/A	N/A
1998–1999	04-9803	Y	Moose	Unknown	Calf	11/11/98	N/A	N/A
1998–1999	04-9804	Y	Caribou	Female	Adult	11/19/98	N/A	N/A
1998–1999	04-9805	Y	Caribou	Female	Adult	11/20/98	N/A	N/A
1998–1999	04-9806	Y	Moose	Female	Adult	12/2/98	N/A	N/A
1998–1999	04-9807	Y	Moose	Unknown	1	12/31/98	N/A	N/A
1998–1999	04-9808	N	Moose	Male	9	1/13/99	N/A	N/A
1998–1999	04-9809	N	Moose	Female	14	2/11/99	90.1	long bone
1998–1999	04-9810	Y	Sheep	Male	10	2/13/99	N/A	N/A
1998–1999	04-9811	Y	Moose	Unknown	Adult	2/24/99	86.2	long bone
1998–1999	04-9812	Y	Moose	Female	18	3/5/99	81	long bone
1998–1999	04-9813	N	Moose	Female	Adult	3/15/99	N/A	N/A
1998–1999	04-9814	Y	Caribou	Unknown	Unknown	3/18/99	N/A	N/A
1998–1999	04-9815	Y	Caribou	Unknown	Unknown	3/18/99	N/A	N/A
1998–1999	31-9801	Y	Moose	Unknown	Calf	11/9/98	42.7	long bone
1998–1999	31-9803	Y	Moose	Male	1	11/18/98	N/A	N/A
1998–1999	31-9804	N	Moose	Unknown	Calf	11/29/98	N/A	N/A
1998–1999	31-9805	Y	Moose	Male	1	12/1/98	N/A	N/A
1998–1999	31-9806	N	Caribou	Unknown	Unknown	12/13/98	N/A	N/A
1998–1999	31-9807	Y	Moose	Male	2	12/16/98	N/A	N/A
1998–1999	31-9808	N	Moose	Unknown	2	12/29/98	N/A	N/A
1998–1999	31-9809	Y	Moose	Unknown	Calf	1/13/99	22.6	long bone
1998–1999	31-9810	Y	Moose	Female	Calf	1/13/99	27.9	long bone
1998–1999	31-9811	Y	Moose	Female	6	2/14/99	87	long bone
1998–1999	31-9812	N	Moose	Female	1	2/22/99	N/A	N/A
1998–1999	31-9813	Y	Moose	Unknown	Adult	3/5/99	89.1	long bone
1998–1999	41-9801	Y	Moose	Female	4	11/10/98	N/A	N/A
1998–1999	41-9802	N	Moose	Female	15	11/29/98	N/A	N/A
1998–1999	41-9803	N	Caribou	Male	7	12/13/98	N/A	N/A
1998–1999	41-9804	N	Moose	Unknown	Adult	1/12/98	86.6	long bone
1998–1999	41-9805	N	Moose	Female	1	2/21/99	89.8	long bone
1998–1999	42-9803	N	Moose	Female	9	1/12/99	81.9	long bone
1998–1999	43-9801	N	Moose	Male	Adult	11/19/98	N/A	N/A
1998–1999	43-9802	Y	Caribou	Unknown	Unknown	1/14/99	N/A	N/A
1998–1999	43-9803	N	Caribou	Unknown	Unknown	2/21/99	N/A	N/A
1998–1999	43-9804	N	Moose	Unknown	Adult	2/24/99	N/A	N/A
1998–1999	44-9801	Y	Sheep	Unknown	Unknown	12/1/98	N/A	N/A
1998–1999	44-9802	N	Moose	Female	Adult	12/14/98	N/A	N/A
1998–1999	44-9803	N	Moose	Female	7	1/14/99	80	long bone

