ESTABLISHMENT OF AND PREY SELECTION
BY A NEW WOLF PACK IN THE
WIGWAM RIVER DRAINAGE

By

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Approved by

[Signatures of审批人员]

Chairman, Board of Examiners

Dean, Graduate School

Date

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Food habits, kill site characteristics, and movements of wolves (*Canis lupus*) were studied from 20 November 1988 through 30 March 1990 in the Wigwam River drainage, in southeastern British Columbia.

Six-hundred twenty-three prey items were identified from 434 wolf scats collected at den and rendezvous sites, and 108 scats picked up during winter tracking. Relative biomass in the wolves' winter diet consisted of elk (*Cervus elaphus*) (60%), deer (*Odocoileus spp.*) (12%), bighorn sheep (*Ovis canadensis*) (10%), and moose (*Alces alces*) (19%). Summer scats indicated relative biomass of wolves' diet to be elk (56%), deer (16%), bighorn sheep (14%), and moose (13%).

Twenty-seven wolf-kills were examined including 9 elk, 14 deer, and 4 moose. Mean consumption rates were 90% for elk, 96% for deer, and 90% for moose. No change in prey consumption rates were observed throughout the winter.

Elk were 1.8 times more available than deer, 3.2 times more than moose, and 4.0 times more than bighorn sheep as judged by track transects, and they were 1.7 times as abundant as deer, and 2.4 times as abundant as bighorn sheep based on data from aerial game counts. Wolf-kill data suggested that wolves selected for deer; however, scat analysis did not corroborate this. Comparison of biomass frequencies and prey availability data suggested wolves may have selected prey based on ungulate densities.

Wolf-kills occurred at elevations below 4000 feet and moderately thick tree cover. Wolves appeared to take advantage of ungulates using plowed or unplowed roads during winter. Two hundred and five kilometers of wolf trails were tracked and recorded during winter. Wolves frequently used unplowed roads and river banks as travel corridors to move throughout their home range.

Wolf populations in the Wigwam Pack went from 8 wolves in winter 1989 to possibly 2 wolves during winter 1990.
ACKNOWLEDGEMENTS

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INTRODUCTION

Wolf (Canis lupus) recovery in northwestern Montana is highly dependent upon the wolf population in southeastern British Columbia (B.C.). Dispersing wolves from Canada are the "seeds" from which wolf recovery in the United States may grow. I examined factors, such as wolf population, movement patterns, prey availability, and prey vulnerability, that influenced the feeding habits of wolves in a big game winter range in southeastern B.C.

Historically, wolves were viewed as vermin and were extirpated from Montana by the 1930s (Ream and Mattson 1982). Wolves in B.C. received similar treatment, however their populations were not so drastically reduced.

The B.C. government paid approximately $1,000,000 in bounties to B.C. wolf hunters and trappers between the early 1900s and 1956. From 1949 to 1961, public attitudes toward wolves remained negative and poisons such as cyanide, strychnine, and compound 1080 became the primary method of wolf control. Early in the 1960s, public attitudes concerning wolves changed, and newly formed conservation groups spoke out against wolf eradication. The B.C. government made substantial changes in its wolf management policies. Wolf poisoning programs in wilderness areas were terminated in 1961. Wolf control was transferred to regional offices in 1964. Wolves in B.C. received big game status in 1966, and by 1976 wolves were designated as
Wolf management is a volatile issue. The basis for this controversy often centers around the question of how a viable wolf population might impact local wildlife populations. To develop effective wolf management policies, resource managers must be aware of wolf-prey relationships and how wolves use habitat within their home range.

Ungulates are the primary prey of wolves (Carbyn 1974, Weaver 1979, Fritts and Mech 1981, Ream et al. 1987). Several ungulate species are abundant and potential prey for wolves in the Wigwam River drainage in B.C.; however, these same species represent a large economic resource to the local area.

Predator-prey relationships are a controversial issue. Some would argue that wolf populations can affect local ungulate numbers and, under certain conditions, wolf predation may regulate prey populations when losses due to predation are additive to other sources of mortality. At low densities, moose populations have been regulated primarily by predators (Bergerud et al. 1983, Messier and Crete 1985). Pimlott (1967) argued that ungulate populations have evolved and adapted effective means to cope with complex mortality factors.

Wolves often select one vulnerable ungulate species when several are present (Murie 1944, Carbyn 1974). In other areas, prey selection apparently is determined by availability (Holleman and Stephenson 1981). How wolf
presence will affect ungulate populations is dependent on prey selection, which in turn is dependent, to some extent, on prey availability. Food habits and prey selection by wolves may determine to what extent wolf recovery will be allowed, because wolves are seen as a competitive threat by some hunters and guide-outfitters.

During the last 4 years, wolf populations have been recovering in southeastern British Columbia (Ream et al. 1987). The Wigwam River drainage supported 2 wolf packs in 1988, and even though access within the pack's home range is "problematic," the area provides an excellent opportunity to determine: 1) food habits and prey selection by wolves, 2) habitat characteristics at wolf kill sites, 3) wolf population in the Wigwam drainage, and 4) wolf movements and home ranges.
STUDY AREA

The Wigwam study area is located approximately 90 km east of Cranbrook, British Columbia and 40 km northeast of Eureka, MT, in the East Kootenay District of B.C. The western boundary of the 1300 km$^2$ area is the Galton Range. Highway 3 forms the northern boundary and Inverted Ridge defines the eastern edge. The study area extends south into the United States for approximately 7 km (Fig. 1).

The topography in the Wigwam River drainage varies from flat river valley bottom to high barren rocky peaks, with forested areas growing on flat valley bottoms as well as steep and gentle slopes. Elevation ranges from 840 m in the northern Wigwam valley to 2250 m on Mount Broadwood in Wigwam Flats. The Flats are characterized by glacial outwash deltas and broad gravel terraces (Figs. 2 and 3). Steep talus slopes are common throughout the study area. The headwaters of the Wigwam River are 4 km south of the U.S.-Canadian border on the eastern side of the Galton Range. The River flows north into B.C. from an elevation of 1550 m at its source to 810 m where it flows into the Elk River.

Snow falls from late November through March and accumulates in varying amounts throughout the study area. Snow depths of 75 cm are common at lower elevations in the southern section, and snow remains on the ground through March. In the northern portion, snow accumulation averages
Fig. 1 Study Area

- Fernie
- B.C.
- Montana
- Idaho
- Elko
- Wigwam Flats
- Lodgepole Road
- Elk River
- Hall Range
- Hwy 3
- Rain Creek
- Inverted Ridge
- Desolation Creek
- Rabbit Creek
- Weasel Cr.

0
30 km

Dirt Road
Figure 2. Wigwam River Terraces Along South Edge of Wigwam Flats.
Figure 3. Wigwam River Flood Plain at Southern Edge of Wigwam Flats.
50 cm but is gone by March. Mean snow depth was 16 cm during winter 1988-89 throughout Wigwam Flats and rarely remained continuously on the ground for more than a week that winter due to strong winds and melting. Snow cover remained in shaded areas on the Flats, but snow on the open terraces and plateaus usually was gone shortly after a storm (Fig. 4).

The vegetation in riparian zones along the Wigwam River is dominated by willow (Salix spp.), cottonwood (Populus trichocarpa), and alder (Alnus incana). Shrubs are further represented by thimbleberry (Rubus parviflorus), and snowberry (Symphoricarpos albus). Forests within the river valley and on the canyon slopes consist of lodgepole pine (Pinus contorta), western larch (Larix occidentalis), Douglas-fir (Psuedotsuga menziesii), cottonwood, and ponderosa pine (Pinus ponderosa) (Fig. 5).

Two plant communities (Pseudotsuga-Agropyron and Pseudotsuga-Poa) consist of large grasslands dominated by bluebunch wheatgrass (Agropyron spicatum) and Canada bluegrass (Poa compressa), with interspersed stands of Douglas-fir (Quenet 1973) (Fig. 6). Bluebunch wheatgrass, Douglas-fir, service-berry (Amelanchier alnifolia), mountain maple (Acer glabrum), Juniper (Juniperus horizontalis), cherry (Prunus emarginata), and buffalo berry (Shepherdia canadensis) occur in the Pseudotsuga-Agropyron community. Plant species found in the Pseudotsuga-Poa community include Douglas-fir, Canada bluegrass, mountain
Figure 4. Wigwam Plate Looking North Toward Mt. Breadwood.
Figure 5.  Wigwam River Canyon in the Southern Portion of the Study Area near the U.S.-Canadian Border.
Fig. 6 Study area showing location and extent of Pseudotsuga-Agropyron and Pseudotsuga-Poa communities. (Quenet 1973).
maple, quaking aspen (Populus tremuloides), buckbrush (Ceanothus sanguineus), rose (Rosa nutkana), serviceberry, and snowberry. Junegrass (Koeleria cristata), pinegrass (Calamagrostis rubescens), and snowberry occur beneath Douglas-fir stands.

Road access to the southern portion of the Wigwam drainage is limited to one poorly maintained dirt road (Wigwam Road) paralleling the River. This road ends 6 km north of the U.S.-Canadian border and no other road access exists in the Canadian side of the drainage. Wigwam Flats is in the northern section of the area and has numerous roads that were used during construction and for maintenance of an underground gas pipeline that runs east to west across the entire Wigwam Flats. Many smaller roads in the Flats are closed year-round, and all roads are closed to vehicles from 1 September to 1 June.

Approximately 85% of the study area is B.C. Provincial Crown land. Shell Oil Ltd. owns approximately 140 km² of land in the Mount Broadwood and Wigwam Flats area. Land south of the Canadian border is part of the Kootenai National Forest. Logging operations take place on leased parcels of land throughout the study area. Shell Oil Ltd. and Chevron Oil also have parcels leased for oil and gas exploration.

No domestic sheep or cattle grazed in the Wigwam area, however cattle did graze in the Sheep Mountain area adjacent to Wigwam Flats. In the past, sheep have been raised on the
farmlands west of the Galton Range along Highway 93. From late spring through the end of fall, outfitters keep horses in their respective hunting territories.

No one resides year-round in the study area, but 3 outfitters have hunting lodges and cabins that are used during spring and fall hunting seasons. Rights to trapping and outfitting are purchased in British Columbia and are exclusive to a given area within each management unit. Six trappers harvest fur-bearers in the Wigwam. Due to low fur prices, trapping pressure has been light on coyote (Canis latrans), lynx (Lynx canadensis), bobcat (Lynx rufus), wolverine (Gulo luscus), and beaver (Castor canadensis). Marten (Martes americana) have received moderate trapping efforts (Bill Warkentin, B.C. Wildlife Branch, Cranbrook, B.C. pers. comm.). In the southern portion of the drainage, the guide-outfitter also owns the trapping rights. In the remaining sections of the Wigwam, 5 trappers own trapping rights within 2 outfitters' territories.

