

Temporal use of the Nushagak Peninsula by wolves, Togiak National Wildlife Refuge, southwest Alaska

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Dillingham, Alaska



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Temporal use of the Nushagak Peninsula by wolves, Togiak National Wildlife Refuge, southwest Alaska. Progress Report

Patrick Walsh and James Woolington¹

Abstract

We investigated the time budgets of wolves in the vicinity of the Nushagak Peninsula in order to make inferences on their likelihood of serving as an important population modifier for Nushagak Peninsula caribou. Using a combination of conventional and GPS radio telemetry, we followed two wolf packs initially located near the Nushagak Peninsula from March 2007 until April 2008. We found one of the packs used the Peninsula 29-42% of the time, while the other pack did not use the Peninsula.

Keywords: *Canis lupus*, Nushagak Peninsula Caribou Herd, GPS radio telemetry.

Introduction

The Nushagak Peninsula caribou (*Rangifer tarandus*) population was established by relocating caribou from the Alaska Peninsula in 1988 after an absence of >100 years (Hinkes and Van Daele 1996). The population increased from an initial stocking of 146 to a peak of ~1,400 in 1997, then declined to a 2006 level of ~500. Potential causal or contributing factors to the population decline are habitat quality decline, age structure changes, and increased predation by wolves (*Canis lupus*) and brown bears (*Ursus arctos*). This project investigated the seasonality and duration of wolf use of the Nushagak Peninsula. Understanding the degree to which wolves use the Nushagak Peninsula will enable us to assess whether predation is a likely factor in driving population dynamics of Nushagak Peninsula caribou.

Wolf predation on caribou has been described by many investigators as the leading source of mortality, and it is commonly related to population declines. McLoughlin et al. (2003) found that predation by wolves was the most common cause of death in caribou in six populations in northcentral Alberta, Canada. Jenkins and Barten (2005) described a population decline of caribou in the Wrangell Mountains of Alaska, and found the decline to be related to increases in predation rates among wolves primarily and other predators secondarily. Farnell and McDonald (1988) found wolf predation to be the principal cause of mortality in the Finlayson caribou herd in the Yukon, and both calf and adult survival were correlated to wolf population density. Gunn et al. (2006) described a 98% decline of caribou on three islands in the south-central Canadian Arctic over a 15 year period. They suspected the causes of the decline were a decrease in adult and juvenile survival associated with human harvest rates and increasing wolf predation. Kojola et al. (2004) found that wolf predation in Finland was an important factor limiting European wild

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forest reindeer (*R. t. fennicus*) population growth. Hayes et al. (2003) described an increase in a woodland caribou population in southwestern Yukon following wolf population reduction. The increase was attributed primarily to increased calf recruitment.

It is reasonable to hypothesize that wolves are an important modifier of the Nushagak Peninsula caribou herd, and this concern is regularly voiced during public meetings by the Bristol Bay Federal Subsistence Regional Advisory Council, the state Nushagak Fish and Game Advisory Committee, and the Nushagak Peninsula Caribou Herd Advisory Committee. These concerns often result in requests for a state regulated predator control program.

However, there are other possible explanations for the decline in Nushagak Peninsula caribou numbers. Collins et al. (2003) hypothesized that unreported human harvest plays a large, but poorly understood role in modifying Nushagak Peninsula caribou population size. Secondly, it is possible that a decline in habitat quality is related to the population decline. Aderman (2006) documented an increase in caribou utilization of lichens during the period 1993-2002, and found that the greatest impact to lichen communities took place on the south half of the Peninsula, which is consistent with a higher population density of caribou in winter, when lichens dominate their diet. Age structure changes have also been hypothesized to be related to the population decline (personal communication, Bruce Dale, Alaska Department of Fish and Game). Under this scenario, the rapid initial growth of the caribou population has resulted in a currently disproportionately high number of old, less productive cohorts of females.

Until this study, there have been no investigations of predation impacts on Nushagak Peninsula caribou. This project assessed whether wolf predation is a likely driver of Nushagak Peninsula caribou population dynamics based on wolf time budgets on and off the Peninsula.

Objectives:

1. Determine the number and pack size of wolf packs located on and adjacent to the Nushagak Peninsula.
2. Determine the seasonality and proportion of time throughout the year that wolves in packs adjacent to the Nushagak Peninsula spend on the Nushagak Peninsula.

Study area

The study area covered the likely ranges of wolves that have the potential to prey on Nushagak Peninsula caribou. This area included the Nushagak Peninsula, plus the headlands of the peninsula to a distance of approximately 30 km (Fig. 1).

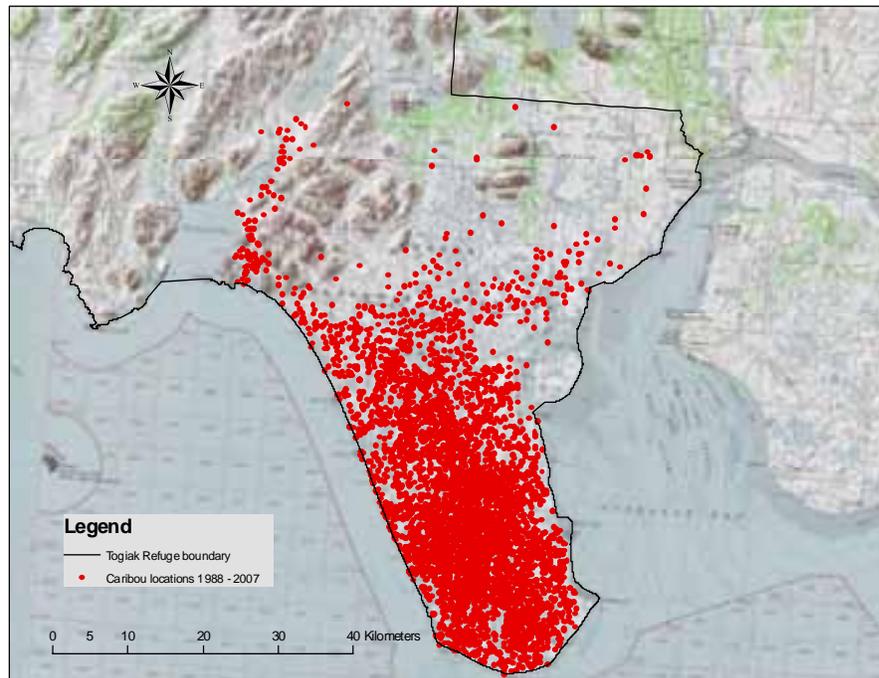


Figure 1. Range of caribou on the Nushagak Peninsula, Togiak National Wildlife Refuge. Caribou locations are monthly locations from approximately 25 caribou instrumented annually with radio transmitters from 1988-2007.

