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DEMOGRAPHY AND DISTRIBUTION OF WOLVES, DENALI NATIONAL PARK AND
PRESERVE, ALASKA - PROGRESS REPORT

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INTRODUCTION

The National Park Service (NPS) is concerned that activities that occur in and adjacent to Denali National Park and Preserve, Alaska (DENA) may adversely affect the natural and healthy character of the existing wolf (Canis lupus) population. In addition, the NPS is interested in determining the relationship between DENA wolves and the prey species they utilize. Predation by large carnivores, primarily wolves and grizzly bears (Ursus arctos), influences the distribution, abundance, and behavior of ungulates inhabiting DENA. Information gathered in DENA, which contains the only extensive area in interior Alaska where wolves and their prey are protected from legal harvest, will be of great interest as a comparison to more manipulated wildlife systems.

Therefore the NPS has undertaken a study of the wolf packs and their prey in DENA.

OBJECTIVES

The primary objectives of this study are to determine the following:

1. the number of wolf packs in DENA,
2. the number of wolves in each pack,
3. the size and location of each wolf pack territory,
4. the extent to which DENA wolf packs use areas outside the park, and
5. denning locations and rendezvous sites for each pack.

The secondary objective of this study, to be accomplished to the extent funds allow, is to test the hypothesis that wolf numbers each year are a function of the number of vulnerable prey available. This hypothesis is suggested by long-term wolf-prey studies in Isle Royale National Park in Michigan and in the Superior National Forest of Minnesota. DENA provides a valuable opportunity to test this hypothesis while trying to understand the role DENA wolves play in ungulate population fluctuations, a subject of considerable management concern.

METHODS AND MATERIALS

The study, now entering its fifth year, is under the direction of co-principal investigators L. David Mech (USFWS) and Layne Adams (USNPS). It uses radio-tracking and direct observation as its primary technique. Field work is performed by biologist Tom Meier and technician John Burch, assisted by various other Park Service employees and volunteers.

Wolves are located by following tracks in snow with a PA-18 Supercub aircraft, then anesthetized with a Cap-Chur rifle (Palmer Chemical Co., Douglasville, GA) fired from a Bell 206B Jet Ranger helicopter. We are currently using a drug dosage of 800 mg of ketamine hydrochloride (Ketaset, Bristol Myers, Syracuse, NY) and 150 mg of xylazine (Rompun, Miles Laboratories, Shawnee, KS) in 5 ml of 20% propylene glycol. Some wolves have also been live-snared in winter or live-trapped in summer (Table 1). The snares used are Thompson

4XX cable snares (Thompson Snare Co.) affixed with stoppers to prevent their contracting smaller than 17" in diameter. Trapping is done with #14 Newhouse traps (Victor Co., Lititz, PA) or Braun padded jaw wolf traps (Wayne's Oddjob Ltd, Campbell River, BC). Ground-captured wolves are injected via jabstick with an initial dose of 300 mg ketamine and 50 mg promazine hydrochloride (Sparine, Wyeth Laboratories, Philadelphia, PA). To date, no capture-related death or serious injury has occurred with any capture method, and all captured wolves have promptly reunited with their packs.

After capture, wolves are weighed, measured and examined. Age is estimated by tooth eruption and wear. Breeding status of females is evaluated by teat development. A 35-cc blood sample is drawn, with a portion being placed in tubes containing EDTA and sent along with prepared microscope slides to a local clinic for hematology analysis. The remainder of the blood is centrifuged to separate serum, to be tested for antibodies by Randall L. Zarnke (Alaska Dept. of Fish and Game) and for blood chemistries by U. S. Seal (U. S. Veteran's Administration, Minneapolis, MN). Heparinized whole blood samples are being submitted for genetic analysis by Robert Wayne (University of California at Los Angeles).

Wolves are fitted with plastic ear tags (Rototags, Nasco West, Modesto, CA) and radio-collars (Telonics, Mesa, AZ). Penicillin is administered (2.4 million units Flo-Cillin, Bristol Laboratories, Syracuse, NY) to help reduce chance of capture-induced infection. Yohimbine hydrochloride (Sigma Chemical Co., St. Louis, MO) is

administered at a dosage of .15 mg per kg of body weight, to counteract the xylazine and promote rapid recovery of darted wolves (Kreeger et al. 1987).

Radio-collared wolves are located with antennae-equipped PA-18 Supercub aircraft. Locations are mapped on 1:63,360 topographic maps and transferred into metric (Universal Transverse Mercator) coordinates. Wolves are sighted on 84% of radio locations (Table 2), and their behavior is then observed. Pup and total pack counts are obtained by aerial observation, and kills, dens and rendezvous sites are located and mapped for future examination. Pack territory sizes are obtained by determining with a planimeter the area of the smallest convex polygon which includes all locations mapped for that pack (excluding obvious forays outside the usual range).

Ground work on the project involves follow-up visits to areas of interest seen from the air. Kill sites are examined to determine the species, sex, age and condition of prey. The area around a kill is examined for signs of a struggle or blood, and the position of the carcass and manner of feeding provide further clues as to whether wolves killed or merely scavenged a particular carcass. Bloody snow, rumen, bladder urine and hair are collected for chemical analysis of prey condition. Marrow (preferably femur marrow) is collected and later weighed and dried to determine percent fat content. Muscle samples are collected when possible, for radio-caesium analysis by the Alaska Department of Fish and Game, to help calibrate studies of wolf food habits by this technique (Holleman and Stephenson 1981). Sex is

determined by the presence of antlers or antler pedicels (moose), antler size (caribou), horn shape and size (sheep), or pelvis shape (all species).

All bones found at the scene are examined for abnormalities, and certain bones are collected if available, for subsequent cleaning and examination. Teeth, preferably incisors, are kept for age determination by sectioning and counting cementum annuli (Matson's, Milltown, MT). Age of younger animals is determined by the pattern of tooth eruption. Sheep are aged by annular rings on the horns and by tooth eruption and tooth sectioning.