Other recreational uses in the Wigwam include fishing, camping, cross-country skiing, snowmobiling, and hunting. Public and guide-outfitter hunting pressure is moderate during the autumn for elk, white-tailed deer (Odocoileus virginianus), mule deer (Odocoileus hemionus), moose, black bear (Ursus americanus), and bighorn sheep, (Bill Warkentin, B.C. Wildlife Branch, Cranbrook, B.C. pers. comm.). Cougar (Felis concolor) are hunted during winter, and black bears are hunted in spring. Grizzly bear (Ursus arctos) hunting
is open during spring under Limited Entry permits. No trapping season for wolves was open in Management Units 4-2 (Wigwam) in 1988-89; however a maximum harvest of 2 adult females (older than 12 months) was allowed during the 1988-89 hunting season. Due to the unknown population status of Wigwam wolves, no harvest was allowed in 1989-90 (B.C. Hunting and Trapping Regs.).

Large migratory populations of elk, mule deer, white-tailed deer, and bighorn sheep use Wigwam Flats for winter range (Appendix A). Other species available to wolves include: moose, snowshoe hares (*Lepus americanus*), and red squirrels (*Tamiasciurus hudsonicus*).
METHODS

This study was conducted from July 1988 to March 1990. Most field work occurred during winter (December through March) with the exception of summer trapping.

Wolves in the Wigwam area were trapped during July 1988 and July 1989. Captured wolves were examined, eartagged, weighed, measured, and radio-collared (Ream et al. 1988). Radio-collared wolves were located 2-3 times per week from the ground. An aircraft was used to radio-track Wigwam wolves when more than 5 days passed without ground contact. Population estimates were determined by track counts, direct sightings and, counting wolves during aerial radio-tracking.

Methods were redesigned after November 1988 because no radio-collared wolves remained in the Wigwam Pack. An unsuccessful effort was made to trap, snare, and radio-collar wolves during winter 1988-89. Eleven road-killed carcasses were used for bait and placed in different areas frequented by wolves. Carcass species included: 4 deer, 4 elk, 1 moose, 1 beaver, and 1 coyote.

Trap lines were run as long as sufficient bait remained and night temperatures did not drop too low. When temperatures dropped below 25 F, all trapping was suspended to avoid freezing a trapped animal's foot.

Food habits, kill sites, travel routes, movement patterns, and wolf populations were found by back-tracking fresh wolf tracks. Wolves were tracked as often and
continuously as possible without disturbing them. Uncollared wolves were located and the age of their tracks was estimated by developing a systematic search schedule. Bi-weekly searches for wolf tracks were conducted in strategic areas throughout the Wigwam drainage near Desolation, Rabbit, and Weasel Creeks just north of the U.S. border. Searches took place 3-4 times a week along Ram Creek, Wigwam River Road, and in the Wigwam River valley adjacent to Wigwam River Road. Daily searches were conducted along Ram Creek Road and Wigwam Flats. Frequently these searches were completed at night using a vehicle or snowmobile with a spot light. Night searches were changed to every 2nd or 3rd night to reduce disturbing wolves traveling in the area. Tracks were counted in river valleys, kill sites, and any other areas where wolves branched out of their typical single-file travel routes.

Food habits were determined by locating wolf kills, examining prey remains at kill sites, and by scat analysis. Wolf kills were located by back-tracking wolves in the snow or by following bald eagles (Haliaeetus leucocephalus), golden eagles (Aquila chrysaetos), and ravens (Corvus corax) to kill sites when wolf tracks could not be found. Species, percent consumption, sex, age, and overall condition of animal before it was killed were recorded. Carcass consumption categories (Ream et al. 1987) were as follows:

99% remains = a little hair and blood.

95% remains = several vertebrae and/or other
bones, 1-3 lower legs, no soft tissue, small amount of hide.

90% remains = 2-4 legs, much hide, most of skeleton gleaned and intact, possible intact head or neck.

85% remains = nearly complete skeleton with some soft tissue.

85% remains = visual estimates based on % of total volume of carcass remaining.

Sex was determined by skulls or pelvises. Age determination of young animals was based on tooth replacement (Severinghaus 1949, Rees et al. 1966). Matson's laboratory in Milltown determined ages of adult animals by cementum annuli techniques (Thomas and Brandy 1973). Nutritional status of prey was estimated by bone marrow fat levels using color and consistency (Cheatum 1949) and dry weight (Neiland 1970).

Wolf scats were collected while tracking wolves in the snow from December 1988 through March 1989. Only scats that were definitely associated with wolf tracks were collected to avoid confusion with scats from other predators. Scats found at kill sites as well as scats between kill sites were collected and age was estimated to nearest day by using changes in the weather and snow conditions. To avoid biasing data collected for food habit studies, no scats were picked up in areas where I left carcasses. No scats were collected anywhere for 56 hours after wolves had fed on
carcasses that I placed for them (Floyd et al. 1978).

Collected wolf scats were heated to kill microorganisms and then washed (Appendix F). Colorado State University Range Laboratory identified a random sample of hair from each scat, and these data were used to estimate food habits. Scat contents were related to prey consumed using techniques described by Floyd et al. (1978). To estimate summer food habits, scats were collected at wolf dens and rendezvous sites in September, after wolves had abandoned the sites.

The regression equation from Floyd et al. (1978) was stated: 

\[ y = 0.38 + 0.02x \]

\( y = \text{kg of prey per collectible scat} \)

\( x = \text{average weight of a given prey} \)

This equation was modified in 1983 for larger prey species by Traves \( (y = 0.265 + 0.01x) \). Biomass data were put into Traves' equation and compared with Floyd et al.

Prey availability was estimated while back-tracking wolves in snow from December through March. At a random point, a 200 m transect was paced off, perpendicular to the wolf trail with the midpoint of the transect on the trail. Transects were separated by 0.5 km intervals along the wolves' trails. Ungulate tracks crossing the transects were recorded by genus (tracks of the two deer species were indistinguishable) to create a relative availability index. Thirty-four prey availability transects were run throughout
the study area. On each transect, the ungulate species closest to a wolf trail was recorded, along with the distance to the wolf trail. The relative abundance of the ungulates available to wolves was compared statistically with relative amounts of ungulate remains found in wolf scats and wolf kills using chi-square.

Habitat characteristics at kill sites, including snow depth, slope, elevation, aspect, tree density, tree cover, and edge were summarized and recorded. Distances from kill sites to the nearest road, trail, or river were recorded. Thirty-five randomly picked sites within the wolves' travel routes were compared with 27 kill sites using discriminant function analysis. Road classification was based on size and use. Primary roads provided main access with a 7 m wide, crushed rock road bed (Lodgepole and Ram Creek roads). Well maintained, less frequently used gravel or dirt roads branching off primary roads were defined as secondary roads (Wigwam Flats Road along the river bottom area). Tertiary roads were jeep trails or poorly maintained dirt roads (Wigwam River Road and roads in the upper terraces of Wigwam Flats).

Movement patterns and travel routes were determined by plotting all wolf tracks and trails on acetate transparencies laid on top of topographic maps.

Setting out carcasses for trap bait had 2 objectives. In addition to serving as a draw bait for trapping wolves, carcass placement also provided insight to how wolves might
respond to dead animals. The condition of these carcasses, how long since the animal had been killed and whether they had been handled by humans or scavenged by other animals were recorded. Descriptions of carcass sites included habitat types, percent canopy, slope, aspect, elevation, distance to nearest roads or rivers, and snow depth.

Temperature (maximum and minimum) was recorded daily and snow depth was measured weekly at a base camp near the center of the study area. To compensate for the 300 m lower elevation in the northern section, these weather data were compared with data from a government weather station in Elko, B.C. This site was less than 16 km away and had similar elevation to the northern Wigwam Flats area.

Two radio-collared wolves from the neighboring Headwaters Pack were located in Wigwam Flats from 24 January 1990 through March 1990. Kill site characteristics and prey species killed by these wolves were recorded; however, data from winter 1989-90 were not used in biomass estimates or chi-square comparisons.

Wolves harvested in the Wigwam study area were checked at a B.C. compulsory check center within 4 days of the kill. The B.C. Wildlife Branch provided wolf harvest data.
RESULTS

Four wolves were trapped during 2 field seasons (Table 1): two were pups and too small to radio-collar, 1 yearling female (#8859) was trapped and collared in the summer of 1988, and a 2-year-old male (#8910) was radio-collared in 1989. Radio contact with #8401 was permanently lost on 17 November, 1988, and wolf #8859 dispersed to Alberta between 18 and 23 October, 1988.

No wolves were caught during the 1988-89 winter. Four coyotes were inadvertently trapped and released. Traps were pulled or covered whenever weather forecasts predicted temperatures below 25 F. However, wet snow repeatedly froze into a solid crust at night allowing wolves to walk on traps. Wolves came into 2 different sets where they urinated on scent posts and stepped on the trap pan that had frozen in place. The traps had to be hit with a shovel to get them to release. Barley hulls and animal hair were used to insulate the trap springs, but low night-time temperatures often caused trap springs to freeze in place, making traps nonfunctional. At 3 other trap sets, it snowed more than 60 cm within 1 day and completely covered traps, carcass baits, and wolf travel routes where snares had been placed.

Food Habits

From August 1988 through April 1989, 542 wolf scats
Table 1: Characteristics of wolves trapped in the Wigwam Pack (Ream et al. 1988, 1989).

<table>
<thead>
<tr>
<th>Wolf No.</th>
<th>Date of Capture</th>
<th>Age at Capture</th>
<th>Wt. (kg)</th>
<th>Sex</th>
<th>Color</th>
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<tr>
<td>8401*</td>
<td>08/28/84</td>
<td>adult</td>
<td>48</td>
<td>M</td>
<td>gray</td>
</tr>
<tr>
<td>8401*</td>
<td>10/5/85</td>
<td>recapture by WEP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8401</td>
<td>12/31/87</td>
<td>recapture by B.C. trapper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8859</td>
<td>07/21/88</td>
<td>14 mos.</td>
<td>39</td>
<td>F</td>
<td>black</td>
</tr>
<tr>
<td>8860</td>
<td>07/29/88</td>
<td>3 mos.</td>
<td>13</td>
<td>F</td>
<td>gray</td>
</tr>
<tr>
<td>8808</td>
<td>07/29/88</td>
<td>3 mos.</td>
<td>14</td>
<td>M</td>
<td>gray</td>
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<tr>
<td>8910</td>
<td>07/23/89</td>
<td>adult</td>
<td>44</td>
<td>M</td>
<td>gray</td>
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</tbody>
</table>

* Wolf #8401 was trapped before the Wigwam Pack existed.
were collected; 484 prey items were identified from 434 summer scats collected from 1 den and 2 rendezvous sites, and 139 prey items were identified from 108 scats picked up during winter tracking (Table 2).