The Nushagak Peninsula, located at approximately 58.6° N latitude, 159.0° W longitude, is a 16 km wide peninsula of treeless lowland tundra extending approximately 32 km into Bristol Bay of the Bering Sea. Plant communities included a mixture of graminoid-dominated wetlands and dwarf shrub heath communities. Lichens were important components of these dwarf shrub communities. The Nushagak Peninsula provided habitat to barren ground caribou since 1988, at which time a population was established through relocation. This population has remained relatively sedentary, with few forays from the peninsula, and grew rapidly from the initial stocking of 146 to approximately 1,400 individuals in 1997, then declined to approximately 500 individual in 2006.

The headlands of the Nushagak Peninsula included a greater variety of landforms, including the southern extent of the Ahklun Mountains, which is composed of rolling hills up to mountains of 1,000 m elevation. The mountainous terrain was primarily vegetated with dwarf shrub plant communities above alder (*Alnus*) slopes at the bases.

Glacial valleys between mountains include three large lakes and six major rivers (the Igushik, Tuklung, Weary, Snake, Kanik, and Ongoke Rivers), as well as many smaller lakes and streams. Lake shore and riparian corridors include mixtures of willow (*Salix*)-dominated tall shrub communities and deciduous forests. Approximately 20% of the Nushagak Peninsula headlands is forested with white spruce (*Picea glauca*). These communities provide habitat to moose (*Alces alces*). In March 2006, a total-count population estimate found a minimum of 165 moose in the Nushagak Peninsula headlands (Togiak Refuge unpublished data). Brown bears (*Ursus arctos*) are common throughout all portions of the study area.

The study area climate was sub-arctic maritime. Temperatures ranged from average daily low and high of -11.9 and -5.8° C in December, the coldest month, to 9.1 and 16.1° C in July, the

warmest month (NCDC 1971-2000, Western Regional Climate Center, data for Dillingham). Annual precipitation (which includes rain plus melted snow) averaged 64.5 cm and snowfall (unmelted) averages 210.6 cm.

There were no roads or human infrastructure within the study area with the exception of the village of Manokotak, a community of approximately 500 individuals located on the Igushik River north of the Nushagak Peninsula, and a commercial fishing village used during the summer at the outlet of the Igushik River. The majority of human activities in the study area consist of subsistence resource gathering activities (hunting, fishing, berry picking, trapping, wood cutting) accessed primarily via boat traffic from the Igushik and Weary Rivers and associated lakes during summertime. During winter, snowmachines provide access to the majority of the study area. Individuals from the villages of Togiak and Dillingham (located to the east and west of the study area) access the study area for subsistence and recreational pursuits, although at a lower rate than residents of Manokotak.

Methods

We captured four wolves from two packs and marked them with radio transmitters. One from each pack was instrumented with a conventional VHF radio collar (Lotek™ model LMRT-3 VHF radio collar with mortality sensor) and the other from each pack was instrumented with a remote-downloadable GPS collar (Lotek™ model GPS4400S collar with mortality sensor, radio drop-off, and advanced scheduler options). The GPS collars were programmed to determine the animal location every three hours throughout the year. Data from the GPS collars were used to provide the primary basis for addressing the research questions. Conventional collars were used to locate animals each time a radio-telemetry survey was flown. Conventional collars were used to provide supporting data on pack sizes, home ranges, and were intended to help maintain continuity with wolf packs in the event that study animals died, left the study area, or were lost.

Capture was performed during winter months at a time following recent snow that permitted visually tracking wolves. Capture operations included spotter crews in two fixed-wing aircraft in communication with a capture crew in a helicopter. Upon locating a group of wolves, the spotter crew directed the helicopter to the location, then maintained visual contact with wolves after they had been darted. Wolves were captured using doses of 500 mg of Telazol dissolved in 2.6 ml of sterile water and delivered with 3 cc Palmer™ darts with 1.9 cm barbed needles. Darts were fired from a Palmer™ capture rifle charged with Very Low Power (brown) .22 charges. Wolves were sexed, weighed, measured, aged by tooth wear (Gipson et al. 2000) into three age classes: Juvenile (< 1 year), Young adult (1-2 years), Mature adult (>2 years), and fitted with radio collars. VHF collars weighed approximately 500 gm and GPS collars weighed 750 gm. Animal care and handling was consistent with the Animal Welfare Act as Amended, 7 USC, 2131-2156 under an Alaska Department of Fish and Game ACUC Assurance.

Radio tracking surveys were flown approximately twice per month year-round. Wolf locations were recorded, as well as activity, habitat, and composition of group when other wolves were present. Additionally, location data stored in GPS collars were remotely downloaded using a Lotek™ Hand Control Unit. Downloaded data were entered into ESRI™ ArcMap v9.0 GIS and used to describe the daily and seasonal use by wolves of the Nushagak Peninsula.

We used caribou location data collected during a separate study (Aderman and Woolington 2001) to define the study area limits, and to make inferences on when wolves were and were not in the proximity of caribou. We estimated wolf home range size and location using the minimum convex polygon module in ESRI™ ArcView GIS 3.3. In determining home range, we eliminated from the polygon open ocean areas and an area in the vicinity of the village of Manokotak where there were no recorded wolf locations.

Results and Discussion

We captured four wolves on 22-23 March 2007 (Figure 2, Table 1). Wolves W0701 and W0704 were located together with no other wolves present. W0702 and W0703 were originally seen with three additional pack members. Subsequent observations confirmed that the study wolves were from two packs, henceforth referred to as the Snake Lake Pack and the Ualik Lake Pack.



Figure 2. Placing a GPS collar on Wolf 0701, 22 March 2007.

Table 1. Age, weight, and gender of wolves captured 22-23 March 2007 on Togiak National Wildlife Refuge.