The following bones are saved: metatarsus (lowest leg bone) to be cleaned and measured as a standard index of growth (Peterson et al. 1982); moose skulls for brain volume measurements (Peterson pers. comm.); mandibles for estimation of age and examination for periodontal disease and other jaw abnormalities; and pelvises and sacra for signs of arthritis (degeneration of the lumbosacral and coxofemoral joints) (Peterson et al. 1982). Bones are cleaned by boiling and immersion in heated solutions of enzyme bleach (BIZ Bleach, Procter and Gamble, Cincinnati, OH). In addition to animals killed or scavenged by wolves, other carcasses road-killed or found incidentally are necropsied for reference specimens. Collared wolves which die, and wolf carcasses collected from trappers and hunters, are necropsied to determine cause of death, reproductive history, diet and pathology.

Other ground-based activities include the collection of wolf scats from roads and trails within the park, and from den and rendezvous areas after annual abandonment. Accessible dens are observed from a distance on the ground for early counts of pup production. Moose and caribou snow urine is collected in winter to assess the nutritional state of the herds. Ground access to the park is afforded by the park road in summer, by landings with helicopters and fixed-wing aircraft where practicable and affordable, by snowmobile and all-terrain cycle in the non-wilderness areas of the park, and by dogsled, ski, snowshoe and foot travel in the wilderness area.

RESULTS AND DISCUSSION

Wolf Captures

Twelve wolves were darted in March 1989; two each from the Clearwater, McLeod Lake, Birch Creek, Little Bear, and Ewe Creek Packs and one each from the McKinley River and Windy Creek Packs. Most of these captures involved the addition of more radio collars to packs which already contained collared wolves, to prevent the loss of contact with these packs. The Little Bear Pack was the only new pack studied.

Four wolves were darted in November 1989; these involved the placement of one additional collar in the Highpower and Foraker River packs, the replacement of a dead collar in the Stampede pack, and the collaring of the lone Chedotlothna wolf.

Radio-tracking

From 1 to 67 locations (average, 25) were obtained for each of the radioed wolves, depending on when each individual was radio-tagged and how accessible it was for radio-tracking (Table 2). The number of actual observations of radioed wolves and/or their packmates varied from 0 to 60 (average, 21) (Table 2). In Fall 1989, 13 packs of wolves and two lone wolves were being monitored (Table 3, Figure 1).

Collared Wolf Packs

Headquarters Pack: In winter 1988-89 the Headquarters Pack consisted of wolves 251 and 307 and their five pups born in 1988. In March 1989, collared two-year-old male 311, originally from the Clearwater Pack, was found with them. He has now remained with the Headquarters pack for 9 months. Wolf 311 could not have lived in the same pack with any member of the Headquarters Pack prior to his joining them, and such an adoption of a strange wolf into a subordinate position is rare.

Six pups were born to alpha female 307 in 1989, and 14 pack members were seen in the fall, indicating the probable survival of all pups born in 1988 and 1989, along with the alpha pair and adopted wolf 311. The pack had grown from one member to 14 in two years.

The Headquarters pack occupies an area south of the park road, west of the Parks Highway, and east of the Teklanika River. This includes much of the area formerly occupied by the Savage Pack (Haber 1977).

The territory, minimally estimated at 227 mi² (588 km²), contains some of the largest concentrations of moose (Alces alces) found in DENA, and most of the pack's known kills have been moose (Table 4). The area also contains sheep (Ovis dalli), and is visited intermittently by members of the Yanert and Denali caribou (Rangifer tarandus) herds.

East Fork Pack: This pack had expanded in size in 1988, when two females produced pups in separate dens and then merged the two litters in mid-summer. There were 18 wolves in the pack through the winter of 1988-1989. Double litters were again produced in 1989, with the white-shouldered alpha female occupying the usual den and collared female 217 using an old den a mile away. Wolf 217 had not been the second breeding female the previous year, and had probably never bred until 1989. In late summer, a total of 10 pups from the combined litters was seen near the main den. The highest pack count observed in early winter (and the largest pack yet seen in this study) was 27 wolves.

The East Fork pack occupies a minimum area of 597 mi² (1546 km²) centered around the Sable Pass area and almost entirely within the designated Wilderness area of DENA. The pack has occasionally made forays north to the Stampede Road, east to Riley Creek, and west to the Muldrow Glacier. The East Fork territory contains excellent moose and sheep habitat, and is used by the Denali caribou herd. The East Fork pack is of great interest to park staff and visitors, being the most readily observable pack in the park. The wolves regularly

travel, make kills, and occupy rendezvous areas within sight of the park road. This visibility was the subject of a newspaper photo essay in November 1989 (Porco 1989).

Clearwater Pack: This pack consisted of three collared and one non-collared wolf in early winter 1988-89. Alpha male 223 was killed by wolves north of the pack territory in January 1989. Two-year-old male 311 dispersed and joined the Headquarters Pack, as described above. In March 1989, alpha female 227 was found with two non-collared companions, both of which were captured and collared. Wolf 227 was killed by other wolves along Clearwater Creek in April. Tracks showed that several wolves had left the site, indicating that she had been killed by another pack and not by wolves 361 and 363, the newly collared female and male. Female 361 remained in the Clearwater territory and produced pups in 1989, so she must have bred while the previous alpha female, 227, was still alive. It is likely that 361 was the sibling to 311 born in 1987, and as such the only surviving member of the Clearwater Pack. Male 363 was found briefly with the McLeod Lake pack, which was probably his natal pack, and then rejoined 361 to raise a litter of six pups in the summer of 1989.

In late December 1989 male 363's collar was heard in mortality mode near Moose Creek, but the site has not yet been investigated as of this writing. No signal was heard from female 361 at that time.

The Clearwater Pack occupies a territory extending from the Kantishna Hills to the Toklat River, and south to the Alaska Range, with a minimum estimate of 424 mi² (1098 km²). The Denali caribou herd spends most of its time in this area, including calving and wintering periods. The territory also contains relatively high moose densities (Meier 1987), and a few sheep. Most of the kills we have found made by the Clearwater wolves have been caribou (Table 4, and previous years' data). The Clearwater Pack, unlike its neighbors, has had a history of poor pup production and frequent dispersal, and had never grown larger than five members until summer 1989. If male 363 proves to be dead, the fate of the pack remains questionable.

Pirate Creek Pack: This group was probably an offshoot of the Clearwater Pack, formed by male wolf 250, wearing a dead radio collar, and female 339, collared near the den in July 1988. Wolf 339 died in November 1988, and no evidence of the male or the pups has been seen since then. The area they occupied is completely used by the Clearwater and McLeod Lake packs.

