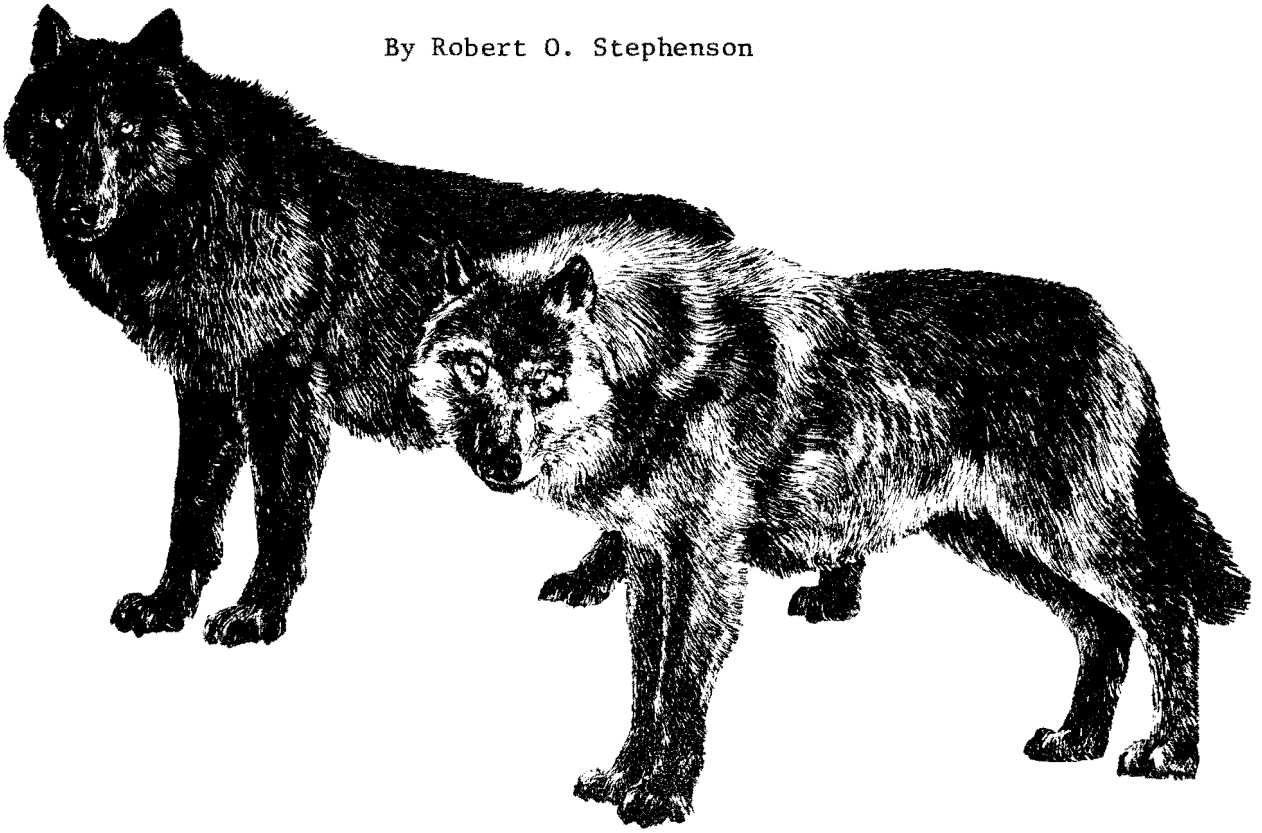
ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

CHARACTERISTICS OF WOLF DEN SITES

By Robert O. Stephenson



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FINAL REPORT (RESEARCH)

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SUMMARY

Wolf den-site structure, physiography and vegetation were studied in the northcentral Brooks Range. Locations of 78 wolf dens were obtained, largely through discussions with Nunamiut Eskimo hunters in Anaktuvuk Pass. Data gathered at 28 of these dens show that wolf den excavations are usually situated on at least a moderately steep, southerly slope in relatively well-drained soil (usually sand) near a source of water. Excavations occur in a variety of land forms including cutbanks, blowouts, dunes, kames, various types of moraines and escarpments. The dens and associated land forms that were inspected were variable in details of dimensions and physical relationships but showed uniformity in aspect, slope and depth of the active frost layer, all of which critically influence drainage.

Entrances to dens were usually 16 to 20 inches in height and width and rarely exceeded 24 inches in either dimension. Dens ranged from 4 to 12 feet in depth and were variable in configuration. Many of the deeper excavations did not extend their full length perpendicular to the substrate but instead curved, sometimes at a right angle, and continued parallel to the surface of the ground. Both ascending and descending excavations were observed; the latter were more common. In most instances a "nest chamber" approximately five feet long, four feet wide and three feet high was located at the end of the excavation.

Four cases in which wolf litters were born in surface or "pit" dens offering none of the shelter associated with the usual den structure were documented. The possible implications of this are discussed.

The potential effects of human disturbance on den use are discussed.

CONTENTS

Summary i
Background 1
Objectives 2
Procedures 2
Findings 2
Physiographic Characteristics of Den Sites. 2
Vegetation Characteristics of Den Sites 14
Discussion 16
Effects of Human Disturbance on Den Use 20
Acknowledgments. 26
Literature Cited 26

BACKGROUND

In 1970 concern for an apparently decreasing wolf *(Canis lupus)* population on Alaska's North Slope prompted studies on several aspects of wolf ecology in this region. One objective of these studies was to obtain information regarding the physical characteristics of wolf dens in order to further a general understanding of wolf ecology in the Arctic and provide a factual basis on which to assess the effects of northern resource development on wolf populations via disturbance of wolf den sites.

From 1915 until 1969 wolf bounties ranging from $10.00 to $50.00 were paid in most of Alaska, prompting inhabitants of some of Alaska's remote areas to seek wolf dens during summer, in order to obtain pup and adult wolves to bounty. This was especially common during the 1950's and 1960's when bounty payments on wolves reached $50.00. Over much of the state dens were excavated as the opportunity arose with little concerted effort being made to locate natal dens. In the northcentral Brooks Range, however, the Nunamiut Eskimo made annual searches for wolf dens over an area of approximately 8000 mi.^{2}. Although this group of Inupiat-speaking Eskimos now resides in the village of Anaktuvuk Pass, the Nunamiut mode of life prior to 1949 was semi-nomadic. Wolf dens were actively sought each summer from about 1940 until 1967, when other sources of cash income became more available. During this period about four groups of from two to five hunters set out each year in late May, traveling and observing at night, and searching for dens until early July. The locations of dens were deduced from observations of the movements, behavior and tracks of adult wolves on hunting forays miles from the den, based on knowledge of summer activity patterns of wolves. During these nearly 30 years of searching for wolf dens the Nunamiut located approximately 100 natal dens. Of these I was able to obtain the locations of 78 through talking and traveling with the Nunamiut during 1970 and 1971. Physiographic data were gathered at 28 of these dens during the summer of 1970 and additional sites were visited in 1972 and 1973. The following report summarizes data obtained during the last few years and constitutes a final report on this aspect of wolf studies in northern Alaska.

