IMPACTS OF HUMAN DEVELOPMENTS AND LAND USE ON CARIBOU: A LITERATURE REVIEW
Volume II. Impacts of Oil and Gas Development on the Central Arctic Herd

by

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EXECUTIVE SUMMARY

1. Although oil exploration on the North Slope has occurred since the 1920's large scale oil development did not begin until the Prudhoe Bay discovery in 1968. Since that discovery, oil development has spread westward into the Kuparuk oilfield, and is continuing with the development of the Milne Point field. Intensive exploration is occurring in the Colville River delta, and in several offshore locations east of Prudhoe Bay. In general the majority of the Central Arctic Caribou Herd (CAH) winter range is in the foothills and summer range (including concentrated calving areas) is on the coastal plain. Movements between these ranges are predominately north-south, whereas movements within the summer range are east-west along the coast and are dependent in part on the intensity of mosquito harassment. Oil development on the summer range could directly contact calving and coastal mosquito relief habitat, as well as affect movements to these habitats. Oil development in the foothills could directly contact CAH winter range, as well as affect movements between summer and winter range.

2. There is ample evidence to demonstrate that the term "herd" can be correctly applied to the CAH. Historic data suggested, and current data has confirmed, that the vast majority of caribou that are found on the CAH summer range belong to the CAH. Calving concentration areas near the coast and in proximity to Oliktok and Milne points, and Bullen Point to the Canning River delta, have been identified since the early 1970's. Although the overall density of calving on the coastal plain has varied from year to year, apparently due to weather and snow ablation during spring migration and early calving, these two areas have consistently been used by more parturient females than have other areas. Data from visual- and radio-collared animals indicate that there is strong fidelity of CAH cows to the CAH summer range and conversely few animals collared in adjacent herds have been re-located on the CAH summer range.

3. Two categories of habitat receive intensive use by CAH caribou--the sedge meadows comprising the calving concentration areas on the coastal plain, and coastal beaches, promontories, and river deltas that are used intensively as mosquito relief areas. The use of coastal sedge meadow habitat by calving caribou is contra-intuitive in that at calving time the availability and nutrient content of forage is greater in the foothills than on the coastal plain. Several hypotheses for the use of the coastal plain during calving have been advanced. These include the hypotheses that calving areas are located where predator densities are lower, or that calving areas are located in proximity to mosquito relief habitat; however, no <u>single</u> explanation for the apparent fidelity of parturient caribou to their calving ground appears to be justified. The potential significance to CAH caribou of continued access to coastal

mosquito relief habitat is discussed. These mosquito relief areas do not appear to provide adequate forage during mosquito harassment bouts, however they do provide habitat where caribou can avoid continual harassment and reduce the amount of energy expenditure that would be likely if such habitat were not available.

4. Our definition of impact is an effect on the ecosystem of caribou such that there has been a reduction in habitat quality, quantity, or the animal's ability to utilize that habitat that has been caused by oil or gas development. The emphasis on habitat-related effects as opposed to demographic effects (e.g., reduced population numbers, reduced calf recruitment) is due to the recognition that the effects of oil and gas development on caribou habitat and its utilization by caribou are spatially extensive and long-term (essentially irreversible). Impacts on CAH caribou that are caused by oil and gas activities on the North Slope include direct habitat loss; avoidance of developments; and disruption of movements. Potential impacts include harassment by aircraft and ground vehicles, and by pedestrians; and an increase in predation or human harvest.

5. The amount of habitat loss directly due to oil and gas development in the Prudhoe Bay, Kuparuk, and Milne Point oil fields was approximately 3,200 ha (8,000 ac) as of 1983. This is a conservative estimate because it includes only habitat covered by gravel or stripped for gravel mining, and does not include additional vegetation losses due to fugitive dust or ponding along roads and drill pads. However, direct habitat loss is an insignificant impact when compared to habitat that becomes unavailable to caribou because of their response to facilities and human activity that are associated with oil and gas development.

6. Harassment of caribou by aircraft can potentially cause injury or mortality to individuals (especially calves), disruption of the cow/calf social bond that could affect a young calf's ability to survive, and an increase in the amount of energy-consuming activities that a caribou engages in (e.g., from walking to running) or a decrease in feeding. Caribou in some herds appear to be sufficiently habituated to aircraft that they do not respond to overflights; caribou in other herds may react to a similar overflight with panicked running. Caribou in other herds appear to be most reactive to aircraft during calving and mosquito season. Overflights of higher than 660 m (2,000 ft) AGL during these sensitive periods, and 330 m (1,000 ft) at other times apper to cause little or no overt reaction. Harassment of caribou by off-road vehicles and pedestrians especially when herds are hunted, appears to cause a stronger reaction than most aircraft harassment; however, comparative observations in the CAH have not been made.

7. Caribou can react to linear developments (e.g., roads, pipelines) and point developments (e.g., drill pads) by avoiding areas around these developments. Avoidance has been measured by the distribution of caribou occupancy. The strength and longevity of the avoidance response by

caribou appear to vary depending on the composition of the caribou group, season of the year, type of development, amount of human activity associated with the development, species and degree of harassment by insect pests present, and the type of topography between the development and caribou as they approach a development.

8. Caribou of the CAH have been observed to avoid "point" developments such as an isolated, active drill rig during summer totally up to 1,200 m (4,000 ft) and partially up to 2 km (1.2 mi). Peary caribou have been observed to avoid an active seismic camp in winter by 2 km (1.2 mi) when the camp was located in flat terrain, but to approach similar camps which are located in hilly terrain.

9. Maternal groups of caribou in the CAH have been shown to avoid the TAPS corridor during all seasons, with the possible exception of the fall rutting period; the Prudhoe Bay oil field during summer; the Spine Road/Kuparuk Pipeline complex and the Milne Point Road during calving; areas of intensive human activity along the Spine Road during mid-summer; and the Milne Point Road during mid-summer. Maternal groups almost totally avoid the Prudhoe Bay oil field, and the area within 4 km (2.4 mi) of the Spine Road during calving. Maternal groups avoid linear developments during the remainder of the summer in direct (but not necessarily linear) proportion to the group's distance from the developments, up to a distance of a few kilometers.

10. Caribou summer movements through and within the oil fields have been reported from the viewpoint of broad scale movements within a subregion (e.g., within or around the Prudhoe Bay and Kuparuk oil fields), or from specific investigations of the behavior of caribou as they attempt to cross linear developments. Caribou movements into the Prudhoe Bay oilfield during mosquito harassment periods have virtually ceased, presumably due to the low clearance (often less than 1 m [3 ft]) of feeder lines and the intensity of human activity there. Caribou movements into and within the Kuparuk oil field have been disrupted by developments and human activity within the field; however, some of these disruptions may be short-term responses to localized areas of intensive human activity, and some return to pre-development patterns may be occurring.

11. The success of caribou in crossing linear developments appears to be dependent on several factors including size of the crossing group, type of development (e.g., isolated road, isolated pipeline, or road and pipeline in proximity), season of the year, type and density of insect pests, amount of human activity associated with the development, and presence of special features to enhance caribou crossing (e.g., ramps, buried sections, elevated pipe).

12. The rate of success by CAH of crossing linear developments varies according to the type of development. In order of <u>decreasing</u> success of crossing by caribou, the following linear developments occur in the CAH

range: buried pipeline, road without traffic, elevated pipeline alone (1.5 m, 5 ft, above the ground), road with traffic, pipeline and adjacent road without traffic, and pipeline and adjacent road with traffic. Traffic levels averaging 15 vehicles/hr have caused a significant decline in crossing success of caribou attempting to cross the Spine Road/Kuparuk Pipeline complex during mosquito season. Traffic levels averaging 6 vehicles/hr have not apparently affected crossing success of a road/pipeline complex. These data should not be interpreted as actual ranges of traffic frequency that can affect crossing success, but do reflect qualitatively the importance of traffic in affecting crossing success. The distribution of traffic during the day (and night) is as important as the average number--for example, if a high frequency of vehicles is concurrent with the approach of mosquito-harassed groups to a road/pipeline, these groups will probably be unable to cross the complex.

13. Although almost all quantitative studies of CAH crossing success have been conducted between late May and August, there have been changes in crossing success over the summer period. These changes in crossing success may be in response to changes in season, but it is difficult to isolate changes in season from other variables such as type of insect pests and intensity of harassment by these pests. The success of crossing linear developments is generally lower during periods of little or no insect harassment in midsummer and during calving. Because most calving occurs north of the Kuparuk Pipeline/Spine Road and parturient females are generally more sedentary, caribou may be less "motivated" to cross the complex then, as opposed to periods of mosquito harassment when their motivation to cross and reach insect relief habitat is greater. On the other hand, during oestrid fly harassment, group size is smaller and the reactivity of caribou to structures and human activity is much lower--caribou will approach and even utilize structures such as roads or under buildings as fly relief. These changes in reactivity to developments and human activity markedly affect crossing success.

14. Group size also affects the success of CAH caribou in crossing linear developments--larger groups have a lower success in crossing developments than do smaller groups. However, often large groups apparently occur in response to increased mosquito harassment; therefore, the effects of mosquito harassment can not be readily isolated from the effects of the social dynamics of large groups *per se*.

15. Buried sections of the Kuparuk Pipeline have been preferentially used by CAH caribou for crossing the pipeline. Ramps which have been constructed specifically to facilitate caribou passage are preferred over adjacent sections of elevated pipeline--this preference appears to be especially noticeable in areas where there are high levels of traffic along the road associated with the pipeline. Ramps may be a very important structure for enhancing the success by large, mosquito-harassed groups in crossing above-ground pipeline and especially road/above-ground pipeline complexes.

16. It is possible that CAH caribou are adjusting to the oil/gas development in the Kuparuk oil field. Caribou crossing success of some of the structures has increased slightly in 1983 and 1984 from that of earlier years. During midsummer 1984 maternal group occupancy along the Spine Road increased from that of several previous years. Large groups of caribou that moved southward from the coast as mosquito harassment declined then crossed the Spine Road/Kuparuk Pipeline complex directly between the Kuparuk River and Central Processing Facility (CPF-1), rather than paralleling the complex westward and "end-running" the developed area as they had done the three previous summers. These data reflect only one year however, and should not be considered definitive evidence. There are no such indications from data concerning the TAPS corridor or the Prudhoe Bay field, or concerning partutient caribou avoidance of the Milne Point Road.

1.0 INTRODUCTION

As Alaska continues to develop its natural resources, human-induced changes will continue to affect the availability and use of habitat by fish and wildlife species in the state. The caribou (Rangifer tarandus) is one of the wildlife species most identified with Alaska, and one of the most important for subsistence and recreational hunting, and for viewing. Experience in assessing the effects of human-induced changes on Rangifer populations elsewhere in the world has indicated that man can significantly alter the relationship between Rangifer and its habitat. In the worst cases, these alterations have resulted in regional and local extirpations. In order to understand these human-induced alterations, and therefore to be better prepared to prevent their occurrence in Alaska, Habitat Division has prepared a report synthesizing the available literature on the effects of man's land use and development activities on Rangifer. The report consists of two volumes. Volume I is a synthesis of the impacts of human land use and development types on Rangifer elsewhere in the world and includes a brief discussion of the prevailing theories about Rangifer population dynamics. Volume II (this volume) is a discussion of the effects of oil and gas development on the Central Arctic Herd (CAH) of Alaska's North Slope of the Brooks Range. This volume focuses on the type of development that is most intensive in Alaska at this time, although available information from other geographic areas and situations is included where appropriate.

1.1 SCOPE AND ORGANIZATION

Although the emphasis of each volume is on impacts to Rangifer that are caused by man's development activities, additional information is included that is designed to assist the reader in evaluating and understanding the impacts information provided. This additional information includes such topics as taxonomy, herd status, aspects of Rangifer life history and habitat utilization, and distribution. The discussion of these topics is limited to that information directly relevant to evaluation of the impacts information. Readers desiring more exhaustive treatment of these general topics should consult Bergerud (1978), Kelsall (1968), Miller (1982), Pullainen (1983), Reimers et al. (1980), and Skoog (1968).

Each volume consists of a narrative text followed by an annotated bibliography of selected pertinent references. The references that have been annotated have been selected because of their relevance to understanding and evaluating impacts discussed in the report. All references that discussed impacts have been annotated. In addition, some references have been annotated that contain information useful in evaluating the impacts literature but do not in themselves contain impacts information.

In this volume, an overview of the history of oil and gas development on the North Slope, and the historic and current distribution and movements of the Central Arctic Herd (CAH) are presented and discussed in section 2.0. This section also includes a discussion of habitats that appear to be used intensively by the CAH, and a discussion concerning the application of the term "herd" to the group of animals we now call the "Central Arctic Herd." In section 3.0 the impacts of oil and gas developments are presented. These impacts are discussed in the context of opposing "schools of thought" among caribou biologists in regards to the effects of human land use and developments on caribou and their habitat. Conclusions and general discussion are presented in section 4.0, and the literature cited and annotated bibliography are presented in sections 5.0 and 6.0 respectively.

1.2 DEFINITION OF IMPACT

For the purposes of this report, an impact is defined as an alteration of Rangifer's environment as a consequence of human land use or development activities that results in a deleterious change in the relationship between caribou and their habitat or between caribou and other wildlife species (such as predators or competing ungulates). Several considerations are worth mentioning in regards to this definition. First, human development activities do not always cause alterations to Rangifer's environment that are deleterious; for example, in some situations wildfire can enhance the availability of forage for caribou. Second, most biologists would agree that, ultimately, the amount of available habitat limits the number of animals supported by the habitat. Other, proximate, factors (e.g., hunting, predation) may be more important in the short term; however, the amount and quality of available habitat ultimately limits populations. Third, the Alaska Department of Fish and Game's (ADF&G) goal is to ensure that caribou habitat is managed for the long-term benefit to the species. This principle is formulated in the ADF&G "Statement of Policy on Mitigation of Fish and Game Habitat Disruptions" (memo Skoog to directors, 3/24/82) in which it is stated that the goal of the department is to "...maintain or establish an ecosystem with the project in place that is as nearly desireable as the ecosystem that would have been there in the absence of the project." One consequence of this goal is that habitat management, as opposed to population management (e.g., seasons and bag limits), must be approached from the standpoint of maximum protection to the habitat because many development projects are on the scale of tens or hundreds of years. As a result, habitat losses or other effects of development that may accompany these development projects are for all practical purposes irreversible. For example, the Trans-Alaska Pipeline System (TAPS) was originally constructed for a 30-year project life based on the perceived (as of the early 1970's) size of the Prudhoe Bay oil discovery. Since then new oil and gas discoveries in adjacent areas, as well as advancing technology in recovery techniques, have extended that project life by several decades.

2.0 OVERVIEW

In order to understand the interaction between caribou of the CAH and oil and gas development it is useful to review the history, past growth, and likely future growth of oil and gas development on the North Slope; and to review salient features of caribou distribution, movements, abundance, and utilization of specific areas (e.g., calving areas) that may affect current and future caribou interactions with oil and gas development.