Little Bear Pack: The Kantishna Hills has been an area little used by the radio collared wolf packs surrounding it (the Clearwater, Bearpaw, McKinley River, McLeod Lake, and Pirate Creek packs). This, together with the death of Clearwater male 223 on Alder Creek, had led us to suspect that another pack of wolves inhabited that area. When the Chitsia Mountain pack was collared in December 1988, it seemed that they might be such a pack, but they turned out to be a seemingly new group, living mostly in the old Bearpaw and Alma Lakes

Pack territories. In March 1989, a pack of seven wolves was found on Little Bear Creek, in the north end of the Kantishna Hills. Two young males, 373 and 375, were captured and radio collared. They appeared to be loosely associated with the pack over the summer and the den was never located, but they were seen with five other adults and five pups in early winter 1989-1990.

The Little Bear Pack appears to live almost entirely in the central part of the Kantishna Hills, occupying an area of at least 306 mi² (793 km²). The Kantishna Hills contain moderate numbers of moose, varying numbers of Denali Herd caribou, and no sheep.

McLeod Lake Pack: Only one collared animal, alpha female 309, remained in this pack in January 1989. Two 10-month-old females, 365 and 367, were collared in March 1989. Pack size fell from 10 to 9 between December 1988 and May 1989. At least four pups were produced in 1989, and the pack consisted of 12 members in fall 1989, including wolves 309 and 367. Female 365 probably dispersed in October.

The McLeod Lake pack occupies a minimum area of 831 mi² (2152 km²), from Wonder Lake west beyond the Foraker River, and from the mountains north to the old park boundary. This area contains an expanding moose population (Meier 1987) and a substantial part of the Denali caribou herd's calving range.

Castle Rocks Pack: This new group, consisting of a pair and their pups, attempted to occupy an area on the edge of several existing

pack territories, near the Castle Rocks Hills, in 1988. Both alpha animals were killed, probably by the McLeod Lake Pack, and in 1989 there was no evidence that any of the pups remained in the area. The territory is occupied by the McLeod Lake Pack and the new Foraker River Pack.

Foraker River Pack: Female wolf 321 was captured as a member of the McKinley River Pack in 1988. That fall she settled with a companion in the southwest part of the McKinley River Pack territory, near the area where the Castle Rocks pair had tried to colonize the previous year. Four pups were produced in 1989. Another wolf from this Foraker River Pack was captured in November 1989, and surprisingly it was a large (94 pound) female at least one-year old. Only two wolves, presumably a male and 321, had been seen in 20 observations of the group prior to the birth of the pups.

In early winter 1989-1990, the Foraker River Pack expanded its range to include a minimum area of 437 mi² (1132 km²) in the Foraker River and lower McKinley River drainages. It is not known to what extent their territory overlaps with that of the McKinley River Pack, since contact with that pack has been lost. The territory, mostly in the 1980 addition to Denali National Park, contains a low density of moose and is occupied year-round by a few members of the Denali and Tonzona caribou herds.

Highpower Pack: This pack, containing collared alpha male 325 and pup 357, consisted of eight wolves in winter 1988-1989. Wolf 357 was

found dead and eaten in the Telida Mountains, outside the pack territory, in January 1989. At least three pups were produced in 1989, as indicated by pack counts of ten in the fall. Male pup 385 was captured in November 1989. The territory, minimally estimated at 240 mi² (622 km²), contains a low density of moose and Tonzona herd caribou.

Telida Mountains Wolf: Female wolf 337 left the Highpower Pack in 1988 and has continued to live in the area around the Telida Mountains. She was accompanied by another black wolf for part of winter 1988-1989, but appears to live alone most of the time. Due to her remote location, we seldom locate this wolf. Her territory as delineated so far includes 231 mi² (598km²).

McKinley River Pack: This pack of ten wolves in 1988 contained two collared animals, male 315 and female 321. Both of these have left the McKinley River Pack to form new groups. Wolf 321 has become the alpha female of the Foraker River Pack, and male 315 is a member of the Chitsia Mountain Pack, occupying the area where the McKinley River Pack had exterminated the Bearpaw Pack. Male wolf 379, found with male 315, was captured in March 1989 and also spent some time with the Chitsia Mountain pack before dispersing to the north. The McKinley River Pack appears to have "budded" and colonized two adjacent areas in two years. The structure of both the Foraker River and Chitsia Mountain packs suggests that more than one wolf may have left the McKinley River pack to form each of them. In fact, we suspected for a time that these two groups were all that was left of

the original pack. However, track searches in November 1989 indicated that a pack of at least seven wolves still occupies the lower McKinley River/Bear Creek area, separate from the other two groups. The placement of a radio-collar in this pack will be a high priority in 1990.

The McKinley River Pack territory (including the Bearpaw area) contains a minimum area of 1089 mi² (2821 km²) of low, densely forested country with a low density of moose and caribou. Salmon are available in several of the streams.

Chitsia Mountain Pack: Female wolf 359 and a black companion traveled widely after she was radio collared along the East Fork of the Toklat River in December 1988. They were found as far away as Wien Lake and Lake Minchumina before settling down in the Bearpaw area. There they were joined by two McKinley River wolves, males 315 and 379. The latter wolf soon dispersed, but male 315 has remained with female 359. There was no evidence that wolf 359 dened in 1989. The Chitsia Mountain Pack presently consists of three gray members and one black wolf, presumably the collared pair, her original black companion, and another wolf of unknown origin.

The Chitsia Mountain Pack territory has been occupied by the Alma Lakes, Bearpaw, McKinley River, and Chitsia Mountain packs during the past three years. The degree to which these various groups are interrelated is not known, except that they range from all-gray to nearly all-black packs, and appear to have replaced one another with

varying degrees of interpack strife. The area contains a low density of moose and caribou, and wolves here have been seen feeding on salmon from the streams. The various packs (excluding the McKinley River Pack) may represent unsuccessful attempts by new pairs and small groups to occupy an area surrounded by larger existing packs. As so far delineated, the Chitsia Mountain territory contains 346 mi² (896 km²).