Wolf ID	Sex	Age	Weight (kg)	Pack	Transmitter type
W0701	M	Young adult	55.3	Snake Lake	GPS
W0702	F	Young adult	47.6	Ualik Lake	Conventional
W0703	M	Mature adult	54.4	Ualik Lake	GPS
W0704	F	Juvenile	39.9	Snake Lake	Conventional

Wolves were surveyed via 28 radiotracking flights during the period 24 March 2007 through 02 April 2008 (Fig. 3). Wolves W0702 and W0704 remained on air throughout the study period. W0701 was heard through 10 May 2007, after which it was not heard nor seen again. Two radio telemetry searches expanded to an area approximately 30 km beyond the known range of W0701 did not detect the wolf. It is possible that it was illegally killed, but we find this unlikely as it

disappeared after the time snow cover facilitated human access into the study area. It is also possible that the radio transmitter failed, but visual examination of all wolves subsequently seen with W0704 did not detect collars. Thus, we speculate that W0701 left the listening area.

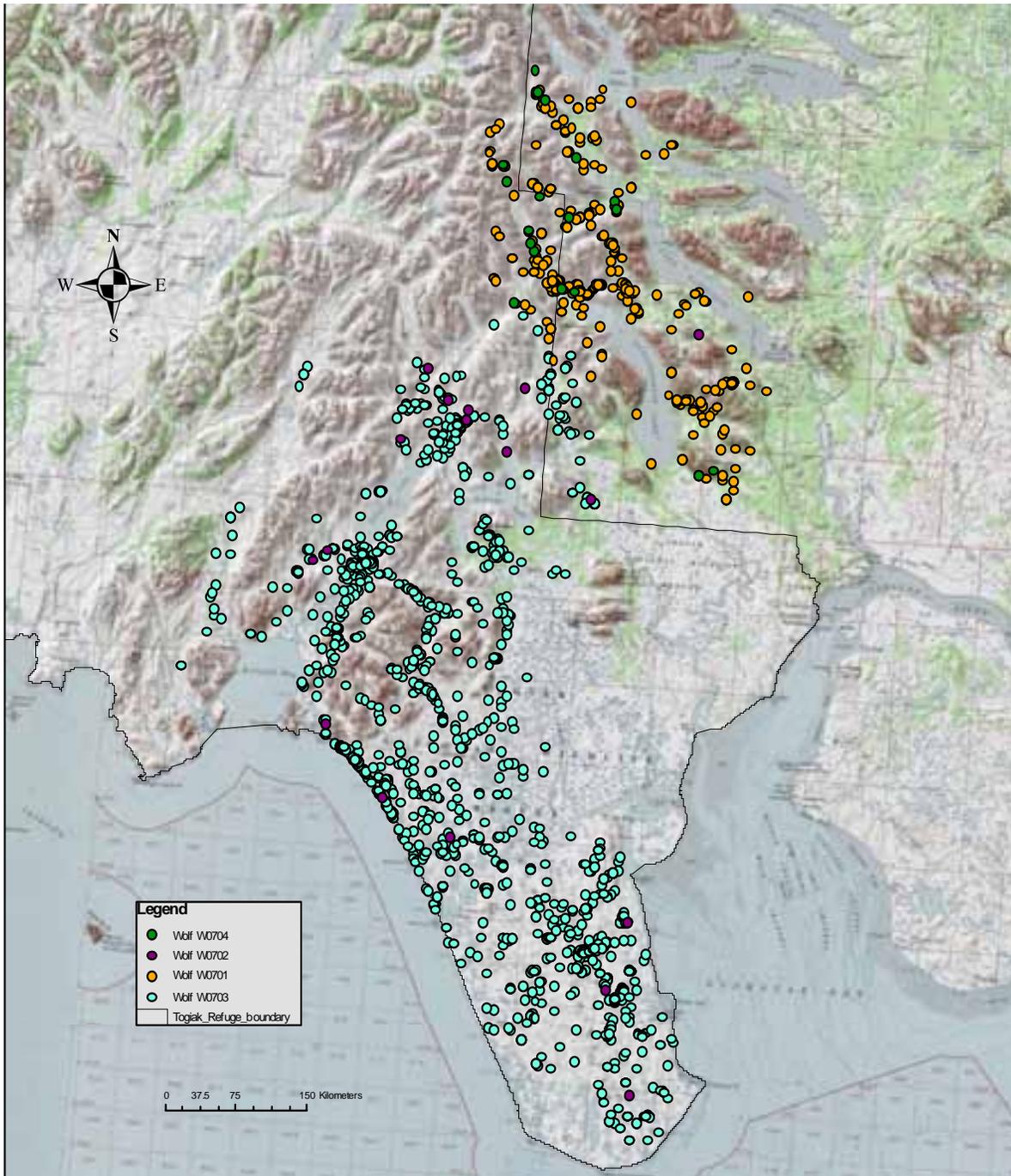


Figure 3. Locations of four wolves radio collared on Togiak Refuge from March 2007 through March 2008. Locations for wolves W0701 and W0703 were collected approximately every three hours. Locations for wolves W0702 and W0704 were collected approximately twice monthly.

W0703 was heard regularly through 17 November 2007, at which time its radio began transmitting a mortality signal. The radio collar was accessed by snowmachine and recovered on 12 March 2008 and was found to be broken at the battery housing (Fig. 4). Thus, the collar

could have slipped from the head of a live wolf, suggesting that W0703 was not necessarily dead. No remains were found with the collar, which was under approximately 1 m of snow.



Figure 4. Wolf W0703's broken radio collar.

Pack Size

Snake Lake Pack

At the initiation of the study, the Snake Lake Pack was known to consist of two individuals: W0701 and W0704. Subsequent to capture, W0701 and W0704 were observed together on three occasions between 24 March and 10 May 2007 (Table 2). They were also located apart on three occasions during this same period, and W0701 was not seen after 10 May. Subsequently, Wolf W0704 was located alone on nine occasions up until 30 January 2008, at which time a single, uncollared wolf was seen with her. She was seen with a single companion on the next three radio tracking flights, which ended on 2 April 2008. Thus, our assumption is that the Snake Lake Pack consisted of a male-female pair until some time in mid-May, after which time the male left. This is the approximate time when pups would have been born, should W0704 have been pregnant. No pups were seen, so it is assumed that if she had pups, they did not survive. We assume that the individual seen with her in spring 2008 was a male, and that she will attempt to raise pups in 2008.