The main prey found in wolf scats in the Wigwam area were: elk, mule deer, white-tailed deer, bighorn sheep, and moose. Remains of ground squirrels, domestic sheep, hares, Red squirrels, mice (*Peromyscus* spp.), domestic cattle, voles (*Microtus* spp.), caribou, black bear, and mountain goat were all found in small amounts in collected wolf scats.

Relative biomass in the Wigwam wolves' winter diets consisted of elk (60%), moose (19%), deer (12%), and bighorn sheep (10%). Summer scats indicated the relative biomass of wolves' diet to be mainly elk (56%), deer (16%), bighorn sheep (14%), and moose (13%). Other prey remains occurred in winter and summer scats, but the amount of biomass was small (Table 3).

Eighteen wolf kills and 2 scavenged carcasses were located and examined in the Wigwam study area during winter 1988-89 (Table 4). Prey species included; elk (39% of the 18 carcasses), deer (50%), and moose (11%). The mean consumption rate of all 1988-89 winter carcasses was 95% (elk = 90% consumption, deer = 96%, and moose = 90%). The wolves only returned to 4 kill sites within 1 week after the kill, but did not feed again on any of the 18 carcasses once they left a fresh kill. Coyotes and birds came to the kills
Table 2. Frequency of occurrence of 623 prey remains identified in 542 wolf scats from the Wigwam River Drainage, B.C. (1988-1989)

<table>
<thead>
<tr>
<th>Prey</th>
<th>Spring/Summer</th>
<th>Winter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>192</td>
<td>50</td>
<td>242</td>
</tr>
<tr>
<td>Deer</td>
<td>88</td>
<td>26</td>
<td>114</td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>71</td>
<td>17</td>
<td>88</td>
</tr>
<tr>
<td>Moose</td>
<td>43</td>
<td>15</td>
<td>58</td>
</tr>
<tr>
<td>Ground Squirrel</td>
<td>19</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>Domestic Sheep</td>
<td>15</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Hare</td>
<td>14</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Red Squirrel</td>
<td>16</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Mice</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Domestic Cattle</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Voles</td>
<td>1</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Caribou</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Black Bear</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Mountain Goat</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>484</td>
<td>139</td>
<td>623</td>
</tr>
</tbody>
</table>

Spring/summer scats = 434
Winter scats = 108

Note: Sum of all the "Totals" for various species does not equal sample size of 542 because some scats contained more than one prey item.
Table 3. Relative frequency of occurrence of prey items in scats (relative biomass of prey items)

<table>
<thead>
<tr>
<th>Species</th>
<th>Spring/summer 1988</th>
<th>Winter 1988-89</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>40% (56%) [64%]</td>
<td>36% (60%) [60%]</td>
</tr>
<tr>
<td>Deer</td>
<td>19% (16%) [10%]</td>
<td>19% (12%) [10%]</td>
</tr>
<tr>
<td>Moose</td>
<td>9% (13%) [18%]</td>
<td>11% (19%) [23%]</td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>15% (14%) [7%]</td>
<td>12% (10%) [6%]</td>
</tr>
<tr>
<td>Ground Squirrel</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Domestic Sheep</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Hare</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Red Squirrel</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td><em>Peromyscus</em></td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Domestic Cattle</td>
<td>1%</td>
<td>0</td>
</tr>
<tr>
<td><em>Microtus</em></td>
<td>0.2%</td>
<td>4%</td>
</tr>
<tr>
<td>Caribou</td>
<td>0.1%</td>
<td>1%</td>
</tr>
<tr>
<td>Black Bear</td>
<td>0.4%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Relative biomass = \[ \frac{(0.38 + 0.02X) \text{ Rel. Freq.}}{(0.38 + 0.02X) \text{ Rel. Freq.}} \]

\( X = \) species mean weights (Appendix C)

Regression equation from Floyd et al. (1978)

Figures in () are derived from Floyd et al. (1978)

Figures in [] are derived from Traves (1983)
as soon as wolves left the sites and consumed any prey remains.

High consumption rates made age and sex determinations difficult. Sex could only be determined on 4 of the carcasses. Two carcasses were male deer and 2 were female elk. Age determinations were possible on 13 of the carcasses. The prey age structure was comprised of 5 elk calves, 2 moose calves, 3 yearling deer, two 3-5 year old deer, and one 23 year old elk (Table 4).

During the 1989-90 winter, only 2 wolves from the Wigwam Pack were located in the southern part of their home range. The Headwaters Pack remained in Wigwam Flats for most of the 1989-90 winter. Nine wolf kills and one scavenged carcass were found in the study area during winter 1989-90. Prey species for the Headwaters Pack included; elk (3), deer (5), and moose (2). The median consumption rate was 95% (Table 5).

**Prey Availability**

Wigwam Flats had very little snow accumulation during the 1988-89 and 1989-90 winters, therefore tracking conditions on the Flats were poor.

Availability transects were concentrated in Wigwam Flats, but were run throughout the entire study area. Transect results indicated elk 1.8 times more available than deer, 3.2 times more than moose, and 4.0 times more than sheep (Table 6). Annual aerial game counts flown by the
Table 4. Wolf kills in the Wigwam area for winter 1988/89
(Wigwam Pack)

<table>
<thead>
<tr>
<th>Species</th>
<th>Date Found</th>
<th>Age</th>
<th>Sex</th>
<th>% Carcass Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>1-02-89</td>
<td>calf</td>
<td>F</td>
<td>85</td>
</tr>
<tr>
<td>Elk</td>
<td>1-12-89</td>
<td>23</td>
<td>F</td>
<td>85</td>
</tr>
<tr>
<td>Elk</td>
<td>1-25-89</td>
<td>calf</td>
<td>?</td>
<td>85</td>
</tr>
<tr>
<td>Elk</td>
<td>3-01-89</td>
<td>calf</td>
<td>?</td>
<td>90</td>
</tr>
<tr>
<td>Elk</td>
<td>3-17-89</td>
<td>?</td>
<td>?</td>
<td>95</td>
</tr>
<tr>
<td>Elk</td>
<td>3-26-89</td>
<td>calf</td>
<td>?</td>
<td>95</td>
</tr>
<tr>
<td>Elk</td>
<td>3-27-89</td>
<td>calf</td>
<td>?</td>
<td>99</td>
</tr>
<tr>
<td>Deer</td>
<td>1-22-89</td>
<td>3 yrs</td>
<td>M</td>
<td>93</td>
</tr>
<tr>
<td>Deer</td>
<td>2-08-89</td>
<td>yrlg</td>
<td>?</td>
<td>95</td>
</tr>
<tr>
<td>Deer</td>
<td>2-08-89</td>
<td>4 yrs</td>
<td>M</td>
<td>95</td>
</tr>
<tr>
<td>Deer</td>
<td>2-10-89</td>
<td>?</td>
<td>?</td>
<td>97</td>
</tr>
<tr>
<td>Deer</td>
<td>2-11-89</td>
<td>2 yrs</td>
<td>?</td>
<td>99</td>
</tr>
<tr>
<td>Deer</td>
<td>2-23-89</td>
<td>yrlg</td>
<td>?</td>
<td>99</td>
</tr>
<tr>
<td>Moose</td>
<td>3-08-89</td>
<td>calf</td>
<td>?</td>
<td>90</td>
</tr>
<tr>
<td>Moose</td>
<td>3-15-89</td>
<td>calf</td>
<td>?</td>
<td>90</td>
</tr>
</tbody>
</table>
Table 5. Wolf kills in the Wigwam area for February 1990
(Headwaters Pack)

<table>
<thead>
<tr>
<th>Species</th>
<th>Date Found</th>
<th>Age</th>
<th>Sex</th>
<th>% Carcass Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>2-05-90</td>
<td>5 yrs</td>
<td>F</td>
<td>90</td>
</tr>
<tr>
<td>Elk</td>
<td>3-04-90</td>
<td>9 yrs</td>
<td>?</td>
<td>95</td>
</tr>
<tr>
<td>Deer</td>
<td>2-04-90</td>
<td>3 yrs</td>
<td>M</td>
<td>90</td>
</tr>
<tr>
<td>Deer</td>
<td>2-04-90</td>
<td>?</td>
<td>?</td>
<td>99</td>
</tr>
<tr>
<td>Deer</td>
<td>2-10-90</td>
<td>8 yrs</td>
<td>?</td>
<td>99</td>
</tr>
<tr>
<td>Deer</td>
<td>2-13-90</td>
<td>6 yrs</td>
<td>?</td>
<td>99</td>
</tr>
<tr>
<td>Moose</td>
<td>2-16-90</td>
<td>calf</td>
<td>?</td>
<td>85</td>
</tr>
<tr>
<td>Moose</td>
<td>3-04-90</td>
<td>?</td>
<td>?</td>
<td>95</td>
</tr>
</tbody>
</table>
Table 6. Prey availability transects - listing the frequency of an ungulate's proximity to a wolf trail.

<table>
<thead>
<tr>
<th>Species</th>
<th>Closest to wolf trail (*1)</th>
<th>Distance (m) from (wolf trail (*2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>16</td>
<td>X = 6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 4.88</td>
</tr>
<tr>
<td>Deer</td>
<td>9</td>
<td>X = 6.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 3.2</td>
</tr>
<tr>
<td>Moose</td>
<td>5</td>
<td>X = 10.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 11.79</td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>4</td>
<td>X = 1</td>
</tr>
</tbody>
</table>

Note: *1 = Number of times (out of 34 transects) given species was closest ungulate to a wolf trail.

*2 = Ungulate species' track was first of any ungulate tracks found nearest a wolf trail. This value represents the average distance from the track to the wolf trail. s = standard deviation.
B.C. Wildlife Branch showed elk on Wigwam Flats (1988-89) were 1.7 times as abundant as deer (white-tailed and mule deer combined), and 2.4 times as abundant as bighorn sheep (Appendix A). Elk, deer, and sheep were much higher in numbers in the northern sections of the study area, and moose were only slightly higher in the southern portion.