2.1 SUMMARY OF OIL/GAS DEVELOPMENT IN THE CAH RANGE

2.1.1 Historic and Current Exploration and Development

Petroleum exploration and development on the North Slope focussed until the early 1960's on the region mostly to the west of the CAH range (figure 1). An excellent summary of the history of that development has been provided by Hanley et al. (1981)--unless otherwise noted the following discussion is adapted from their report. In 1923, the northern foothills of the Brooks Range and the coastal plain west of the Colville River were set aside as Naval Petroleum Reserve No. 4 (now called National Petroleum Reserve-Alaska, or "NPR-A"). Until the 1940's, petroleum exploration consisted only of geologic reconnaissance. However, in the 1940's and 1950's, 36 test wells and extensive seismic and other surface exploration resulted in the discovery of nine oil and gas fields, none of which contained commercial reserves. The most extensive oil field was found near Umiat, and has an estimated 70 million barrels of recoverable reserves. No field development has occurred there. A small gas field was developed near Barrow, and since 1949 this field has been supplying Barrow and nearby naval installations. None of these fields are within the main portion of the CAH range; however, the Umiat field is within an area of winter range occasionally shared by CAH and Western Arctic Herd (WAH) caribou.

Although drilling in the Umiat area continued sporadically until 1965 (Hanley et al. 1981) intensive large scale development on the North Slope did not begin until the discovery of a large oil reservoir at Prudhoe Bay in 1968. A confirmation well, drilled in 1969, indicated a significant find called the Sadlerochit Formation. Development in the Prudhoe Bay area by 1970 consisted of the Deadhorse Airport (used by scheduled airlines), a small system of roads connecting the airport to ARCO base camp, and several drill pads with associated access roads. A small amount of additional drilling and facilities development had occurred by 1974 including a road toward the West Dock, and the start of the main connector road (called the "Spine Road") westward between Prudhoe Bay and what is now the Kuparuk field (figure 2). The early "boom" in expansion occurred in late 1974-75 with the construction of the TAPS, the 48 in diameter pipeline to carry crude oil from Prudhoe to Valdez, and the expansion of the drill pad, flowline, and access road network to TAPS Pump Station 1. In addition as the Prudhoe Bay area continued to grow, an infrastructure and support facility network also grew. Additional construction camps for support contractor personnel, oil field service industries (e.g., tire shops, drilling mud contractors, drill rig repair industries, heavy equipment parts dealers and repair facilities), and the gravel removal operations ("material sites") upon which most of these facilities depended, all grew rapidly during the 1974-75 period, and have continued expanding to the present. It is likely that facilities for removing oil and gas from the Sadlerochit Formation are nearly complete. In the Prudhoe Bay Unit, there are some 50 drill site or oil facility (e.g., gathering centers) pads in place (including associated access roads and flowlines), 25-30 support facility pads in the Deadhorse area, 4-5 gravel pits, 2-3 water reservoirs, and a major road system leading west to the Kuparuk oilfield, and to the East Dock and West Dock barge facilities.

In addition to the Prudhoe Bay field oil development is occurring in the Kuparuk field situated between the Kuparuk and Colville rivers (figure 3). By 1978, development consisted of a handful of drill sites and the continuation of the Spine Road from the Prudhoe Bay Unit, across the Kuparuk

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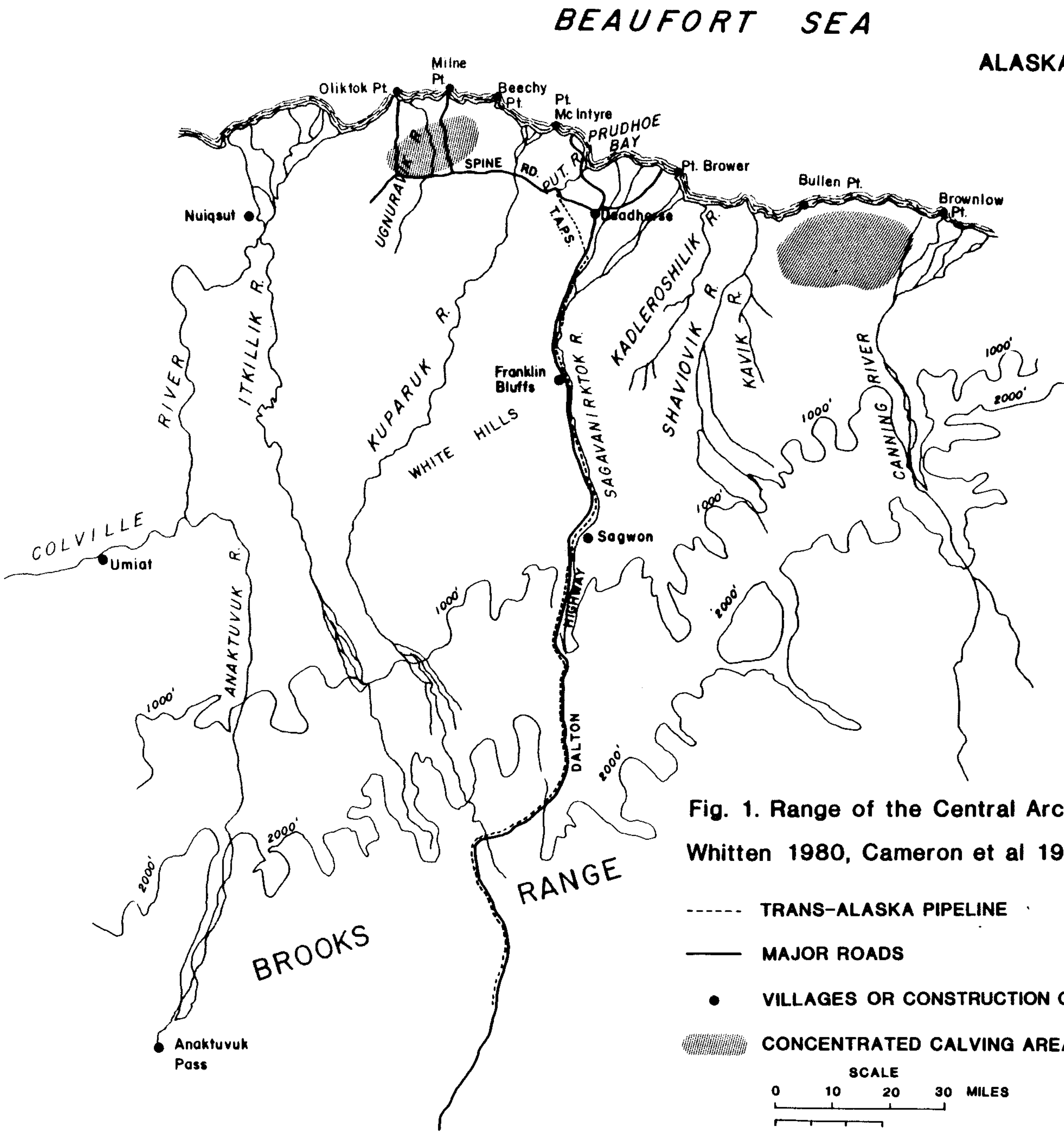
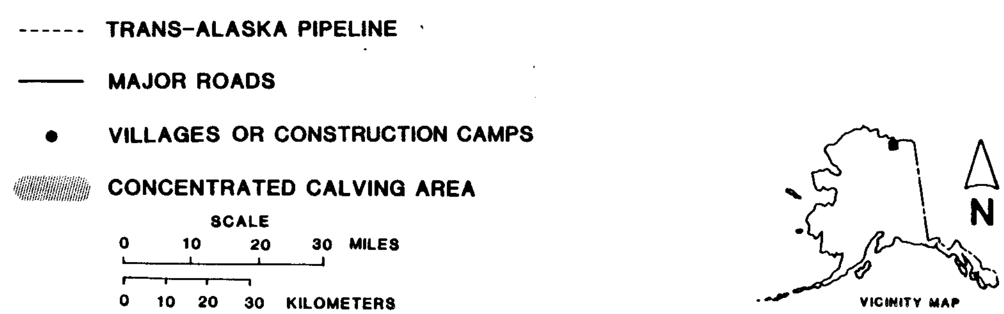


Fig. 1. Range of the Central Arctic Herd (Adapted from Cameron and Whitten 1980, Cameron et al 1983, and Lawhead and Curatolo 1983)



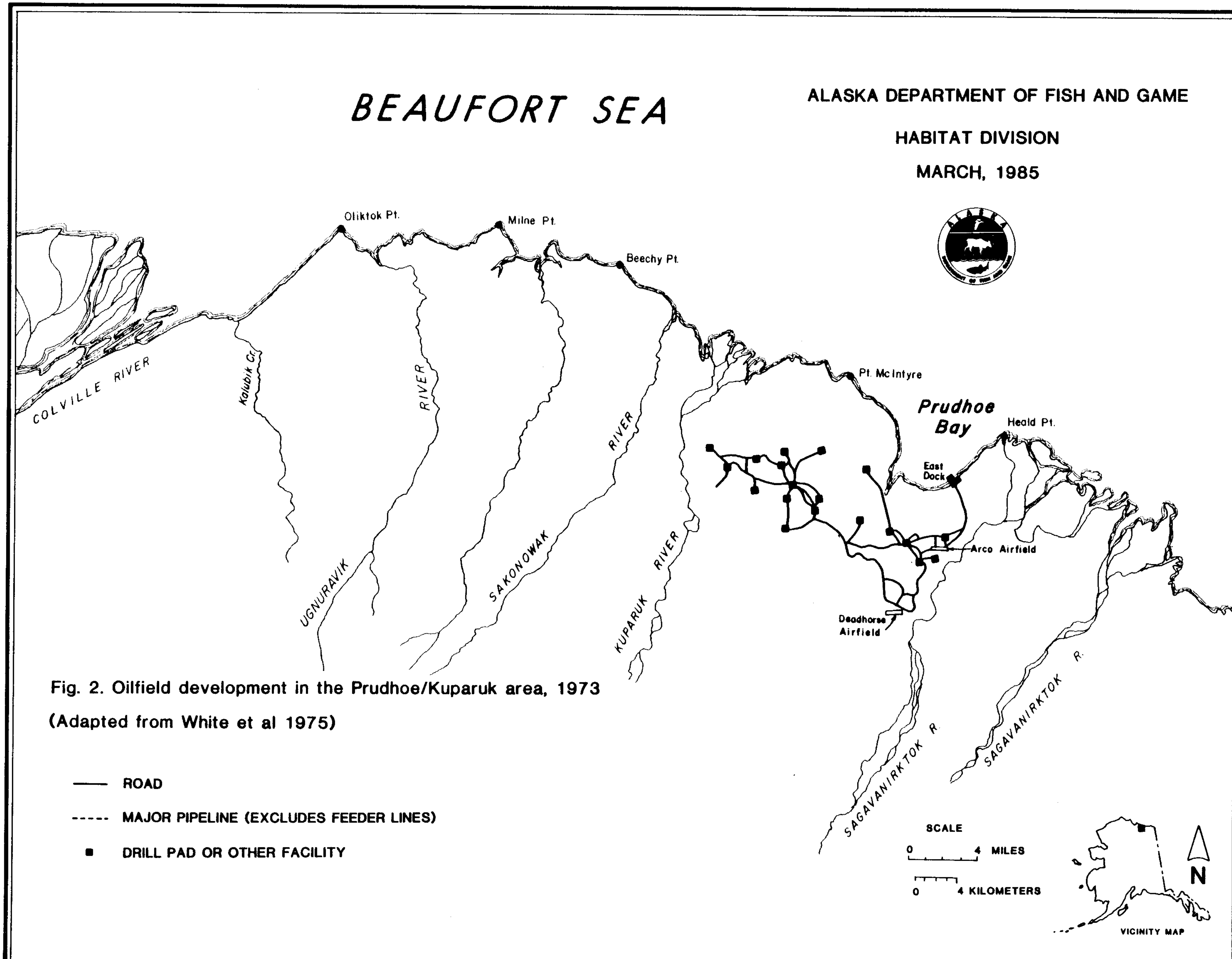


Fig. 2. Oilfield development in the Prudhoe/Kuparuk area, 1973
(Adapted from White et al 1975)

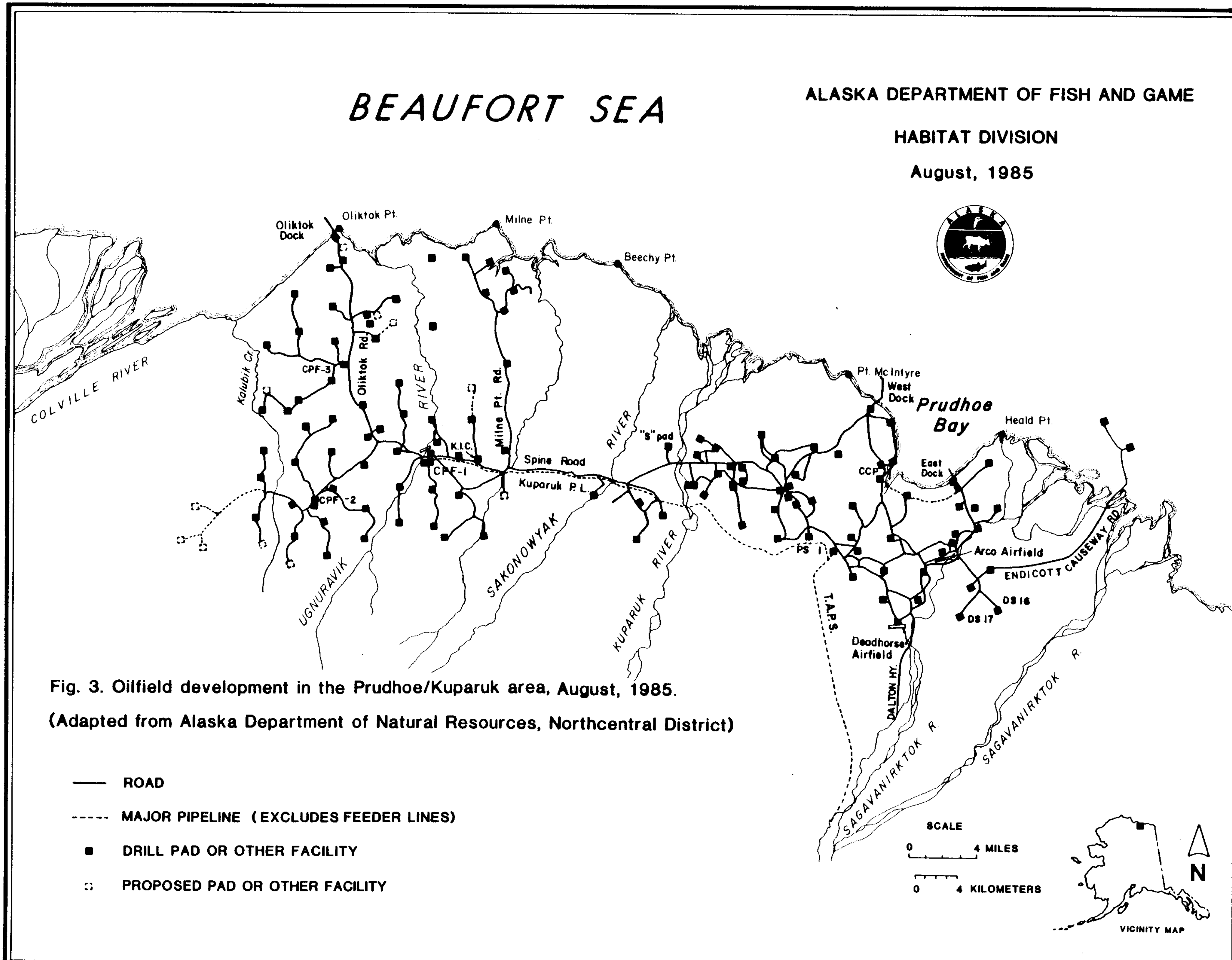


Fig. 3. Oilfield development in the Prudhoe/Kuparuk area, August, 1985.
(Adapted from Alaska Department of Natural Resources, Northcentral District)

- ROAD
- MAJOR PIPELINE (EXCLUDES FEEDER LINES)
- DRILL PAD OR OTHER FACILITY
- PROPOSED PAD OR OTHER FACILITY

River to the Kuparuk field. Growth of the Kuparuk field continued, and in 1980 construction began on the major 24 in diameter pipeline connecting the Kuparuk field to TAPS Pump Station 1 (figure 3). A major facility, Central Processing Facility 1 (CPF-1) was completed in 1980. Construction of the Kuparuk Pipeline was completed from CPF-1 to TAPS Pump Station 1, a distance of 27 mi (43 km), in 1981. CPF-2 was completed in 1982, and numerous additional drill pads, access roads, a jet airport, and flowlines and gathering centers were also completed. Currently in the Kuparuk field there are 52 drill sites and processing facilities, 5 material sites, and 4 water reservoirs. Although most of the major oilfield support facilities are still located in the Prudhoe Bay area, expansion of the Kuparuk oilfield is continuing. In winter 1984-85 alone, construction of an additional 182 mi (109 km) of flow lines occurred; in 1985-86 construction of another 142 mi (85 km) is forecast. Although many of these flow lines are placed on support structures currently in place, others will be entirely new and will be accompanied by new access roads.