OBJECTIVE

To characterize the ecology of wolf den sites in Arctic Alaska.

PROCEDURES

During the summer of 1970, 28 dens in the northcentral Brooks Range were visited by helicopter, fixed-wing aircraft, and on foot. A Den Data Form (Fig. 1) was completed for each den and black and white and color photographs were taken at each site. A 48-inch soil coring apparatus was used to measure depth to frost and to obtain soil profiles. Plant specimens were identified with the help of Dr. David R. Murray, University of Alaska. The degree of slope and micro- and macrorelief were estimated. Soil moisture was rated subjectively as dry, moist, or wet (free water present). If mass soil movement was involved in the full or partial destruction of excavations this was noted. Other aspects of physiography that were recorded are indicated in Fig. 1. In a few cases an indication of the soil type, aspect, and status of a den was obtained from the Nunamiut.

FINDINGS

Physiographic Characteristics of Den Sites

Table I includes data on those quantifiable physiographic parameters that appear to most succinctly characterize dens. Others, including macro- and microrelief, vegetation, dimensions of entrances, wind exposure, trails and the view available from dens and certain aspects of den use will be discussed below. Sites visited by the investigator are indicated by an asterisk(*). For several dens, including Nos. 2, 4, 7, 8, 15, 29, 35, 36, 37, 47, 49, 52, 56, 57, 58, 59, 60, 61, 62, 63, 69 and 74, little but the location has been recorded.

A brief discussion of the recent geologic history of the Brooks Range is necessary for an interpretation of the data.

The pre-Pleistocene history of the Brooks Range and North Slope is still unsettled. For a discussion of the relevant information on this topic the reader is referred to Porter (1966).

On the north slope of the Brooks Range streams flow generally northward through deep, U-shaped, glacially sculptured valleys. Six Pleistocene glaciations are recognized; each successive glaciation was of lesser magnitude and thus terminated further south than the preceding one (Detterman et al. 1958). Signs of these glaciers, including kames, and ground, lateral and terminal moraines, are prominent features of valley floors and, because of their elevated nature, often support well-drained soils. In addition to material deposited by glaciers *per se*, these elevations are often covered with eolian deposits in the form of

Fig. 1

DEN-DATA FORM

Den No.:_____ Date:_____ Species:_____ Unit:_____

Drainage:_____ Elevation:_____ Lat.:_____ Long.:_____

Specific area:_____

_____

Activity Status:_____

Scats: No. Pup_____ No. Adult_____

Apparent age:_____

Food remains:_____

_____

Macrorelief: _____

Microrelief: _____

Percent slope:_____ Aspect:_____ Wind exposure:_____

Entrances: No.:_____ Ht.:_____ Wdth.:_____
Apparent depth:_____ (Sketch construction on back)

Distance to water:_____

View from den:_____

Trails:_____

Soil: Texture:_____ Friability:_____ Parent material:_____
Root penet._____ Moisture:_____ Color:_____
Active frost zone:_____ Dry or wet frost:_____
Slumping?_____

Vegetation: Growth form:_____
Plant cover (%):_____
Comm. association:_____
Species:_____

Prey populations:_____

_____

Comments:_____

_____

Table 1. Physiographic characteristics of wolf den sites in Arctic Alaska.

Drainage	No.	Substrate or Soil	Land Form	Root Penetration (inches)	Soil Moisture	Soil Color	Active Frost Zone (ft.)	Mass Soil Movement	Aspect	°Slope	Distance to water (ft.)	No. Usuable Excavations	No. Defunct Excavations	Depth (ft.)	Elevation (ft.)
Ank*	3	Bedded Limestone	Bedrock Escarpment	-	-	-	-	-	S	50°	10	1	0	25	3200
Ank*	30	Fine Sand	Cutbank/ Blowout	5-8	Moist	Brown	4	Yes	WSW	50°	15	0	1	-	1900
Ank*	31	Fine Sand	Cutbank/ Moraine	36	Moist	Brown	4	Yes	S	70°	75	2	0	4,6	1900
Ank	64	Bedded Limestone	Bedrock Escarpment	Very old den, collapsed due to water erosion of limestone, 1966. Reported to have been a larger cave than Den 3.					S			0	1	25	2300
Okm*	13	Fine Sand	Blowout/ Moraine	30	Moist	Brown	4	Yes	SW	10°	150	2	1	12	2100
Okm*	14	Fine Sand	Moraine	6-20	Moist	Brown	4	No	S	20°	100	3	0	7,4,3	2300
Okm*	16	Fine Sand	Blowout/ Moraine	4-8	Moist	Brown	4	No	S	10°	20	0	2	-	2500
Okm*	17	Fine Sand	Kame Terrace	10-12	Moist	Brown	4	Yes	SE	5-30°	20	0	1	C.7	2500
Okm*	18	Clay-Gravel	Lateral Moraine	8-10	Moist	Tan	4	Yes	S	70°	30	0	1	C.5	2950
Okm*	32	Fine Sand	Ground Moraine	4-8	Moist	Brown	4	Yes	S	10°	20	0	2	-	2450
Okm	26		Ground Moraine												
Okm	43	Shallow pit - no excavations - pups found exposed													
Okm	45	Sand	Cutbank												
Okm	46		End Moraine												
Okm	48		Dune												
Okm	71	Sand	Dune												
Okm	72	Sand	Cutbank												
Okm	73	Rocks	Cutbank												
Klk*	19	Shallow pit - no excavations - pups found exposed													
Klk*	20	Clay	Lateral Moraine	3-4	Dry	Tan	4	Yes	SSE	60°	75	3	5	9,5,4	2000
Klk	21	Rock	Escarpment												3000
Klk*	22	Sand	Dune												1900
Klk*	23	Sand	Cutbank												1800

Table 1. (continued).