Prey availability transect data describing the frequency of an ungulate species' proximity to a wolf trail was compared statistically with wolf kills using chi-square. There was no significant difference between ungulates available as indicated by their proximity to wolf tracks and prey species killed (chi-square = 1.93; df = 2; P > 0.05).

No significant difference was found in a species' proximity to wolf trails and frequency of occurrence based on relative numbers of prey consumed calculated from scat data (chi-square = 2.04; df = 3; P > 0.05).

There also was no significance between prey species killed and species identified in collected scats (chi-square = 3.69; df = 2 P > 0.05).

**Characteristics at Kill Sites**

Kill site characteristics were pooled from winters of 1988-89 and 1989-90 yielding 27 wolf kill sites. The kills occurred in a wide range of topography. Elevation of kill sites ranged from 840 m to 1425 m. Seven kills (26%) were located on the river flood plains, 5 (19%) on flat plateau-like areas, 6 (22%) on unplowed secondary and
tertiary roads, 6 (22%) on gently sloping hillsides, and 3 (11%) on very steep slopes (>45 degrees).

The small sample size (27) made it difficult to categorize habitat types when the kills occurred in such a wide variety of habitats. Four kills (15%) were found in western larch forests; 7 (26%) in aspen groves; 4 (15%) in lodgepole pine forests; 4 (15%) in dense lodgepole pines and western larch; 1 (4%) on a grassy, open plateau; 1 (4%) in cottonwoods with light undergrowth shrubs; 4 (15%) on snow-covered, gravel flood plain with very little tree or brush cover; 1 (4%) on a snow-covered gravel flood plain with willow thickets; and 1 (4%) along a river bank among willows and cottonwoods.

Significant variables selected using F-test values (P > 0.05) included snow depth (F value 20.29), slope (22.72), elevation (28.17), tree density (40.93), proximity to roads (15.91), and cover (14.22). Aspect (0.01) and edge (0.81) were not considered significant and were therefore dropped from further analysis. Two-variable discriminant function analysis suggested that tree density and elevation had some predictive value (Fig. 7). Wolf kills occurred at elevations below 4000 feet and moderately thick tree cover.

Canopy coverage varied throughout the study area. (Figs. 8-11). Lightly canopied areas at low elevations distinguished kill sites from random sites. Kills were generally not found in dense tree cover.

Wolves appeared to take advantage of ungulates using
Fig. 7. Discriminant Function Plotting Independent Covariates Tree Density and Elevation With Dependent Variable Kills

Discriminant Functions

<table>
<thead>
<tr>
<th></th>
<th>Group One</th>
<th>Group Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-38.5236</td>
<td>-25.1291</td>
</tr>
<tr>
<td>Density</td>
<td>4.5261</td>
<td>2.5935</td>
</tr>
<tr>
<td>Elevation</td>
<td>1.4501</td>
<td>1.2392</td>
</tr>
</tbody>
</table>

\[ d_1(x) = -38.523 + 4.526 \times D + 1.4501 \times E \]
\[ d_2(x) = -25.129 + 2.594 \times D + 1.239 \times E \]

where:
- \( D = \) density
- \( E = \) elevation for a location \( X \)
roads even though many of the snow-covered roads did not appear very different from surrounding areas. Twenty-two percent of the kills were found on unplowed tertiary roads, and >80% were located <500 m from unplowed secondary or tertiary roads. Snow cover at kill sites ranged from <2.5 cm to 53 cm, with an average snow depth of 18 cm. Seventy-two percent of all kills occurred in < 20 cm of snow and 10% occurred in >50 cm.

Movements

No radio-collared wolves remained in the Wigwam area soon after this study began. Therefore, home ranges could not be described as originally planned.

I tracked and recorded 205 km of wolf trails during winter 1988-89. The study area was divided into 3 sections (north, central, and south), and tracks were plotted on topographic maps. In all 3 sections, wolves frequently used roads and river canyons.

Wigwam Flats was located in the north section. A total of 79 km of wolf trails was recorded in this section; 40% (32 km) of the tracks were on secondary or tertiary roads, 27% were along the river banks, and 33% were in forested areas away from roads. Fourteen out of the total 18 kills were located on Wigwam Flats during winter 1988-89. Wolves left the kill site within 2 days of the kill >90% of the time. Six of these kills were found on river flood plains. Wolves traveled along parallel roads and dropped down onto
Figure 8. Open Cover in Study Area. Tree Density Type 1.
Figure 9. Thin Cover in Study Area. Tree Density Type 2.
Figure 10. Moderate Cover in Study. Tree Density Type 3.
Figure 11. Dense Cover in Study Area. Tree Density Type 4.
the flood plain to make a kill 4 times. Wolves made heavy use of roads and river banks to approach potential prey as well as when leaving a kill site.

The central section was a heavily forested, steeply banked river canyon and served as a corridor between the north and south sections; 84 km of tracks were recorded, 29% on an unplowed primary road, 23% in forested areas away from roads, and 48% along the Wigwam River banks.

Roads for wolf travel in the southern sections were limited to an unplowed tertiary road; 42 km of wolf tracks were followed, 12% were on the road, 64% along the river banks, and 24% in forested areas away from the road.

The wolf population on Wigwam Flats changed during winter 1989-90. The Headwaters Pack (2 adults and 8 or 9 pups) dominated the area for the entire winter. This pack had denned the previous year in the headwaters of the North Fork of the Flathead River. During 1987 and 1988, the Wigwam Flats and Sheep Mountain areas were on the western fringe of their home range (Fig. 12). In the past, the Headwaters Pack only occasionally used the Wigwam area. In 1990, this pack's movement on the Flats was very different from their previous patterns as well as the patterns of the Wigwam Pack in 1988-89. From late January through mid-March 1990, I continuously located the Headwaters Pack on the Flats. The pack left the Flats in late February, but returned 2 days later. The Headwaters wolves killed 7 ungulates and scavenged 1 winter-killed elk during a 10 day
Fig. 12 — Headquarters Pack and Wigwam Pack home range overlap in Wigwam Flats.
period in February 1990. After making kills, the Headwaters pack did not leave the Flats.

Many times tracks suggested the Headwaters pack made a kill and some of its members remained at the kill site, while others left the immediate area. The kills all had high consumption rates (>90%). Radio locations showed that the two adults, which were the only radio-collared wolves, always remained together. I followed radio-collared wolves away from kill sites but also found tracks of wolves (as well as wolves themselves) that remained behind at the kill sites. These tracks later met up with tracks for other members of the pack. This splitting up and regrouping (pups and adults) continued throughout the winter. The farthest distance I found the pups away from the adults was approximately 4-5 km. Possibly, the wolves spent 1 or two days apart from the rest of the pack. The number of pups remaining at the kill site varied from 4 to 7. Tracking data showed no evidence of another pack in the Flats.

Wolf #8910 was located only once in Wigwam Flats in January 1990. In contrast to the previous year (1988-89), the Wigwam Pack (now only consisting of 2, possibly four wolves) remained in the southern portion of the Wigwam drainage for most of the 1989-90 winter. Wolves traveled along the Wigwam Road, banks of the Wigwam River as far south as the U.S. border, up the smaller river drainages (Rabbit, Weasel, and Desolation creeks) just north of the border. No tracks were found along Ram Creek, or Ram Creek
Road from January to March 1990.

**Characteristics at Carcass Sites**

Eleven carcasses were set out throughout the 1988-89 winter, mostly in riparian areas where wolves frequently traveled. Wolves came to 3 carcasses and fed on only 2 of them, therefore the sample size was too small for statistical analysis. Some of the carcasses had been handled by humans and some were touched only by people wearing gloves. Wolves did not avoid carcasses that were covered with human scent. Two of the carcasses visited by wolves had been handled by highway road crews and researchers not wearing gloves.

Nine carcasses previously had been scavenged by birds or coyotes. Both carcasses used by wolves were in fairly unscavenged condition. The 3 carcasses examined by wolves were found soon after they died and had not been heavily scavenged.

All 3 of the wolf-visited carcasses were on or within 500 m of roads that were closed during winter. Two of these carcasses were out in open river bottoms with heavy brush cover nearby. The third carcass was in the open with no cover within 200 m.

All carcasses were scavenged by birds and coyotes. Golden eagles, bald eagles, and ravens appeared at the sites within days. Coyotes and eagles dominated the carcass sites. Ravens were lower on the hierarchy scale, with
magpies (*Pica pica*) feeding at the sites when other scavengers were less abundant. The time it took for scavengers to remove all soft tissue ranged from 6 to 17 days, depending on carcass size, location, number of scavengers present, and weather conditions.

Wolf Population

The first known litter of the Wigwam Pack was born in 1987. Ream et al. (1988) described pack formation and history (Table 7). My study began during summer 1988 when the pack consisted of 12 wolves. One wolf pup had been harvested during the 1987 fall hunting season, two wolves (both 1 year old) were harvested during the 1988 fall hunting season (Appendix I), one wolf dispersed in 1988, and one radio-collared wolf was either killed, left the area, or the radio-collar malfunctioned in fall 1988. When the winter 1988-89 field season began, no radio-collared wolves were present and the pack consisted of 1 adult, 3 yearlings, and 4 pups. Track counts indicated the Wigwam Pack remained at 8 wolves throughout the winter. As spring (1989) came and snow cover melted, tracks were more difficult to find. The tracks that could be found indicated the pack was no longer using the roads and river valleys as they had during winter. I continued tracking wolves in the Wigwam through April 1989, but never found more than a single wolf's set of tracks in the pack's previous spring home range.

One 2-year-old male wolf was trapped and radio-collared
during summer 1989. Radio locations during the remaining summer and fall indicated the wolf (W8910) was alone. This wolf was later seen several times during winter 1989-90 with another wolf in the Wigwam area. From the end of January through mid-March 1990, ground surveys were run throughout Wigwam Flats, Ram Creek drainage, Lodgepole Road, and the southern portion of the Wigwam River drainage (including Desolation, Rabbit, and Weasel creeks). Whenever wolf #8910 was tracked, only 1 and sometimes 2 sets of wolf tracks were seen. In areas 12 to 15 km south of #8910 locations, several surveys showed 2 additional sets of tracks and one time a set of 3 wolf tracks. The age of these tracks were estimated by snow and weather conditions. It seemed unlikely that these tracks belonged to #8910 or any wolves from the adjacent Headwaters Pack. When these additional tracks were found, the Headwaters Pack had been radio-located 35 to 40 km north during the same time period.