Within the area of the Kuparuk oilfield lies Conoco's Milne Point Unit, north of the Spine Road (or "West Sak Road") between the Oliktok Road and the Kuparuk River (figure 3). Construction of a road 14 mi (23 km) from the West Sak Road to Milne Point, and several drill sites and access roads, was completed in 1981. A pipeline along the Milne Point Road was constructed during winter 1984-85.

2.1.2 Projected Development

Expansion of the oil field network around the Prudhoe Bay and Kuparuk areas is already underway. Drill sites in the West Sak shallow oil sands formation in the southern Kuparuk field are being constructed. If the projections of reservoir capacity are correct, the Kuparuk oilfield infrastructure could increase fourfold. Just to the west of the Kuparuk oilfield, exploratory wells are being drilled in the Colville River delta and immediately offshore. Should recoverable reserves be discovered there, it is likely that the infrastructure for transporting oil from that area, and for maintenance and development of the new field, will tie into the existing Kuparuk oilfield infrastructure. Immediately to the south of the Kuparuk oilfield, additional fields are being explored in the Hemi Springs Unit, and in the Eileen West End area.

Considerable onshore and offshore exploration has occurred both east and west of Prudhoe Bay. Sohio's Endicott project, offshore of the Sagavanirktok River delta (figure 3), is scheduled for development in the next few years. Exploratory drilling is being proposed for leases in Foggy Island Bay off the eastern channel of the Sagavanirktok River. ARCO Alaska will be developing the Lisburne Formation in Prudhoe Bay; however, its onshore facilities will be mostly contained within the existing Prudhoe Bay development area. Onshore facilities such as pipelines, gravel sites, and access roads would accompany almost any offshore development.

Oil exploration drilling has taken place east of Prudhoe Bay to the Canning River, and seismic exploration and exploratory drilling has occurred on the Arctic National Wildlife Refuge. To the west of Prudhoe Bay, exploratory wells have been drilled in Harrison Bay and NPR-A. If significant oil reservoirs are discovered in any of these coastal areas, an east/west pipeline (possibly with an associated road) to connect these reserves to TAPS is likely. If a significant reservoir were discovered in southern NPR-A, an east/west transportation corridor along the northern Foothills of the Brooks Range (in the WAH range) to another TAPS pump station is likely. If all the reservoirs are developed, there could be major transportation corridors across the coastal areas from Harrison Bay (in the Teshekpuk Lake Herd [TLH] range) to Kaktovik (in the Porcupine Herd [PH] range). It is also likely that the road networks associated with these oil fields could also be extended to connect the villages of Kaktovik and Nuiqsut with the Dalton Highway.

Northwest Alaska Pipeline Company (NWA) has proposed to construct a buried, 48 in. diameter gasline from Prudhoe Bay through Canada to the "Lower 48." Although preliminary exploration and design have been completed, the Alaskan portion of the project was temporarily deactivated in 1982 pending a more favorable economic climate. The gas pipeline would parallel the TAPS line through that portion within the CAH range. As currently proposed, the gas pipeline would be operated below 32° F and would be buried throughout the alignment with the exception of several major river crossings. Although commercial gas reserves in NPR-A appear to be limited (Hanley et al. 1981), there is the possibility that such reserves could be considered commercially viable if the NWA pipeline were built (ibid.).

2.2 CAH DISTRIBUTION AND MOVEMENTS

Barren-ground caribou typically share several characteristics that are important in regards to evaluating the impacts of human developments. These characteristics include extensive seasonal movements and distribution, the tendency of pregnant females to congregate with other pregnant females in more or less geographically distinct areas to which they return year after year in order to have their calves, and utilization of certain habitat types (other than calving areas) more intensively than others (Bergerud 1978, Skoog 1968, Miller 1982). In the following sections these characteristics will be discussed with respect to the CAH in order to describe the "normal" range of variation of movements, distribution, and habitat use by caribou of the CAH as a baseline for the evaluation of the impact of oil and gas development, to confirm the use of the term "herd" as applied to the CAH, and to identify any types of habitat that may be relatively more important to the CAH than other habitats. The latter two points are especially important in view of the controversy surrounding the observations of apparent displacement of CAH from certain spatial areas of its range, and the possible consequences of such displacement (reviewed in section 3.0).

Historic and current CAH distribution, movements, and abundance are summarized below. More details are available in the original references, and detailed maps will be provided in the department's forthcoming Alaska Habitat Management Guide-Arctic Region. Two qualifications are necessary before proceeding: (1) "historic" information is readily available as far back as the late 1950's, and even information from the 1950's and early 1960's is not reliable because of the small number of observations and lack of systematic surveys, and (2) even with the increased use of sophisticated technology (e.g., airplanes, helicopters, radiotelemetry, computers) in the recent study of caribou biology, because of the inadequate data base prior to the development of the Prudhoe Bay oil field, pre- and post-development comparisons are often really educated guesses rather than absolute facts.

2.2.1 Distribution and Movements Prior to 1980

Prior to the discovery of oil at Prudhoe Bay, knowledge about the CAH distribution was based on scattered observations incidental to other work in the area. No systematic repeated surveys were conducted before ADF&G began intensive studies in the area in 1975.

Cameron and Whitten (1976), Carruthers (1983a and b), Carruthers et al. (1984), Child (1973), Gavin (n.d.), and Skoog (1968) have provided summaries and discussions of historic caribou distribution, movements, and abundance in the central North Slope region. Skoog (1968) reviewed the historical distribution and abundance information for the PH, WAH, and the "central Brooks Range herd" and concluded that in the 1920's and 1930's there were two herds in northeastern Alaska - the PH and the "central Brooks Range herd." The "center of habitation" of the "central Brooks Range herd" during this time was along the south slope of the Brooks Range between the western Phillip Smith and eastern Endicott mountains. In 1937 several thousand animals wintered in the foothills of the Kuparuk River and were likely part of a northward shift in the center of occupancy of the "central Brooks Range herd" that continued into the 1940's. In the 1950's the "central Brooks Range herd" increased rapidly and then disappeared, presumably joining the WAH. In 1964 there appeared to be only two calving areas, associated with the PH and WAH respectively. Skoog's map of caribou herds identified in 1968 shows only the PH and WAH, and the boundaries of each herd do not overlap - the area between the Canning and Colville rivers is not included in any herd (figure 2, ibid.). There are few observations referencing the area of the central North Slope between 1968 and 1970. Hemming and Glenn (1969, figure 3) mapped calving areas in 1968 that correspond closely to the current TLH calving area (northeast of Teshekpuk Lake) and to the current western concentrated calving area of the CAH; however, these were labelled as "Porcupine Herd calving areas." In 1971 Hemming apparently considered that the calving area between the Colville and Sagavanirktok rivers was part of the WAH because he drew the boundary between the range of the PH and WAH at the Sagavanirktok River, and did not mention a "central Brooks Range herd" or a CAH (Hemming 1971, figure 1). Carruthers (1983b), reviewed Skoog (1968), and suggested that the CAH has been a "remnant" herd at least twice in the past--once during the decline of the WAH (and possibly also the PH) prior to their increase in the 1940's and 1950's, and once again in the early 1970's when the WAH again declined. Child (1973) mentioned a previous report which documented 45,000 wintering on the coast near the Sagavanirktok River in 1958. Gavin (n.d.) described influxes of large numbers (tens of thousands) of caribou that he assumed were WAH and PH animals into the CAH range during the 1969-70 period. In summary, prior to 1969-70, information regarding the exact distribution, or even the presence, of the CAH is scanty; however, caribou were consistently observed between the Colville and Canning rivers from the Brooks Range to the coast and calving was documented on the coastal plain between the Colville and Sagavanirktok rivers.

Following the discovery of oil at Prudhoe Bay in 1968, the petroleum industry began investigating the distribution and movements of caribou in the Prudhoe Bay region (Gavin n.d.). The proposal to construct a natural gas pipeline from Prudhoe Bay eastward to Canada prompted a number of studies of the PH in the early 1970's, with some overlapping coverage of the CAH (e.g., Roseneau and Curatolo 1976, Roseneau et al. 1974). Child (1973) and White et al. (1975) reported on caribou movements in 1971-72 near Prudhoe Bay. Beginning in 1974, ADF&G began long-term investigations of the CAH (Cameron and Whitten 1976). These sources provide an overview for the 1969-79 period.

Although Gavin (n.d.) conducted no winter surveys, he surmised that between 1969-1977 less than 100 animals of the CAH wintered on the coastal plain. Caribou of the CAH were thought to winter south of the Brooks Range in the early and mid-1970's (ibid.), and were found to winter mostly in the foothills on the north side of the Brooks Range in the latter part of the 1970's (Cameron and Whitten 1978). Ingress of individuals from the WAH occurred during fall of 1976 (Roby 1978, Gavin, n.d.). In 1977-78, much of the CAH appeared to winter in the northern foothills and onto the coastal plain (Cameron and Whitten 1978).

Spring migration usually consisted of movements during May of mostly cows and yearlings in a generally northward direction along the major river valleys. Gavin (n.d.) reported that in spring 1971 heavy snow in the foothills delayed migration, and that calving took place between the foothills and "elevations" [latitudes?] equivalent to Franklin Bluffs. In 1972, heavy snows again resulted in delayed spring migration toward the coastal plain (ibid.). Spring migrations from 1973 through 1979 appeared to follow a pattern similar to that observed in later years (ibid.).

Calving generally occurred on the coastal plain, and was often concentrated in two areas--one between the Ugnuravik and Kuparuk rivers, and the other between the mouth of the Canning River and Bullen Point (Gavin n.d., Child 1973, Cameron and Whitten 1978) (figure 1). Although he conducted no systematic surveys, Gavin (n.d.) reported that in 1970 most caribou appeared to calve in the vicinity of the Kadleroshilik River and Bullen Point on the east, and between the Ugnuravik and Putuligayak rivers in the west (cf. figure 2, ibid.). The latter area is quite similar to the calving area in 1968 (cf. figure 3, Hemming and Glenn 1969). In 1971, calving occurred primarily in the foothills (cf. figure 5, ibid.) presumably because of deep snow on the coastal plain. In 1972, 500 cows and calves were located along the coast west of the Kuparuk River, and 1200 caribou, mostly cows and calves, between Prudhoe Bay and the Canning River (ibid.). Although Gavin (n.d.) reported only 8 cows and 5 calves within the "Prudhoe Bay area," he never described the area he referred to. Child (1973) stated that "recently" [early 1970's?] the Prudhoe Bay development area had been used for calving by the 3,000 or so caribou that resided in the Prudhoe Bay area. In 1973, the distribution of calving was similar to that of 1972, but 5-6000 animals were involved (ibid.). Of these 5-6,000, only 42 animals (all cows, calves, and yearlings) were counted in the Prudhoe Bay development area. In 1974, calving concentrations were in locations similar to those of 1972 and 1973; approximately 10,000 animals were involved. Calving counts in the Prudhoe Bay development area yielded 51 animals. 1975 calving survey results were reported by Gavin (n.d.); however, calving apparently was so widely scattered along the coast that concentration areas were not discernible. For the same year, Cameron and Whitten (1976) reported only that calving was observed "from the latitude of Happy Valley Camp north to the coast." Gavin (n.d.) reported that in late May of 1976, large numbers of caribou had moved into the area between the Ugnuravik and Kuparuk rivers, and between the Shaviovik and Canning rivers. Only a handful of animals calved in the Prudhoe Bay area. Cameron and Whitten (1978, 1979) reported that calving in 1977 was distributed fairly uniformly between Oliktok Point and Bullen Point, and inland to approximately 70° N.L. and that little if any calving took place in the Prudhoe Bay development area. However, Cameron and Whitten (1978) flew only as far inland as 70° 05' N.L. (i.e., only the coastal plain) during the calving period, and did not survey farther east than Bullen Point until late June; therefore, calving concentrations east of Bullen Point could have been missed. Fixed-wing surveys of the White Hills-Franklin Bluffs uplands areas during calving yielded no observations of calving concentrations in that area (K. Whitten, pers. comm. 1985). In 1978, extensive snow cover and flooding prevailed over the coastal calving areas (Whitten and Cameron 1985), and scattered calving occurred further inland than in dry years (ibid.). Nevertheless the density of calving was greater along the coast than further south and a calving concentration in the area southeast of Oliktok Point and extending almost to the Sakonowyak River was observed, and another concentration area was suspected to occur between Bullen Point and the Canning River delta (Cameron and Whitten 1979) although survey coverage did not extend to there. A few hundred animals calved near Franklin Bluffs (ibid.). At least 10 cows, and possibly more, calved within the "Prudhoe Bay oilfield" (Gavin, n.d.). In 1979, when the coastal plain was relatively dry and snow free, almost all calving occurred within 24 km of the coast (Cameron and Whitten 1980a), and there was concentrated calving in the Oliktok Point-Milne Point area. As in 1978, however, survey coverage did not extend east of Bullen Point, and a concentration area near the Canning River delta could have been missed.

Given the qualifications which were mentioned previously for Gavin's work, it appears that with the exception of several years when snow conditions apparently affected the distribution of calving, the general distribution of calving remained similar for the period between 1969-79, except that calving declined in the Prudhoe Bay area.

Between 1969-1979, during the post-calving period (approximately June 10-July 1), the portion of the CAH caribou that was involved in calving remained near the calving areas, and began to aggregate and to exhibit local movements in response to the onset of the mosquito season (approximately July 1-August 1) (Gavin n.d., Child 1973, White et al. 1975).