Drainage	No.	Substrate or Soil	Land Form	Root Penetration (inches)	Soil Moisture	Soil Color	Active Frost Zone (ft.)	Mass Soil Movement	Aspect	°Slope	Distance to water (ft.)	No. Usuable Excavations	No. Defunct Excavations	Depth (ft.)	Elevation (ft.)
Klk*	24	Fine Sand	Dune/Kame	8-20	Moist	Brown	4	Yes	S	30°	50	-	-	-	1750
Klk	28	Clay	Lateral Moraine						S						3600
Klk	41		Gravel Cutbank												2200
Klk*	42	Fine Sand	Ground Moraine	8-10	Moist	Brown	4	Yes	S	40°	100	3	1	6,8	1890
Klk	51	Sand	Dune									2?			1870
Klk*	44	Sand	Blowout												1700
Klk	50	Rock	Ground Moraine												3400
Ngu	54	Sand	Cutbank												
Kpa*	25	Limestone	Bedrock Escarpment						E	60°	100	1	0	12	3200
Jon	1	Sand	Cutbank						SE	60°	10				900
Jon*	5	Sand, Rock	Gravel Cutbank	8-30	Moist	Brown	4	No	S	20°	10	1	0	8	2500
Jon*	6	Kanayut Conglomerate	Escarpment	-	-	-	-	-	SSW	50°	300	2	0	12	2800
Jon*	55	Boulders							S						3000
Itk	10	Sand	Kame						SW	40°	100				2400
Itk	11	Sand	Ground Moraine						S	15°	50				2200
Itk	40	Sand-Rock	Alluvial Fan						SW						3000
Itk*	65	Fine Sand	Dune	8-20	Moist	Brown	4	No	S	30°	100	3	5	6-12	2300
Itk*	66	Fine Sand	Blowout	10-20	Moist	Brown	4	No	S	30°	50	0	1	8	2400
Nfk*	38	Sandy Loam	Wooded Kame	48	Moist	Brown	4	Yes	SSW	4°	10	0	1	4	1850
Nfk*	39	Limestone	Escarpment	-	-	-	-	No	S	30°	500	2	0	10	2400
Nfk	34	Sand							S		100				2000
Atg*	9	Fine Sand	Dune	36	Moist	Brown	4	No	S	20°	200	3	3	3-6	2600
Tlk	27		Pingo												700
Tlk*	12	Sand-Gravel	Ground Moraine	Shallow pit - pups exposed			-	-	S	20°	200				2200
Clv*	33	Med. Sand	Dune	12-18	Moist	Brown	4	Yes	SSW	15°	100	1	0	7	120
Inr	67	Sand	Dune												55
Mde	68	Sand	Dune												50

Table 1. (continued).

Drainage	No.	Substrate or Soil	Land Form	Root Penetration (inches)	Soil Moisture	Soil Color	Active Frost Zone (ft.)	Mass Soil Movement	Aspect	°Slope	Distance to water (ft.)	No. Usuable Excavations	No. Defunct Excavations	Depth (ft.)	Elevation (ft.)
Chr	75														2600
Chr	76	Sand													3200
Chr*	77	Alluvial Sand	Cutbank	36	Moist	Brown	4	No	S	40°	150	1	0	7	700
Lpn	78														1600
Shv	79	Eolian Silt	Pingo	15	Moist	Brown	2	Yes	S	60°	200	1	2	6	400

Abbreviations:

Ank - Anaktuvuk
Ngu - Nigu
Itk - Itkillik
Tlk - Toolik
Mde - Meade
Okm - Okokmilaga
Kpa - Kurupa
Nfk - North Fork of Koyukuk
Clv - Colville
Chr - Chandler
Shv - Shaviovif
Klk - Killik
Jon - John
Atg - Atigun
Inr - Inaru
Lpn - Lupine

*Indicates those dens visited by author in 1970 or 1971.

stabilized and semi-stabilized dunes. Other dunes, primarily of a poorly developed longitudinal type, occur in discontinuous and isolated forms along most of the rivers and larger streams (Black 1951). The source of this eolian material is glacial debris and water-sorted fines resulting from the extensive glaciation the valleys have undergone. Each year a very slow eolian reworking of the uppermost soil layers on the drier places occurs aided by the exposure of additional material by frost action. These soils are invariably at least moderately well drained; "free" water is rarely present.

Dunes are generally mantled with vegetation and appear inactive, but, depending on their locations, are often pitted with linear, unvegetated blowouts oriented in the direction of prevailing winds that blow parallel with the valley (Porter 1966).

Soils forming under these conditions of free drainage and deriving from parent mineral material have been classified as Arctic brown soils by Tedrow and Cantlon (1958:168). In their words, "Their areal extent is small and is confined primarily to escarpment areas, ridge, terrace edge, and stabilized dunes. The upper mineral horizon approximates a dark brown color and is acid in reaction. Colors grade through various yellow-browns and grey-browns with depth. The active layer is usually deep. Arctic brown soil has been reported in Alaska north of the 71st parallel." As Tedrow and Cantlon point out, mature, zonal soils are of only local occurrence in the Arctic tundra region due to the rarity of well-drained soils and low rate at which podzolization processes occur.

The Brooks Range lies in the zone of continuous permafrost in Arctic Alaska (Hopkins et al. 1955). The ground thaws during spring and summer to a variable depth that depends on the character of the surface material, topography, exposure, vegetation cover and overall drainage conditions. According to Porter (1966:18), "...at the end of the thaw period the active layer on till extends as much as 16 inches below the surface, whereas in more permeable kame-terrace gravels the depth of thaw may reach several feet. Where a thick mat of vegetation is present the ground thaws to a depth of only a few inches. Mudflow scars up to four feet deep indicate the depth of thaw on some favorable exposed slopes with limited vegetation cover. The average thaw depth by late summer, however, probably is of the order of about 12 inches."

The physiographic data presented in Table 1 show that characteristically wolf den excavations (as opposed to dens in naturally occurring rock formations) are situated on at least a moderately steep, southerly slope in a relatively well-drained soil (usually sand) and near a source of water. Various land forms are used including cutbanks, blowouts, dunes (at various stages of stabilization), kames and various types of moraines. The dens and associated land forms inspected were variable in details of dimensions and physical relationships but showed uniformity in aspect, slope and depth of the active frost layer, all of which critically influence drainage.

Southerly slopes receive the greatest net radiation during the year and are the first to thaw in spring, often preceding northerly slopes by several days or weeks. Another factor, probably equally important, in determining the dry nature of den soils relative to surrounding areas is their elevated, exposed nature. These sites characteristically remain almost snow-free during the winter because the high winds typical of the region (and especially common in the north-south valleys) allow little or no snow accumulation.

The depth of the active layer at den sites, which at all but one den was greater than four feet, is indicative of the special drainage conditions required for den soils. The active layer over the great majority of the North Slope rarely exceeds 20 inches.