Table 2. Snake Lake Pack composition observed during aerial surveys, 24 March 2007 -- 2 April 2008.

Date	W0701	W0704	Together or apart?	Other wolves present
24 March 2007	X	X	Together	
29 March 2007	X	X	Together	
6 April 2007	X	X	Apart	
26 April 2007	X	X	Apart	
27 April 2007	X	X	Together	
Date	W0701	W0704	Together or apart?	Other wolves present
10 May 2007	X	X	Apart	
25 May 2007	X			
31 May 2007	X			

6 June 2007	X	
7 June 2007	X	
2 July 2007	X	
19 July 2007	X	
13 August 2007	X	
15 September 2007	X	
28 November 2008	X	
15 January 2008	X	
30 January 2008	X	1
7 March 2008	X	1
18 March 2008	X	1
2 April 2008	X	1

Ualik Lake Pack

At the time of capture, the Ualik Lake Pack was believed to consist of five individuals: W0702, W0703, and 3 other uncollared wolves. In subsequent surveys (Table 3) only four adults were observed. The wolves in this pack were generally united during winter months, and generally operated independently during non-winter months. Based on radio locations of Wolf W0703 during the period mid-May through mid-July 2007, a concentration of locations hypothesized a den location (Fig. 5). On 31 July 2007, one of us (Walsh) observed the suspected den site from a location approximately 1 km away for 8 continuous hours (Appendix A). A total of six pups and four adults were observed. Based on observed behaviors, we suspect that uncollared wolves were the dominant female and dominant male, and that W0702 and W0703 were both subordinate adults.

Table 3. Ualik Lake Pack composition observed during aerial surveys, 24 March 2007 -- 2 April 2008.

Date	W0702	W0703	Together or apart?	Other wolves present
24 March 2007	X	X	Apart	
29 March 2007	X	X	Together	
6 April 2007	X	X	Together	
26 April 2007	X	X	Together	2
27 April 2007	X	X	Together	2
10 May 2007	X	X	Apart	2 with W0702
25 May 2007		X		
31 May 2007		X		
4 June 2007		X		
6 June 2007		X		
7 June 2007		X		
2 July 2007		X		
19 July 2007	X	X	Apart	
25 July 2007		X		
13 August 2007	X	X	Apart	
Date	W0702	W0703	Together or apart?	Other wolves present
27 August 2007	X	X	Apart	
15 September 2007	X	X	Apart	
1 November 2008	X	X	Apart	8 with W0702

28 November 2008	X		8
12 December 2008	X	Off air	8
8 January 2008	X	Off air	8
5 March 2008	X	Off air	4
7 March 2008	X	Off air	
2 April 2008	X	Off air	

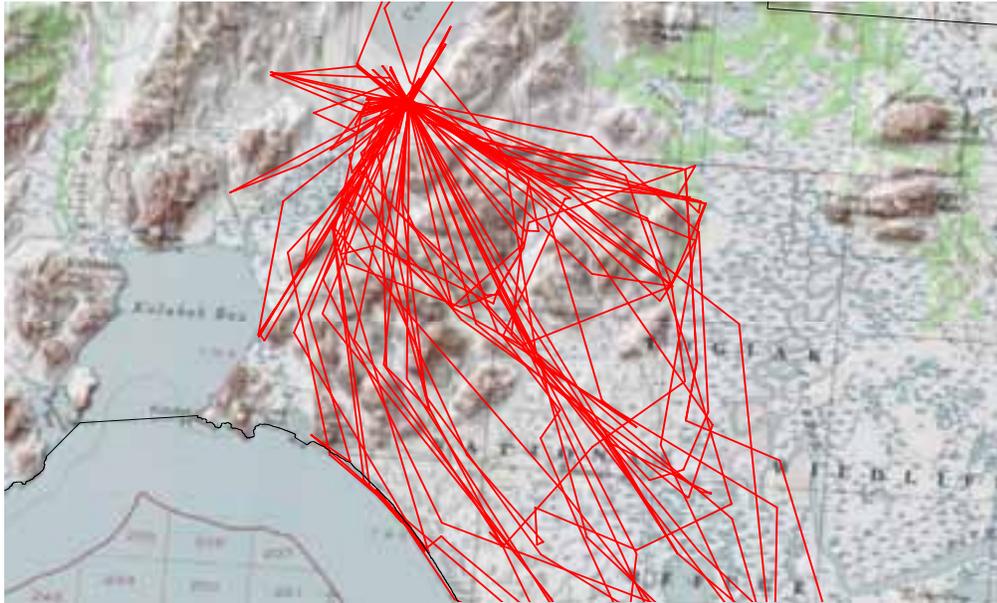


Figure 5. Lines drawn between successive locations of Wolf W0703 collected every 3 hours during 16 May --15 August 2007. Lines converge at den site.

Use of Nushagak Peninsula

Overall time budget

We recorded no occasions in which the Snake Lake Pack ventured onto the Nushagak Peninsula. We recorded regular activity by the Ualik Lake Pack on the Nushagak Peninsula. Of a total of 1,883 locations collected on Wolf W0703 from 22 March -- 17 November 2007, 915 were located on the Nushagak Peninsula. However, of these, 120 were associated with a stream outlet near Picnic Beach (Fig. 6), which is a location receiving little use by caribou, and suspected to be a site where wolves preyed on salmon migrating upriver. Thus, assuming that these locations were not associated with the Nushagak Peninsula caribou, a total of 795 of 1,883 locations, or 42% of this wolf's time budget was potentially associated with Nushagak Peninsula caribou. Of a total of 17 locations collected on Wolf W0702 from 23 March 2007 -- 7 March 2008, five were located on the Nushagak Peninsula. Thus, 29% of this wolf's time budget was potentially associated with Nushagak Peninsula caribou.