As the mosquito season approached, bulls, yearlings and nonparous cows drifted north, and some joined maternal groups; others remained on the coastal plain but did not join maternal groups. During the mosquito season, heavy use of coastal deltas, points, and beaches, and unvegetated floodplains of the major rivers for relief from mosquitoes by all sex and age classes was well documented (Gavin, n.d., Child 1973, White et al. 1975, Cameron and Whitten 1976, 1977, 1978; Roseneau et al. 1974). Movements to these areas often involved several thousand animals. Movements involving thousands of animals were observed for the portion of the CAH summering west of the Sagavanirktok River by Child (1973) and Gavin (n.d.). Similarly, Roseneau et al. (1974) noted that in early July, 1973, 3-4000 animals had crossed the Canning River from the west, headed eastward for 10-20 miles, then reversed course and moved back westward. A similar pattern of movement had been observed in 1972, and they concluded that these animals were from the "Prudhoe Bay" or "Central Arctic Herd." In the early 1970's movements through the Prudhoe Bay field were common, occasionally involving thousands of animals moving to and along the coast and to the nearby points and river deltas in response to wind direction and mosquito density (Child 1973, White et al. 1975). In contrast to information about the calving period, information about the mosquito season suggests that historic carbiou use of the Prudhoe Bay area as a movement corridor was high.

Because it is important to understand the effect that mosquitoes and oestrid flies have on the summer distribution and movements of CAH caribou, a short digression here is appropriate. Caribou summer movements and distribution often occur in response to the intensity of mosquito and oestrid fly harrassment. Because of the predominance of northeasterly winds, caribou tend to drift eastward along the coast (into the wind) and form large aggregations as mosquito harassment increases. Minor movements also occur in response to less severe mosquito harassment. For example, because night-time temperatures are often lower than those during the day mosquito activity often declines, and caribou that spent the day along the coast drift back inland to feed. Likewise, caribou utilize short-term and/or localized shifts in wind direction in order to avoid mosquitoes. This results in short-term movement patterns which occur in response to short-term fluctuations in mosquito density. Nevertheless, the general movement pattern is toward the coast and eastward, dependent on length and intensity of mosquito harassment. In addition to selection of habitats favorable for relief from mosquitoes, caribou on the North Slope also tend to avoid habitats where mosquitoes are dense (e.g., sedge marshes, lake margins) in spite of the presence of highly nutritious forage in these habitats (White et al. 1975). Similar movement patterns occur in the TLH (Reynolds n.d.).

In late July and early August oestrid flies emerge and begin to harass CAH caribou (Curatolo and Murphy 1983). Two types of oestrid flies occur on the North Slope - nose bots (Cephenomyia trompe L.) and warble flies (Oedemagena tarandi L.). Roby (1978) and Sjenneberg and Slagsvold (1979) have described the life cycle. The life cycles of both species consist of an adult which follows the caribou to lay its eggs on them, and which develops into a larva which remains in the caribou, pupates during the winter, and falls to the ground in early summer. The pupa then develops into an adult and the cycle continues. The adult warble fly lays eggs on the back and legs of caribou. The eggs hatch into larvae which burrow through the skin, and reside and grow there until early the following summer when they emerge through the skin and fall to the ground, eventually to develop into the adult fly. The adult nose bot fly hovers in front of the caribou's head until it can eject its eggs up the caribou's nose. The egg-larva-pupa stages occur in the nasal passages, pharynx, and pockets of the soft palate. As the larvae become ready to be expelled early in the following summer, they return to the nasal cavities. The caribou's coughing and sneezing in response to this movement causes expulsion of the larvae. In contrast to warble flies which are more irritating than debilitating, nose bots can result in physical disruption of breathing, secondary infections (including pneumonia), and death from cranial edema (Sjenneberg and Slagsvold 1979). Because the adults are strong fliers and locate caribou by scent, oestrid flies are abundant during wind conditions that would result in reduced harassment by mosquitoes. During the oestrid fly season caribou tend to seek relief by using microhabitats with a minimum of vegetation and maximum wind (e.g. dry ridges, gravel bars, manmade objects such as drill pads and roads) (Roby 1978, Curatolo and Murphy 1983); however, in contrast to their response to mosquito harassment caribou respond to fly harassment by dispersing in small groups throughout the summer range (Cameron et al. 1983, Carruthers et al. 1984, Curatolo and Murphy 1983, Lawhead and Curatolo 1984).

Following the end of the oestrid fly season, approximately the end of July to mid-August, caribou are scattered in small groups over the coastal plain. As fall approaches, these groups join other groups and begin to drift southward, forming the fall migration. In most years between 1969 and 1979, fall migration southward appeared to occur along much the same river drainages as spring migration (Gavin n.d.). Cameron and Whitten (1976) noted that fall migration appeared to be a little more hurried than the gradual northward drift of spring migration, and that during fall migration maximum mixing between maternal and other groups occurred as rutting activity commenced. Following the rut, caribou again scattered into small groups on winter range in the foothills (ibid.) although a few animals often winter on the coastal plain, and in some years many animals wintered on the coastal plain.

2.2.2 Distribution and Movements After 1980

Since 1979, numerous studies have been conducted on various aspects of the CAH. In addition to ongoing road and aerial studies of TAPS and the Prudhoe Bay area, regional calving surveys, and regional studies of the distribution and movements of radio collared caribou, ADF&G has focused on caribou utilization of the Kuparuk Development Area (KDA) (e.g., Cameron and Whitten 1979, 1980a; Cameron et al. 1981; Smith and Cameron 1983, 1985a,b; Whitten and Cameron 1983, 1985; Dau and Cameron 1985). Industry has also sponsored studies in the Sagavanirktok River delta (Wright and Fancy 1982; Fancy 1980, 1983; Fancy et al. 1981), the Lisburne Development Area (Woodward-Clyde Consultants 1983), the Kuparuk area (e.g., Robus 1983, Robus and Curatolo 1983, Lawhead and Curatolo 1984, Curatolo and Murphy 1983, Murphy 1984), and region-wide (Carruthers et al. 1984). Although the primary purpose of these studies may not have been to gather distribution or movements data, information from these studies has contributed to our knowledge of this topic.

Although the gross distribution and movement patterns observed by ADF&G and by Gavin in the 1970's have continued to the present, local variations (especially during calving and post-calving) have been observed. Between 1981 and 1983 most of the CAH was distributed throughout the southern and northern foothills (e.g., Franklin Bluffs to White Hills) during fall and early winter (Carruthers et al. 1984). During the rut (October) caribou were most common in the northern foothills (cf. figure 24, ibid.), whereas by mid to late winter most were found in the southern foothills and west of the Sagavanirktok River (ibid.). It was especially during the late winter period that the distribution of animals from the CAH, WAH, and TLH overlapped, notably in the Itkillik and Anaktuvuk river areas but also in the Galbraith Lake area (ibid., Valkenburg and Davis in press). In 1982, almost 25% of the CAH was found on the coastal plain in late winter (mid-April) 1982 (p. 45, ibid.).

Local variations in calving and post-calving movements and distribution have been attributed to the effects of human development (ref. section 3) and to environmental conditions such as snow cover and flooding. Whitten and Cameron (1985) noted that during spring of 1979 and 1981, relatively dry conditions prevailed on the coastal plain, and almost all calving occurred within 24 km (14 mi) of the coast. In 1979, a concentration area was located in the Milne Point-Oliktok Point area; however, no calving surveys were flown east of the Sagavanirktok River (Cameron and Whitten 1980a, ibid.). In 1981, when the entire area within 40 km (24 mi) of the coast was surveyed during calving, concentrations were located in the Milne Point-Oliktok Point area and the Canning River delta area (Cameron and Whitten 1980a, Whitten and Cameron 1985). Carruthers et al. (1984) however, place the western concentrated calving area in 1981 and 1983 near the mouth of the Kuparuk River (cf. figure 13, ibid.). Carruthers et al. did not survey the Canning River delta in 1981 (ibid.) therefore they did not observe the eastern calving concentration described by Whitten and Cameron (1985). In 1982, Carruthers et al. (1984) noted that calving was distributed farther inland than was the case in 1981 and 1983, and that this was coincident with a later spring. In 1980 and 1982, late breakup resulted in a few caribou calving up to 160 km (96 mi) inland although densest calving still occurred near the coast (Whitten and Cameron 1985, Carruthers et al. 1984). The Kuparuk and Canning river areas supported the highest densities of calving caribou, and the Prudhoe Bay area had a near absence of calving (Whitten and Cameron 1985). In 1983 the general distribution of calving was along the coast and was densest in the Kuparuk area in the west, especially in the area north of the West Sak Road (Spine Road) and south of Milne Point, and between Mikkelsen Bay and the Canning River in the east (Dau and Cameron 1985, Lawhead and Curatolo 1984). Calving was absent in the Prudhoe Bay area (figure 1 in Lawhead and Curatolo 1984). Other less dense calving areas included Franklin Bluffs/Kadleroshilik River area, the White Hills, the hills east of the Kavik River, and a zone south of the Prudhoe Bay developed area (ibid.).

As was the case with calving distribution, current post-calving distribution and insect-induced movements have remained similar to those during the late 1970's. Seasonal movements to favored mosquito relief areas such as coastal deltas, beaches, and promontories have continued, as has the generally northward summer "drift" of many bull and yearling groups in response to increasing mosquito levels inland. Utilization of the Sagavanirktok River delta has continued (Fancy 1982, 1983; Wright and Fancy 1982). Minor use in 1983 of the coastal edge of the Prudhoe Bay field was documented (Woodward-Clyde 1983). Use of the Prudhoe Bay developed area in 1983 was primarily by bulls, although on 22 July approximately 4,500 caribou of mixed sexes moved into the West Dock area from the west, then split into several groups which eventually moved back south and west that evening (text and figure 4.5 in Woodward-Clyde 1983). At least some of the movement back west was thought to be due to low clearance on feeder oil lines, and to disturbance by traffic further east (Lawhead and Curatolo 1984). Whitten and Cameron (1983) had observed no large groups of caribou to move through the Prudhoe Bay area between 1975-78. Although they observed large post-calving groups approaching the Prudhoe Bay development area from both east and west, these had deflected and fragmented except for a few animals. Lawhead and Curatolo (1984) reported that in 1983 the oscillatory, mosquito-induced movements of caribou west of the Sagavanirktok River (where development is most intense) were similar to those of the caribou east of the Sagavanirktok River -- i.e., although movements to and from the coast may be disrupted by the oilfield development, the gross movement patterns still occur.

The general pattern of caribou movements and distribution in response to oestrid flies, that was identified prior to 1979, has continued (Cameron et al. 1983, Lawhead and Curatolo 1984, Carruthers et al. 1984). In summer 1982 caribou remained in two generally nonoverlapping aggregations, one on each side of the Sagavanirktok River, during calving and the mosquito season (Cameron et al. 1983). A similar pattern of caribou distribution occurred in 1983 (Lawhead and Curatolo 1984). Following the onset of the oestrid fly season, and as the mosquito season ended, caribou dispersed widely in small groups. During this dispersal period caribou from each of the previously nonoverlapping aggregations tended to mix (ibid.) although there appeared to be a tendency for caribou from the eastern aggregation to move across the Sagavanirktok River and mix with animals from the western aggregation rather than vice versa (cf. figure 4, ibid.).

2.3 CONCLUSION AND DISCUSSION

2.3.1 Is There a Central Arctic Herd?

Skoog (1968) has defined a herd as "A group of caribou which uses one calving area repeatedly over a period of years, distinct from the calving area of any other group." Despite its obvious emphasis on the female portion of the herd--bulls are not generally present on the calving grounds of most Arctic herds (Miller 1982, Skoog 1968)--this definition has been accepted as a working hypothesis by most North American caribou biologists. Skoog recognized that "over a period of years" does not necessarily mean "every year"--for example, he noted that in some years heavy snow cover can preclude cows from reaching calving areas (ibid., p. 214). Skoog also recognized that sporadic and minor interchange of animals between herds could also occur, but that the calving area remained generally in the same location and that the vast majority of cows associated with that herd would use the same calving area (ibid.). An additional but not necessary feature of the definition of a herd is that the calving ground is included within the "center of habitation" --i.e., that area within a region which is the focal point of herd movements, and is the last area to be inhabited by the herd as its numbers decrease (ibid.).

Significant records for the CAH date back only to the early 1970's. Although Hemming and Glenn (1969) found a calving area in 1968 in the same area that is now considered the CAH western concentrated calving area (figure 1) in 1968 they considered this area to be part of the PH. Observations and survey data since 1970 (table 1) indicate that during 12 of the last 15 years, calving concentrations occurred in the Kuparuk area between Oliktok and Milne points, and that during at least 10 of the last 15 years calving concentrations were known to occur in the area between Bullen Point and the Canning River delta. During two other years calving was suspected to occur in the latter location; however, surveys were not

Table 1. Location of concentrated calving areas, Central Arctic Herd, 1970-84

Year	Concentration Areas	Calving Survey Coverage	Comments	Source(s)
1970	(1) Ugnuravik River to Putuligayak River along coast (2) Canning River to Bullen Point on coast	No systematic surveys	n/c	Gavin (n.d.)
1971	"Foothills"	" "	Deep snow on coastal plain	ibid.
1972	(1) Along coast west of Kuparuk River (2) Prudhoe Bay to Canning River	" "	n/c	ibid.
1973	Same as 1972	" "	More animals in each concentration area	Child (1973)
1974	Same as 1972 and 1973	" "	n/c	Gavin (n.d.)
1975	Scattered throughout coastal plain - no concentration areas apparent	" "	n/c	Gavin (n.d); Cameron and Whitten (1976)
1976	(1) Ugnuravik to Kuparuk rivers (2) Shaviovik to Canning rivers	" "	Surveyed in late May rather than peak of calving	Gavin (n.d.)
1977	No concentrations located - uniformly distributed on coastal plain from Oliktok Pt. to Bullen Pt.	(1) Coastal plain between Oliktok Pt. and Bullen Pt. by helicopter during peak of calving (2) Franklin Bluffs to White Hills by fixed-wing during calving	n/c	Cameron and Whitten (1978); Whitten, pers. comm., 1985

Table 1 (continued)

Year	Concentration Areas	Calving Survey Coverage	Comments	Source(s)
1978	(1) Between Oliktok Pt. and Sakonowyak River, on coastal plain (2) Between Bullen Pt. and Canning River delta (suspected only)	(1) Helicopter surveys at end of calving - more intensive in Kuparuk area - no coverage east of Bullen Pt.	Persistent snow cover and flooding during calving	Cameron and Whitten (1979)
1979	(1) Between Ugnuravik River and Milne Point (2) Suspected, Bullen Pt. to Canning delta	Same as 1978	Relatively dry and snow free during calving	Cameron and Whitten 1980; Whitten and Cameron 1985
1980	(1) Oliktok Pt. to Milne Pt., on coastal plain (2) Bullen Pt. to Canning River delta	Same as 1978, except addition of coverage to Canning River and Colville River deltas	Late snowmelt and extensive flooding - although concentration areas used most heavily, more calving inland	Cameron et al. (1981); Whitten and Cameron (1985)
1981	Same as 1980	Same as 1980, except addition of coverage to east side of Canning River delta, and west side of Colville River delta	Relatively dry and snow-free during calving; relatively little calving inland	Cameron et al. (1983); Whitten and Cameron (1985)
	Mouth of Kuparuk River	Systematic survey by fixed-wing, Colville River east to between Bullen Pt. and west side of Canning River delta, end of calving	n/c	Carruthers et al. (1984)
1982	Milne Pt. to Oliktok Pt. area	(1) Entensive helicopter surveys in Kuparuk oilfield (2) Reconnaissance fixed-wing to Canning River delta	Late snowmelt and extensive flooding - relatively more calving inland	Whitten and Cameron (1985); Smith et al. (1984)

Table 1 (continued)

Year	Concentration Areas	Calving Survey Coverage	Comments	Source(s)
	Concentration areas near Bullen Pt. and Oliktok Pt.	Same as 1981, except coverage reduced between Kadleroshilik and Canning rivers	Late snowmelt; calving up to 100 km inland	Carruthers et al. (1984)
1983	(1) Kalubik Ck. to Beechey Pt. (2) Mikkelsen Bay to Canning River	Fixed-wing during calving, northern foothills to coast, Canning to Colville rivers; locations by radiotelemetry	n/c	Lawhead and Curatolo (1984)
	Same as 1981	Same as 1981, except extend to Canning River	n/c	Carruthers et al. (1984)
	Oliktok Pt. to Milne Pt.	Same as 1982, except no surveys of Canning River area	n/c	Dau and Cameron (1984)
1984	Same as 1983	Same as 1983	n/c	Dau and Cameron (1984)

actually conducted there, therefore, calving could not be confirmed (table 1). Furthermore, in 1971 when most of the CAH calved in the foothills, there was deep snow on the coastal plain--a situation which has been linked in subsequent deep snow years (e.g., 1980, 1982) to a greater degree of calving inland than is the normal case (Whitten and Cameron 1985). Further evidence that cows which calve in these two concentration areas comprise a distinct herd is provided by data from radio-collaring and visual collaring studies between 1975 and 1982 (Cameron et al. in press). These studies indicate that a minimum of 90% of radio-collared females older than two years that were collared in the CAH were relocated there in at least three subsequent summers; and that observed rates of relocation there were 98, 91, and 79% for one, two, and three years respectively after collaring (ibid.). Additionally, no cows radio-collared in the range of another Arctic herd, and which subsequently appeared on the calving ground of that herd, have been relocated on the calving ground of the CAH (ibid.). During intensive radio-tracking in 1984, Lawhead and Curatolo (1984) accounted for all radio-collared CAH cows within the summer range of the CAH. These data and observations provide sufficient evidence that according to the criteria of Skoog (1968) there is a CAH.