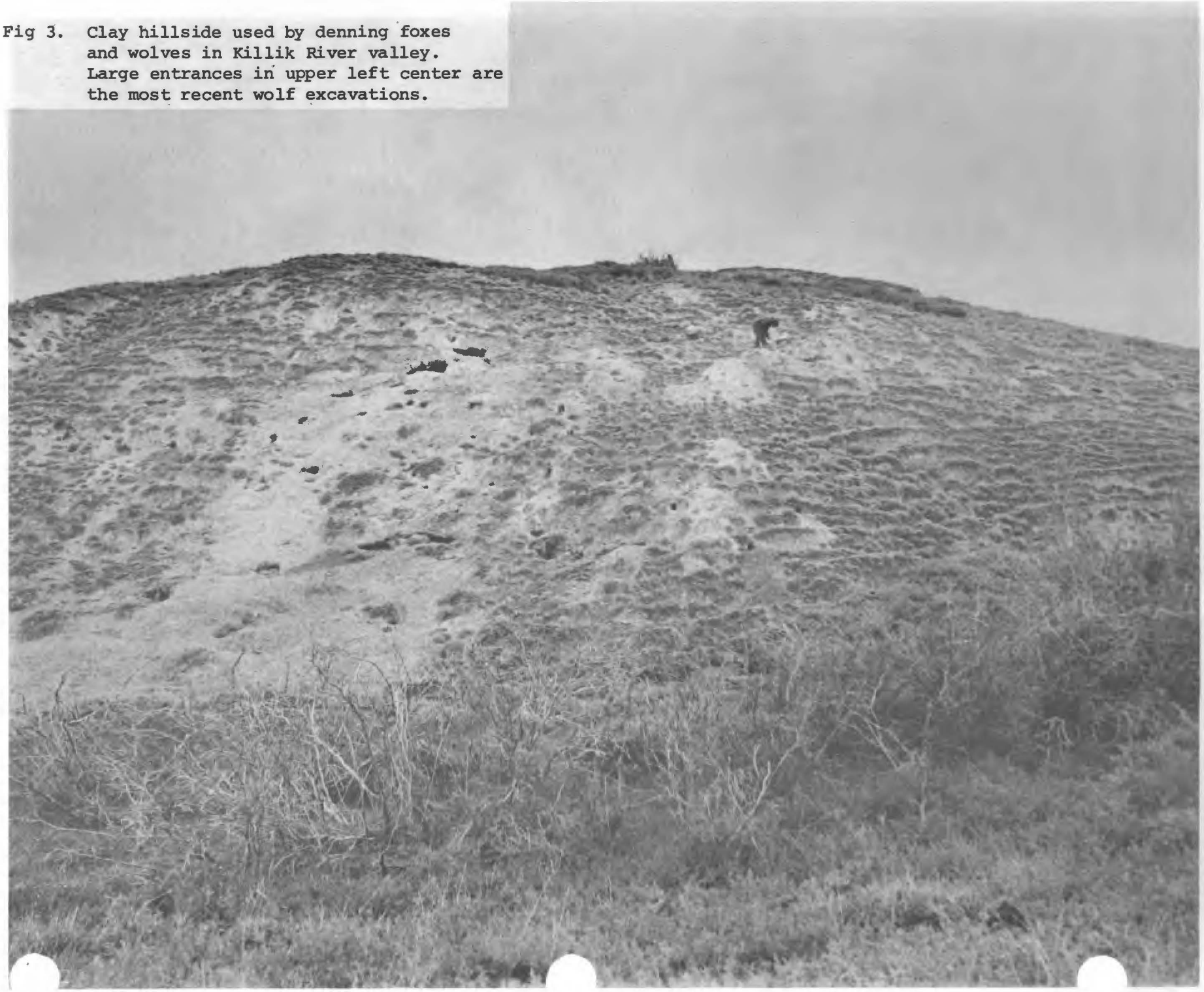
The only den at which frozen ground was encountered at less than four feet was Den No. 78, located 30 miles from the Beaufort Sea northeast of Sagwon near the upper crest of a pingo approximately 70 feet in height. Of five excavations in the crest of this pingo only one extended more than two feet perpendicular to the surface, allowing adult wolves to enter. The remaining four excavations terminated in ice. Only on the southern crest of the pingo was the active layer even this deep. The deepest excavation occurred in a small promontory where exposure and drainage conditions were optimum.

Truly zonal soils occurred only at the more stabilized sites. The greatest root penetration (three to four feet) and the highest percentage of plant cover occurred at these locations. Many dens were located in less stabilized locations that showed signs of considerable soil movement caused by high winds. Soils at these sites might better be referred to as regosols since zonation was absent, and the soils were comprised of parent material unaltered by soil forming processes. Even at these sites some vegetational stabilization was noted and dens were usually constructed in one of the older dunes in a given complex. A den excavated in this sandy soil may last from one to several years, depending on the particular soil and moisture conditions involved. Sagging, slumping, and eolian soil movement act at varying rates and in combination to alter dens. As data in Table 1 indicate, the same site may be renewed and used repeatedly. Dens constructed in the more stable morainic deposits (Fig. 2) generally appear to be more durable because of greater root penetration, the established nature of the vegetation and a lesser amount of eolian soil movement.

Three dens were located in clay soils. One of these, Den 18, was used once several years ago and is now collapsed. This den lies at the base of a very steep 300-foot slope on which signs of mass soil movement were obvious, undoubtedly accounting for the destruction of the den. Den 20 (Fig. 3) showed signs of recent use and had three recently formed entrances and five other excavations that had collapsed or were destroyed by humans. The clay at this site was tan with a dark yellow horizon about six inches below the surface. Limestone cobbles, ranging from two to five inches in diameter, were scattered throughout the soil. In July the soil was dry and extremely hard. This soil becomes softer when wet,

Fig. 2. Den area in ground morraine in Killik River valley.

Fig 3. Clay hillside used by denning foxes and wolves in Killik River valley. Large entrances in upper left center are the most recent wolf excavations.



accounting for the collapsed excavations. It is the experience of the Nunamiut, and it is reasonable to expect, that extreme dryness most often causes the collapse of dens formed in sandy soil while extreme wetness is responsible for collapse in clay soil. A den located in an area frequented by ground squirrels *(Spermophilus undulatus)* was visited in 1972 and found to have been completely filled with dirt by ground squirrels. The Nunamiut that had found this den three years earlier mentioned that the odor left by the wolves very likely provoked the ground squirrels to fill the burrow.

Naturally occurring rock formations (Figs. 4 and 5) are the most stable substrate in which wolf dens occur and, in some cases, have provided essentially unchanging den sites for decades and perhaps even centuries. Even these, however, are subject to destruction through tectonic and gravitational forces, and in the case of limestone formations, by the dissolution of the substrate by water.

A description of each den would be beyond the scope of this report but a general characterization will be undertaken here to supplement data given in Table 1.

Entrances to dens excavated by wolves were usually 16 to 20 inches in height and width and rarely exceeded 24 inches in either dimension. Depths ranged from 4 to 12 feet and configuration of the excavations showed great variability. Many of the excavations, and especially the deeper ones, did not extend their full length perpendicular to the substrate but instead curved, sometimes at a right angle and continued parallel to the surface of the ground. Both ascending and descending excavations were observed, the latter being more common. In the majority of cases a "nest chamber" was located at the end of the excavation. The size of "nest chambers" varied but generally they were four to five feet long, three to four feet wide and two to three feet high.

At dens with two or more separate excavations of similar vintage the "nest chamber" was usually located in the deepest one, although other, smaller "chambers" might occur in the other excavations as well. In some cases, two or more excavations terminated in a single "nest chamber."

With the exception of dens that had been temporarily occupied by porcupines (*Erethizon dorsatum*), den interiors were devoid of organic material such as hair, vegetation, bones, scats, etc. Several of the Nunamiut indicated that this was invariably the case; never have they found a den like that described by Haber (1968) in Mt. McKinley National Park in which the "nest chamber" was lined with fur.