Birch Creek Pack: Seven wolves have been collared from this large pack in the northwest part of DENA. Two have had their collars chewed off (male 257 and female 345). Two have probably dispersed (female 263 and female 347). Three remain with the pack (male 301, female 369, and female 371). The pack consisted of 23 wolves in winter 1988-1989, and pups were produced in summer 1989, but no more than 15 have been seen so far this winter.

The Birch Creek Pack occupies the lake country east of Lake Minchumina, but has made forays for 40 miles in several directions from there. The core territory of the Birch Creek Pack includes a minimum of 1155 mi² (2991 km²) of lowland forest, lakes and rivers containing a moderate density of moose, very few caribou, and many beavers (Castor canadensis). Several beaver skulls were found at the den complex both times we visited it.

Totek Hills Pack: Wolf 237, formerly of the Sushana Pair of wolves in the northeast corner of the park, remains with this pack, which occupies an area of at least 470 mi² (1217 km²), just north of DENA

between the Toklat and Teklanika Rivers. The territory extends slightly into the park and into the range of the Denali caribou herd, but the pack probably depends primarily on moose. The highest count of the pack in winter 1988-1989 was seven wolves. Ten wolves have been seen in the pack in early winter 1989-1990, indicating that pups probably were produced in summer 1989.

Stampede Pack: Wolves 349 and 351 and their pups continue to occupy the Stampede Road corridor, and have extended their range to the east and south at the expense of the Ewe Creek Pack territory. They have also made forays as far west as the Toklat River. The pack consisted of seven wolves throughout winter 1988-1989, and seven pups were seen in summer 1989. No more than 10 wolves have been seen in the pack in fall 1989, so several of the yearlings or pups must have died or dispersed in autumn 1989. The radio-collar on alpha male wolf 351 failed in October 1989. He was recaptured and fitted with a new collar in November. The Stampede Pack territory covers a minimum of 386 mi² (1000 km²) of mostly open tundra with forested stream beds, containing a moderate density of moose and intermittent large numbers of Denali Herd caribou.

Ewe Creek Pack: This group, on the northeast corner of DENA, contained five wolves in winter 1988-1989. Two of these, females 341 and 343, had been collared previously, and two more, male 381 and female 383, were collared in March 1989. Yearling female 341 was trapped by a local trapper on the Healy River in March. Male yearling 381 dispersed to the south in summer 1989, and was recently

shot sixty miles to the southeast, near the Susitna River. There was no evidence of denning or pup production in the pack, which presently consists of females 343 and 383 and an unknown third animal. They have not been found west of the Parks Highway since June 1989. The pack territory prior to that time covers a minimum area of 341 mi² (883 km²). The Ewe Creek Pack is consistently found in more mountainous terrain than any other pack in the study area, and has over the years killed proportionately more sheep than the other packs. They also have access to moose in the Dry Creek, Moody Creek and Healy River valleys, and to occasional bands of caribou from the Denali, Delta and Yanert herds.

Windy Creek Pack: Alpha female 377 was captured in the Yanert River valley in March 1989. She was found there by homing in on male 245, the only collared member of the Windy Creek Pack at that time. The pack has never been found north of the Alaska Range before or since then. The pack contained five wolves in winter 1988-1989, produced five pups in summer 1989, and contained eight wolves in fall 1989. The territory (minimum area = 257 mi² [666 km²]) contains high moose densities, intermittent high caribou numbers (from both the Nelchina and Denali herds), and some sheep.

Swift Fork Pair: Two wolves, male 353 and female 355, captured in fall 1988, occupied an area on the extreme west end of the park. They were large, pale colored wolves which looked a great deal alike and may have been related. No evidence of additional wolves in the

group was seen. The female was killed by wolves in February 1989, and the male died of unknown causes in May of the same year.

Chedotlothna Wolf: The tracks of a single wolf were found around a sheep kill and a scavenged moose in the Somber Creek area, in the extreme west end of DENA, in November 1989. Male wolf 389 was captured on the Chedotlothna Glacier. This is the same area where the Swift Fork pair of wolves lived. Wolf 389 appears to be living alone, so we have still been unable to make contact with a pack of wolves to the west of the McLeod Lake Pack territory. Wolves certainly inhabit the area, as demonstrated by the wolf-caused mortality among radio-collared Tonzona herd caribou (Layne Adams, pers. comm.).

Non-Collared Wolf Packs

A few wolf packs exist in addition to those monitored by radio telemetry. Tracks of a pack of wolves have been followed in the Deep Creek area south of Lake Minchumina, and among the lakes south of there. This area seems to be outside the territories of the Highpower and Birch Creek wolves. It is a densely forested area, and capturing the wolves would be difficult. As discussed earlier, we also suspect the presence of a large pack of wolves in the Swift Fork/Tonzona area at the west edge of DENA, but have so far been unable to find them for capture.

South of the Alaska Range, there are probably wolf packs frequenting the West Fork of the Chulitna River (west of the Chulitna and Windy

Creek territories) and the headwaters of the Yentna River in the southern Preserve area. Other parts of DENA south of the range contain little prey habitat, and any wolves which enter the park must spend most of their time outside of it.

Wolf Densities

Based on radio-collared wolf pack sizes and territories at least partly in DENA, and having a sufficient number of radio-locations (Mech 1973), the mean density of wolves is about one per 39 mi² (100 km²) (Table 3). We have estimated that some 2,752 mi² (7,128 km²) of DENA is unsuitable habitat for wolves or their prey due to high altitude or glaciation, leaving approximately 6,668 mi² (17,270 km²) of suitable habitat. Extrapolating our wolf density over this area gives an estimate of 173 wolves in DENA. This estimate has increased for the third consecutive year, and again probably represents a real increase in wolf density in the park. The number of packs and the number of wolves per pack have both apparently increased in DENA in recent years.

Wolf Mortality and Emigration

In 1989, six collared wolves died in and around DENA. As in previous years, the most common cause of death was killing by neighboring wolf packs. This was the fate of Clearwater wolves 223 and 227, Highpower wolf 357, and Swift Fork wolf 355. Nearly all of the wolves we have found killed by other wolves have been at the edge of their territories or outside of them. The carcass of Swift Fork wolf 353 was completely decomposed when investigated, but there was no

evidence of human involvement. Ewe Creek wolf 341 was legally trapped near the Healy River.