The concept that caribou herds exist as discrete entities characterized by traditional movement patterns has recently been challenged (Carruthers 1983a, Carruthers et al. 1984). According to Carruthers (1983a) the two key components of Skoog's (1968) definition--the existence of a recognizable calving area, and the fidelity and traditional movements of caribou cows to the calving area--remain unproven. Furthermore, Carruthers (1983a) and Carruthers et al. (1984) argue that because the CAH has been an area of overlap between the WAH and PH, it exists only as a "remnant herd" that will one day reassert its affinity with the WAH, or possibly "swamped" by large numbers of WAH animals as they re-establish the range occupied by the WAH when the latter's numbers were much higher in the early 1970's. Although an extensive discussion of Skoog's (1968) definition of a caribou herd is beyond the scope of this report evidence has accumulated that calving areas of several Arctic herds have been located in the same area since intensive work using modern techniques began in the early 1970's. The WAH core calving area has been located in approximately the same area since at least the early 1960's, and possibly for the past 100 years (Kuropat 1984). The PH core calving area has been in the same area for 10 of the past 12 years (K. Whitten, 1985, pers. comm.). The core calving areas of the Beverly, Bathurst, and Kaminuriak caribou herds in the Northwest Territories have been in the same area for at least the past 15 years (Fleck and Gunn 1982, Gunn and Miller in press). As was mentioned earlier the CAH concentrated calving areas have been located in the same area numerous times over the past 15 years. Recent radio-tracking data has confirmed that cows from the CAH return to the calving area for at least 3 years after they had been radio-collared and that radio-collared cows from other herds have not calved on the calving areas of the CAH (Cameron et al. in press).

There are, however, examples of changes in the location of calving areas. Some of these changes have been short-term. Weather conditions during spring migration and calving can prevent parturient cows from reaching the calving area, or being able to give birth once they have reached the area. Snow conditions have been considered responsible for some herds calving in areas other than their traditional calving areas (e.g., the FH in 1985, Valkenburg and Davis in press; the DCH in 1981, Davis and Valkenburg 1984). The causes of other short-term changes in calving locations are not easily explained. For example in 1984 at least 20% of the radio-collared adult and juvenile cows of the DCH apparently calved with the adjacent YH (Davis et al. in press). Between the 1950's and 1983, and again in 1985 (Valkenburg pers. comm., 1985) the DCH had calved in approximately the same location, and their calving area had remained distinct from that of the YH. There is also at least one example in which fidelity to a calving area has been sporadic over the past 25 years. Until 1963, the FH's core calving area had been west of the Steese Highway near Preacher Creek (Davis et al. 1978). In the early 1970's the FH core calving area changed to upper Birch Creek (ibid.). Between 1976 and 1983, the major calving areas changed annually although most of them were located in areas that had been used as secondary calving areas historically (Valkenburg and Davis in press). In 1984 the core calving area was again located in upper Birch Creek. In 1985, deep snow over most of the area that had previously been primary calving areas resulted in the FH calving in a completely new location (Valkenburg and Davis in press). Some of the annual variation in calving locations can be attributed to weather conditions (as in 1985); however, this factor alone cannot explain the variation because weather conditions during the period when calving areas changed annually ranged from mild to severe. Of the examples presented above only the FH has been inconsistent in returning to the same general calving areas, and even the FH had exhibited some tendency to use calving areas for several years before changing. Skoog (1968) recognized that short-term variations in calving area locations could occur, and attributed these variations to the normal plasticity of response by caribou to environmental changes. Although not all herds (i.e., FH) meet the criterion of traditional use of a recognized calving area, the preponderance of evidence confirms the validity of this criterion in its application to caribou.

Hemming (1971), Bergerud et al. (1984), Carruthers (1983a), Carruthers et al. (1984), Child (1973), and Roseneau et al. (1974) have all mentioned that the CAH appeared to be an area of overlap between the WAH to the west and the PH to the east, and that the CAH is a "remnant" of the WAH. Most of these conclusions were reached before there had been intensive surveys, especially those involving radio-collared animals, in the ranges of the herds mentioned. Hemming (1971) for example relied on Skoog (1968), and in 1968 Hemming and Glenn (1969) labelled as PH two calving areas that we now consider to belong to the CAH and TLH respectively. Roseneau et al. (1974) originally considered animals that they had observed in the Canning River area to be PH, but after further observation attributed these animals to the CAH. It is easy to conceive that as the WAH reached 300,000 animals in the late 1960's, and as the PH reached 100,000 animals at the same time, extensive movements into the winter range of the CAH could mask the presence of a smaller, resident herd. Movements such as these have occurred frequently in the past 10 years, as has been noted (Cameron and Whitten 1977, Carruthers et al. 1984, Whitten and Cameron 1985). These types of movements do not negate the presence of a CAH nor should they be used as evidence against the existence of a CAH. In attempting to discount what they described as a "myth" that the CAH exists, Bergerud et. al. (1984) and Carruthers (1983a) have hypothesized that the CAH is a remnant herd in an area of overlap between two adjacent herds.

Although we believe that the CAH fits the definition of a herd, the discussion of this point should not overshadow the fact that regardless of whether or not the animals that utilize the calving concentration areas in the Oliktok Point/ Milne Point area and the Bullen Point/Canning River delta are called the "Central Arctic Herd," the habitat in these areas has been selected by parturient cows for the majority of years of record; therefore, it is highly probable that these areas confer some advantage to these parturient cows or to their offspring. Although the characteristics that may be involved in this selection will be discussed in more detail in the next section, suffice it to say that this is important habitat for the herd at its current numbers, and should the "expansion" of WAH animals into this area occur as Carruthers (1983a), Carruthers et al. (1984), and Bergerud et al. (1984) predict, this habitat may become even more important as the number of animals using it increases.

2.3.2 Habitats Receiving Intensive Use by the CAH

Two types of habitats receive intensive use by the CAH--concentrated calving areas, and coastal mosquito relief areas. Other types of habitat may be utilized intensively but these have yet to be identified, possibly because most research on the CAH has been carried out during the summer. Research beyond the summer period has been primarily aerial surveys (e.g., Cameron et al. 1983, Carruthers et al. 1984) at varying intervals throughout the year. Results of these surveys have suggested that concentrations of CAH animals do not frequently occur at other times of the year except during the rut (ibid.) which does not appear to occur at a location consistent from year to year.

We assume that selection of certain types of habitat by proportionately large numbers of animals over a period of years indicates that use of these habitats confers some advantage to the animals, and that a reduction or loss of access to these habitats is likely to be a disadvantage (e.g., Bergerud et al. 1984, Cameron 1983, Gunn and Miller in press, Whitten and Cameron 1985). The identification of the patterns of use and the features that result in the selection of these intensively used habitats by caribou can assist us in interpreting the long-term as well as immediate importance of these types of habitat to caribou of the CAH.

The patterns of use of the two concentrated calving areas of the CAH have been discussed in a previous section and will be only summarized here. Parturient caribou move to the calving areas in mid-May, calve between approximately May 23/June 10, and then form large aggregations on or near the calving area. Immediately following calving, maternal cows and their newborn calves tend to gradually join with other cows and calves and remain relatively sedentary on the calving area. This sedentary period may be critical in allowing the cow and newborn calf to establish strong social bonds (A. T. Bergerud 1985 pers. comm.; Lent 1966; White et al. 1981). In the CAH these "post-calving aggregations" often occur prior to significant mosquito activity (Lawhead and Curatolo 1984, Murphy 1984); however, they can occur at the same time that mosquito harassment increases (Murphy and Curatolo 1983).

Fleck and Gunn (1982), Gunn and Miller (in press), Kuropat (1984), Kuropat and Bryant 1980, Lent (1980), and Whitten and Cameron (1985) have discussed a number of attributes of calving areas in several Arctic herds, including vegetation, topography, weather, and low predator density.

Fleck and Gunn (1982) reviewed attributes of the Bathurst, Beverly, and Kaminuriak herds of northern Canada. Calving caribou have been found in the same locations during 54 surveys of these herds between 1957 and 1985 (Gunn and Miller in press). Vegetation abundance and composition on these calving areas did not overtly differ from surrounding areas. Vegetation phenology appeared to be retarded by a few weeks compared to surrounding areas although newly emergent vegetation was usually available within 2-3 weeks after calving. Wolves, wolf dens, and bears did not appear to be common; however, the data were somewhat conflicting. Variety in topographic relief characterized the Bathurst and Kaminuriak calving grounds but not that of the Beverly herd. In short, no universal factor or set of factors obviously distinguished the calving grounds of these herds from surrounding areas in the same herd's range. The authors concluded that "the most obvious characteristic of the calving grounds is that cows traditionally return there to calve."

Kuropat (1984), Kuropat and Bryant (1980), and Lent (1966, 1980) have described attributes of the core calving area of the WAH in the Utukok River uplands. Caribou have returned to calve in that area since the early 1960's, and possibly since the late 1800's (Lent 1966). The interaction of topographic and meterological features results in earlier snowmelt and advanced vegetation phenology on the core calving area compared to surrounding areas in the foothills. As a result of this interaction the emergence of cottongrass (Eriophorum vaginatum), a highly nutritious and digestible forage, occurs during and immediately after calving. Additional highly nutritious species also become available shortly after nutrients in cottongrass begin to decline. Kuropat (1984) believes that not only does the availability of this nutritious and digestible forage provide an early source of energy for the lactating cow, but it may also facilitate earlier grazing by the calf thus giving them a boost in summer growth. Although the presence and timing of nutritious forage may explain why maternal cows use the Utukok uplands instead of adjacent areas in the North Slope foothills, these features alone do not explain why WAH caribou do not calve on the South Slope of the Brooks Range, where forage is available even earlier than on the Utukok uplands, and through which cows migrate to reach the core calving area. One reason for this puzzling behavior may be that predator densities may be higher on the South Slope; therefore, calving areas are located on the North Slope where predator densities are assumed to be lower (J.L. Davis pers. comm., 1984). Wolf densities in the North Slope foothills have fluctuated considerably since the 1950's, were low in the mid 1970's (Stephenson 1979), and have remained low since then (Barnett 1983). During caribou calving the core calving area has the highest grizzly bear density of any area on the North Slope (1/43 km^2 [1/17 mi^2]), and this high bear density appears to be a direct result of the proximity of the calving area (Reynolds 1979). Although the presence of this high density of bears appears superficially to argue against the hypothesis that calving areas are located in areas of relatively low predator density, the absolute density of total predators, including bears (Reynolds 1979), may be lower than that on the South Slope. However, at present there are insufficient data to reliably test this hypothesis.

Roby (1978), Whitten and Cameron (1980), and Whitten and Cameron (1985) have discussed attributes of the CAH calving concentration areas. The coastal areas are not characterized by better forage conditions than are areas further inland; however, these areas are characterized by a generally lower density of predators and by proximity to coastal mosquito relief areas. Vegetation phenology is advanced in the foothills relative to that on the coastal plain. Therefore, CAH cows migrating to the coast leave a relatively snow-free area with good forage availability to calve in areas along the coast that are often at least partially snow-covered and generally wetter than are areas in the foothills. Although Whitten and Cameron (1980) and White et al. (1975) analyzed the nutrient value of forage in the CAH range, the analysis did not include forage from either of the calving concentration areas, and the forage may be of better quality or availability in these areas. The coastal plain is generally freer of predators than the foothills and the location of the CAH concentrated calving area may be in response to that (Roby 1978). It is difficult to test this hypothesis because wolves have been essentially eliminated from the CAH range since 1977, and bears have never been particularly numerous. One attribute of the CAH concentrated calving areas is that they are both located within 24 km (14 mi), and often within 8 km (5 mi) of the coastal mosquito relief habitat (Whitten and Cameron 1985). This attribute is shared by the TLH (Reynolds n.d., Silva 1985) and the PH (Whitten et al. 1985) although the latter leaves the coastal plain during post-calving and moves east into the Yukon Territory (ibid.).

There appears to be no universal attribute, or set of attributes, that characterizes all calving areas that receive what we would consider traditional use by caribou. Some herds calve in areas that provide high-quality forage (e.g., WAH) but other herds apparently do not (e.g., CAH, Beverly, Bathurst, and Kaminuriak herds). Predator densities are low on some herds' calving areas (e.g., CAH) but are not necessarily low on others (e.g., WAH, PH). Access to coastal mosquito relief habitat is a common attribute of the CAH, TLH, and PH, whereas the WAH moves to upland areas in the foothills and mountains of the Brook Range during mosquito season (Davis and Valkenburg 1979; pers. obs.). Nevertheless our failure to understand <u>why</u> caribou continue to use these areas year after year should not overshadow the fact that they do, and that this use has continued in spite of caribou and predator fluctuations and the vagaries of weather.