As used here, the term macrorelief refers to the local relief of the formation in which a den was excavated, relative to the nearest level terrain. Macrorelief ranged from six feet to several hundred feet. One den was excavated in a cutbank six feet above the maximum water level of the Chandler River. Another den was found on the coastal plain in a series of dunes 6 to 15 feet above the surrounding level tundra near Ocean Point on the Colville River. A few dens were in mountain sides 200 to 500 feet above the valley floor. Most dens,

Fig. 4. Den and associated limestone escarpment in dense spruce forest along Koyukuk River Two entrances leading to a common chamber are located along the bottom of the escarpment at lower center in photograph.

Fig. 5. Entrance to cave in Anaktuvuk River valley which has been used by denning wolves on at least three occasions in recent years. The cave extends 25 feet under the bedded limestone escarpment.

including those located in dunes, moraines, kame terraces and cutbanks, were from 10 to 100 feet above the level terrain (often above a flood plain or lake).

The microrelief at dens ranged from a few inches to a few feet. The greatest microrelief usually was found at dens adjacent to blowouts (Fig. 6). The percent plant cover ranged from a few percent to nearly 100 percent. The lowest density of plants occurred on relatively unstabilized soils.

Some of the dens examined were originally red fox (*Vulpes fulva*) dens that had been enlarged by wolves for their own use. Clark (1971) reported that each of nine wolf dens examined on Baffin Island showed some evidence of burrowing by Arctic foxes (*Alopex lagopus*). Arctic foxes have likewise been reported to usurp ground squirrel burrows (Macpherson 1969, Stephenson 1970). The soil types and site characteristics required for ground squirrel, fox, and wolf dens generally appear to coincide. Unoccupied wolf dens are commonly used by porcupines, perhaps more in winter than in summer; a few quills and numerous scats were found in several dens and the Nunamiut stated that on several occasions porcupine quills, supposedly picked up in dens, were found in wolf pups during summer.

Vegetation Characteristics of Den Sites

Den site vegetation displayed high stand-to-stand diversity, and was rarely aggregated into types; each habitat was modified locally by frost action, permafrost, cryopedological processes, local relief, parent material differences, drainage patterns, irregular snow accumulation and animal activity. Thus immediately adjacent areas support widely different vegetational types, often with considerable intergradation. The climax concept is probably not applicable here due to exigencies of the northern environment which produce disorder, especially in the substratum (Johnson et al. 1966). As a result of these factors, analytical treatment of den site vegetation is very difficult.

A mosaic of habitats, supporting widely different plant associations, was characteristic of sites located at dunes and blowouts. The more stabilized soils, usually those on terraces above the den entrance, supported heath-shrub communities comprised of varying densities of willows (often dwarf type), dwarf birch, ericaceous shrubs, and occasionally alder. Species include *Salix arctica* (prostrate only), *S. alaxensis, S. pulchra, S. glauca, S. lanata, Betula nana exilis, B. glandulosa, Arctostaphylos* sp., *Empetrum nigrum, Vaccinium* sp., *Ledum* sp., *Chamaedaphne calyculata* and *Alnus crispa*. The less stable soils, usually in dune and blowout troughs below the den entrance, supported associations of perennial and annual herbs, grasses and sedges. Species commonly encountered here were *Trisetum spicatum, Calamagrostis purpurascens, Agropyron violaceum, A. boreale, Deschampsia caespitosa, Poa glauca, P. arctica, Arctogrostis latifolia, Hierochloe odorata* and *Lupinus arcticus*.

Cutbanks supported shrubs including most of those mentioned above. Herbaceous species such as *Equisetum* sp., *Parnassia* sp., *Aconitum delphinifolium, Lupinus arcticus, Rumex arctica, Papaver Macounii, Saussurea angustifolia* and *Valeriana capitata* were common between patches of shrubs.

Fig. 6. Den entrances near Galbraith Lake typifying the construction of dens located along blowouts on partially stabilized sand dunes.

The larger clay-rock lateral moraine in which Den 20 was located was vegetated only by the pioneer annual herb *Artemesia alaskana*, which formed an open cover on about 50 percent of the slope.

Vegetation at Den 25, an alpine site, included the species *Salix glauca glabrescens, Cassiope tetragona, Boykini Richardsonii, Dryas integrifolia* and various mosses and lichens.

Those dens visited on the south slope of the Brooks Range, along the North Fork of the Koyukuk and the Lower John River, were situated under varying densities of white spruce (*Picea glauca*), aspen (*Populus tremuloides*) and alder (*Alnus crispa*). Ground cover included the species *Rosa acicularis, Rubus chamaemorus* and *Equisetum arvense*.

DISCUSSION

There are many descriptions of wolf dens in the literature. Dens in Arctic Alaska conform in general with the characteristics noted for dens in other areas in that they are located in well drained soil near water, or in naturally formed caves or around boulders. In forested regions wolves have also been reported to den in abandoned beaver *(Castor canadensis)* houses or dams, among the roots of large trees, in hollow logs and in rock caves. Descriptions of wolf dens located in various types of terrain are reviewed by Mech (1970). Clark (1971) examined nine wolf den sites on Baffin Island and concluded that the prerequisites for wolf dens in that area included suitable soil structure, a supply of water, early disappearance of snow, good drainage, good visibility and convenient access to caribou *(Rangifer tarandus)*. These criteria seem to hold in the Alaskan Arctic as well, although it would be purely conjectural to state that a view (good visibility) of the surrounding country is a prerequisite for a successful den. Haber (1968) also suggested that wolves select elevated places for dens partly because of the good view of surrounding country and the resultant increased opportunity for sighting game. Joslin (1966) found that the visibility from six dens in Algonquin Park, Ontario varied from 5 feet to 200 feet and averaged only 100 feet. Similarly, a few dens located during the present study were situated so as to provide only a limited view of the surroundings; sometimes only the area within 50 feet of the den was visible because of dense vegetation. A den located in a heavily timbered valley on the North Fork of the Koyukuk River is surrounded by dense vegetation yet has been one of the most consistently used dens known to the Nunamiut during the past 20 years. Thus, it would seem more accurate to view the location of dens on elevated terrain as resulting primarily from drainage requirements rather than a preference by wolves for dens from which they can see well.

It would appear to be pointless to speculate further about the genesis of wolf den sites, i.e., regarding the factors that lead a female wolf to excavate a particular site. However, one Nunamiut hunter, Bob Ahgook, offered an observation that is perhaps worth mentioning. He noted that some dens in the Brooks Range are located at places where

wolves rest while traveling during winter. These sites are often warm south slopes on elevated terrain. Wolves commonly dig in exposed soils and Mr. Ahgook suggested that an adult female might begin excavating a den, enlarging a fox or ground squirrel burrow, or at least gain an awareness of suitable locations during winter visits to these sites.