Table 5 Continued

Winter	Prey ID #	Killed on sample day?	Prey species	Sex	Age	Date of kill	% Fat[a]	Bone type
1998–1999	45-9802	Y	Moose	Female	1	11/18/98	N/A	N/A
1998–1999	45-9804	Y	Moose	male	1	12/14/98	N/A	N/A
1998–1999	45-9805	Y	Moose	Unknown	Calf	1/14/99	N/A	N/A
1998–1999	45-9806	N	Moose	Female	19	2/11/99	74.8	long bone
1998–1999	46-9801	N	Moose	Male	1	11/29/98	88.3	long bone
1998–1999	46-9802	N	Moose	Unknown	Calf	12/13/98	N/A	N/A
1998–1999	46-9803	N	Moose	Female	18	1/14/99	67.9	long bone
1998–1999	46-9804	N	Moose	Female	C	2/12/99	29.2	long bone
1998–1999	46-9805	N	Moose	Unknown	Unknown	2/21/99	N/A	N/A
1998–1999	46-9806	N	Moose	Unknown	Unknown	3/3/99	N/A	N/A
1998–1999	46-9807	N	Moose	Unknown	Unknown	3/15/99	N/A	N/A
1998–1999	49-9801	N	Moose	Female	14	3/2/99	78.9	long bone
2000–2001	04-0001	N	Moose	Unknown	Adult	10/29/00	94.3	long bone
2000–2001	31-0001	N	Moose	Unknown	Calf	10/29/00	27.6	long bone
2000–2001	31-0002	Y	Moose	Unknown	Calf	11/01/00	N/A	N/A
2000–2001	31-0003	Y	Moose	Female	Adult	11/02/00	92.9	long bone
2000–2001	31-0004	Y	Moose	Unknown	Calf	11/04/00	N/A	N/A
2000–2001	31-0006	Y	Moose	Unknown	Calf	11/17/00	N/A	N/A
2000–2001	31-0007	N	Moose	Unknown	Unknown	11/27/00	N/A	N/A
2000–2001	31-0008	Y	Moose	Male	1	11/28/00	N/A	N/A
2000–2001	31-0009	Y	Moose	Unknown	Calf	12/27/00	62.1	long bone
2000–2001	31-0012	Y	Moose	Unknown	Adult	01/30/01	N/A	N/A
2000–2001	31-0013	Y	Moose	Unknown	Adult	1/31/01	89.3	long bone
2000–2001	31-0014	Y	Moose	Female	Adult	2/01/01	80.4	femur
2000–2001	31-0014		Moose	Female	Adult	2/01/01	66.2	jaw
2000–2001	31-0015	N	Moose	Female	Adult	3/3/01	74.0	N/A
2000–2001	31-0016	N	Moose	Unknown	Calf	3/04/01	N/A	N/A
2000–2001	31-0017	Y	Moose	female	Calf	3/06/01	N/A	N/A
2000–2001	31-0018	Y	Moose	Unknown	Calf	3/07/01	N/A	N/A
2000–2001	31-0019	Y	Moose	unknown	Adult	4/2/01	84.4	long bone
2000–2001	31-0020	N	Moose	Female	Adult	3/14/01	81.9	long bone
2000–2001	41-0001	Y	Moose	Female	Adult	11/01/00	87.8	long bone
2000–2001	41-0002	Y	Moose	Unknown	Adult	11/29/00	88.8	long bone
2000–2001	41-0003	Y	Moose	Male	1	12/16/00	77.4	long bone
2000–2001	41-0004	Y	Moose	Female	Adult	1/21/01	90.0	long bone
2000–2001	41-0004		Moose	Female	Adult	1/21/01	72.0	jaw
2000–2001	41-0005	Y	Moose	Unknown	Unknown	1/30/01	N/A	N/A
2000–2001	41-0006	Y	Moose	Unknown	Unknown	2/10/01	N/A	N/A
2000–2001	41-0007	N	Moose	Female	Adult	3/01/01	84.5	humerus
2000–2001	41-0007		Moose	Female	Adult	3/01/01	66.0	jaw
2000–2001	41-0010	Y	Moose	Female	1	4/4/01	81.7	femur
2000–2001	41-0010		Moose	Female	1	4/4/01	88.2	metatarsal

