Pack Size of Wolves, *Canis lupus*, on Caribou, *Rangifer tarandus*, Winter Ranges in Westcentral Alberta

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We studied pack size of Wolves (*Canis lupus*) on Woodland Caribou (*Rangifer tarandus caribou*) winter ranges in westcentral Alberta. These Caribou winter ranges are experiencing increasing pressure from resource extraction industries (forestry, energy sector) and concerns have been raised regarding increased Wolf predation pressure on Caribou in conjunction with landscape change. Thirty-one Wolves, from eight Wolf packs, were fitted with radiocollars on two Caribou winter ranges in the Rocky Mountain foothills, near Grande Cache, Alberta (2000-2001). There was a mean of 8.2 Wolves/pack and between 30 and 39 Wolves on each of the RedRock/Prairie Creek and Little Smoky Caribou ranges. The average pack size of Wolves in this region does not appear to have increased over that recorded historically, but the range (5-18) in the number of Wolves per pack varied considerably over our study area. Wolves preyed predominately on Moose (*Alces alces*), averaging one Moose kill every three to five days. There was some indication that pack size was related to prey size, with the smallest pack preying on Deer (*Odocoileus* spp.). It was clear that Caribou could not be the primary prey for Wolves, due to their low numbers, and relative to the pack size and Wolf kills we observed.

Key Words: Wolf, *Canis lupus*, Caribou, *Rangifer tarandus*, Moose, *Alces alces*, White-tailed Deer, *Odocoileus virginianus*, predation, pack size, colour phase, kills, Alberta.

Pack size of Wolves (*Canis lupus*) can provide an important indication of ungulate abundance (Fuller 1989; Schmidt and Mech 1997; Hayes et al. 2003) and human impacts on the landscape (Mech 1995). The number of Wolves in each pack can be related to prey availability (Fuller 1989) and may be regulated by dispersal, pup survival and disease prevalence (Mech 1970; Mech et al. 1998). The amount of food available to each Wolf has been inversely related to pack size (Thurber and Peterson 1993; Schmidt and Mech 1997), with smaller pack sizes found in areas of low ungulate density (Messier 1985). In contrast, pack size may remain stable when the amount of food per Wolf decreases, possibly due to a genetic advantage for the breeding pair when sharing limited food with their offspring (Schmidt and Mech 1997). Maximum Wolf pack size may be regulated by behaviors within the pack, such as social dominance, which can facilitate dispersal. Pack size has also been related to prey size. Average pack size of Wolves hunting White-tailed Deer (*Odocoileus virginianus*) is generally less than seven (Mech 1970; Fuller 1989), whereas packs preying on Moose (*Alces alces*) are generally larger, having ten or more Wolves per pack (Peterson et al. 1984; Mech et al. 1998; Hayes et al. 2003). Vucetich et al. (2004) demonstrated that larger packs are better able to compete with ravens and do accrue a foraging advantage. Reports of large Wolf Packs with over 20 members have been documented in regions where there is little Wolf harvest (Hayes and Harestad 2000) or in protected areas (Carbyn et al. 1993; Peterson 1995; Mech et al. 1998; Smith et al. 2004).

Predators may negatively affect endangered prey species when landscapes become impacted by human disturbance (Schneider 2001). Landscapes in westcentral Alberta are facing increased pressures from forest harvesting and the energy sector (oil and gas). Forest harvesting may alter the movements and distribution of Wolves (Kuzyk et al. 2004) and ungulates (Smith et al. 2000), and in combination with linear corridors (roads, seismic lines) from oil and gas activities, can enhance human access to once remote areas and possibly increase human-caused Wolf mortality from shooting and trapping. Enhanced predation by Wolves, facilitated by landscape change such as increased travel efficiency on linear corridors (James and Stuart-Smith 2000) and associated increases in alternate prey populations (James et al. 2004), is thought to be the primary factor for Caribou declines in Alberta (Edmonds 1988; McLoughlin et al. 2003). In Alberta, Woodland Caribou (*Rangifer tarandus caribou*) are classed as a threatened species under the provincial Wildlife Act and on the Species at Rist Act Public Registry [SARA, http://www.sararegistry.gc.ca/species/SpeciesDetails_e.cfm?sid=636] and special management considerations are necessary to maintain numbers and habitat (Edmonds 1998; Dzus 2001). More information is required on Wolf populations, such as pack sizes, to be better able to predict long-term changes in the dynamics of Wolves and Caribou associated with land-

scape change (Weclaw and Hudson 2004). The objective of this paper is to present current information on pack size and associated predation by Wolves that can be used in decision-making processes for long-term Caribou conservation.