As indicated in Table 1 the Nunamiut reported two instances in which wolf pups were found lying in shallow pits offering none of the shelter associated with the usual den structure. An additional case was reported during more recent conversations with the Numamiut, and on May 15, 1971 I examined one of these "pit dens" (Table 1, Den 12) on the uplands between the Sagavanirktok and Toolik Rivers approximately 50 miles north of Galbraith Lake. Five pups (4 males and 1 female) less than one day old were found in a depression two feet deep and three feet in diameter (Fig. 7). The pit had been dug on the southern exposure of a 50-foot high gravel moraine overlooking two small lakes. An adult male and an adult female wolf were present at the den. Snow was from 10 to 20 inches deep on the surrounding flat terrain but the southern aspect of the moraine was free of snow (Fig. 8). The area did not appear to have been used during the previous year. However, David R. Klein, Alaska Cooperative Wildlife Research Unit, reported the occurrence of an active den in the same area on May 19, 1970. Four adults and approximately six pups were seen from a helicopter on that occasion. The pups were nursing a female in a depression that did not appear to extend underground. Thus it is possible that this den, or at least one of similar construction, was used in 1970 in the same general area. Pup mortality would probably be high under these conditions since the pups would be vulnerable to predation by ravens (*Corvus corax*), gulls (*Larus* sp.), jaegers (*Stercorarius* sp.), and several species of raptors unless an adult wolf was present until the pups were at least a few weeks old.

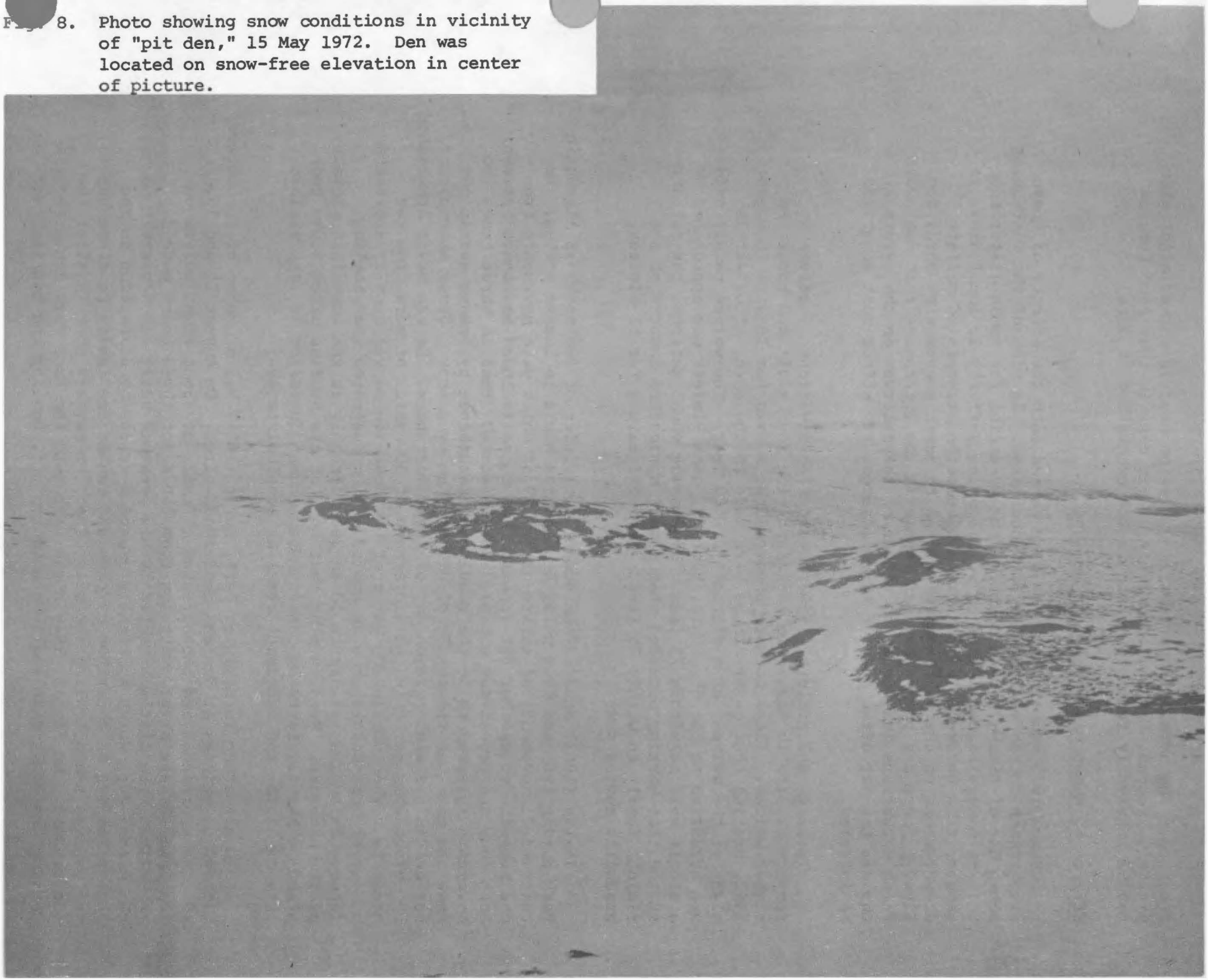
It is tempting to postulate that inexperienced female wolves with their first litter might be more prone to give birth in pit dens and show generally less proficient maternal behavior like that commonly seen in primiparous female dogs of the husky breeds (Earl Norris, Leonard Kriska, pers. comm.). However, female dogs became reproductively mature earlier than female wolves (6 to 8 months and 21 months, respectively) and this phenomenon would likely be less prevalent in wolves.

Whether or not the occurrence of pit dens is prevalent among a specific age class of female wolves, the fact remains that these dens may occur more commonly than is currently recognized. A number of factors might severely lessen the chance that one of these dens would be found by humans: 1) the greater mortality to pups expected under these conditions could mean that these dens would persist for only a short time, 2) fewer adult wolves might be associated with these dens, and 3) these dens are not restricted to the elevated terrain usually associated with wolf dens. The overall effect of these factors, if operative, would be to make pit dens far less conspicuous than the more common excavations.

The Nunamiut offered another possible explanation for the occurrence of pit dens, noting that they might be employed when parturition takes place while the female wolf is some distance from the den which she has

Fig. 7. Five wolf pups in "pit den" near Sagavanirktok River, 15 May, 1971. Note head of freshly killed ground squirrel to right of pups.

Fig. 8. Photo showing snow conditions in vicinity of "pit den," 15 May 1972. Den was located on snow-free elevation in center of picture.



prepared. The normal temperamental variation seen in wolves might also partially account for the occurrence of pit dens in that some females may be inherently less proficient in the excavation of dens.

Effects of Human Disturbance on Den Use

Since 1970 some insight has been gained into the effects of human disturbance in the vicinity of wolf den sites. In view of the increasing human use of Alaska's back country, the potential for human disturbance to have a significant impact on wolf denning activity in local areas is greater than before. The following discussion attempts to collate observations on the reactions of wolves to human presence at natal den sites. There are only a few references in the literature that deal with these situations and since the effect of the observer on the events at the den has not often been of major interest the effect must sometimes be inferred.