No evidence was found of a Wigwam Pack denning success, or subsequent pups. My estimate of the Wigwam Pack was that two and possibly up to 4 wolves were in the Wigwam Pack's home range during winter 1989-90. I found no evidence of any other pack (other than the Headwaters) being present in the Wigwam Pack home range.

Den Site

The 1988 Wigwam pack den was located approximately 2.2
km from the 1987 den and was very similar to traditional wolf dens described in the literature (Ballard and Dau 1983). The den was located in the southern portion of the pack's home range, on a southwestern slope of an alluvial terrace that paralleled the Wigwam River. Wigwam River Road ran along the top of the terrace which was 10 m above a river valley bottom. The terrace wall sloped approximately 40 degrees to the southwest. Soil was composed of well drained clay and sand. Dense lodgepole pine tree cover with numerous deadfalls dominated the den area while Canada bluegrass and Kinnikinnik (Arctostaphylos uva-ursi), rose, and spiraea (Spiraea betulifolia) grew under trees. Alders grew along Wigwam Road where superficial springs kept the road wet throughout the summer months.

The den was located on a convex curve along the terrace, on a knoll facing southwest. Wolves dug the main entrance tunnel into the west face of the hill under thick lodgepole deadfall (Fig. 13). Directly over the top of the hill, on the southern slope, were several diggings, holes, and smaller tunnels (Fig. 14). A clear view of 180 degrees could be seen from the south facing slope of the den hill. The Wigwam River was downslope 0.5 km to the west. Wolf trails radiated out in all directions from the den hill, but trails on the southern slope appeared to have been used more heavily. In contrast to other den site descriptions, this den was located <30 m from a tertiary road that was used several times a week by 1 or more vehicles.
Figure 13. 1988 Wigwam Pack Den.
Figure 14. 1988 Wigwam Pack Den.
The only entrance tunnel measured 30 cm high X 45 cm wide and was dug into the hill 1.4 m, sloping gradually downhill at a 20 degree angle. There, it split in two directions forming a "T" shaped tunnel. The west section of the "T" was 30 cm high X 61 cm wide and extended 1.2 m. The east section was 30 cm high X 50 cm wide and extended 1.2 m. Ceiling thickness of the tunnels averaged 25 cm. A small section of the ceiling had collapsed directly above where the branching tunnels formed a "T." It was not possible to tell whether this was another entrance or a result of the ceiling eroding away.

Two rendezvous sites were used by the 1988 Wigwam Pack. Site #1 was located < 0.5 km west of the den site and < 0.5 km from the Wigwam River. Site #2 was on the other side of the River, 1.4 km southeast of the den and < 0.25 km from the water. Both areas were in grassy clearings surrounded by thick lodgepole pine cover.

Wolf Mortalities

Nine wolves (3 males and 6 females) were harvested in southeastern B.C. during the 1987 and 1988 hunting seasons (Appendix G and H). Three of these wolves were killed within my study area (402), 5 were killed in the adjacent B.C. management unit (401), which is located east of unit 402, and 1 was killed outside these 2 management units. Ages were not all recorded by the B.C. Wildlife Branch, but those that were ranged from 6 months to 2-1/2 years. Out of
the 9 wolves killed, 56% of the time more than 1 wolf was killed at the same location and time. Two other wolves harvested in 1984 in southeastern B.C. (outside of 401 and 402) were also shot together. The 5 wolves killed in unit 401 were all killed within 300 m of a primary or secondary road. The 3 wolves killed in the Wigwam area (402) were killed in areas with little or no road access.
DISCUSSION

Food Habits

Wolves frequently select the most vulnerable ungulate species when several are present. Deer, being easier to kill than elk or moose, are often the predominant prey when the 3 exist together. Gunson (1983) reported wolves selecting deer over elk or moose in Alberta. Wolves killed more deer in northeastern Minnesota even though moose were more abundant than deer (Mech 1977). Carbyn (1974) noted that wolves selected elk and deer over moose during a mild winter in Jasper National Park; a strong preference for elk over moose was also observed during a year of deeper snow.

In other areas, prey selection apparently is influenced by prey availability and relative abundance (Carbyn 1974; Holleman and Stephenson 1981). Elk outnumbered moose by 2.4:1 in Riding Mountain National Park, Manitoba, and as a prey species outnumbered moose 15:1 (Carbyn 1983). Elk provided 30 to 46% of wolves' annual diet and made up 42% of the ungulate population in Jasper National Park (Carbyn 1974).

Winter food habit analysis for the Wigwam Pack was based on prey availability estimated by transects and aerial ungulate counts, prey items identified in wolf scats, and wolf kills. There are some inherent problems with these estimates. Aerial ungulate counts occurred primarily over Wigwam Flats. Given that the Flats are a major winter range
for elk and sheep, and that deer and moose were more widely distributed throughout the entire study area, deer and moose populations were probably underestimated relative to more easily observed elk. Wolf scats and kills generally were found by chance when tracking wolves or following birds. Therefore, the number of scats and kills not found must be considerable. Given these limitations of my data, availability transects found elk 1.8 times more available than deer, 3.2 times more than moose and 4.0 times more than bighorn sheep. Aerial ungulate counts found elk 1.8 times more abundant than deer and 2.4 times more than bighorn sheep. Wigwam wolves killed 7 elk, 9 deer, and 2 moose during a designated time period. Based only on kill data, wolves killed elk in a much small proportion than expected on the basis of relative abundance in the Wigwam winter range population. Thus, kill data would suggest that wolves are selecting for deer. However, the frequency of a species as a wolf kill was no different from the frequency of that species' occurrence in availability transects (chi-square = 1.93; df = 2; P > 0.05). I presumed a significant difference with observed values of 7 kills and 16 transect occurrences for elk. However when expected values were examined, the lack of significance is better understood.
<table>
<thead>
<tr>
<th></th>
<th>Elk</th>
<th>Deer</th>
<th>Moose</th>
</tr>
</thead>
<tbody>
<tr>
<td># of kills</td>
<td>7 (8.6)</td>
<td>9 (6.8)</td>
<td>2 (2.6)</td>
</tr>
<tr>
<td>Transect freq.</td>
<td>16 (14.4)</td>
<td>9 (11.3)</td>
<td>5 (4.4)</td>
</tr>
<tr>
<td>Totals:</td>
<td>23</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>

Totals: 23 18 7 48

(expected values) = 18 x 23/48 = 8.6
18 x 18/48 = 6.8 etc.

Using chi-square for comparisons between frequency distributions, and setting the probability of a type I error at 0.05, the analysis would suggest that the deviations within the groups are due to sampling error.

Food habits of wolves frequently are estimated by scat analysis. How well the frequencies of prey hair identified in scats represent the proportion of prey species eaten is questionable. Pimlott et al. (1969) and Voigt et al. (1976) felt that scat analysis gave an accurate estimation of some prey species consumed. Mech (1970) thought small prey species were overrepresented in comparison to larger prey species. Weaver (1979a) pointed out that detecting remains of different size prey in scats may not be constant. Meriwether and Johnson (1980) noted that different size prey were digested to varying degrees, increasing difficulty in comparing consumption with percentage found in scats. Floyd et al. (1978) reported that remains of small prey were identified in greater proportion relative to the prey's weight, but in smaller proportion to the number of prey individuals, than were remains of larger prey. O'Gara (1986) suggested that large prey were underrepresented in
scat analysis, and that amounts of carrion consumption may be overestimated when compared to amounts of fresh kills. Traves (1983) stated that different amounts of undigestible hair would be found in summer and winter scats due to seasonal differences in the weight of prey pelage.

Scat data did not corroborate the selection of deer over elk in the presence of a significantly higher elk population. Comparison of biomass frequencies and transect frequencies suggest that these wolves were selecting prey based on ungulate densities rather than vulnerability of a particular species (chi-square = 2.04; df = 3; P > 0.05). In the Wigwam, elk are high in density and wolves may be selecting elk because of their high availability.

Prey selection of deer, as suggested by kill data, is probably inaccurate due to such a small sample of carcasses. No significance is found when comparing prey species (kills) and scats (chi-square = 3.69; df = 2; P > 0.05). Carbyn (1974) speculated that when scats and kills are collected in only part of wolves' home ranges, there is a potential for bias in the data. The small sample size of the Wigwam study must be taken into consideration and generalizations about food habits should be interpreted accordingly. Mean consumption rates for deer were 96%, compared to 90% for elk. This higher deer consumption led me to believe that I undoubtedly missed many deer kills throughout the winter because there was nothing left to find. However this would seem to contradict relative
frequency of occurrences of prey items in scats for elk (36%) and deer (19%) shown in Table 3.

No changes in prey consumption rates were observed throughout winter 1988-89. Rates remained high (>90%). Moose and elk had slightly lower consumption rates, but that could easily be attributed to the smaller size of deer. High carcass consumption has been reported in areas of low prey density (Peterson 1977), but Wigwam wolves consumed over 90% of most carcasses in an area of high prey availability.

Trace amounts of black bear hair were found in winter and summer scats. Paquet and Carbyn (1986), Horejsi et al. (1984), and Ramsay and Stirling (1984) recorded incidences of wolves killing denning black bears. Summer and winter scats might suggest wolves killing bears in summer or denning bears in winter. The data also suggests wolves scavenge bear carcasses throughout the year.

Waiting until wolves left rendezvous sites, to avoid disturbing them, created a problem. Coyotes sometimes come into wolf feeding areas soon after wolves leave and this could possibly have introduced inaccuracies in the scat analysis. This was unavoidable because the wolves occasionally used the rendezvous sites until fall. A judgment had to be made whether or not to go into the den and rendezvous sites, to collect wolf scats, and minimize the possibility of coyote scats. The other possibility was to wait until the wolves had definitely left before
collecting scats. I chose to wait until the wolves stopped using the areas on a regular basis. When I did collect scats, the presence of many fresh wolf scats and few fresh coyote size scats offered evidence that coyotes had not seriously contaminated my collection data.

Summer scat analysis indicated a slight decrease, compared to winter scats, in the relative frequencies of occurrence in elk and moose, and a slight increase in deer and bighorn sheep. Domestic sheep hairs were found in 3% of the summer scats and 4% of the winter scats. Domestic cattle was found in 1% of the summer scats. I found no evidence or heard no reports from local ranchers of wolves killing livestock. A more plausible explanation would be wolves scavenging winter kills or calf carcasses. Carbyn (1974) also noted that he could not be certain how much scats (and subsequent biomass data) reflected scavenging or predation.