The second type of habitat receiving intensive use by CAH is coastal mosquito relief areas. In contrast to the utilization of the concentrated calving areas utilization of coastal mosquito relief areas has immediate and observable benefits to the individuals--relief from harassment by mosquitoes. Movements to and utilization of coastal mosquito relief areas are fairly predictable because the intensity and duration of mosquito harassment can be predicted reliably if temperature and wind conditions are known (cf. section 2.2.1). In mild stages of harassment by mosquitos, caribou move in small groups into the wind and toward the coast. As the intensity of harassment by mosquitoes increases from moderate to severe, or under conditions such as prolonged moderate harassment, caribou form large groups that number several hundreds to thousands of cows, calves, yearlings and bulls. These groups move rapidly into the wind and along the coast where they congregate on coastal dunes, beaches, promontories and river deltas. Caribou remain on these wind-swept and vegetation free areas until harassment by mosquitoes abates. As mosquito harassment abates (for example, during the night when temperatures usually drop, or during prolonged periods of cool, windy weather) animals drift inland to feed. This pattern of movement has been observed for the eastern and western portions of the CAH, as well as the TLH (Reynolds n.d., Silva 1985). This drift inland demonstrates that these coastal areas are not optimum foraging areas; therefore, their primary function is to provide relief from mosquitos. However, the proximity of mosquito relief areas to the concentrated calving areas may in itself be a significant feature, especially for maternal cows with young calves which have limited mobility and endurance.

The importance of access to coastal mosquito relief habitat can only be speculated upon at this time. Presumably, it is important to caribou to minimize mosquito harassment by moving to coastal areas where forage is less desirable than further inland. Comparisons of body condition have not been made between maternal cows and their calves that utilize coastal areas (as almost all the CAH cows do) and the comparatively few that remain inland during mosquito season. Likewise, comparisons of calf survival have not been made between maternal cows in the aforementioned situations. However, there is evidence that points to the link between summer nutrition of cows and their ability to raise a calf the following year, and to early nutrition of the calf and its ability to survive not only the first summer, but also the following winter. Although forage nutrient content is an essential component of the summer forage cycle the availability of time for foraging and the ability to avoid engaging in energy-consuming activities, such as running from mosquitoes, is equally important (Dauphine 1976, Reimers 1980, Reimers 1983, Thomas 1982, White et al. 1981).

Dauphine (1976) investigated seasonal fat cycles and reproduction in caribou of the Kaminuriak herd in Northwest Territories and concluded that "... the full recovery of both sexes of all fat deposits in summer appeared to be of critical importance to reproduction, growth, and winter survival." Caribou are adapted to marginal subsistence during the winter, but must rely on full nutritional recovery during the summer. Disturbance on the summer range, such as by predators, humans, or insects, which can decrease forage intake or provoke energy-consuming activities such as running, may result in insufficient nutrition during the summer, and can cause cows to miss conception at some point in order to "catch up" on their nutritional reserves (ibid.). Malnutrition in calves may be a direct result of the calf not obtaining sufficient forage energy later in the summer when it feeds on its own, but can also be affected by its birth weight (Skogland 1985) as well as the cow's ability to provide the calf with energy during lactation. Dauphine (1976) believes that malnutrition is rarely a direct cause of death in Kaminuriak herd calves; however, it probably renders calves more vulnerable to other forms of mortality.

The link between nutrition and reproduction has been studied in Peary caribou inhabiting the High Arctic Islands of northern Canada (Thomas 1982). Peary caribou females apparently fail to conceive following a severe winter when fat reserves obtained the previous summer and overutilized the following winter cannot be sufficiently compensated for during the following summer (ibid.). The demands of pregnancy can also catch up with Peary caribou cows even in the absence of unusually severe weather. After several years of raising a calf, cows may skip conception for one or more seasons. Although the situation with Peary caribou is not directly analagous with that of the CAH, primarily because the former live in an extremely harsh region where weather-related population die-offs are common, it does point out that caribou nutrition and reproduction are related.

The link between nutrition and reproduction and calf survival has been further confirmed by Skogland (1985) studying several wild reindeer herds in southern Norway. Skogland (1985) related the condition of the female in late winter with the body size of her calf at birth and with the date of birth. Apparently, calves must reach a minimum size before parturition can occur. Calves that did not reach this minimum size until later in the calving season often had reduced post-natal survival during the first summer and winter because they were unable to make up this weight. Young cows on poorer quality range also conceived one or two years later than cows of the same age on better quality range, and this failure to conceive also correlated with a minimum body size at breeding season. Although Skogland (1985) has emphasized winter nutrition, Reimers (1980, 1983) and White et al. (1981) believe that summer nutrition is an important determinant of individual body size, and hence of conception and calf survival. White et al. (1981) also emphasize that there is no a priori reason to disregard either summer or winter nutrition as important to mainland caribou herds. Herds living on Arctic islands, such as Peary caribou and Svalbard (Spitzbergen) reindeer, are in a negative energy balance for 10 months of the year and require an abundance of high quality summer forage and minimal disruption of feeding (Reimers 1980) for survival. Reimers (1980, 1983) emphasizes that in regards to mainland reindeer herds disruptions to foraging that are caused by disturbance due to insects, predators, or humans, can seriously affect herds that are on poor quality summer or winter range.

The Norwegian and High Arctic island examples do not directly relate to the current condition of the CAH. The densities of wild reindeer herds in Norway far exceed those of the CAH, and this type of "grazing syndrome" (cf. Skogland 1985) is unlikely to occur at current CAH densities. Likewise, the CAH does not inhabit High Arctic islands where weather conditions are severe and forage availability unpredictable. These examples do, however, serve to relate the potential importance of disruptions of foraging in summer in terms of changes in conception and survival rates. The Kaminuriak herd example is probably more closely analagous to the CAH. The Kaminuriak herd at the time of Dauphine (1976) study had a density of 1 caribou/4.5 km^2 (1 caribou/1.75 mi^2) (calculated from Dauphine 1975) as compared to the current density of the CAH of 1 caribou/3.2 km^2 (1 caribou/1.21 mi^2) (calculated from Carruthers et al. 1984; Cameron, pers. comm. 1985). Although densities are somewhat similar between the CAH and Kaminuriak herds, the latter herd migrates 640 km (380 mi) between forested winter range and the calving area whereas the former remains on the North Slope year-round and a portion winters on its summer range. These characteristics suggest that there is greater potential for summer foraging reduction to have demographic effects on the CAH. Nevertheless, there has been no documentation to date that recruitment is a problem in the CAH, or that disruptions of foraging during summer have led to demographic responses.

The observed intensive use of coastal mosquito relief habitat and the importance of summer nutrition (ability to forage effectively as well as selection of nutritious forage) in the life cycle of CAH caribou argue for maintaining coastal mosquito relief habitat as a viable part of the CAH ecosystem.

3.0 IMPACTS

3.1 INTRODUCTION

As has been discussed earlier (ref. subsection 1.2) our definition of impact is an effect on the ecosystem of caribou such that there has been a reduction in habitat quality or availability, or the individual animal's ability to utilize that habitat, between the ecoystem prior to development and the ecoystem during and after the development. The emphasis on habitat-related effects is a consequence not only of the management authority of Habitat Division but also of the recognition that the long-term and spatially extensive characteristic of most activities associated with large development projects results in habitat effects that are essentially irreversible. Because of this characteristic, management of habitat, as opposed to management of populations (e.g., through controls on human or predator harvest), necessitates a more conservative approach. The linkage between characteristics of caribou habitat and habitat utilization and population demographics have been discussed briefly in subsection 2.3.2; this linkage will be further explored in subsection 3.1.1 where the two major "schools of thought" about factors that control caribou populations are presented. In addition two "case histories" involving effects of human development activity on wild reindeer habitat utilization will be discussed in subsection 3.1.2. One of these, the Norilsk pipeline in northern Siberia, has resulted in loss of winter habitat and migration routes between summer and winter range; however, the net effect on the population has not been demonstrated. The second case history, the transportation corridor and associated activity across the Dovrefell plateau in southern Norway, has shown that interruption of movements and avoidance of developments have resulted in demographic characteristics of lowered reproduction, as well as reductions in individual body size and other features.

In the following subsections the impacts of direct habitat loss, harassment, avoidance of develoment, disruption of movements, and increase in predators or human harvest are addressed.

3.1.1 "<u>Schools of Thought</u>"

Our definition of impact in terms of utilization or availability of habitat to caribou is not unanimously shared in that there are two major "schools of thought" concerning the relative importance of factors that may affect caribou populations. Although there is considerable overlap between the schools, the relative emphasis which each school places on habitat relationships is different. One school of thought has already been discussed in section 1.2. This school of thought emphasizes the importance of habitat relationships such as the quality, quantity, and availability of forage, and the animal's ability to utilize it effectively without adverse effects on grazing. Although this school of thought recognizes the importance of predation and human harvest in controlling caribou populations in the short term, it views these factors as less important over the long term. Proponents of this school of thought are likely to view the impacts of a pipeline in terms of access to forage or effects on grazing.

The second school of thought is most thoroughly articulated by Bergerud (1978) and by Bergerud et al. (1984). Proponents of this school of thought feel that habitat relationships in terms of forage availability and utilization are a relatively insignificant factor in North American caribou life history as compared with the effects of predation and human harvest. This school of thought views habitat relationships in terms of predator avoidance, therefore the foremost component of habitat is space--space in which to avoid predators. Proponents of this school of thought are likely to view the impacts of a pipeline in terms of its effects on physically restricting caribou movements so that caribou become less able to escape from predators, or by creating other conditions conducive to increased predation, and by the potential for creating increased access by hunters to caribou.

These schools of thought are not mutually exclusive, and most caribou biologists are philosophically distributed along a continuum between the two schools.

3.1.2 Case Histories

There are two case histories that demonstrate the effects of linear developments on Rangifer. The first case is that of the Norilsk gas pipeline corridor in the Taimyr region of the Soviet Union (figure 4). In this case a gasline corridor disrupted fall and winter migration of wild reindeer, and resulted in deflecting these migrations to adjacent areas. Soon thereafter the reindeer abandoned a portion of their winter range because they were unable to reach it. The second case is that of the Snohetta herd in the Dovrefjell region of southern Norway. In this case a highway and railroad corridor across a wild reindeer range resulted in a cessation of migration between summer and winter range, and eventually in a decline of the population when the animals spent both winter and summer on summer range and overgrazed their range.

In the 1940's an electric railroad was established between the industrial (primarily mining) center of Norilsk and the port of Dudinka, which linked the Kara Sea to the north with the railroad line (figure 5). The Yenisey River was kept open into late fall to Dudinka by icebreakers. This industrial complex is located within the range of the Taimyr wild reindeer herd. In the early 1960's the general pattern of fall migration in this area had been for reindeer to spend the summer in the north near Lake Taimyr, and for the major portion of the herd (several hundred thousand animals) to migrate southeastward to winter ranges in the Putorana Mountains and for a smaller portion of the herd (a few tens of thousands) to move southward across the Yenisey River near Ust'port (figure 5) and generally to the south and west onto winter range (Syroechovskii 1984). In fall of 1967, movements changed so that the majority of the herd moved southward and came into contact with the railroad and road corridor between Norilsk and Dudinka because they had been unable to get across the Yenisey River farther north due to the broken ice and open water caused by ice breakers (Geller and Borzhanov 1984). Many animals drowned in the attempted crossing of the

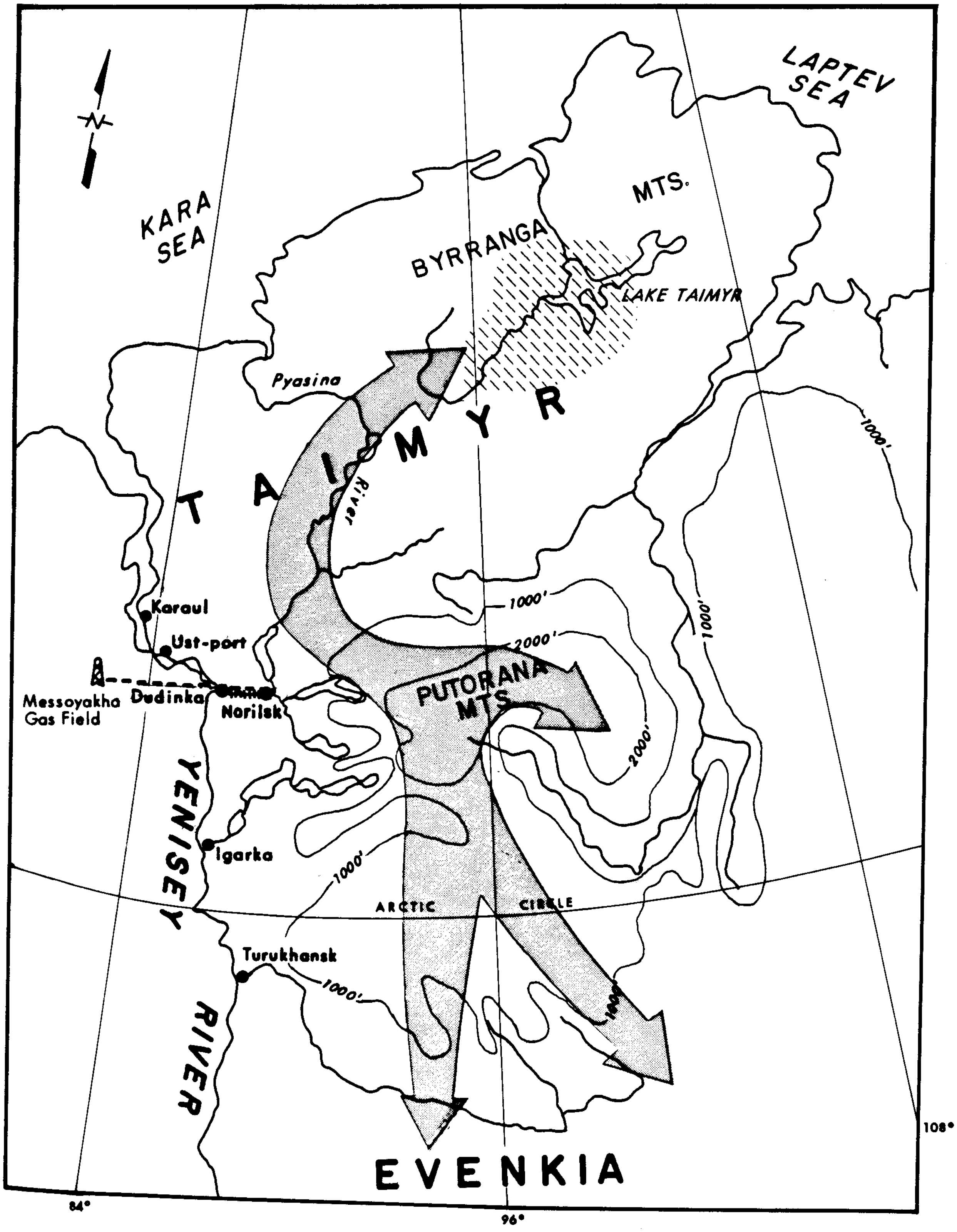


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Fig. 4. Caribou Movements in the Taimyr Region, USSR.