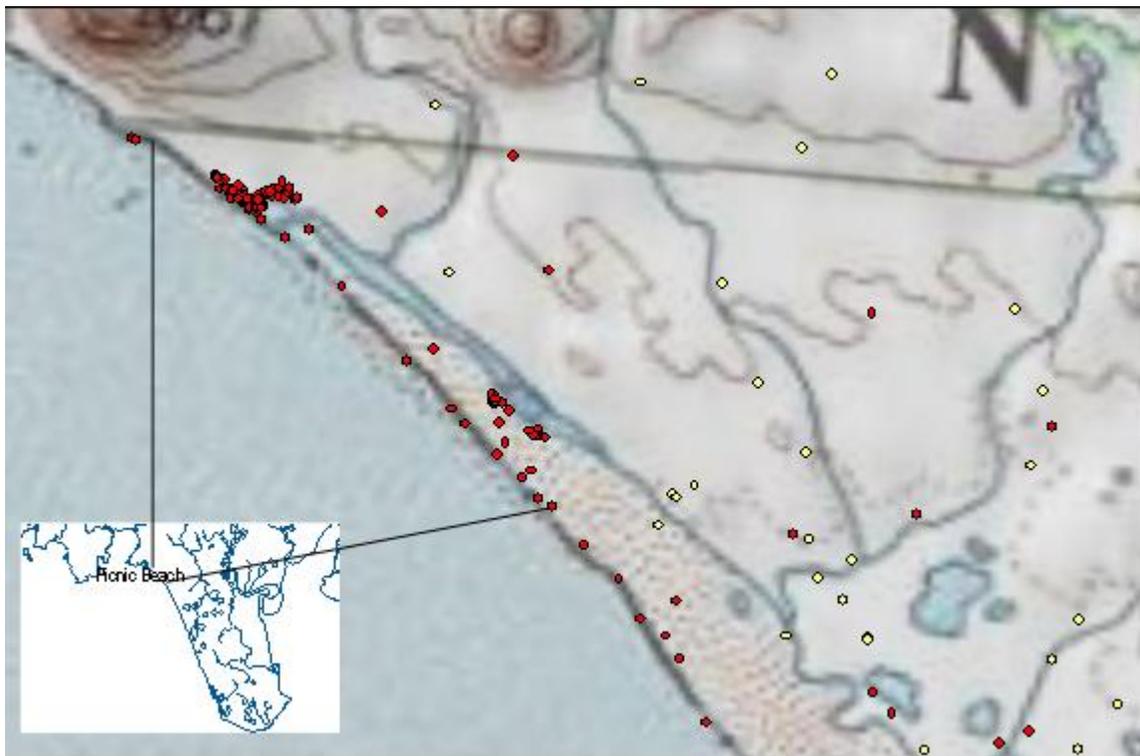


Figure 6. Concentration of locations of Wolf W0703 (red points) at stream mouth near Picnic Beach. Yellow points are caribou locations observed during radio telemetry surveys from 1988--2007.

Seasonality of wolf use of Nushagak Peninsula

Wolf use of the Nushagak Peninsula (based on the locations of Wolf W0703 from March through November) was variable in timing. W0703 made 25 discrete trips onto the Peninsula, varying in time from less than one day up to 21 days (Fig. 7).

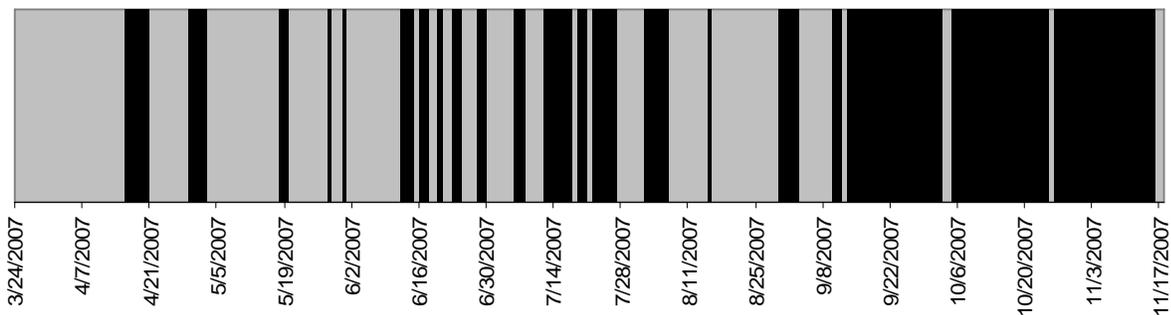


Figure 7. Time budget for Wolf W0703, 24 March -- 17 November 2007. Black areas represent days on Nushagak Peninsula.

During late winter and spring, W0703 spent the majority of his time north of the Nushagak Peninsula (Fig. 8). He made two trips to approximately the mid-point of the Peninsula during this time period, and briefly visited the den site on two occasions.

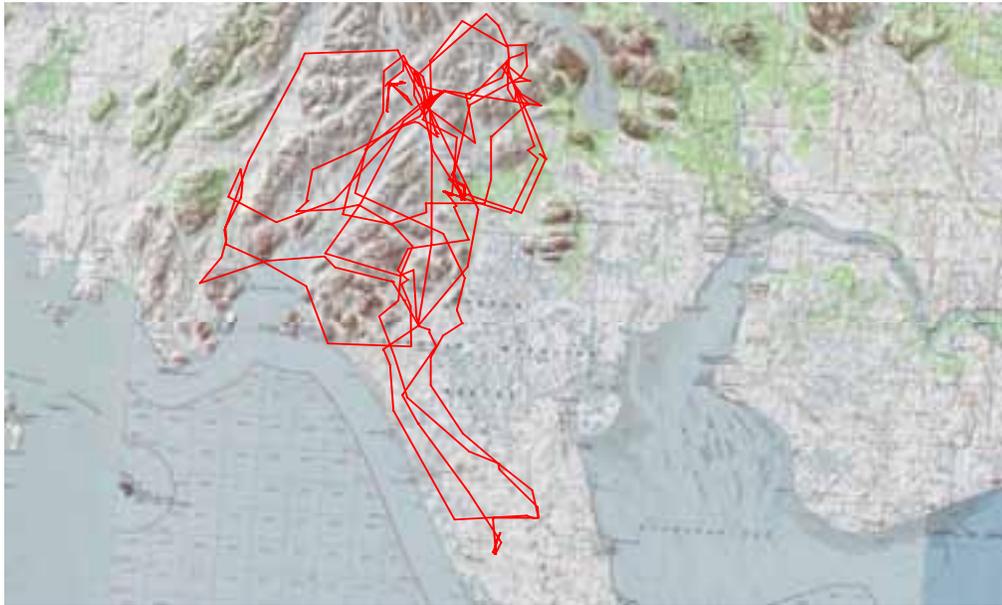


Figure 8. Movements of Wolf W0703 23 March -- 15 May 2007.