Study Area

The study area is approximately 5000 square kilometres, located in the foothills of west-central Alberta, near the town of Grande Cache (54°N 119°W). The area is classed into subalpine and boreal natural subregions (Beckingham and Archibald 1996), and contains several main rivers but lakes are scarce. Elevations range from 1300-1800 metres, and the climate is subarctic, with short wet summers and long cold winters. Temperatures average 16°C in July and -13.5°C in December (Beckingham and Archibald 1996). The forests are primarily Lodgepole Pine (*Pinus contorta*) and some White Spruce (*Picea glauca*). The wetlands support mostly Black Spruce (*Picea mariana*) and some Tamarack (*Larix laricina*). Some south facing slopes have Aspen (*Populus tremuloides*) and willow (*Salix* sp.).

The study area contains three major Caribou herds: the Red Rock/Prairie Creek and Al La Peche are mountain herds and represent a migratory ecotype, while the Little Smoky herd is boreal or sedentary ecotype (Edmonds 1988). Population size for the mountain herds is estimated at 600-750 Caribou (Edmonds 1998), and the Little Smoky herd is estimated at fewer than 100 animals (Smith 2004). The study area also supports a high diversity of other large mammals. Moose are found at densities ranging from 0.12 to 0.25 Moose per square kilometer (Alberta Fish and Wildlife unpublished data). Other ungulates occurring in the area are Elk (*Cervus elaphus*), Mule Deer (*Odocoileus heminous*), White-tailed Deer, Bighorn Sheep (*Ovis canadensis*), Mountain Goats (*Oreamnos americanus*) and Wild Horses (*Equus cabalus*). Wolves (*Canis lupus*), Coyotes (*Canis latrans*), Grizzly Bears (*Ursus arctos*), Black Bears (*Ursus americanus*) and Cougars (*Felis concolor*) also exist throughout the study area.

Wolf Captures and Monitoring

Wolf captures were conducted on two Caribou winter ranges in the winters of 2000 and 2001. Four Wolf packs were located on the winter range of a migratory mountain Caribou population (Red Rock/Prairie Creek herd) and four packs located on the winter range of a sedentary boreal Caribou population (Little Smoky herd) (Figure 1). Ungulate baits were placed in strategic locations seven to ten days prior to the initiation of the Wolf capture operation, to enhance detection of Wolves. Wolves were located by following trails in the snow from a fixed-wing aircraft (Mech 1966; Mech et al. 1998). All Wolf handling was approved by the Faculty of Agriculture, Forestry and Home Economics Animal Care Policy (Number 96-99D), subject to the protocols of the Canadian Council of Animal Welfare. Wolf captures were accomplished by either helicopter darting (Ballard et al. 1991) or netgunning, then physically restraining the Wolf with restraining forks, and hand-injecting 1-2 mls of telazol at 200mg/ml (Kuzyk 2002). Adults were distinguished from pups by tooth eruption patterns (Van Ballenberghe and Mech 1975) whereas yearlings were classed on subjective physical criteria (size), as there is no definitive method to categorize yearling Wolves (Mech et al. 1998). Adult Wolves were fitted with store-aboard GPS (Global Positioning System) collars (Lotek Engineering Systems, Newmarket, Ontario or Televilt GPS-Simplex, Lindesberg, Sweden) or VHF (Very High Frequency) radiocollars (Lotek Engineering). Pups were fitted with VHF collars only. All Lotek GPS collars were equipped with remote dropoff units, intended to release when signaled from the air. All radiocollared Wolves were relocated by aerial radiotracking (Mech 1974) within one to four days of capture to determine if they had rejoined their packs. Color phases of Wolves were recorded as gray, black, or white following Dekker (1986), and adding a category of blue.

Wolf pack size was recorded during aerial radiotracking in February and March of each year, when pack size would be at a minimum (Mech 1970), thus yielding a conservative estimate. Most packs were intensively monitored in March of 2000, increasing the chances of a good count. The best estimates of Wolf pack size were made when the Wolves were traveling in single file on a linear corridor or river. Lone Wolves were assumed to account for 10% of the total population (Fuller 1989). We did not extrapolate our pack size data to determine Wolf density, due to insufficient temporal data required to adequately determine annual territory sizes. In addition, our broader project objectives entailed studying Wolves in late winter, corresponding with winter range occupancy by migratory Caribou. It is the winter range of these caribou that is currently undergoing industrial development, and thus of primary conservation concern.