Kills

Wolf predation rates may increase as snow depth increases (Pimlott et al. 1969; Peterson 1977; Haber 1977). Nelson and Mech (1986) reported a significant positive relationship between snow depth and wolf predation rates on white-tailed deer. Snow depth was recorded at all Wigwam kill sites, but 72% of the kills occurred in <20 cm of snow. The remaining 5 kills were too small a sample for statistical analysis.
Even though predation rates appear to be more directly related to snow depth, it also has been observed that cold weather reduces fat supplies in deer and makes them more vulnerable to wolf predation (Mattfield 1974; Parker et al. 1984; Nelson and Mech 1986). The 1988-89 winter in the Wigwam study area was not unusually harsh (Fernie and Elko weather data 1988-89). Mean consumption rates of deer were 90%, and out of 9 wolf-killed deer, I located no femurs at kill sites. Therefore it was not possible to determine deer condition by bone marrow-fat techniques.

Two problems occurred in determining age or sex of wolf kills. The wolves usually consumed at least 90% of the carcasses, so very little was left at the kill site to examine. Finding a skull, pelvis, or mandible was the exception. The other problem was finding the carcass before other scavengers located it. If I went in too soon on a kill, I risked chasing the wolves off and thereby increasing their kill rate. If I waited too long, the eagles, ravens, and coyotes cleaned up the carcass. Most of the carcasses were found within 2 days after the kill.

Surplus killing by wolves has been reported by Eide and Ballard (1982) and Kruuk (1972), but I never found evidence of this in the Wigwam drainage. Of 19 kills during winter 1988-89 and 9 kills in winter 1989-90, 85% consumption was the lowest amount for any carcass.

Ungulates responded to wolf kills in an unexpected manner. I noticed on numerous occasions that elk and deer
came back to the general area of a kill within days. Often times they walked within a few feet of a fresh carcass. The Headwaters Pack remained in the Flats for the entire 1989-90 winter and ungulates were not displaced from the area.

**Prey Availability**

Prey selection is influenced by prey availability (Holleman and Stephenson 1981). It would therefore be useful to develop a simple method of estimating availability. Ungulate transects taken perpendicular to wolf trails, similar to this study's attempt, might be a useful technique.

Transect analysis showed that elk tracks were found closest to a wolf trail 1.8 times more often than deer and four times more than bighorn sheep. Aerial ungulate counts over the Flats recorded elk being 1.7 times as abundant as deer and 2.4 times as abundant as bighorn sheep. B.C. Wildlife Branch aerial surveys had definite limitations because they were not flown frequently and they tended to underestimate deer. Transect data indicated that bighorn sheep frequently were found on open plateaus, but transect surveys were not run in high rocky habitats where sheep commonly are located. Sheep were probably underestimated using track transects because of this.

Researchers considering using this technique should be aware of its limitations. Relative time was always difficult (if not impossible) to determine. Setting the
wolf tracks as a reference point, one must assume that ungulate tracks were there first. Even with similarly aged tracks, this was a rather large and often times erroneous assumption. Ungulates may not have been in the area before the wolf and then later may have walked back over the same area again after the wolf. The only way to deal with this problem was to remain consistent and count all recognizable ungulate tracks and not make subjective interpretations about their age.

Animal behavior also affected this technique. Initially the design was to count all ungulate tracks that crossed the transect to estimate ungulate availability. This approach would give biased results because gregarious animals (i.e. elk) might walk single file through an area, leaving fewer tracks that were intersected by the transect than a single animal that meandered about cutting back and forth over the same area. Results from the transect would incorrectly estimate prey availability. To minimize these potential errors, the transect technique was redesigned to count only the first ungulate track, closest to the wolf trail.

Snow conditions presented problems to this technique. Wolves have higher track loads and are able to travel on top of crusted snow easier than ungulates (Formozov 1946; Kelsall 1969; Mech and Frenzel 1971). Blowing snow may not have affected deep ungulate tracks, but shallow tracks or wolf tracks that did not penetrate the snow frequently were
covered. Poor snow conditions in the Flats limited the usefulness of prey availability transects. Continued use of this technique in larger sample sizes would give a better indication concerning whether the design was workable.

**Kill Site Characteristics**

Two problems were evident when kill site characteristics were analyzed. Defining the actual kill site is subjective. Is the kill site where the wolves first attacked its prey, where the greatest struggle occurred, or where the prey actually died? How large an area should be included? Many kills had long distances between these areas and different stages of the "kill" occurred in various types of habitats. I attempted to minimize subjective interpretations at each kill site by defining kill sites as the spot where I found the dead ungulate. Second, an incomplete sampling of wolf kills was obtained because kills had to be located by tracking wolves that were not radio-collared. Even though 27 kills was a small sample size, some generalizations can be made when comparing kill site locations and wolf travel routes.

Based on my data, tree density and elevation were important habitat characteristics that distinguished random areas from kill sites (Fig. 7).

The significance of elevation probably was related to where different prey species spent the winter. Kills were found at elevations ranging from 840 m to 1440 m (Fig. 15).
**Fig. 15 - Elevation of wolf killed ungulates. Carcass remains where located during winters 1989 and 1990.**
White-tailed deer usually winter in relatively lower elevations where snow cover is less (Pengelly 1961; Telfer and Kelsall 1979; Keay and Peek 1980; Jenkins 1985). At elevations below 1000 m, deer were the dominant prey species, while elk occurred as a prey species more frequently at higher elevations up to 1440 m. No kills were found above 1440 m. There is an obvious limitation to this analysis because one might criticize (and rightfully so) that tracks and kills were only found in easily accessible areas (i.e. areas with road access or lower elevations with gentler topography). My only defense is that given no radio-collared wolves, one must make the best of a tough situation. The wide distribution of habitat types where tracks and kills were found (described in Results) give an indication of the search effort.

Several kills were located in river flood plains where old, unused roads had been cut high above the river into the river canyon and paralleling the river. Wolf tracks were continually found along those roads. One possible hypothesis could be that wolves traveled those high roads to have a wide vantage point over ungulates browsing in the flood plains below. Banfield (1954) described wolves "patrolling" areas for caribou. Mech (1970) cited Cowan observing wolves traveling ridge tops in Banff National Park, until they spotted elk on lower slopes and then rushed them. I found 4 kills that supported this hypothesis.
Population Dynamics

Eight wolves were in the Wigwam Pack from fall 1988 until spring 1989. Track counts during winter 1989-90 suggested there were 2, possibly 4 wolves in the home range of the Wigwam Pack. Without radio-collared wolves, no data are available on which to base possible explanations for the decrease in wolf numbers. Several hypotheses that might offer insights include: 1) wolves were shot or poisoned; 2) wolf numbers have not changed but sampling errors have caused inaccurate counts; 3) death from some canine disease has reduced the Wigwam population; and 4) Wigwam wolves moved out of the area.

There are mixed opinions among B.C. hunters concerning wolves as a potential threat to high ungulate populations. Hoffos (1987) found 45% of hunters responding to his survey agreed that wolves and bears were responsible for local ungulate declines, while 43% disagreed. When asked if bears and wolves caused major declines in ungulate populations throughout the province, 32% agreed and 58% disagreed. I believe that many hunters would not think twice about shooting wolves (or using any other method of destroying wolves), whether or not there is a hunting season. One problem with illegal control is that a few individuals can devastate a small recovering wolf population, regardless of what the general population feels. The history of wolf eradication in parts of North America suggests that poisoning wolves is not difficult. Illegal wolf killing in
remote areas is extremely difficult to substantiate. It would be naive to think that illegal wolf kills never occur, but I found no direct evidence of wolf killing to the extent that would explain the reduction in the Wigwam Pack size. However, just because I found no evidence does not mean the Wigwam Pack was not shot, poisoned, or in some other way illegally killed.

Again, without radio-collared wolves, it is incredibly difficult to consistently locate and document wolf home ranges. Tracking wolves during winter 1989-90 gave some insight to the population size of the Wigwam Pack, but one must realize the limitations of a single biologist hiking around a 1300 km² study area trying to document wolf numbers.

Radio-collared wolf #8910 was seen several times from the air with another wolf during winter 1989-90. Young dispersing wolves or older wolves that were physically unable to travel with a pack often become lone wolves (Jordan et al. 1976; Mech and Frenzel 1971). Carbyn (1980) and Van Bellenberge et al. (1975) reported movements of lone wolves traveling within other wolves' home ranges. Lone wolves remain in a home range that is occupied by another pack, especially if the lone wolf once belonged to that pack. Ream et al. (1987) reported a lone wolf (#8401) sharing a winter range with the Magic Pack in Glacier National Park. Their home ranges overlapped, but there was always a temporal separation. Whenever the Magic Pack moved
into an area where #8401 was located, the lone wolf moved out. Without radio-collared wolves it is quite difficult to follow pack movements, dynamics with other wolves, or determine the existence of another pack. This may have been going on in the Wigwam area. Wolf #8910 may be a lone wolf interacting in a similar way with other wolves of the Wigwam Pack. Whether this occurred during winter 1989-90 is not known, but it illustrates how this type of sampling error could easily contribute to inaccurate wolf counts in the Wigwam drainage.

Ream et al. (1989) reported finding the remains of 2 pups approximately 2 weeks old at a den site in Glacier Park, Montana. No evidence of other live pups was found and the exact cause of death could not be determined. Disease was considered a possible cause because 2 wolves within that pack tested positive for canine parvovirus (CPV). Wigwam wolf #8910 had an extremely high blood titer for CPV. The virus can live up to 10 years in the ground or other environments (dens, forest, etc.). CPV destroys the animals' white blood cells and can be fatal to pups and adults. Pups gain immunity from their mothers, but lose it approximately 16 weeks after birth. Sudden death syndrome occurs in pups when the heart is damaged (Stephens, Alpine Veterinary, pers. commun.). Mech et al. (1986) stated there was no conclusive evidence to substantiate wild wolves dying from CPV, but he added that it was difficult to retrieve carcasses of dead wolves soon enough to accurately determine
whether the cause of death was CPV. Therefore hypothesizing CPV as a cause of the reduction of Wigwam wolves is difficult, but it remains a possibility.

In the spring of 1989, track counts showed that Wigwam wolves were no longer using the river valleys in the same manner they were during the winter. This change occurred in a few days, but did not appear too unusual because wolves normally change travel patterns once pups are born. Adult wolves branch out from den or rendezvous sites and often hunt alone or in smaller groups (Mech 1970). There was no response to several howling surveys, and it appeared the wolves had left the area or their numbers had been substantially reduced. Why would a pack of wolves leave their traditional denning area within their home range?