Of the suitable wildlife habitat in DENA, 36% lies in the old park or wilderness area where wolves have complete protection, 41% lies in new park areas open to subsistence hunting and trapping, and 23% lies in preserve areas open to sport hunting and trapping. What data we have suggest that there is little harvest of wolves within DENA by subsistence or sport hunters and trappers. Some wolves are taken each year from packs whose territories straddle the boundary of the park. We have been buying wolf carcasses taken in the area surrounding DENA in order to estimate harvest and also to obtain necropsy information. In winter 1988-89, we again contacted trappers around DENA in an attempt to collect wolf carcasses for necropsy, and eight wolf carcasses were obtained, mostly from the Healy area. Two wolves (one collared and one not) were trapped from the Ewe Creek pack on the east edge of DENA. No other known harvest took place from the collared packs. The survival of all wolves in the East Fork, Stampede and Headquarters packs through the winter demonstrated that no wolves were removed from these groups.

Patrolling of the western part of DENA cannot be intensive enough to locate all carcasses or airplane landing sites, so counts of radio-collared packs may be the best way to detect aerial hunting. Pack counts and behavioral observations of collared packs did not show any evidence of aerial hunting in winter 1988-1989.

Four collared wolves that had dispersed away from DENA packs were killed by humans in 1989. East Fork male 215, missing for three years, was trapped near Nabesna--some 250 miles southeast of his birthplace. East Fork male 239, missing for one year, was killed near the Wood River, 100 miles east. McKinley River male 379, missing for seven months, was snared near Chena Hot Springs, 200 miles northeast. Ewe Creek male 381, missing for six months, was shot near the Susitna River, 60 miles southeast of his last known location. All four of these wolves were reported to have been accompanied by more than one companion when they were killed. Because wolves 379 and 381 had not been gone during a mating season, they could not already have mated and founded these packs.

In addition to the dispersed wolves whose fates are known, two others, Birch Creek female 347 and McLeod Lake female 365, ceased to be heard with their packs in 1989, and probably dispersed. Monitoring of collared animals provides a measure of the rate of dispersal of wolves out of DENA but no way of detecting immigration into the area, some of which undoubtedly occurs.

Wolf productivity

Pup production and survival to fall averaged 4.0 pups per pack, lower than the average of 5.1 in 1988 but higher than in the two previous years of the study. This average is a minimum figure, because we were not confident that we had counted all of the pups in several packs (Table 3).

In addition to the production of pups in existing packs, wolf numbers have been augmented by the formation of new pairs and subsequent pack formation. In 4 years we have seen the formation of 8 new pairs of wolves in or adjacent to DENA (The Sushana, Chulitna, Castle Rocks, Pirate Creek, Stampede, Foraker, Swift Fork, and Chitsia groups). The Little Bear Pack also probably formed since the beginning of this project. In addition, the Headquarters and Clearwater packs both reformed from a single surviving wolf pairing with an arrival from outside the territory. Of these newly formed groups, 6 survive as new packs, and 5 were eliminated (one by aerial poaching, the others by intraspecific strife and/or starvation). One entire pack, the Bearpaw Pack, was also eliminated by intraspecific strife.

Prey investigations

Information about wolf prey has been gathered through wolf and bear scat collection, snow-urine collection, kill examinations, radio-cesium analysis of wolf muscle tissue, and direct observations of prey and wolf-prey interactions. More than 1,600 wolf scats were collected in 1989 from the Windy Creek, Stampede, Birch Creek, Highpower, McLeod Lake, East Fork, Clearwater, and Headquarters dens and rendezvous sites and from roads and trails scattered around the park. No scats have yet been analyzed.

Dr. Glenn DelGiudice of the University of Minnesota began collecting snow urine in DENA in March 1987, in order to assess the nutritional state of wintering caribou and moose. Project personnel continued these collections in winter 1988-89. In 1989, 245 caribou and 22

moose snow urine samples were collected. Results of these analyses will be available in a separate report.

Radio-collared wolves were observed interacting with moose 6 times, sheep 8 times, caribou 11 times, bears 16 times, and other wolf packs 4 times. In May 1989, the Clearwater and McLeod Lake packs were located daily to study their use of the caribou calving grounds.

Remains of 59 moose, 35 caribou, and 16 sheep were examined in 1989 to determine age, sex, condition, abnormalities and cause of death. These were all carcasses found by tracking radio-collared wolves (Table 4); the remains of another 73 animals which died from vehicles, bear predation, or unknown causes were also examined. Ages from tooth cementum have been obtained where possible for all specimens collected through September 1989. Kills of caribou and moose calves are especially prevalent in spring and summer respectively, and many bulls of both species are taken in fall around breeding season. Generally, the wolves seem to be taking a preponderance of young-of-the-year and old animals, with the mean age of females killed being considerably older than that of the males. Sheep kills seem more non-selective and opportunistic, and are probably often the result of the wolves finding the sheep on favorable terrain.

Our tallies of kills found with collared packs (Table 4) are not a representative sample of the kills made by these packs, because our flying efforts are not distributed evenly over the year, wolves spend

more time at the kills of larger animals, and some types of kills are more visible from the air than others. Complete counts of kills made by a pack are not possible in the snow-free season because kills are more difficult to see, wolves cannot be backtracked to kills they have left, wolves are generally not travelling in large groups, and they are taking more small prey (calves, beavers, small mammals). It is desirable to measure predation rates during the winter by locating wolves at least once a day and backtracking them in the snow to their last known location in order to find all kill sites. This technique requires suitable flying weather over a period of at least two weeks, and snow conditions that allow backtracking of packs. Such conditions are very rare in DENA, and to date we have not obtained a satisfactory estimate of predation rate for any season of the year.

Many cases of skeletal abnormalities and other possibly debilitating factors have been found among prey remains, but because the incidence of these conditions in the general prey population is unknown, it is not known to what degree they contribute to prey vulnerability. The average femur marrow fat content of prey eaten by wolves is 58%, with little difference between killed and scavenged prey. Jaw necrosis, which can result in abnormal occlusion and tooth loss, is common in adult moose and sheep taken by wolves. Arthritis of the lumbosacral joint (between the sacrum and sixth lumbar vertebra) appears to be related to age in moose, with severe arthritis common in animals 15 years of age and older. Few skeletal abnormalities have thus far been found among the remains of caribou eaten by wolves.