Wolf kills were determined during a two-week period in March 2000 by aerially locating radiocollared Wolf packs and finding their ungulate kills (Mech 1974). Flights were conducted twice daily in hopes of detecting Wolf-killed deer (Fuller 1989). When a Wolf pack was located, Wolves were counted and the area searched for ungulate carcasses. A kill was assumed to be caused by Wolves if there were bloodtrails indicating a successful chase and a disarticulated carcass (Hayes et al. 2000). At each kill site, the number and behavior of Wolves were recorded (Mech 1966). All Wolf-killed ungulates that could not be identified to species, gender and age (adult-calf) from the air were later ground inspected.

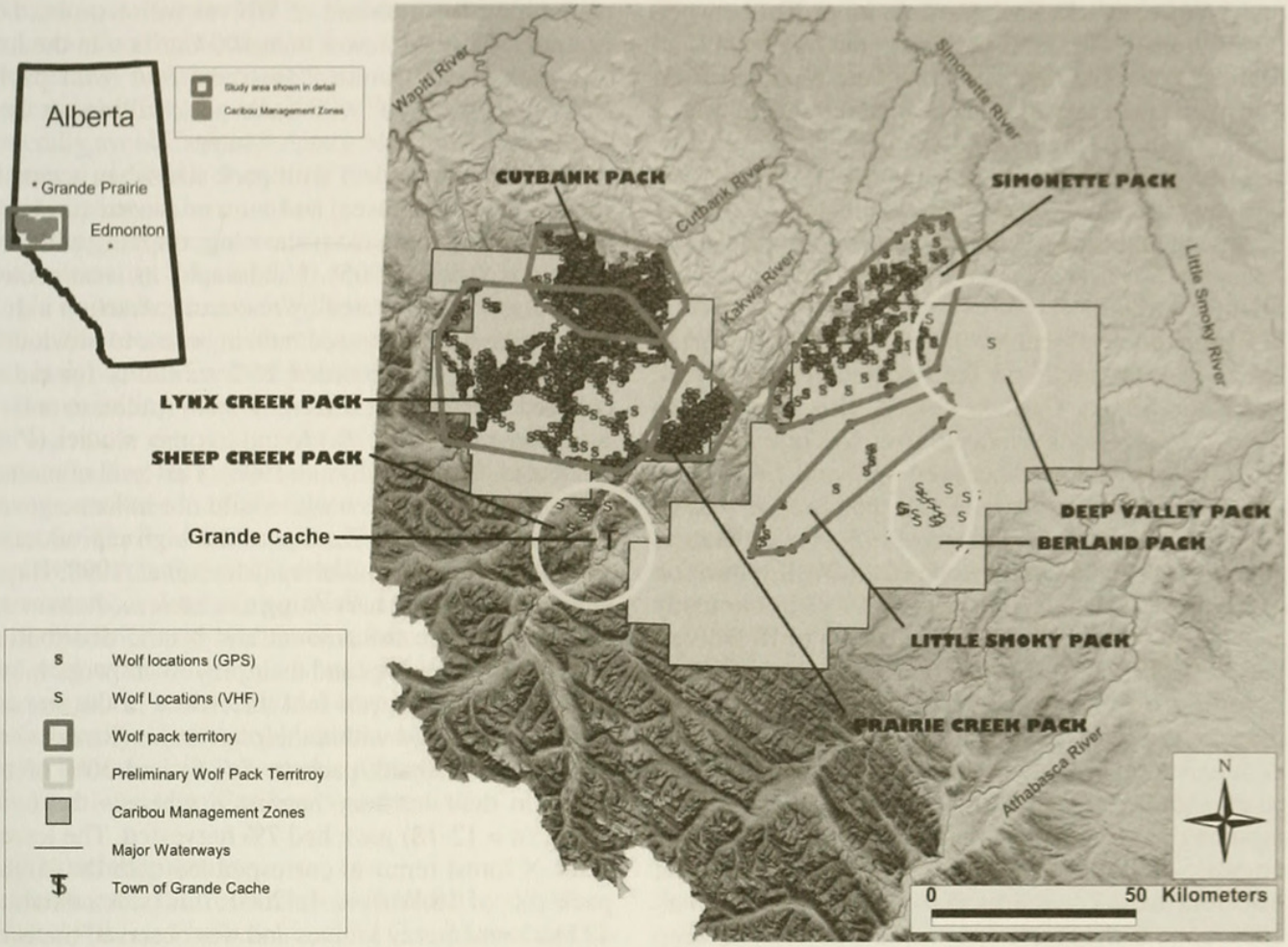

FIGURE 1. Distribution of eight Wolf packs on two Caribou winter ranges in west-central Alberta during 2000 and 2001.