For the next 1.5 months (16 May -- 30 June 2007), W0703 remained relatively close to the den, making a minimum of 34 visits to the den site (Fig. 9). During this time period, he also made nine trips onto the Peninsula. Each of these trips was of a single day or less duration, and ended in a return to the den site. These trips accessed only the northern third of the Peninsula, perhaps to minimize the travel distance to the den. This time period coincides with the caribou calving season, during which time four caribou tracking flights occurred. Based on the locations of radioed caribou, over 75% of the caribou were distributed south or east of the area accessed by Wolf W0703, so we assume that the majority of the Nushagak Peninsula caribou herd was not vulnerable to wolf predation during the calving season.

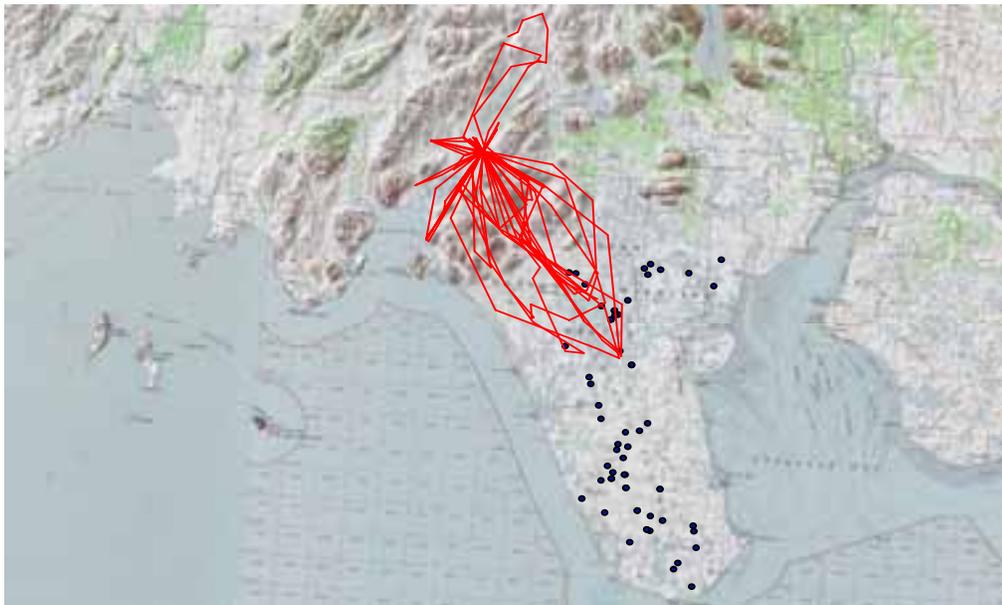


Figure 9. Movements of Wolf W0703 (red lines) during and immediately after the caribou calving period (16 May -- 30 June 2007). Blue points are caribou locations collected during telemetry surveys 23 May, 31 May, 4 June, and 8 June 2007.

During the next 1.5 months (01 July -- 15 August 2007), Wolf W0703 made a minimum of 25 visits to the den. He also made a total of six trips onto the Peninsula (Fig. 10), spending a total of 18 of 26 days there between 12 July and 6 August. These trips were of greater distance and duration than those made during the early denning period. Caribou locations, based on two telemetry flights, were distributed throughout the Peninsula.

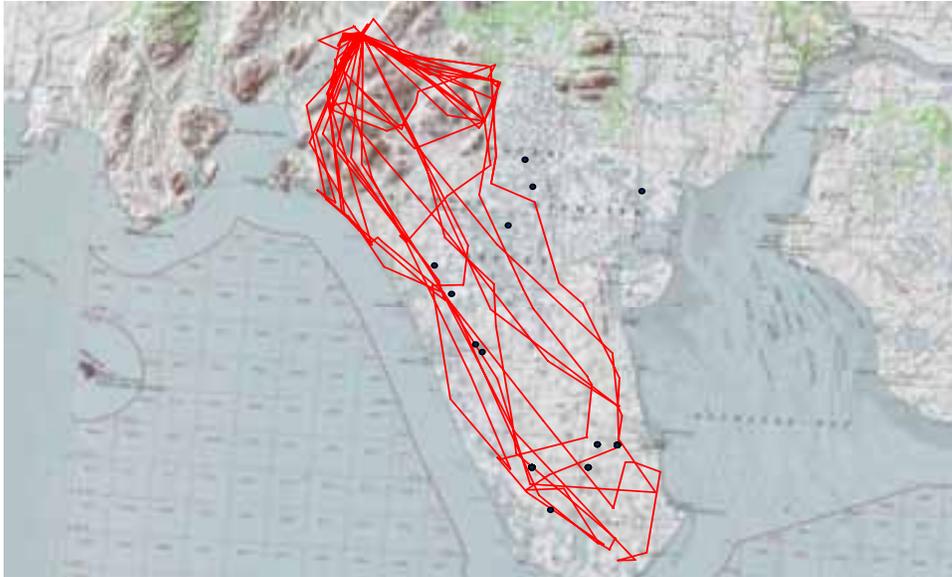


Figure 10. Movements of Wolf W0703 01 July -- 15 August 2007. Blue points are caribou locations collected during telemetry surveys 2 and 25 July 2007.

During the next month (16 August -- 14 September 2007), W0703 concentrated his activities near Picnic Beach, a location relatively unused by caribou (Fig. 11). He made five short-duration trips to the mid-point of the Peninsula into an area used by caribou, based on a caribou radio telemetry flight conducted 27 August 2007. During this time period, W0703 made two brief visits to the den.