Theberge and Pimlott (1969) reported observations of wolves at a rendezvous site in Algonquin Park involving four adult and three pup timber wolves. These workers observed the wolves for 16 days in August 1962, stating that observations were made in the open, often within sight of the wolves, at a distance of 500 feet. The wolves rarely paid any attention to the observers, however, once Pimlott was approached by a single wolf to within 75 feet. Discussing vocalizations, the authors stated that barking occurred when a wolf approached members of the Pimlott family to within 75 feet. The wolf barked for 11 minutes, gradually moving away.

Joslin (1967) studied the summer activities of two packs in Algonquin Park during 1961 and 1963 using broadcasted howls to locate wolves. He observed 21 movements of entire packs, 19 of which were movements from one homesite to another (it appears that these included movements between both dens and rendezvous sites). Joslin stated that in three cases the movements appeared to be the result of disturbance by humans and in one case the move was the result of disturbance by a bear *(Ursus americanus)*, but he did not elaborate on any of these instances. He was never approached by wolves when he howled at a distance of 300 yards or more from the homesite. When within 200 yards of the homesite he was usually approached by one or more wolves when he howled and he suggested that howling induces an active resistance to an intruder only in the immediate vicinity of the homesite. Keep in mind that both of the studies cited above took place in heavily forested country where human intrusion is less visible than in alpine and subalpine areas at equal distances.

In his study in McKinley Park, Murie (1944) had a number of encounters with wolf families at den and rendezvous sites. On August 14 and 15, 1940 he approached and photographed a family of about eight wolves on the upper Savage River, watching them for about three hours each day. The wolves were little affected by his presence until his departure on the second day, which apparently caused a temporary disruption in the pack's feeding on a caribou carcass and caused the family to disperse; one pup was heard howling two miles from the carcass shortly after the disturbance. On May 15, 1940 Murie went into the East Fork den after causing the adult male and female to run off, howling and barking, and

took a one-week-old pup. The wolves remained at the den until July 7, when they moved one mile from the den. During this time Murie watched them almost daily from an elevation one-half mile away, across the river. This caused little if any disruption in the events at the den, according to Murie.

On July 9, 1941 Murie crept to within 100 yards of the East Fork den which was again occupied, and photographed the wolves for a short time after which he and a companion tried to approach several pups on a gravel bar near the den. On July 12, they again visited the area and attempted for one hour to photograph the wolves at a rendezvous site near the den. They frightened the pups, and one adult male barked and howled for the hour or so that the two men stayed. In spite of the intrusion the wolves (in this case comprising two families) remained at the rendezvous and another attempt to photograph them on July 31 still did not cause them to move.

Clark (1971) conducted a study of the Baffin Island tundra wolf in an 1800 square mile area on central Baffin Island in spring and summer 1966-1969. Data were gathered primarily by observing wolves at occupied dens. Very little human activity had occurred in this area during the last 100 years although some wolves were shot at a DEW Line site on the western edge of the study area during the ten years prior to 1963. At the time of the study this population of wolves probably showed a minimum of conditioned fear toward man. Wolf dens were observed from blinds. Clark concluded that these wolves usually divide the short denning period between two den sites, the whelping den and the summer den, and that the shift to a summer den may be made as early as the pups' fourth week. Clark did not detect any clear effect of human presence on the timing of den movements, but did note a marked difference in response to human intruders on the part of a female wolf that was foot-trapped in a tagging program. Unfortunately, he doesn't discuss the distances involved in making observations at dens although one gets the impression that these distances were one-fourth mile or less. Thus, it is difficult to assess his conclusions.

Harry Reynolds of the Alaska Department of Fish and Game relayed information that he had obtained from Elmer Debock of the Canadian Wildlife Service, Edmonton. In the summer of 1973 Debock entered a den east of the Mackenzie River, N.W.T. and handled and tagged an entire litter of pups. About two weeks later he found the wolves still present at the den and again entered the den to determine the status of the litter. Later checks revealed that the wolves remained at the den until the normal time.

Audrey McGoun, a graduate student in the Department of Wildlife Management at the University of Alaska, reported (pers. comm.) that in 1973 she and an assistant camped within two miles of a rendezvous site along the Canning River which was being used by 11 pups and 4 adult wolves. The wolves were observed primarily from the tent but on one occasion the observers traveled in a circle around the wolves and passed within one-half mile of them. In addition, helicopters associated with other activities passed near the wolves and almost daily flew over the wolves so that they could be observed. These disturbances did not

appear to distress the wolves to any great extent other than causing them to disperse somewhat and hide among the willows. However, there was apparently some possibility that the wolves were unaware of the observers' presence.

In 1966 BLM surveyors discovered a wolf den near Olnes (near the Elliott Highway north of Fairbanks) and flew over and around the den with a helicopter on several occasions to better observe the wolves. Fish and Game personnel visited the area about two weeks after the den was discovered and found that the wolves had vacated the den (Richard Bishop, ADF&G, pers. comm.).

The above cases encompass the range of variety in response described by the Nunamiut for wolves in the northern Brooks Range. The statements related below derive from the collective experiences of two Nunamiut hunters at a total of roughly 60 active wolf dens during the period 1940-1973.

During summer wolves are relatively less aroused upon encountering a human being or strange wolf while hunting away from the den. In winter they are generally more aggressive toward other wolves and more wary of humans. To illustrate, during the summer of 1972 two adult wolves slept 400 m below one of our camps for about two hours with full knowledge of our presence. This occurred within six miles of Anaktuvuk Pass. Such a thing is unheard of during winter. However, the den area is vigorously defended against intrusion by alien wolves, bears (*Ursus arctos)* and other large animals.

There are a number of things that the Nunamiut consider to be critical factors determining the response of denning wolves to human intrusion. These include the following:

1) The date of disturbance with regard to den chronology.
2) The type of disturbance, i.e. number of people, whether or not firearms were discharged, etc.
3) The distance from the den where the disturbance takes place.
4) The duration of the disturbance.
5) Whether the disturbance is repeated.
6) The age and experience of the adult wolves, and particularly the parent female, with regard to human contact.
7) The particular personality traits of the adult wolves involved, with the female being, again, the most important.

One Nunamiut observed that in his experience the period when female wolves may be most readily prompted to choose another den is during the last few days prior to parturition. A relatively small disturbance has more telling effects at this phase of denning activity. He attributed this to the ease with which a new site may be reached at this time compared to the time following parturition. The decision to move appears to be made less readily when each pup must be carried separately to the new den. It also seems likely that when the pups are old enough to travel some distance the bitch would be somewhat more inclined to take them from the natal den in response to a disturbance, although this is strictly conjectural.