Table 5 Continued

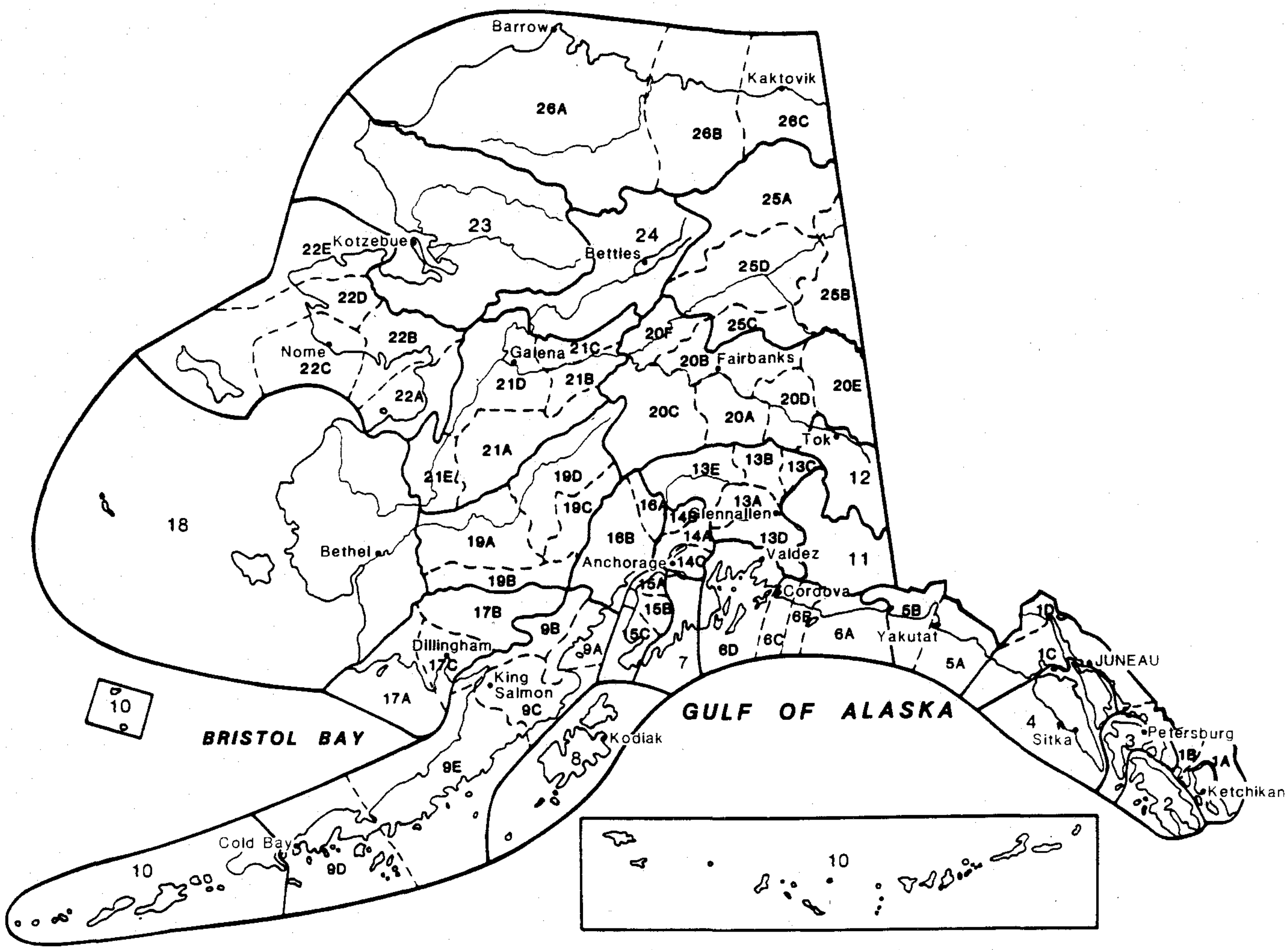
Winter	Prey ID #	Killed on sample day?	Prey species	Sex	Age	Date of kill	% Fat[a]	Bone type
2000–2001	43-0001	Y	Moose	Male	1	11/01/00	79.2	long bone
2000–2001	43-0001		Moose	Male	1	11/01/00	62.8	jaw
2000–2001	43-0002	N	Moose	Male	1	11/15/01	N/A	N/A
2000–2001	43-0004	N	Caribou	Unknown	Unknown	12/14/00	N/A	N/A
2000–2001	43-0005	Y	Moose	Female	Adult	12/29/00	6.2	long bone
2000–2001	43-0006	N	Moose	Female	Calf	1/22/01	33.7	16-Mar
2000–2001	43-0006		Moose	Female	Calf	1/22/01	48.1	26-Jan
2000–2001	43-0007	Y	Caribou	Female	Adult	1/23/01	11.0	long bone
2000–2001	43-0007		Caribou	Female	Adult	1/23/01	12.0	long bone
2000–2001	43-0008	N	Moose	Unknown	Adult	1/29/01	88.2	long bone
2000–2001	43-0009	N	Moose	Unknown	Calf	2/07/01	88.4	long bone
2000–2001	43-0011	N	Moose	Male	Calf	3/1/01	61.6	femur
2000–2001	43-0011		Moose	Male	Calf	3/1/01	40.1	jaw
2000–2001	43-0011		Moose	Unknown	Calf	3/01/01	74.6	metatarsal
2000–2001	43-0012	Y	Moose	Unknown	Calf	3/07/01	36.2	humerus
2000–2001	43-0012		Moose	Unknown	Calf	3/07/01	49.0	jaw
2000–2001	43-0013	N	Moose	Unknown	Calf	4/01/01	45.8	long bone
2000–2001	44-0001	N	Moose	Male	1	10/29/00	66.3	long bone
2000–2001	44-0002	Y	Moose	Male	1	11/04/00	70.4	long bone
2000–2001	44-0004	N	Caribou	Unknown	Adult	11/27/01	N/A	N/A