The importance to wolves of prey species other than the three large ungulates in the park is unknown, although scat analyses should provide information. Beavers may be a seasonally important source of food for wolves living in the low-lying lake and stream country in the northwest part of the park. Salmon carcasses are available from the Toklat, McKinley, Kantishna and Bearpaw Rivers and Bear and Moose Creeks, particularly in places where the rivers remain open for part or all of the winter, and sign of wolves feeding on them has been found.

Wolf project personnel have been assisting Layne Adams of the Alaska Regional Office, National Park Service, in his investigation of caribou movements and mortality in Denali Park. Activities have included the radio-collaring of calf and adult caribou, herd composition counts, monitoring of collared caribou, and investigation of mortalities.

Other studies wolf project personnel have assisted with include moose and Dall sheep censuses within DENA, analysis of wolf scats from Gates of the Arctic National Park and Preserve, monitoring of radio-collared moose and bears, and intensive monitoring of wolves and bears on the caribou calving grounds.

CONCLUSIONS AND RECOMMENDATIONS

This project has been underway for 4 years, and will probably continue through fiscal year 1992.. The primary objectives of the

study, to provide information on the structure of the DENA wolf population and the effects of human activities on it, have been realized to a large extent. However, the history of human/wolf interactions in this area is long and varied, and even in the brief duration of this project, both legal and illegal taking of wolves has varied greatly from one year to the next. The results of a few years of data may not adequately measure the long-term situation. So while the emphasis of the study may change, we will continue to gather basic information on wolf population structure in DENA. We will continue to monitor the wolf packs now being followed, to examine fluctuations in wolf density and productivity over time. The territories of collared wolf packs have not yet all been completely delineated, and shifts in territories have occurred which affect the degree to which wolves are influenced by human activities outside DENA. Additional wolves will need to be collared to replace those lost through dispersal, death or radio failure. The radio-collars being used are expected to last at least 3 years before battery failure. One collar has now been broadcasting for nearly 4 years.

As the study has progressed, more packs have been identified and radio-collared, and more of the collars have been on older, high-status wolves that are likely to remain with their packs for a long time. This has allowed a smaller proportion of the project budget to be used for wolf capture, and more for wolf monitoring and prey investigations. We will continue to concentrate on wolf/prey interactions, emphasizing those aspects that complement the ongoing caribou research in DENA. More kills will be examined in order to

provide sample sizes sufficient to characterize prey used and to examine relationships between prey taken, weather, and wolf densities. In fiscal year 1991 and 1992, we will try to obtain predation rates by intensive monitoring of several packs in mid to late winter. Intensive monitoring of wolves on the caribou calving grounds will continue.

Funding for fiscal year 1990 will not allow wolves to be monitored as frequently as in previous winters, so we will concentrate on capturing only enough wolves to avoid losing contact with packs, investigating dead wolves, and obtaining pack counts over winter.

The results of wolf research at DENA are proving valuable in a number of ways. Park management has used information from this study to help make decisions about the park's back-country closure system. The monitoring of wolf packs in winter increases the chance of detecting poaching, and may even discourage poaching. Information on predator-prey interactions in DENA provide a valuable comparison for managers of other, more manipulated systems. From a purely scientific standpoint, the Denali wolf population can provide insights about wolves and their prey which are unavailable elsewhere, particularly when taken in conjunction with the other large mammal research being done in the park. Finally, the information gained from this work should allow park staff and visitors to better understand the wolf. Several stories about Denali's wolves have appeared in popular publications in recent months (Mech 1989; Meier 1989; Porco 1989). Along with information disseminated by the park's

interpretive staff, these should help increase public awareness of the values of Denali's wolves.

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Table 1. Wolf Captures, Denali National Park and Preserve.

WOLF	AGE	SEX	WEIGHT (LB)	PACK/AREA	COLOR	DATE CAPTURED	METHOD	FATE
205	A	F	73	Headquarters	gray	03-18-86	snare	killed by East Fork wolves 4-86
213	P/Y	F	80	Clearwater	gray	03-31-86	dart	disp NE, trap 2-88 McComb Plateau
215	P/Y	M	75	East Fork	gray	03-31-86	dart	disp E, trap 2-89 Nabesna area
217	Y/A	F	55	East Fork	gray	03-31-86	dart	still present
219	Y/A	F	60	Headquarters	gray	04-01-86	dart	dispersed North 3-87
221	A	M	105	East Fork	gray	04-01-86	dart	last heard 8-87 (in territory)
223	A	M	120	Clearwater	gray	04-02-86	dart	killed by wolves 1-89
151	Y/A	F	75	Clearwater	gray	04-02-86	dart	disp SW, shot 2-88 Styx River
227	A	F	75	Clearwater	gray	04-07-86	dart	killed by wolves 4-89
229	Y/A	M	75	Alma Lakes	black	04-08-86	dart	last heard 12-86
231	P	M	75	Headquarters	gray	04-20-86	dart	to Chulitna pack, shot 3-88
233	P/Y	F	70	Alma Lakes	black	04-21-86	dart	disp W, shot 11-86 Minchumina
235	A	F	93	Sushana	gray	12-13-86	dart	drowned/killed by wolves 3/87
237	A	M	115	Sushana	gray	12-13-86	dart	still present, Totek Hills Pack
239	P	M	100	East Fork	gray	01-25-87	snare	disp E, shot 4-89 Wood River
241	A	F	74	Headquarters	gray	02-02-87	snare	killed by Yanert R. wolves 3-87
243	A	M	75	Windy Creek	gray	02-11-87	dart	last heard 4-88. dispersed?
245	A	M	72	Windy Creek	gray	02-11-87	dart	still present
249	A	M	120	Dillinger	gray	02-12-87	dart	moved SW, died Lyme Village area
250	Y	M	105	Clearwater	gray	03-12-87	dart	to Pirate Cr pack, collar failed
251	A	M	94	Headquarters	gray	03-13-87	snare	still present
253	A	M	105	McLeod Lake	gray	03-14-87	dart	last heard 11-88. collar failure?
255	P/Y	M	102	McLeod Lake	gray	03-14-87	dart	last heard 7-87. dispersed?
257	P/Y	M	93	Birch Creek	black	04-06-87	dart	collar chewed off 8-87
259	P/Y	M	95	Bearpaw	black	04-08-87	dart	killed by McKinley R. wolves 2-88
261	P	F	70	Bearpaw	gray	04-15-87	dart	killed by McKinley R. wolves 3-88
263	P	F	75	Birch Creek	gray	04-15-87	dart	last heard 8-88. dispersed?
980	A	M	80	Ewe Creek	gray	08-28-87	trap	recaptured 11-87
792	Y	M	102	McLeod Lake	gray	11-20-87	dart	died 12-88, disease
980	A	M	102	Ewe Creek	gray	11-22-87	dart	snared 5-88 just outside park bdy
5051	A	M	110	East Fork	gray	11-22-87	dart	still present
301	P/Y	M	95	Birch Creek	black	02-25-88	dart	recaptured 10-88
307	A	F	85	Headquarters	gray	02/26/88	dart	still present
309	A	F	90	McLeod Lake	white	02/27/88	dart	still present
311	P	M	72	Clearwater	gray	02/27/88	dart	still present
313	Y	F	70	Bearpaw	black	03/01/88	dart	killed by McKinley R. wolves 3-88
315	A	M	115	McKinley R.	gray	03/01/88	dart	still present
321	Y	F	95	McKinley R.	gray	03/01/88	dart	still present
325	A	M	135	Highpower Cr.	black	03/03/88	dart	still present
337	Y	F	95	Highpower Cr.	black	03/03/88	dart	still present