TOWNS

PIPELINES

RAILROAD

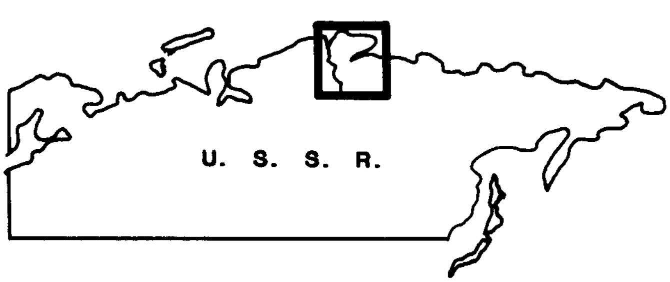
GAS FIELD

1000' MSL

2000' MSL

CALVING AREA

GENERAL MIGRATION ROUTE



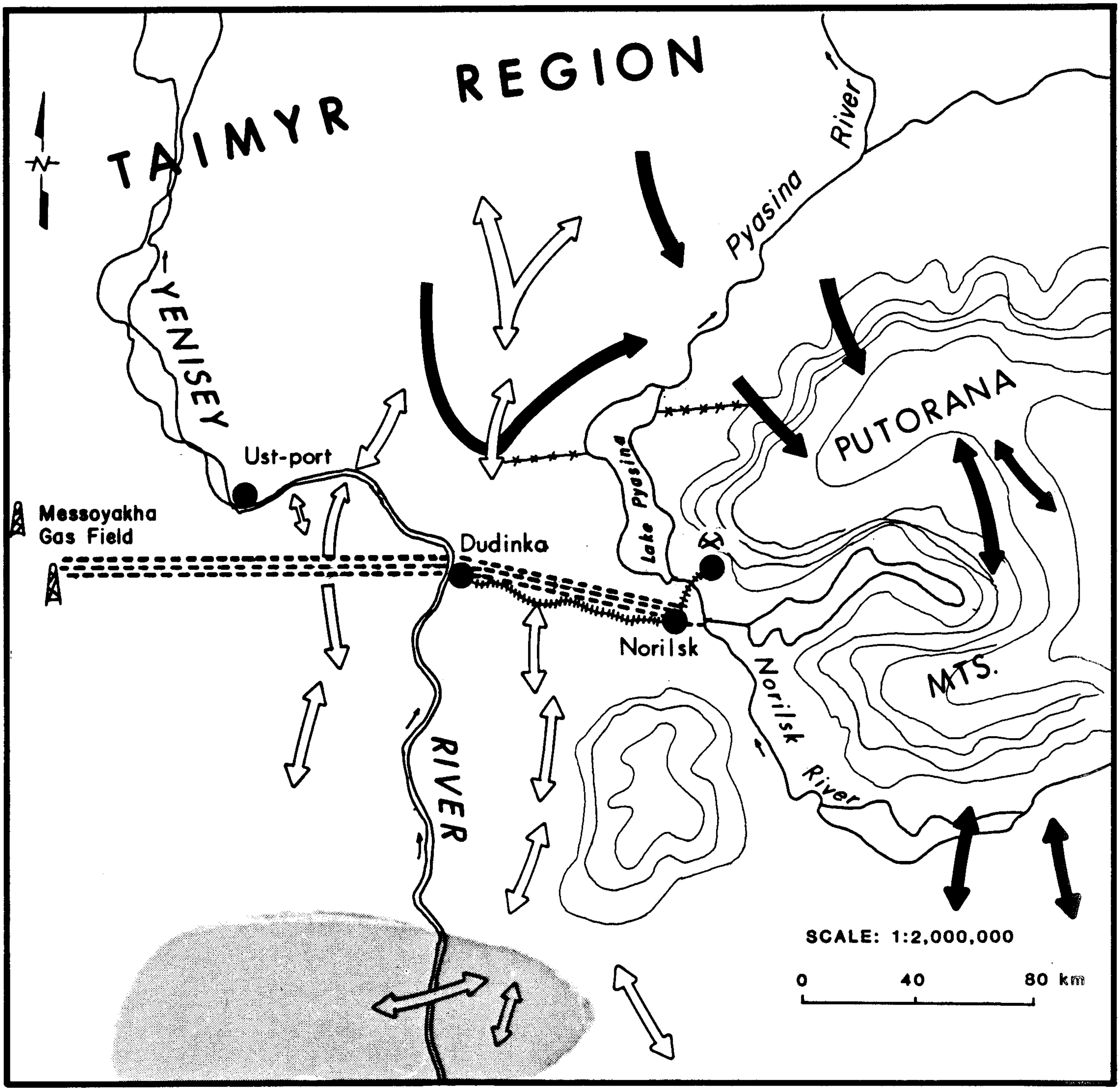
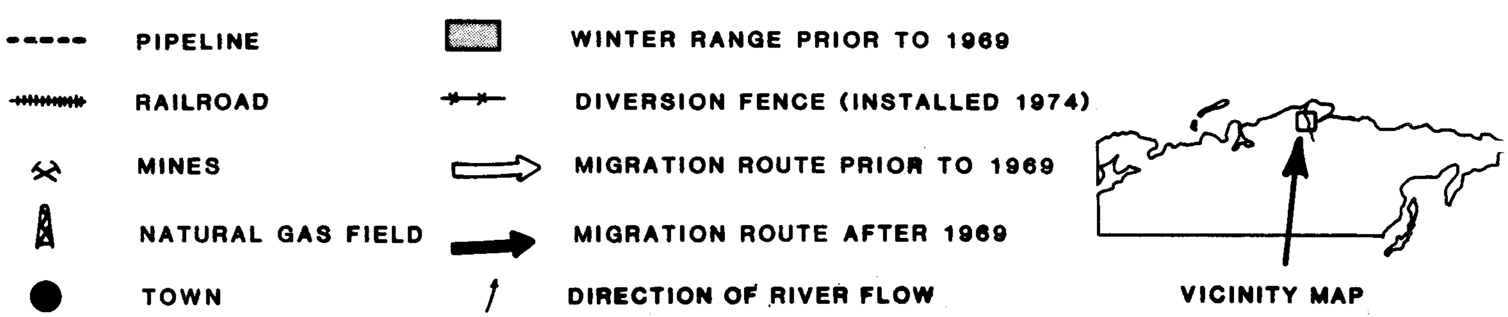


Fig. 5. Caribou Movements and the Norilsk, U.S.S.R., Transport Corridor. (After Jakimchuk 1979; Klein 1984, pers. comm.; V. Lazmakhanin 1985, pers. comm.; Skrobov 1972; Soviet base map courtesy of D.R. Klein)



Yenisey River, or were injured or killed in collisions with trains between Norilsk and Dudinka. Most of the herd moved onto winter ranges into Evenkia (figure 5) or west across the Yenisey River. In spring 1968 the reverse movements occurred, and wild reindeer again came into contact with the railroad corridor where mortality from collisions with trains occurred, and animals wandered through the city of Norilsk in an attempt to circumvent the railroad corridor and the water pipeline between the city of Norilsk and the Norilsk River (ibid.). In fall 1968 a majority of the herd again moved through the Norilsk area--mortality of calves due to drowning while attempting to cross the ice-choked Yenisey River was again documented (Skrobov 1984), and animals were again diverted into the Norilsk area, eventually moving south to the same wintering areas they had used in 1967.

In 1968-69, construction was completed on a 60 cm (24 in) diameter gasline connecting Norilsk with the Messoyakha gas fields located 150 km (90 mi) to the west (figure 5). This pipeline was elevated 1 m (3 ft) above the ground, and paralleled the Norilsk-Dudinka railway corridor for part of its length. No reindeer crossing structures were provided although occasional topographic changes (e.g., ravines) resulted in sections of the line being elevated 2-3 m (6-10 ft) above the ground. The first encounter with the pipeline by reindeer occurred during their spring migration northward in 1969, when tens of thousands of cow groups, after crossing the railroad (which also deflected and halted movements somewhat) encountered the pipeline, and "ran back and forth" until they encountered a ravine or an area of drifted snow where they could cross (Skrobov 1984). Many of the groups would not cross the pipeline, and returned to the railroad track. Many groups deflected westward between the railroad and pipeline until they encountered the port of Dudinka, or until they reached a buried section of the gasline where it crossed the Yenisey River. Although train traffic was limited in order to allow animals to cross, some animals remain stranded into the summer--over 20,000 animals, mostly cows, were still south of the corridor in late May (Klein 1980; Skrobov 1984). Zabrodin (1984) reported that a higher than normal incidence of warbleflies was reported for a portion of the Taimyr herd in 1970, and he attributed this to the fact that reindeer had been delayed farther south than normal because they were unable to get across the Norilsk pipeline.

Harassment because of hunting may have contributed to the disruption of migration. According to Skrobov (1984) "...poaching increases near Norilsk at the time of reindeer migrations. In 1969 ... they had killed 300 reindeer, undoubtedly a very conservative estimate."

In fall 1969, reindeer diverted around the Norilsk-Dudinka area, and did not encounter the pipeline/railroad/highway corridor. Subsequent movements were not as large as those in 1967-68; however, in 1970 a second gasline was constructed parallel and 1 km (½ mi) away from the first. During the period between 1967-70 due to the widespread public reaction and outcry from the Soviet scientific community, the government retrofitted the pipeline with sections of pipe elevated 3-6 m (10-20 ft) above the ground, 75-100 m (225-300 ft) wide and at intervals of 3-4 km (2-2½ mi) in order to provide crossing locations for the reindeer (Klein 1980). Many of the reindeer were still unable to negotiate both pipelines so fences were constructed between the two pipelines to divert the animals from crossings on one pipeline to adjacent crossings on the other. By 1970 the total number of reindeer using the Norilsk-Dudinka area for migration had declined to only several tens of thousands. Only one-quarter of those encountering the corridor managed to cross it--the rest either remained in the area, or diverted through the Norilsk industrial complex. After several years in which many of the reindeer apparently failed to accommodate to the crossing structures, a large wing fence was constructed (presumably in 1974 or 1975) northwest of Norilsk to divert animals completely from the area and into previously lightly used winter range in nearby Putorana Mountains (Klein 1980) (figure 5). This fence, which also utilizes a large lake as part of the barrier, consists of two segments totalling 56 km (34 mi).

Since the wing fence was constructed, the Taimyr herd wintered primarily in the Putorana Mountains and did not migrate across the Yenisey River (Klein pers. comm., 1984). The Taimyr herd has increased to 800,000 animals as of 1985, but does not use the historic winter range along the Yenisey River (V. Lazmakhanin 1985, pers. comm.). Serveral years ago a portion of the herd again deflected into Norilsk during spring[?] migration (ibid.). The population total for the Taimyr herd may also include that of two adjacent herds; however, the Taimyr herd has increased considerably in the past 10 years.

There are several conclusions from the Norilsk case history: (1) the transportation corridor, by virtue of its geographic location, disrupted movements and caused local destruction of winter range (primarily lichen range) prior to the construction of the first pipeline; (2) the gas pipeline initially created a physical barrier to movements, however even after it was retrofitted with crossing structures, many reindeer did not cross the structures and either deflected around the complex entirely, or remained in the area later than the usual season of use; (3) although no widespread direct population effects were observed, mortality due to collision with trains and drowning due to deflections into the Yenisey River, did occur; and (4) physical barriers that were erected to deflect wild reindeer away from the Norilsk area also disrupted their movements to a portion of their historic winter range and this winter range has been abandoned by wild reindeer for the past ten years. In spite of these disruptions the Taimyr herd has had sufficient alternative range available to allow the herd to double in size over the past 10 years.

Bergerud et al. (1984), Jakimchuk (1980), Skogland (1985), and Skogland and Molmen (1980) have summarized the available information about the history of the Snohetta herd of mountain caribou in southern Norway (figure 6). Unless otherwise stated, the following summary is from Skogland and Molmen (1980). Archaeological and biological investigations have indicated that wild reindeer have inhabited the Snohetta region at least periodically since 1100 A.D. Due to the increased use and efficiency of firearms, hunters in the late 19th century reduced wild reindeer to the point that in 1920-25 it was believed that the Snohetta herd numbered only a few hundred individuals. Bergerud et al. (1984) mention that in 1900, the herd numbered 1,000, and that 250 of them were on the Knutsho range and the remainder on the Snohetta range (figure 6). Traditional migration patterns were to winter in the Rondane and Knutsho areas in the eastern portion of the Dovrefjell region, and to migrate westward to the Snohetta area to calving and summer ranges. However, these migrations ceased when the herd was at extremely low numbers

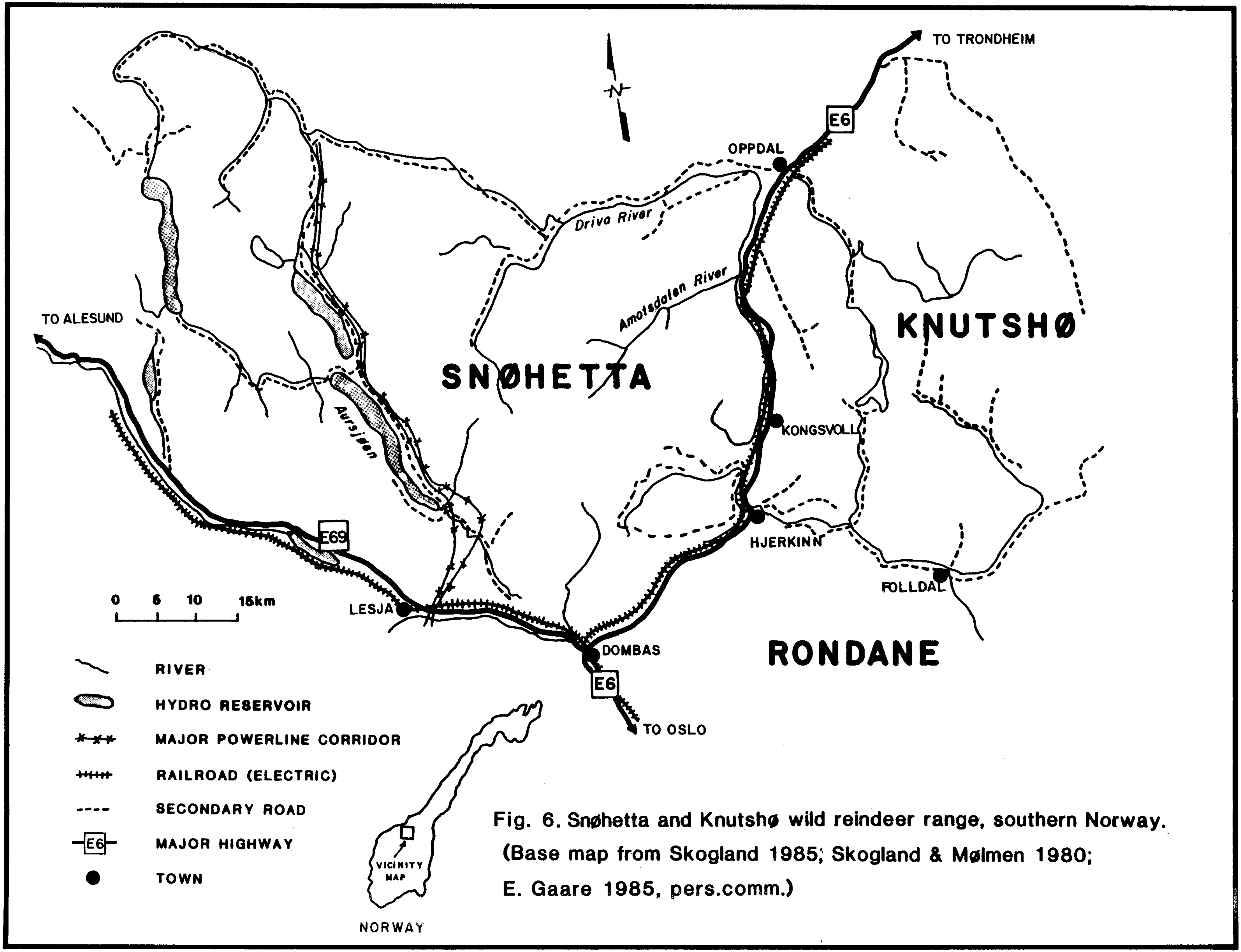


Fig. 6. Snøhetta and Knutshø wild reindeer range, southern Norway. (Base map from Skogland 1985; Skogland & Mølmen 1980; E. Gaare 1985, pers.comm.)

in the 1920's, and the herd remained year-round on the Snohetta range. The literature is unclear about whether or not there were two separate herds, or only one herd entirely on the Snohetta range. In 1921, construction of a railroad across the Dovrefjell began, and continued to the 1930's. During the railroad construction period, no animals crossed from the Snohetta to the Knutsho area. The herd gradually increased [in the 1930's, presumably] so that a controlled hunting program was in place. During World War II, Nazi occupation forces prohibited hunting and the herd increased to 10,000 animals by the 1950's (figure 6 in Skogland and Molmen 1980). Between 1946-53, several large hydroelectric projects flooded much of the calving areas in the Snohetta region, and a series of roads and transmission lines crossed several of the Snohetta calving areas which had been in use even during the early 1900's when the Snohetta herd was at low numbers (figure 6). Reindeer use of some of these calving areas ceased when the areas were inundated but other areas were abandoned because of the increased disturbance to the animals that was caused by activity along roads and by other developments such as powerlines (Skogland and Molmen 1980). During this period (1950's) a road, paralleling the railroad, was constructed across Dovrefjell. By the middle of the 1950's, the Snohetta group numbered 15,000 animals. Marked destruction of lichen range in the Snohetta area was documented. The destruction occurred because not only had animals remained year-round on what had previously been only summer range, but also because the herd had outgrown the available forage even if it had used the Snohetta area only during summer.