2000–2001	44-0005	Y	Sheep	Male	Adult	11/30/01	N/A	N/A
2000–2001	44-0006	Y	Moose	Female	Adult	1/22/01	35.0	long bone
2000–2001	44-0007	Y	Moose	Male	1	12/28/01	N/A	N/A
2000–2001	44-0008	N	Moose	Unknown	Adult	3/2/01	81.8	long bone
2000–2001	44-0009	Y	Moose	Female	Adult	3/3/01	66.7	humerus
2000–2001	44-0009		Moose	Female	Adult	3/3/01	67.0	jaw
2000–2001	44-0012	N	Moose	Female	Adult	12/26/00	N/A	N/A
2000–2001	44-0013	N	Moose	Unknown	Unknown	1/29/01	N/A	N/A
2000–2001	46-0002	Y	Moose	Male	1	11/04/00	70.8	long bone
2000–2001	46-0003	N	Moose	Female	Adult	11/17/00	51.6	long bone
2000–2001	46-0004	N	Moose	Female	Calf	11/26/00	21.5	long bone
2000–2001	46-0005	Y	Moose	Unknown	Adult	12/16/00	83.6	long bone
2000–2001	46-0006	N	Moose	Female	Adult	12/26/00	86.0	long bone
2000–2001	46-0007	Y	Moose	Female	Adult	1/31/01	86.6	long bone
2000–2001	60-0001	N	Moose	Unknown	Calf	10/30/01	N/A	N/A
2000–2001	60-0002	Y	Moose	Unknown	Calf	11/03/01	N/A	N/A
2000–2001	60-0003	Y	Moose	Unknown	Calf	11/30/01	N/A	N/A
2000–2001	60-0004	N	Moose	Female	Adult	12/16/00	83.4	long bone
2000–2001	60-0005	N	Moose	Female	Calf	12/29/00	8.5	long bone
2000–2001	60-0006	Y	Moose	Female	Adult	1/21/01	85.8	long bone
2000–2001	60-0007	N	Moose	Female	Calf	1/29/01	26.3	long bone
2000–2001	60-0008	Y	Moose	Female	Adult	3/8/01	87.1	long bone