TABLE 1. Sex ratio, age class and color phase of Wolves (n=31) captured in west-central Alberta during 22 January – 13 March, 2000 and 15–17 February, 2001.

Sex Ratio (n=31)	Age Class (n=31)	Color Phases (n=31)
14 Males	15 adults	19 black (61%)
17 Females	8 yearlings	8 gray (26%)
	8 pups	3 white (11%)
		1 blue (2%)

Results

Thirty-one Wolves were captured on two Caribou ranges: 18 captured in 2000 and 13 in 2001 (Table 1). Nine Wolves were aerially darted and 24 were netted (two recaptures). There were no capture-related Wolf mortalities during this study. A total of 16 GPS (14 Lotek and 2 Televilt) and 17 VHF radiocollars were deployed. There were seven known mortalities of radiocollared Wolves (23%) over fifteen months: two were shot and five died of natural or unknown causes. Colors phases of the radiocollared Wolves were 61% black, 26% gray, 11% white and 2% blue.

Eight Wolf packs were located on the two Caribou ranges (Tables 1 and 2; Figure 1). There were between 54 and 77 (mean = 66) Wolves on the Little Smoky and Red Rock/Prairie Creek Caribou ranges, equating

TABLE 2. Pack size of Wolves on the Red/Rock Prairie Creek (RPC) and Little Smoky (LSM) Caribou winter ranges in west-central Alberta in late winters of 2000 and 2001.

Wolf Pack	Estimated pack size	Caribou herd
Lynx Creek	12 – 18	RPC
Cutbank	7 – 8	RPC
Prairie Creek	5 – 6	RPC
Sheep Creek	6 – 7	RPC
Simonette	7 – 11	LSM
Little Smoky	7	LSM
Deep Valley	9	LSM
Berland	8 – 11	LSM
Total (Range)	54 – 77	
Total (Mean)	65.5	
Mean	8.2	

TABLE 3. Ungulate kills by Wolf packs in west-central Alberta in March 2000.

Wolf Pack	Days Monitored	Moose kills	Deer kills	Ungulate kills/day
Lynx Creek	9 (Mar 2-10)	2		1/ 4.5
Cutbank	14 (Mar 2-15)	3		1/ 4.7
Simonette	14 (Mar 2-15)	4	2	1/ 1.8

Note: Prairie Creek pack not entered as only one Elk kill was located.

to 8.2 Wolves/pack. Each Caribou range had between 30-39 Wolves with Wolf pack sizes ranging from 5-18 (Table 2). Twelve ungulate kills were recorded from four Wolf packs during 14 days of monitoring in March 2000 (Table 3). Ungulate kills consisted of seven cow and two calf Moose, two deer (unknown species) and one cow Elk. Wolves preyed predominately on Moose, averaging one Moose-kill every three to five days.

Discussion

We recorded a mean pack size of 8.2 Wolves/pack for eight Wolf packs on the RedRock/Prairie Creek and Little Smoky Caribou ranges. This is similar to the 8.7 Wolves/pack averaged over five other Alberta Wolf studies conducted between 1975 and 1985 (Gunson 1992) and marginally higher than the 6.8 Wolves per pack recorded in January 1995 in west-central Alberta during the Yellowstone-Idaho Wolf relocation (Kneteman 1995*). Pack size of Wolves in our study area varied considerably, ranging from 5 to 18 Wolves/pack. The larger Wolf packs (Lynx Creek n = 18; Simonette n = 11) preyed primarily on Moose, whereas the smallest pack (Prairie Creek n = 5) preyed predominately on deer, consistent with results from other nearby studies (Carbyn 1974; Weaver 1994). A confounding factor in estimating numbers of Wolf-killed ungulates in west-central Alberta is the difficulty of detecting Wolf-killed deer (Kuzyk 2002; Kuzyk et al. 2005), due to the small size and cryptic color of deer, and the short time required for Wolves to consume deer carcasses (Fuller 1989). All Wolf packs in this study were observed either hunting deer or at deer kills. During intensive monitoring in March 2000, the Prairie Creek pack was seen hunting deer, and was thought to have made deer kills, but those were never detected from the aircraft. This resulted in somewhat ambiguous information, as data indicate this pack killed only one Elk in nine days of monitoring. But further analysis of GPS data collected during the nine-day monitoring period suggested the Prairie Creek pack had made a minimum of three deer kills (Franke et al. 2006). The importance of deer to Wolves in this study area should not be underestimated. Kuzyk et al. (2005) found Wolves in this study area traveled 4.2 times less when near ungulate carcasses then when away from them, and suggested that Wolf packs preying primarily on deer, as opposed to Moose, may pose a greater predation risk to Caribou due to associated increase travel and encounter rates. Further research to quantify the importance of deer in this Wolf-ungulate system should be initiated such as measuring Wolf encounter rates with deer (Kunkel et al. 2004).