Much of the Nunamiut experience with denning wolves involved animals that had some degree of fear of man, whether learned from other wolves or conditioned in the individual. They have probably also encountered wolves that have acquired neither of these fears but which have varying degrees of innate wariness towards people. An equally important factor to be considered in evaluating the response of wolves to man is the inherent difference in temperament. For instance, parent females usually evidence great anxiety when humans enter a den area, first barking and then howling at the intruders while staying within a few hundred yards of the den. In some cases, however, females simply leave the den area without vocalizing. Male wolves characteristically show less anxiety than females, moving further from the den, vocalizing less, and sometimes leaving the area. However, some have responded to intrusion in a manner similar to the "typical" female parent. Thus it is hard to make generalizations that have predictive value regarding response to human intrusion. However, the Nunamiut have made a few normative statements which follow.

During the summer adult wolves rarely bark or howl at humans unless they are within about one-half mile of a den or rendezvous site where pups are located. Occasionally young wolves bark when they first encounter humans, however. The distance from the den and pups at which human presence first causes wolves to vocalize could probably be viewed as the distance at which human presence causes intense anxiety to adult wolves rearing pups. Disturbances of this type, if sustained or repeated over a period of a few days are often sufficient to cause the bitch to move the pups.

The den does not need to be approached directly to cause movement of the pups, however. As a rule of thumb, the Nunamiut say that camping a mile or so from the den may cause the pups to be moved after a period of four or five days, particularly when pack dogs are present at the camp or when human scent is found close to the den (if the den is approached when the wolves are not present). The greater the number of people, their activity, and the visibility of the camp, the greater will be the inclination to move the den. Beyond two miles the presence of humans does not usually cause wolves to move, if human scent is not left closer to the den (for some wolves human scent may be as important as visible presence in causing anxiety).

An experience we had with denning wolves in 1972 might be of interest as an example of the response one might expect from a female wolf that is extremely wary of humans. The den in question was located 12 air miles from Anaktuvuk Pass and the parturient female had lost the lower part of one hind leg, almost certainly in a trap.

The den area was located in a general way on May 24, but observation during the next day failed to show any activity. The area was then visited by Bob Ahgook and myself and we inadvertently disturbed the female who had been resting about 300 yards from the den. From her appearance Bob judged that she had either just had or was just about to have her pups. We withdrew to our camp one and one-half miles away and attempted to observe the den area as much as possible for the next several days, with minimal activity in the camp area. We saw the wolves on only a few occasions due to topographic features which allowed only a

limited view of the den area. On June 2, a yearling wolf which was seen only on this occasion barked and howled at the camp for about one hour at a distance of about one-fourth mile. For a few days prior to June 7, no activity was seen and we assumed that the pups had been moved. We again visited the den on June 7, to explore the area before leaving, and found the female still there. We withdrew immediately and again began observing the den area. Later that day, about ten hours after having disturbed the female for the second time, we saw both parent wolves at the den and watched the female carry one pup away. We did not see other pups moved, but since the one pup was moved shortly after we began observation that evening, it is very possible that an unknown number of others had been moved prior to that time. At any rate, the litter was moved after we had camped one and one-half miles from the den for 13 days and visited the den area proper on the first and last days of that period, when only the female wolf was present.

During the summer of 1974 I had another encounter with denning wolves which resulted in the female moving her pups. On June 28, I set up camp two miles south of an active den located north of Sagwon on the coastal plain. Noise from the turbine helicopter used to reach the den area elicited no response from four pups seen near the den entrances. An adult male, adult female, yearling male and six pups were observed at the den during the ensuing 10 days. On the evening of June 29, the adult male traveled south from the den and when about one-half mile away noticed the tent. The wolf proceeded to a point approximately 300 yards downwind of the camp, behind a low rise, then disappeared to the east. Although very curious and alert, the wolf did not evidence alarm at discovering the camp. This was the only response to the camp observed until July 7; during this time the wind blew predominately from the north and the wolves hunted primarily north, east, and west of the den. On July 7, following several days of cold, snowy weather, the female wolf apparently first became aware of the camp. During the evening the weather had cleared and the two adult wolves, and occasionally the pups, were heard howling over the course of about two hours. For no particular reason I finally answered with one howl and watched as both adults stopped howling, looking intently toward the camp for a few minutes. The female then moved to within one mile of the camp and alternately watched the camp and slept for over an hour before returning to the den where she frequently looked intently toward the camp and appeared anxious, investigating the den area intensively. Six hours after returning to the den she was observed traveling east with three pups following her. However, she and the pups returned to the den, where the remaining three pups waited, after having gone one mile. They remained at the den for an additional 24 hours. The following morning the female and all six pups were observed as they traveled east for two miles, using the same route as on the previous day. Although the female and pups moved out of sight and appeared to be heading toward the Shaviovik River three miles east of the den an aerial search the following day revealed that the six pups had been left at what appeared to be an old wolf den in a pingo two miles east of the original den. The female and pups had crossed this pingo without even pausing on the previous day.

Judging from her decisive reaction, the adult female was probably not previously aware of human presence near the den. Things that might account for her rapid movement of the litter include: 1) previously having been hunted, 2) the combination of a foreign "wolf howl" and human presence, 3) the fact that the camp was located in full view of the den, and 4) the fact that the pups could travel fairly readily at the time of the disturbance. This incident constitutes one of the most drastic reactions of a denning female to human intrusion of which I am aware and probably illustrates one extreme in the range of reaction to human presence.

If I were forced to generalize about this aspect of human-wolf interaction I would say (based on the statements by the Nunamiut and the literature) that with wolves that are generally shy of humans, such as those around Anaktuvuk, human presence (i.e. hikers, camps including one or a few people) more than about two miles from the den for a limited period of time does not cause any significant alteration in the behavior of wolves due to disturbance. At distances less than this, prolonged presence may cause abandonment of the den, especially if the den is visited more than once. Visits to the den proper probably have the greatest effect in causing abandonment but more than one visit seems to be necessary to actually cause abandonment.

In areas where wolves have relatively frequent contact with humans but where the contact is of a generally benevolent nature such as in National Parks, and in areas where wolves have had virtually no contact with humans such as on Baffin Island, they could be expected to tolerate a somewhat higher level of disturbance before moving a litter of pups. In heavily forested regions the critical distances might be less than in alpine and subalpine habitats referred to above since human intrusion would be visually less apparent.

There is, as yet, no reason to assume that being transferred from one den to another is necessarily detrimental to wolf litters. This behavior is sometimes employed in the absence of human disturbance, perhaps in response to flooding or collapse of a den, persistent disturbance by bears, or changes in prey availability. Clark (1971) found that wolves on Baffin Island regularly transferred litters from what he termed "whelping dens" to "summer dens" about midway through the denning period when pups were as young as four and as old as nine weeks of age. He speculated that the shift in den locations could be governed by the increasing size of the growing pups (which would make the whelping den too small to shelter them), shifts in the location of caribou in summer, or the wariness of the denning bitch of human observers in the area. In Clark's study the only known loss of young-of-the-year up to the time of departure from "summer dens" occurred when three of six pups disappeared after being led away from a den by a female wolf. The pups apparently drowned while crossing a large river. Mortality from various causes is a possibility but by no means a certainty when wolf litters are moved.

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