Table 5 Continued

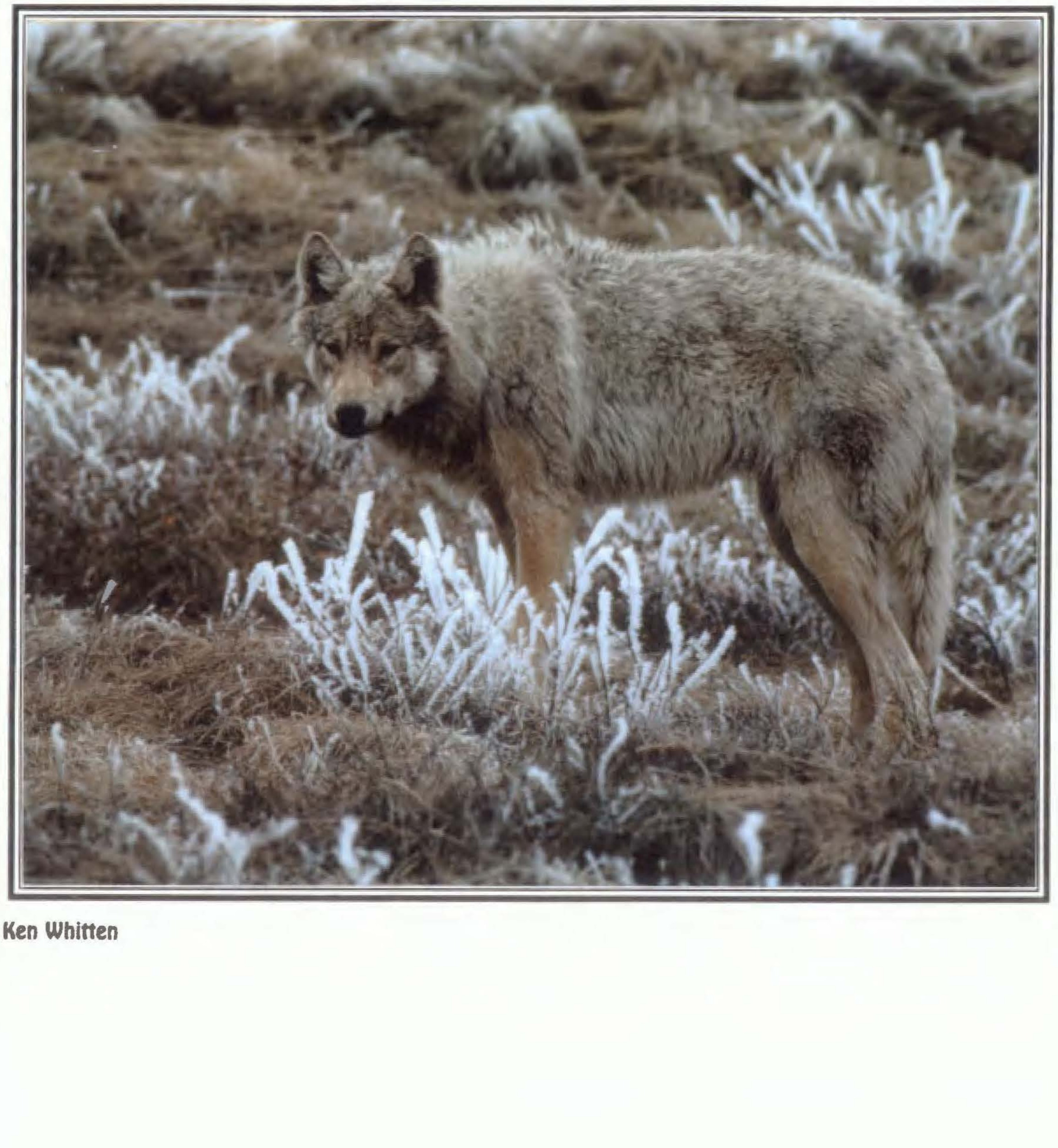
Winter	Prey ID #	Killed on sample day?	Prey species	Sex	Age	Date of kill	% Fat[a]	Bone type
2000–2001	60-0009	Y	Moose	Unknown	Calf	4/04/01	14.4	long bone
2000–2001	61-0001	N	Sheep	Female	Adult	10/29/01	N/A	N/A
2000–2001	61-0002	Y	Sheep	Unknown	Unknown	11/01/01	N/A	N/A
2000–2001	61-0003	Y	Moose	Male	Calf	11/02/00	14.9	long bone
2000–2001	61-0004	N	Moose	Unknown	Adult	11/14/01	N/A	N/A
2000–2001	61-0005	N	Sheep	Unknown	Unknown	11/26/01	N/A	N/A
2000–2001	61-0006	N	Moose	Unknown	Adult	12/14/01	N/A	N/A
2000–2001	61-0007	N	Moose	Unknown	Adult	12/26/00	89.6	long bone
2000–2001	61-0008	Y	Moose	Unknown	Adult	12/27/00	90.8	long bone
2000–2001	61-0009	Y	Moose	Unknown	1	1/31/01	87.4	long bone
2000–2001	61-0010	Y	Moose	Female	Adult	2/08/01	26.9	long bone
2000–2001	61-0011	N	Moose	Unknown	Adult	2/20/01	86.6	long bone
2000–2001	61-0012	N	Moose	Unknown	Adult	3/7/01	86.4	long bone
2000–2001	61-0013	N	Moose	Unknown	Adult	3/07/01	89.0	long bone
2000–2001	61-0014	Y	Moose	Male	1	3/07/01	88.9	femur
2000–2001	61-0014		Moose	Male	1	3/07/01	61.2	jaw
2000–2001	61-0014		Moose	Male	1	3/07/01	87.5	metatarsal
2000–2001	61-0015	N	Moose	Female	Adult	4/1/01	28.4	long bone
2000–2001	61-0016	N	Moose	Female	Calf	4/1/01	N/A	N/A
2000–2001	63-0001	Y	Moose	Male	1	10/30/01	N/A	N/A
2000–2001	63-0002	Y	Sheep	Unknown	Unknown	11/02/01	N/A	N/A
2000–2001	63-0003	Y	Moose	Male	Calf	12/16/00	66.5	long bone
2000–2001	63-0004	N	Moose	Unknown	Adult	1/29/01	N/A	N/A
2000–2001	63-0005	N	Moose	Unknown	Unknown	2/7/01	N/A	N/A
2000–2001	63-0006	N	Moose	Unknown	Calf	4/01/01	78.8	long bone
2000–2001	64-0001	N	Moose	Female	Adult	3/1/01	64.0	long bone
2000–2001	64-0002	N	Moose	Unknown	Calf	3/01/01	61.7	long bone

[a] Not corrected for nonfat residue in dried sample.

Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.



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