Table 1. (Continued). Wolf Captures, Denali National Park and Preserve.

WOLF	AGE	SEX	WEIGHT (LB)	PACK/AREA	COLOR	DATE CAPTURED	METHOD	FATE
333	A	F	95	Castle Rocks	gray	03/04/88	dart	killed by wolves 11-88
335	A	M	105	Castle Rocks	white	03/04/88	dart	killed by wolves 11-88
330	P	F	70	Ewe Creek	gray	04/14/88	dart	recaptured 6-88
330	Y	F	51	Ewe Creek	gray	06/19/88	dart	dispersed East 10-88
339	A	F	100	Pirate Creek	gray	07/03/88	dart	died 11-88 disease
341	Y	F	75	Ewe Creek	gray	10/21/88	dart	trapped 3-89 Healy River
343	Y	F	74	Ewe Creek	gray	10/21/88	dart	still present
301	A	M	107	Birch Creek	black	10/22/88	dart	still present
345	P	F	58	Birch Creek	gray	10/22/88	dart	collar chewed off 1-89
347	P	F	60	Birch Creek	black	10/22/88	dart	last heard 7-89. dispersed?
349	A	F	95	Stampede	gray	10/23/88	dart	still present
351	A	M	115	Stampede	gray	10/23/88	dart	recaptured 11-89
353	A	M	120	Swift Fork	tan	10/23/88	dart	died 5-89 unknown natural causes
355	A	F	90	Swift Fork	tan	10/24/88	dart	killed by wolves 2-89
357	P	M	75	Highpower	gray	10/24/88	dart	killed by wolves 1-89
359	A	F	84	Chitsia	gray	12/06/88	dart	still present
361	Y	F	70	Clearwater	gray	03/18/89	dart	still present
363	A	M	97	Clearwater	gray	03/18/89	dart	still present
365	P	F	75	McLeod Lake	gray	03/18/89	dart	last heard 9-89. dispersed?
367	P	F	82	McLeod Lake	gray	03/18/89	dart	still present
369	Y/A	F	85	Birch Creek	gray	03/19/89	dart	still present
371	P	F	72	Birch Creek	black	03/19/89	dart	still present
373	P	M	75	Little Bear	gray	03/19/89	dart	still present
375	P	M	82	Little Bear	gray	03/19/89	dart	still present
377	A	F	97	Windy Creek	gray	03/20/89	dart	still present
379	A	M	109	McKinley R.	gray	03/20/89	dart	disp NE, snare 11/89 Chena Road
381	P	M	70	Ewe Creek	gray	03/26/89	dart	disp S, shot 1/90 Susitna River
383	P	F	62	Ewe Creek	gray	03/26/89	dart	still present
351	A	M	115	Stampede	gray	11/17/89	dart	still present
385	P/Y	M	84	Highpower	gray	11/20/89	dart	still present
387	Y/A	F	94	Foraker	gray	11/20/89	dart	still present
389	A	M	85	Chedotlothna	gray	11/21/89	dart	still present

Table 2. Total Number of Wolf Radio-locations in 1989.

Pack	Wolf No.	No. of locations	Visual Observations
Headquarters	251	67	58
	307	66	58
	311	30	26
East Fork	217	63	60
	5051	60	58
Clearwater	227	23	22
	311	3	2
	361	46	34
	363	51	36
Little Bear	373	25	21
	375	25	19
McLeod Lake	309	56	44
	365	35	32
	367	30	29
Foraker River	321	19	17
	387	3	3
Highpower	325	13	10
	357	2	1
	385	3	3
Telida Mountains	337	8	4
Mckinley River	315	21	19
	379	5	4
Chitsia Mountain	359	22	15
	315	15	12
	379	1	1
Birch Creek	301	18	14
	345	2	0
	347	14	12
	369	12	10
	371	12	9
Totek Hills	237	8	8
Stampede	349	50	45
	351	44	40
Ewe Creek	341	21	14
	343	34	21
	381	8	5
	383	13	6
Windy Creek	245	13	13
	377	13	12
Swift Fork	353	7	6
	355	4	4
Chedotlothna	389	5	4
total	39	970	811
average (N=39)		25	21

Table 3. Basic Data on Radioed Wolf Packs in DENA, Fall 1989 (See Fig. 1).