Wolves often abandon den sites when disturbed (Banfield 1954; Joslin 1966; Mech 1970). Chapman (1977) reported Alaskan wolves abandoning den sites when disturbed by humans within 2.4 km. During late April and early May 1989, extensive road work (with chain saws and a front-end loader) was done on the Wigwam Road approximately 5-6 km from the previous year's den site. The 1988 den was 2.5 km from the 1987 den and was located 35 m from the road. The location of the 1989 den was unknown (if there was a den), but possibly, the road work was close by the den, and caused the wolves to abandon the den site.

Wolves are territorial (Mech 1970, 1973, Peterson 1977). Territories are not always fixed in specific areas

Mech (1977) described "buffer zones" as areas within wolf territories that overlap with adjacent packs. Wolves from either pack tend to spend less time in the overlap areas to avoid confrontation with other wolves. During winter 1988-89 whenever the Wigwam Pack made a kill in Wigwam Flats, it did not remain in the area for more than a few days. I located the Headwaters Pack in Wigwam Flats 3 times during that winter, but there was always a temporal separation between the 2 packs. Wigwam Flats was an area of territorial overlap.

Mech (1977) further reported that buffer zones between wolf territories tended to remain in the same location with time, unless food became an issue. In 1989, the Headwaters Pack size changed from 3 to 11. The food requirements of 11 wolves might be sufficient cause for the Headwaters Pack to shift their home range into Wigwam Flats where prey is abundant. The southern section of the Wigwam Pack's home range and eastern portion of the Headwater Pack's home range apparently has adequate prey, but prey is much more abundant in Wigwam Flats. The home range shift of the Headwaters Pack may have caused the Wigwam Pack to lose the northern
portion (Wigwam Flats) of their territory, and this may have caused the Wigwam Pack to then shift its home range. Pack displacement is a possible cause for the decrease in the Wigwam Pack size. Increasing reports of wolf sightings in southeastern B.C. and Montana may be linked to Wigwam wolves (Fig. 16).

Other possible explanations exist for pack movements; and possibly some other event caused the decrease in the Wigwam population, and the Headwaters Pack adjusted their home range to occupy the void created by the absence of other wolves in the Flats. However, if I had to speculate on what actually happened, I would suggest illegal killing caused by local intolerance to wolves in ungulate winter ranges was a contributing factor.

**Den Sites**

Wolves frequently use the same den site more than once (Murie 1944, Novikov 1956, Mech 1970, Ballard and Dau 1983). Chapman (1977) noted that wolves were very sensitive to human disturbances and suggested a 1.6 km radius around active dens as protection. Joslin (1966) documented 5 wolf dens not being used again after being disturbed by humans. The 1988 Wigwam den was similar to those described by Stephenson (1974), Ballard et al. (1983), and Ryon (1977). This den was located <30 m from a dirt road that had light, but repeated vehicle traffic. The Wigwam Pack did not move out of this den prematurely. However, the following year the pack did not den in that area.
Reported Activity
Confirmed Activity
Monitored Pack
Pack Removed in Control Action
Wigwam Pack

Figure 16  WOLF PACK LOCATIONS IN MONTANA, 1990
Management Recommendations

Many people view wolves as wilderness animals that require huge roadless areas undisturbed by human. Wigwam wolves continuously used habitat that was criss-crossed by roads, seismic clearings, gas pipeline clearcuts and, was bordered by a large lumber mill. These features did not appear detrimental to wolves; however, the human access to wolf habitat that came with roads and clearcuts had significant impact on wolves. Access roads contribute to legal and illegal wolf killing. More research should be aimed at looking into the effects of open road densities. Human-caused wolf mortality remains a serious obstacle to wolf recovery.

Long-range wolf recovery management must deal with local public attitudes and potential human conflicts with wolves. I believe that wolves have a much better long-range hope of recovery when the B.C. public is involved. Local B.C. hunters and outfitters want some form of wolf management involving wolf control through public hunting and trapping. Much of the local Canadian public does not feel any sympathy for Americans who long ago destroyed their predator populations (not to mention wolves being recently destroyed for killing livestock in Montana) and are now asking B.C. to maintain higher wolf populations so that dispersers will initiate recovery in the U.S. B.C. locals have a saying: "American wolves eat B.C. sheep." This hostility and frustration is often taken out on wolves.
Unfortunately from a U.S. viewpoint where we are struggling with a small fragile wolf population, this means actively supporting public harvest of wolves in southeastern B.C. Closing wolf hunting and trapping in Management Unit 402 has resulted in repeated illegal wolf killings. In winter 1991, at least 5 wolves from the Headwaters Pack, which had moved into Wigwam Flats, were poisoned. Whether or not long-range wolf recovery has benefitted from total protection of these wolves is questionable.

I support a hunting and trapping season in unit #402 and suggest that the bag limits be set according to management goals based on a predetermined wolf population that B.C. would allow in #402. Factors that should be considered would be litter successes or failures, pup survival, age structure in the pack, and location of home ranges. Continued monitoring would be extremely important. During past wolf seasons, 56% of the time more than 1 wolf has been killed at the same time and same location. Therefore, it is very easy to overshoot the harvest quota. Road access is an important consideration because 6 out of 9 wolves harvested in 2 seasons were within 300 m of a road. Quotas should be a certain number of wolves with no consideration of age or sex. One possibility would be to have wolf hunting not coincide with the general big game season. Too many hunters have the attitude that "I might as well shoot a wolf while I'm here." Having a separate and later fall wolf season (similar to and perhaps paralleling
cougar in the winter) might accomplish two things. It would allow the public to be actively involved with wolf management and raise the status of wolves as a game animal.

Another recommendation would be to stress the importance of travel corridors. Wigwam wolves continuously used river bottom land, canyons, and other specific areas to travel throughout their home range or disperse into new areas. These corridors need not be prime wilderness, but they do need to be areas where adequate cover provides protection. Low road densities would prevent high vulnerability to poachers, and minimal human activity would ensure that wolves do not come in conflict with ranchers or farmers.

Wolves are wide ranging predators and innate dispersers. Wolves do require large areas in which they can exist without coming in conflict with people. Wolf recovery would benefit from management decisions where corridors were left in relatively natural states, connecting large national forests or wilderness areas. Wolves would then be able to use their intelligence, adaptability, and reproductive potential to recover in southeastern B.C. and Montana.
LITERATURE CITED


Murie, A. 1944. The wolves of Mt. McKinley. USDI NPS Fauna Ser. 5. 238pp.


### Appendix A. B.C. WILDLIFE BRANCH AERIAL GAME CENSUS IN WIGWAM STUDY AREA

<table>
<thead>
<tr>
<th>Wildlife</th>
<th>Grassmere</th>
<th>Wig. Flats</th>
<th>Sheep Mountain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1987</strong></td>
<td>0</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>1988</strong></td>
<td>0</td>
<td>2</td>
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<td><strong>1989</strong></td>
<td>0</td>
<td>x</td>
<td>1</td>
<td>x</td>
</tr>
<tr>
<td><strong>1990</strong></td>
<td>0</td>
<td>9</td>
<td>9</td>
<td>x</td>
</tr>
</tbody>
</table>

**Coyote**

**Elk**
- South Wigwam: 12 (1989)
- Wig. Flats: 158 (1990)
- Sheep Mountain: 1000 (1989)
- Total: 1184 (1989)

**Moose**
- South Wigwam: 11 (1990)
- Wig. Flats: 7 (1990)
- Total: 18 (1990)

**White-tailed Deer**
- Grassmere: 3 (1990)
- Wig. Flats: 3 (1990)
- Sheep Mountain: 306 (1990)
- Total: 341 (1990)

**Mule Deer**
- Grassmere: 1042 (1990)
- Wig. Flats: 450 (1990)
- Sheep Mountain: 86 (1990)
- Total: 1578 (1990)

**Bighorn Sheep**
- Grassmere: 59 (1990)
- Wig. Flats: 212 (1990)
- Total: 271 (1990)

Counts taken by B.C. Wildlife Branch
Each number represents an aerial count taken in mid-January of that year.
x = no animals counted on that flight
Appendix B. Prey Species for Wolves in the Wigwam Drainage

**Cervidae**

Elk (*Cervus elaphus*)

Moose (*Alces alces*)

Mule Deer (*Odocoileus hemionus*)

White-tailed Deer (*Odocoileus virginianus*)

Caribou (*Rangifer tarandus*)

**Bovidae**

Rocky Mountain Bighorn Sheep (*Ovis canadensis*)

Rocky Mountain Goat (*Oreamnos americanus*)

Domestic Sheep

Domestic Cattle

**Equidae**

Horse

**Canidae**

Gray wolf (*Canis lupus*)

Coyote (*Canis latrans*)

**Ursidae**

Grizzly bear (*Ursus arctos*)

Black bear (*Ursus americanus*)
Leporidae
Snowshoe hare (Lepus americanus)

Castoridae
Beaver (Castor canadensis)

Sciuridae
Columbian ground squirrel (Spermophilus columbianus)
Golden-mantled ground squirrel (S. lateralis)
Red squirrel (Tamiasciurus hudsonicus)

Cricetidae
Deer mouse (Peromyscus maniculatus)
Meadow vole (Microtus pennsylvanicus)
Red-backed vole (Clethrionomys gapperi)
Muskrat (Ondatra zibethicus)

Avian
Anseriformes
Galliformes
Appendix C. Prey found at wolf kill sites in the Wigwam River drainage.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>Cervus elaphus</td>
<td>211.0</td>
</tr>
<tr>
<td>Moose</td>
<td>Alces alces</td>
<td>270.0</td>
</tr>
<tr>
<td>Mule deer</td>
<td>Odocoileus hemionus</td>
<td>54.0</td>
</tr>
<tr>
<td>White-tailed deer</td>
<td>Odocoileus virginianus</td>
<td>54.0</td>
</tr>
</tbody>
</table>

Weights used for relative biomass estimates for winter and summer 1988-89 prey consumption estimates (Ream et al. 1987).