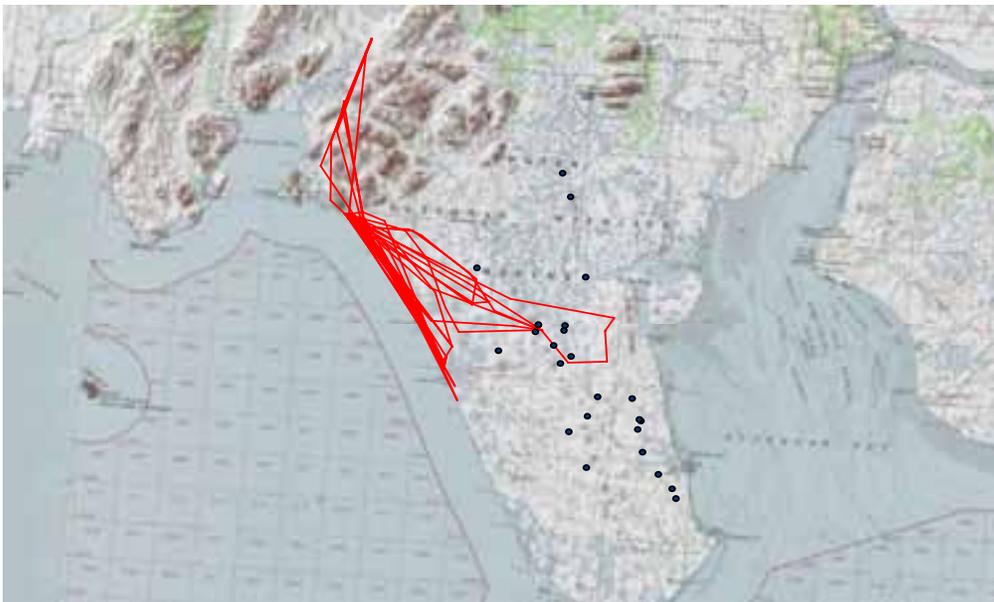


Figure 11. Movements of Wolf W0703 16 August -- 14 September 2007. Blue points are caribou locations collected during a radio telemetry survey 27 August 2007.

From 15 September until 17 November, at which time W0703's collar was lost, he was continuously on the Peninsula for all but four days (Fig. 12). His locations coincided with the locations of caribou collected during radio telemetry surveys 26 September, 7 October, and 26 November 2007.

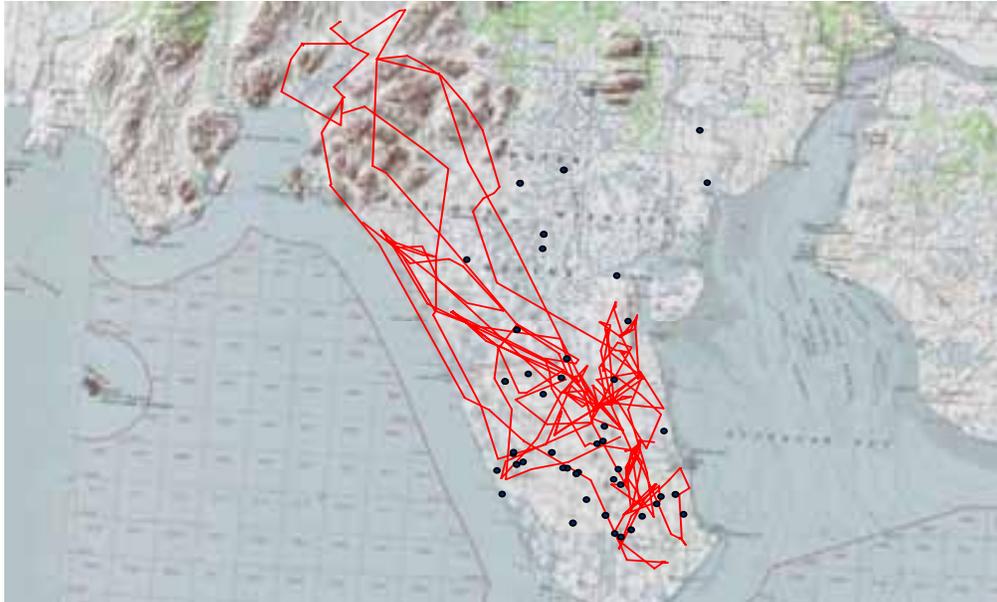


Figure 12. Movements of Wolf W0703 15 September -- 17 November 2007. Blue points are caribou locations collected during radio telemetry surveys 26 September, 7 October, and 26 November 2007.

Caribou predation

Caribou predation by wolves was documented on two occasions. Incidental to radio telemetry surveys, Wolf W0703 was observed at newly-dead caribou carcasses on 18 and 25 July. Both events occurred on the Nushagak Peninsula. In the first event, an adult cow and a calf were located approximately 100 m apart, with W0703 approximately 30 m from the calf (Fig. 13). In the second event, W0703 was located a short distance from a dead, partially skinned, caribou cow.



Fig. 13. Wolf W0703 and caribou calf carcass as viewed from a fixed wing aircraft, 18 July 2007.

Annual Range

Annual ranges were calculated using all location data collected through 2 April 2008 (Table 4, Fig. 14). Ualik Lake Pack annual ranges were larger than Snake Lake Pack ranges, and within packs, larger for males than females. Given the small sample sizes for the two wolves with conventional radio collars, it is likely that additional locations will cause their estimated annual ranges to increase in size. Also, given that the range for W0701 was based on locations collected exclusively during the spring, this is probably also an underestimate of the true annual range size. Additional data collection will further refine individual and pack range areas.

Table 4. Number of locations and size of home ranges for Togiak Refuge wolves from Snake Lake and Ualik Lake packs.

Wolf	Pack	Gender	No. locations	Annual range size (km ²)
W0701	Snake Lake	Male	387	1,047
W0702	Ualik Lake	Female	16	1,836
W0703	Ualik Lake	Male	1916	2,873
W0704	Snake Lake	Female	20	482