No.	Pack	Min. Territory Size in km ² *	No. Wolves	Pups	Minimum km ² /Wolf**
1	Headquarters	588 (98)	14	7	42
2	East Fork	1546 (89)	27	10	57
3	Clearwater	1098 (112)	12	6	137
4	Little Bear	793 (35)	12	5	66
5	McLeod Lake	2152 (99)	12	4	179
6	Foraker River	1132 (28)	7	4	162
7	Highpower	622 (23)	10	3+	62
8	Telida Mountains	598 (11)	1	0	598
9	McKinley River	2821 (33)	7***	?	313
10	Chitsia Mountain	896 (29)	4	0	224
11	Birch Creek	2991 (48)	15	2+	199
12	Totek Hills	1217 (15)	10	3+	122
13	Stampede	1000 (71)	10	7	100
14	Ewe Creek	883 (49)	3	0	294
15	Windy Creek	666 (25)	8	5	83
16	Chedotlothna	N/A (5)	1	N/A	N/A
totals		19003 (770)	153	56+	
averages		1267 (48)	9.6	4.0+	

* Number of pack locations in parentheses (since 10/01/88).

** This figure represents the inverse of wolf density, so higher numbers represent a lower density of wolves.

*** McKinley R. pack size estimated from tracks — no collared animals.

Calculation of average wolf density:

Combined area of Headquarters, East Fork, Clearwater, Little Bear, McLeod Lake, Foraker River, Highpower, McKinley River, Chitsia Mountain, Birch Creek, Stampede, Ewe Creek, and Windy Creek pack territories: 17,188 km²

minus areas of overlap between the above: -3,502 km²

area occupied by 137 wolves: 13,686 km²

average density of wolves in 12 pack territories: 1 wolf per 100 km²

Table 4. Prey items found with collared DENA wolf packs, 1989.

Fig. 1 Number	Pack	Number of carcasses examined			
		Moose	Caribou	Sheep	Bear
1	Headquarters	14	1	0	0
2	East Fork	5	12	8	2
3	Clearwater	3	3	5	0
4	Little Bear	3	0	0	0
5	McLeod Lake	4	8	0	0
6	Foraker River	3	1	0	0
7	Highpower	4	0	0	0
8	Telida Mountains	1	0	0	0
9	McKinley River	6	0	0	0
10	Chitsia Mountain	0	0	0	0
11	Birch Creek	4	1	0	0
12	Totek Hills	2	0	0	0
13	Stampede	5	3	0	0
14	Ewe Creek	3	2	2	0
15	Windy Creek	0	2	0	0
16	Chedotlothna	1	0	1	0
17	Swift Fork	1	2	0	0
total		59	35	16	2

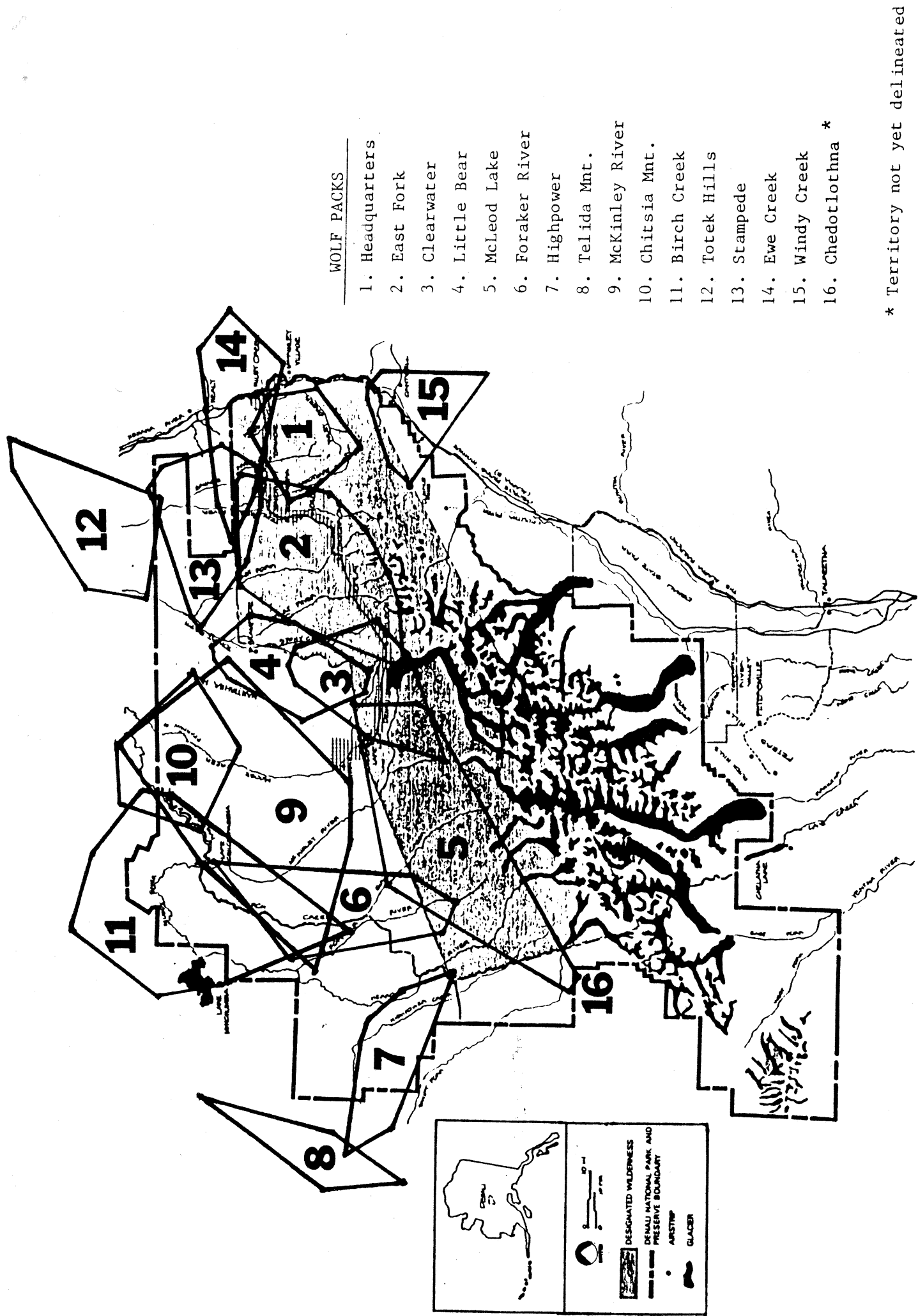


Fig. 1. Minimum 1989 wolf pack territories in and around DENA (See Table 3).