Moose weights (Franzman and Ameson 1957, Franzman and Baily 1977). Newborn moose calf weights 13.3 kg (Ballard and Taylor 1978) and gains 1.3 kg/day (Franzman and Ameson 1973). At 15 days of age, moose calves weight approx. 32.7 kg and 90% is consumable, yielding 29.5 kg. Yearling moose weight 197.5 kg and are 75% consumable (Franzman and Ameson 1973).
Appendix D. Biomass estimated by Floyd et al. techniques

\[ y = 0.38 + 0.02x \]
\[ y = \text{kg of prey per collectible scat} \]
\[ x = \text{mean prey weight (appendix C)} \]

**Elk**

average weight = 211 kg (includes bulls, cows, and calves)

\[ y = 0.38 + 0.02 \times 211 \text{ kg} \]
\[ y = 0.38 + 4.22 \]
\[ y = 4.6 \text{ kg prey/scats} \]

Relative total weight of each type of prey eater =

\[ (4.6 \text{ kg prey/scat}) \times (50 \text{ scats}) = 230 \text{ kg prey} \]

Relative number of individuals of each prey type consumed =

\[ (230 \text{ kg prey}) \times \text{(elk/211 kg)} = 1.1 \text{ elk eaten} \]

Ratio of number of individuals eaten =

\[ (1.1 \text{ elk eaten}) / \text{relative number of some other prey species being compared to elk (i.e. - deer was determined to have relative value of 0.7 individuals eaten)} \]

\[ (0.7 \text{ deer eaten}) / (1.1 \text{ elk eaten}) = 0.64 \]

**Deer**

average wt = 54 kg

\[ y = 1.46 \]

\[ (1.46) \times (26 \text{ scats}) = 37.96 \text{ kg prey} \]
\[ (37.96) \times \text{(deer/54 kg)} = 0.7 \text{ deer eaten} \]
Moose

average wt. = 270 kg

y = 5.78

\[(5.78)(15 \text{ scats}) = 86.7 \text{ kg prey} \]

\[(86.7)(\text{moose}/270\text{kg}) = 0.32 \text{ moose eaten} \]

\[(0.32 \text{ moose eaten})/(1.1 \text{ elk eaten}) = 0.29 \]

Bighorn Sheep

average wt. = 45 kg

y = 1.28

\[(1.28)(17 \text{ scats}) = 21.76 \]

\[(21.76)(\text{sheep}/45\text{kg}) = 0.48 \text{ sheep eaten} \]

\[(0.48 \text{ sheep eaten})/(1.1 \text{ elk eaten}) = 0.44 \]

The ratio of numbers of individuals eaten was tallied in column 7 of the following biomass table and had a sum total value of 2.37. This total was then divided into each species' value in column 7 to get a relative number of individuals eaten. This value is presented in column 8.

Examples from biomass tables:

<table>
<thead>
<tr>
<th>Species</th>
<th>Column 7</th>
<th>Column 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>1.0</td>
<td>1.00/2.37 = 0.42</td>
</tr>
<tr>
<td>Deer</td>
<td>0.64</td>
<td>0.64/2.37 = 0.27</td>
</tr>
<tr>
<td>Moose</td>
<td>0.29</td>
<td>0.29/2.37 = 0.12</td>
</tr>
<tr>
<td>Sheep</td>
<td>0.44</td>
<td>0.44/2.37 = 0.19</td>
</tr>
<tr>
<td></td>
<td>2.37</td>
<td>1.00</td>
</tr>
</tbody>
</table>
### Biomass Estimates of 1988-89 winter scats (Floyd et al.)

<table>
<thead>
<tr>
<th>Prey</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>211 kg</td>
<td>4.6</td>
<td>50</td>
<td>230</td>
<td>1.00</td>
<td>1.1</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>Deer</td>
<td>54 kg</td>
<td>1.46</td>
<td>26</td>
<td>37.9</td>
<td>0.16</td>
<td>0.7</td>
<td>0.64</td>
<td>0.27</td>
</tr>
<tr>
<td>Moose</td>
<td>270 kg</td>
<td>5.78</td>
<td>15</td>
<td>86.7</td>
<td>0.38</td>
<td>0.32</td>
<td>0.29</td>
<td>0.12</td>
</tr>
<tr>
<td>Sheep</td>
<td>45 kg</td>
<td>1.28</td>
<td>17</td>
<td>21.76</td>
<td>0.09</td>
<td>0.48</td>
<td>0.44</td>
<td>0.19</td>
</tr>
</tbody>
</table>

1 = Assumed weight of prey (kg)  
2 = Prey per scat (kg) = y  
3 = Number of scats  
4 = Kg eaten  
5 = Ratio of weight eaten  
6 = Number of individuals eaten  
7 = Ratio of number of individuals eaten  
8 = Relative number of prey individuals

Assumed prey weights = species mean weight (Appendix C)

Column 8 values (from Floyd et al.) were used for chi-square analysis. The total number of ungulates recorded as "closest ungulate to a wolf trail" in the prey availability transect was 34. By multiplying the percentage value for each species (from column 8) times the total of 34, I obtained a value of how often one would expect to find that
species in the transect data based on its occurrence in wolf scats.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Expected values</th>
<th>Observed in transects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>(34) (0.42) = 14.3</td>
<td>16</td>
</tr>
<tr>
<td>Deer</td>
<td>(34) (0.27) = 9.2</td>
<td>9</td>
</tr>
<tr>
<td>Moose</td>
<td>(34) (0.12) = 4.1</td>
<td>5</td>
</tr>
<tr>
<td>Sheep</td>
<td>(34) (0.19) = 6.5</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix E. Biomass estimates of 1988-89 winter scats
Traves 1983)

Data were also analyzed using Traves' (1983) modified biomass regression equation: \( y = 0.265 + 0.01x \)

<table>
<thead>
<tr>
<th>Prey</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>211 kg</td>
<td>2.38</td>
<td>50</td>
<td>119</td>
<td>1.00</td>
<td>0.56</td>
<td>1.00</td>
<td>0.40</td>
</tr>
<tr>
<td>Deer</td>
<td>54 kg</td>
<td>0.81</td>
<td>26</td>
<td>21.06</td>
<td>0.18</td>
<td>0.39</td>
<td>0.70</td>
<td>0.28</td>
</tr>
<tr>
<td>Moose</td>
<td>270 kg</td>
<td>2.97</td>
<td>15</td>
<td>44.55</td>
<td>0.37</td>
<td>0.17</td>
<td>0.30</td>
<td>0.12</td>
</tr>
<tr>
<td>Sheep</td>
<td>45 kg</td>
<td>0.72</td>
<td>17</td>
<td>12.24</td>
<td>0.09</td>
<td>0.27</td>
<td>0.48</td>
<td>0.19</td>
</tr>
</tbody>
</table>

1 = Assumed weight of prey (kg)
2 = Prey per scat (kg) = y
3 = Number of scats
4 = Kg eaten
5 = Ratio of weight eaten
6 = Ratio of number of individuals eaten
7 = Relative number of prey individuals
Assumed prey weights = species mean weight (Appendix C)
Appendix F. Methods for Analysis of Scat Samples
to Estimate the Frequency of Prey Items

1. Dry samples at 100 degrees C to kill any vectors.
2. Place dried samples in nylon bags.
3. Soak the samples over night in a detergent solution
   with added household bleach to inhibit microbial
   degredation and odor.
4. Gently agitate in washing machine. Use 2 washes (with
   soap) and as many rinses as needed to remove the
   soluable materials. Rinse water should appear clear.
   Spin the water out between washes and rinses.
5. Dry spin bags in cloth dryer at low heat with a sheet
   of fabric softener until dry.
6. Place material in a shallow pan and separate bones,
   hair, and feathers into subsamples.
7. Examine the fragments to identify the prey items and
   determine minimum number of items consumed.
8. Mount subsample of the hair using clear nail polish,
   then identify all types of hair on the slide.
9. Identify each type of feather in the subsample,
   mounting them with nail polish as needed.

All work was done by Composition Analysis Laboratory, Range
Science Department, Colorado State University.

<table>
<thead>
<tr>
<th>Date Killed</th>
<th>Location</th>
<th>UTM's</th>
<th>Sex</th>
<th>Age</th>
<th>Wt</th>
<th>Skull</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/18/87</td>
<td>Lower Flathead</td>
<td>5432 N</td>
<td>F</td>
<td>2.5 yrs</td>
<td>39kg</td>
<td>263L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>684 E</td>
<td></td>
<td></td>
<td></td>
<td>147W</td>
</tr>
<tr>
<td>09/27/87</td>
<td>3 Mile Lake</td>
<td>5438 N</td>
<td>F</td>
<td>6 mos.</td>
<td>?</td>
<td>222L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>685 E</td>
<td></td>
<td></td>
<td></td>
<td>118W</td>
</tr>
<tr>
<td>10/07/87</td>
<td>Wigwam River</td>
<td>5437 N</td>
<td>F</td>
<td>6 mos.</td>
<td>?</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td></td>
<td>656 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/26/87</td>
<td>Howell Creek</td>
<td>5438 N</td>
<td>M</td>
<td>6 mos.</td>
<td>?</td>
<td>239L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>680 E</td>
<td></td>
<td></td>
<td></td>
<td>122W</td>
</tr>
<tr>
<td>10/26/87</td>
<td>Howell Creek</td>
<td>5438 N</td>
<td>F</td>
<td>6 mos.</td>
<td>?</td>
<td>232L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>680 E</td>
<td></td>
<td></td>
<td></td>
<td>121W</td>
</tr>
<tr>
<td>10/26/87</td>
<td>Howell Creek</td>
<td>5438 N</td>
<td>F</td>
<td>6 mos.</td>
<td>?</td>
<td>227L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>680 E</td>
<td></td>
<td></td>
<td></td>
<td>109W</td>
</tr>
<tr>
<td>11/04/88</td>
<td>Weasel Creek (Wigwam Drainage)</td>
<td>5430 N</td>
<td>F</td>
<td>6 mos.</td>
<td>27kg</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td></td>
<td>662 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/04/88</td>
<td>Weasel Creek</td>
<td>5430 N</td>
<td>M</td>
<td>6 mos.</td>
<td>54kg</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td></td>
<td>662 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix H: Wolves Harvested Outside Management Units 401 & 402

Descriptive

<table>
<thead>
<tr>
<th>Date Killed</th>
<th>Location</th>
<th>UTM's</th>
<th>Sex</th>
<th>Age</th>
<th>Wt</th>
<th>Skull</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/18/84</td>
<td>Paliser River</td>
<td>5596 N</td>
<td>M</td>
<td>??</td>
<td>17kg</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>602 E</td>
</tr>
<tr>
<td>10/18/84</td>
<td>Paliser River</td>
<td>5596 N</td>
<td>M</td>
<td>??</td>
<td>23kg</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>602 E</td>
</tr>
<tr>
<td>09/17/87</td>
<td>Ward Creek</td>
<td>5434 N</td>
<td>M</td>
<td>??</td>
<td>45kg</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>603 E</td>
</tr>
</tbody>
</table>