No Caribou kills were detected during this study, probably due to the low numbers of Caribou in the region (Smith 2004) and the short time it takes Wolves to consume a carcass (Hayes et al. 2000). Nevertheless, Caribou could not be the primary prey for Wolves in westcentral Alberta, as the numbers of Caribou could not support the numbers of Wolves we recorded. For example, there are fewer than 100 Caribou in the Little Smoky herd (Smith 2004), and four Wolf packs overlap their range, with each pack killing an estimated 40-85 ungulates each winter.

Humans may impact Wolf pack size when access to remote areas increases, and human-caused mortality to Wolves increases from shooting, trapping and road collisions (Mech 1995). Landscapes in west-central Alberta are being altered by resource extraction industries which have increased human access to previously remote areas. We recorded 23% mortality for radiocollared Wolves over fifteen months, similar to annual mortality rates (20-27%) found in other studies (Pletscher et al. 1997; Mech et al. 1998). This level of mortality is thought to be low and would not influence overall Wolf population size due to the high reproductive and dispersal rates of Wolves (Mech et al. 1998; Hayes et al. 2003). Forest harvesting can increase human access and change the amount and spatial distribution of habitats for Wolves and their prey. Wolf packs in our study area had a seven-fold difference in the amount of forest harvested within their territories (Kuzyk et al. 2004). The Cutbank pack (n = 7-8) had 36% of the forest in their territory harvested whereas the Lynx Creek (n = 12-18) pack had 7% harvested. The lowest level of forest removal corresponded with the largest pack size of 18 Wolves. In 2001, this pack contained 12 black and 6 gray Wolves and was observed traveling on a road in an open forest cutblock (Kuzyk 2001). This pack size exceeds the largest recorded from nearby studies: 12 Wolves in the Simonette River area (Bjorge and Gunson 1989) and 10 Wolves in northern Jasper National Park (Weaver 1994).

The color phase of a Wolf may influence its detection by humans (Mech et al. 1998) and subsequent mortality. Radiocollared Wolves in this study were predominantly black (61%), similar to those recorded in nearby Jasper National Park (53% black) (Dekker 1986). It is noteworthy that black Wolves may change to a lighter color possibly due to aging or physiological stress (Gipson et al. 2002). Black Wolves may be more easily detected by hunters, especially during winter and on fragmented landscapes. The two Wolves shot during our study were black, and of the seven total mortalities (2 shot, 5 natural or unknown), five Wolves were black (71%).

Lone and small groups of Wolves are also an important component of this population. During the two years of our monitoring, several Wolves dispersed from their natal territories, as individuals or in small groups (<3 Wolves), consistent with other research (Gese and Mech 1991). These lone Wolves, or small groups, could represent 10-30% of the Wolf population (Fuller 1989; Mech et al. 1998) and may be an important factor when assessing predation risk to Caribou. Such Wolves would be travelling great distances to establish new territories (Mech 1970), and may use human trails as travel routes

(Kuzyk and Kuzyk 2002), thereby increasing their chances of encountering Caribou. In addition, pairs of Wolves may have proportionately higher kill rates than larger packs (Hayes et al. 2000). Further, if Wolf packs generally avoid Caribou habitats due to a lack of Moose (James et al. 2004), dispersing Wolves may select these habitats to avoid being killed by resident pack Wolves defending their territories, a primary cause of natural Wolf mortality (Mech 1994). Conducting research on single or small groups of Wolves would be logistically difficult but resulting information could lead to important insights into Caribou predation risk from Wolves.

Documenting current pack size and prey relations of Wolves in our study area is an important step in understanding the potential implications of landscape change and resultant alteration of predator/prey systems for Caribou in the area. However, as pack size could theoretically remain constant while overall numbers increase, determining Wolf density is necessary. In combination with additional information on kill rates and prey availability, this would permit evaluation of the numerical and functional responses of Wolves in this system to landscape alteration, and provide a foundation for examining alternative management strategies aimed at long-term Caribou conservation.

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