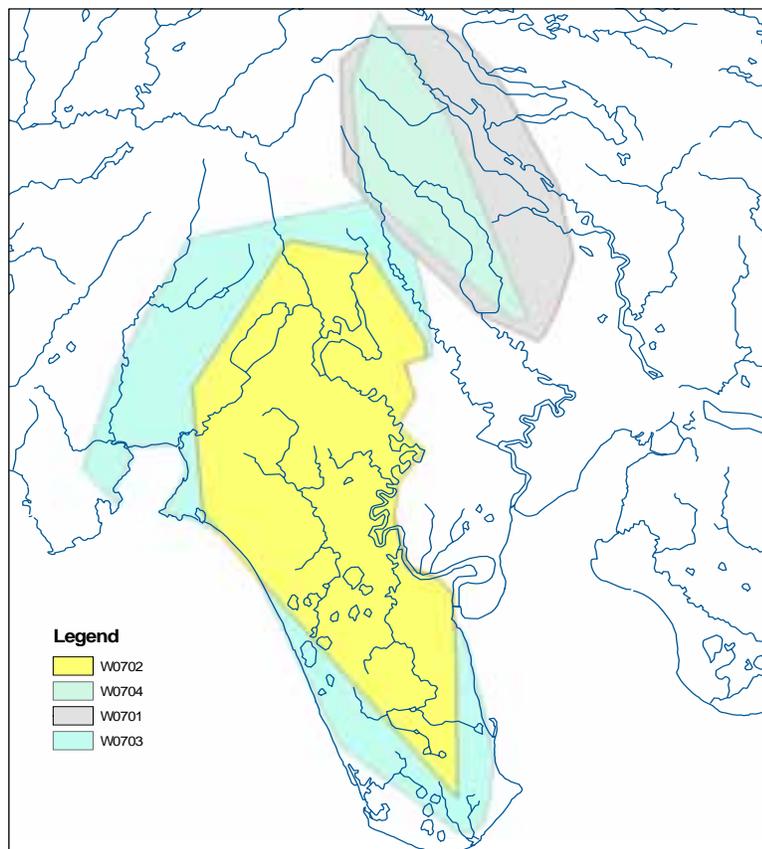


Figure 14. Modified minimum convex polygon annual ranges of all study wolves, March 2007 through April 2008.

Conclusions

Objective 1. Determine the number and pack size of wolf packs located on and adjacent to the Nushagak Peninsula.

During the period March 2007 through April 2008, there were at least two wolf packs in the vicinity of the Nushagak Peninsula. The Snake Lake Pack consisted of 1-2 adults and no pups. The Ualik Lake Pack consisted of 4-5 adults and 6 pups.

Objective 2. Determine the seasonality and proportion of time throughout the year that wolves in packs adjacent to the Nushagak Peninsula spend on the Nushagak Peninsula.

The Snake Lake Pack did not use the Nushagak Peninsula. The Ualik Lake Pack (based primarily on locations from one individual from March 2007--November 2008) used the Peninsula approximately 29-42% of the time, with a concentration of time there in the late summer and fall. The pack used the northern third of the Peninsula during the caribou calving season, and was potentially in contact with approximately a quarter of the caribou herd at that time.

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Appendix A. Den watch notes, Ualik Lake Pack

31 July 2007

Patrick Walsh

I was inserted by Robinson R44 helicopter to watch the suspected den location for the Ualik Lake wolf pack. As we approached the suspected den site, we heard female W0702 on the radio at the den area but couldn't see her. Arrived 0950 on the ground at a ridge about 400' above the valley below. Helicopter left, I set up in a concealed location and spotted 3 wolf pups ~150m north of the den coordinate. One ran to the north to greet an arriving adult, then the others joined, for a total of 4 pups. They play with the newly arrived wolf, which had a dark collar--I assume it was W0702. This wolf moved ~50m to where a second adult was laying down, bringing all 4 pups with her. The second adult had no collar. W0702 lay down briefly, then departed in 4-5 minutes, disappearing in brush to east.

1020-1045 Mother (I assume) and pups remain in original vicinity, moving once ~50m. Mother resting and pups playing, walking 30-40m away, and resting. Wind is directly from me--so it's possible the female senses me.

1045-1230 Mother and pups slept. Mother lifted head and looked around every 10 min or so. Airplane went by 1133, going through the pass 1 mile south and mother showed no reaction. Weather is full overcast, ceiling 800', 50 degrees, light winds NE.

1230 3 pups got up, stretched, moved ~40m, then lay down. Mother stretched and lay back down. Pups within 20m of mother.

1233 Mother up, then loped ~40m to N. Her LR leg is injured. She's not using it at all. 3 pups moved with her, then all lay down.

1305 Another airplane came through the pass -- no reaction.

1405 No change. All still sleeping.

1413 Aircraft flight through pass--about 1/2 mi from wolves. Mother lifted head and one pup moved a few feet.

1423 High altitude aircraft overflight. No reaction.

1425 Aircraft through pass. No reaction.

1440 High altitude aircraft overflight. No reaction.

1441 Aircraft through pass. No reaction.

1442 3 pups up and moved 30 m. Lay back down.

1515 Aircraft flew up the valley to Ualik Lake, 3/4 mi from wolves. No reaction.

1516 Aircraft through pass. Pups got up, moved a bit, laid down. Adult moved 30m.

1530 A new adult entered the area in a very submissive manner. Tail and head down, hesitant, then rolling over and laying on back when the big female approached. This wolf had a black collar--165.031. A minute later a second new adult arrived--not as submissive. It appeared that this wolf nursed the pups--hard to see. Also, one or the other new wolves might have regurgitated food. A 5th pup showed itself! After a bit of tussling with pups, the 2 new adults lay down, then the original adult loped off on 3 legs to the N, then to the SW for about 1/2 mile, then stopped to eat something from 1544-1600. She departed then and I lost sight of her.

1600 2 pups visible at the same original den location.

1612 The injured wolf returned and 6! pups ran out to greet her, nipping/licking at her mouth, rolling on back and begging. She regurgitated and they fed. While so doing another adult entered the group. No collar. Probably the mother? Showed submission, then regurgitated for pups as a plane flew through the pass.

1622 All wolves (6 pups, 1 injured adult) lay down. Uncertain where the other 2 adults are.

1640 Aircraft through pass--no reaction.

- 1642 Uncollared, uninjured adult moved ~60m to outside edge of group area.
- 1645 Same wolf departed, moving W. Lost sight.
- 1700 Collared 165.031 moved through pack area. Lost sight at west edge.
- 1705 2 more aircraft. No reaction (1 high, 1 low)
- 1711 Aircraft passed by @1000' and 1/2 mile distance. Injured wolf looked up but showed no concern. Wolf then got up. LR leg appears broken at tarsal/metatarsal.
- 1722 Aircraft through pass. No reaction. Pups are 1/2 height of adults. Appear to be 15-20 lbs. Small coyote size.
- 1800 Helicopter returned to pick me up. Injured adult watched it without getting up until it had landed. Wolf then got up and disappeared into brush. We flew to the location where the injured wolf was feeding and found half of a salmon carcass on the open tundra! It was far from water, so the wolf had cached it there from a previous trip or the other wolves had dropped it there.
- After reconsideration, I suspect that the injured wolf is the pack's dominant male, and not female. The other uncollared adult is the dominant female, and the two collared animals are subordinate pack members.