During the severe winter of 1956, approximately 200-600 animals moved across the highway and railroad to the eastern (Knutsho) side of Dovrefjell, probably as a result of starvation on the western (Snohetta) side (Jakimchuk 1980). A reduction hunt was initiated in 1960; however, in 1965 winter starvation on the Snohetta range was still high in spite of the fact that the Snohetta group had been reduced to 1,500 animals (figure 6 in Skogland and Molmen 1980), and that approximately one-third of the group had migrated to Knutsho in winter. During the 1960's the road was upgraded, and in the 1970's became a major travel route (E. Gaare 1985, pers. comm.). In 1972, high water in the Driva River along the road/railroad corridor prevented parturient cows on the Knutsho range from migrating to calving areas on the Snohetta range (Jakimuchuk 1980). Since then Knutsho animals have remained on their range to calve. Apparently, a portion of the Snohetta group also now migrates to Knutsho during the winter, crossing the highway at night when traffic is less (E. Gaare 1985, pers. comm.). The situation as of the early 1980's was that a portion of the Dovrefjell reindeer remained year-round in the Snohetta area, a portion summered in the Snohetta and wintered in the Knutsho region, and a portion remained year-round in the Knutsho (Skogland and Molmen 1980). However, for the past 3 winters the entire Snohetta herd has remained year-round on the Snohetta side of the transportation corridor (E. Gaare 1985, pers. comm.).

Skogland and Molmen (1980) conclude that: (1) hydroelectric development in the west and the transportation corridor on the east have acted as "semibarriers" to movements between seasonal habitats; (2) reindeer have been able to adjust to structures associated with the development (e.g., roads, snowfences, and a railroad), however the associated human activity has caused avoidance of many areas as well as disruption of traditional migration routes; and (3) overgrazing and destruction of lichen winter ranges has been caused by the restriction of migration. Bergerud et al. (1984: p. 15) however, argued that "the halt in migration was probably a result of a contraction of the range because the herd's numbers were low." Although Bergerud et al. (1984) may be correct that the construction of the Dovrefjell railroad may not have been directly responsible for the cessation of migration in the 1920's, they do not address the observation that migration to Knutsho did not begin again until the Snohetta group had experienced widespread starvation and a severe winter. Topographic barriers to movements are few along the historical migration routes, and it seems likely that reindeer would not remain in the same area until starvation forced them to move elsewhere unless some other feature of their environment, such as a transportation corridor, were restricting their movements. Furthermore, Bergerud et al. (1984) do not address the fact that use of the traditional calving areas in the western portion of Snohetta had virtually ceased by all but a few bulls after the road and powerline corridors and the hydro reservoirs had been constructed. The evidence points to human developments as being responsible for the herd's decline.

These two cases illustrate that linear transportation systems can disrupt movements between seasonal ranges to the point that utilization of portions of their habitat is eliminated. In the Norilsk case there have been no population effects documented, however this herd is similar to many North American Arctic herds in that wild reindeer densities were very low. The Snohetta case provides evidence of a demographic effect--the herd would have starved because of overgrazing its range if a reduction hunt had not been carried out in the 1960's. Since then animals of the Snohetta herd have been characterized by small body size and reduced reproduction in comparison with the adjacent Knutsho herd, due to the overgrazed condition of the Snohetta winter range (Skogland 1985).

3.2 DIRECT HABITAT LOSS

One immediately visible result of oil field development is the proliferation of roads, drill pads, and pipeline work pads that is necessary to provide access for vehicles and equipment and a stable, all-weather working surface that will support heavy equipment such as drill rigs. On much of the North Slope, pads and roads are constructed of gravel that is placed and compacted directly on the ground, thus destroying the underlying vegetation. Additional vegetation is destroyed when material sites are excavated in order to provide the gravel for roads and pads; however, the greatest amount of vegetation damage or destruction in addition to that covered with gravel is due to temporary or permanent ponding on the uphill side of roads and pipeline workpads when inadequate drainage structures (such as culverts) are placed in these roads or workpads. Walker et al. (1984) have determined that ponding accounts for vegetation loss equivalent to more than one-third that of gravel overlay (cf. table 11, ibid.). Additional losses or changes in vegetation occur when "fugitive" dust from the road systems covers nearby vegetation, or from minor oilspills or unauthorized off-road vehicle travel (ibid.).

Although not all plant species or vegetation types are of equal value to caribou, or are even used by caribou, the current oil fields are located in the summer range of the CAH, and many forage species and plant communities are utilized by caribou during this period (White et al. 1975). Therefore, we assume that all vegetated areas within the Prudhoe, Kuparuk, and Milne Point fields are potential caribou forage and that the overlaying of these vegetated areas with gravel for roads, pads, etc. causes a direct loss of caribou habitat. Walker et al. (1984) have used remote sensing and automated mapping techniques in combination with field verification in order to calculate the area of the Prudhoe Bay oil field that has been covered with gravel. Similarly, we have estimated the amount of area covered by gravel in the Kuparuk and Milne Point fields. These data are combined in Table 2 and show that as of 1983 approximately 7,901 acres (3,186 ha) have been covered with gravel in the Prudhoe, Kuparuk, and Milne Point fields. The data for the Kuparuk and Milne Point fields are probably conservative in estimating the amount of habitat lost because they do not include small pads that are not apparent from a 1/63,500 scale map, and do not consider losses due to ponding, fugitive dust, or oil spills. However, even if the amount of direct habitat loss (i.e., vegetation covered by gravel) were an order of magnitude larger, it would be of minor significance when compared to the amount of habitat that would become unavailable because caribou avoid developments, and when compared to the total summary range of the CAH.

3.3 HARASSMENT

The overt responses of caribou to overflying aircraft and to the approach of ground vehicles and "pedestrians" (e.g., hikers) have ranged from a minor change in ongoing behavior, such as a simple orientation toward the direction of the stimulus, to strong escape reactions such as panicked running. Conflicting conclusions about the importance of these responses to the animal's habitat utilization and survival have been reached. Harassment by aircraft can cause caribou injury or death resulting from strong escape reactions, especially when animals are in large, mosquito-harassed groups (Calef et al. 1976, Roseneau and Curatolo 1976), increased energy expenditure as a result of escape responses and disruption of grazing (Calef et al. 1976), increased calf abandonment due to disruption of the cow-calf bonds immediately after calving (A.T. Bergerud, pers. comm., 1985; Lent 1966), and long-term abandonment of range (Calef et al. 1976). Bergerud (1978), Bergerud et al. (1984), and Valkenburg and Davis (1985) acknowledge that caribou can react strongly to harassment by certain types of disturbance; however, they maintain that caribou can habituate to these types of disturbance, and furthermore, that there is no empirical evidence that links harassment with demographic consequences or range abandonment by North American caribou. In spite of these seemingly conflicting points of view even the latter investigators conclude that unnecessary harassment, especially on the calving grounds, should be avoided (e.g., Bergerud 1978).

For the purposes of this report "harassment" is defined as a specific human activity that results in an overt change of an animal's behavior such that the behavior as a result of harassment would be considered more bioenergetically "expensive" to the animal or that could result in injury to the animal. Such behavioral changes can range from cessation of feeding to increased locomotion (e.g., from walking to running). The animal probably perceives the source of the harassment (for example, an airplane) as a potential predator or pest (e.g., warble fly); however, it is possible that it is merely reacting to a sudden novel stimulus.

Table 2. Area covered by gravel, Prudhoe Bay and Kuparuk oil fields, to 1983

	Construction pads[1] ac (ha)	Roads[2] mi(km)	ac(ha)	Material Sites[3] ac (ha)	Total ac (ha)
Prudhoe[4]	4182(1693)	209(348)	1193(483)	---	5375(2176)
Kuparuk[5]	1213 (485)	76(122)	461(184)	652(261)	2326 (930)
Milne Pt. Unit	91 (36)	18 (29)	109 (44)	66 (26)	266 (106)
Total	5486(2214)	303(499)	1763(711)	718(287)	
GRAND TOTAL					7967(3212)

1) Pad size in Prudhoe field measured from air photos (cf. Table 11 in Walker et al. 1984); pad size in Kuparuk field and Milne Pt. Unit scaled from 1/63,000 maps, or estimated as 1000' x 1000' (330 m x 330 m)

2) Roads in Prudhoe field measured from air photos (cf. Table 11 in Walker et al. 1984); roads in Kuparuk field and Milne Pt. Unit scaled from 1/63,000 maps, road width assumed to be 50 ft (16 m) at base

3) Data provided by J. Nolke, pers. comm., 1985; includes excavated area and area covered by stockpiled overburden; Milne Pt. Unit data scaled from airphotos

4) Includes all oilfield development between Sagavanirktok and Kuparuk rivers; data from Walker et al. 1984

5) Includes all oilfield development between Kuparuk and Colville rivers, excluding that within Milne Pt. Unit

Two qualifications should be noted. First, the following discussion will be limited to overt behavioral responses as an indication of harassment because these responses can be most easily monitored. This does not infer that physiological responses (for example, elevated heart rate or change in blood chemistry) do not occur, nor that these are not significant. Second, the indirect effect of hunting (i.e., increasing the animal's reactivity to disturbance) will not be explicitly discussed. Bergerud et al. (1984) and Valkenburg and Davis (1985) have noted that caribou in herds that associate a particular type of stimulus with hunting (e.g., an airplane) appear to be more reactive to that stimulus than are caribou that do not. Third, caribou may react to nonspecific sources of disturbance (e.g., the general level of noise and activity associated with a construction camp) using the same behavioral patterns as though they were reacting to a specific source of disturbance. Reactions to nonspecific sources of disturbance will be discussed in section 3.4 and 3.5.

Harassment by fixed-wing aircraft and helicopters is discussed in section 3.3.1. Harassment by ground vehicles and pedestrians is discussed in section 3.3.2.

[Note: The discussion that follows is synthesized from Volume I; readers desiring further information should consult that volume.]

3.3.1 Harassment by Aircraft

Aircraft transportation is an essential component of oil and gas exploration and development in the Arctic because of the remote nature of most of the region. Increased aerial activity can be associated directly with petroleum development (e.g., seismic surveys, crew shuttles to remote camps, cargo slinging, safety and security inspections) as well as indirectly due to the attraction of aircraft to areas with facilities such as landing strips from which these aircraft can stage flights unrelated to oil development (e.g., sightseeing, hunting, prospecting). Aircraft involved in these activities can range from commercial jets which land at scheduled intervals at developed airports, to bush aircraft which can land in remote locations.

The potential effects of aircraft harassment on caribou include accelerated energy expenditure as a result of increased locomotion which would often accompany severe reactions to overflights, decreased energy intake as a result of interruptions of grazing or ruminating, and injury or mortality resulting from severe escape responses--the latter especially in regards to young calves. Several investigators have questioned the premise that aircraft harassment has a significant adverse effect on caribou productivity. These investigators consider that caribou in most situations can habituate to aircraft as long as the animals do not associate aircraft with a negative stimulus (e.g., hunting) (Valkenburg and Davis 1985), and that caribou can withstand periodic severe disturbance without adverse effects on their productivity (Bergerud et al. 1984). These investigators do not condone harassment nor do they necessarily believe that harassment is unimportant in all cases; however, they provide examples (such as the Delta Caribou Herd in Interior Alaska, and several Newfoundland herds) in which caribou have been subjected to extreme levels of aircraft harassment and this has had no noticeable effect on the herd's productivity. Although several studies have monitored the reactions of caribou to fixed-wing aircraft only three of these (Calef et al. 1976, Davis and Valkenburg 1979, Valkenburg and Davis 1985) used equivalent response categories and are therefore directly comparable. These studies, all of which were conducted in conjunction with other activities (e.g., population censuses, radio-tracking), identified several variables that influence the responses of caribou to fixed-wing aircraft. These variables include aircraft height above the animals, season of the year, group size, and the caribou's previous experience with overflying aircraft. Conclusions from these studies are as follows:

Season: Caribou appear to be most reactive during calving, and during post-calving, especially when in large, mosquito-harassed groups. There are also some indications that caribou in early winter are very reactive to aircraft; however, these data are from studies that are not directly comparable with other studies (e.g., McCourt et al. 1974). In general, overflights of greater than 660 m (2,000 ft) above ground level caused only minor reactions by caribou, although a few observations suggested that when caribou were under severe mosquito harassment, overflights of several thousand feet above ground level caused the animals to gallop wildly.

Group size: There is some evidence that larger groups are more reactive than are smaller groups; however, in the situations for which this evidence was described, other factors such as season of the year could be more influential than group size per se.

Previous experience: Anecdotal observations and the results of systematic data collection have suggested strongly that animals which have had considerable number of aircraft overflights and few chances to associate these overflights with negative experiences (such as hunting) may be less reactive to aircraft.

In almost all studies, aircraft maintaining flight altitudes of 660 m (2,000 ft) above ground level caused little or no disturbance to caribou during any season, and flight altitudes above 300 m (1,000 ft) above ground level caused few strong responses by caribou.

Investigators have reported conflicting results with respect to the responses of caribou to helicopter overflights. Calef et al. (1976) feel that helicopters are potentially more damaging to caribou than are fixed-wing aircraft because helicopters could more easily pursue caribou for long distances. Miller and Gunn (1979, 1980) and Gunn et al. (1985) have conducted the only systematic studies. The former investigators observed the overt responses of Peary caribou, a subspecies inhabiting the High Arctic Islands of Canada. The latter investigators observed the overt responses of Beverly caribou, inhabiting mainland Northwest Territories, to helicopter overflights and various types of simulated landings. The conclusions of Miller and Gunn include the following:

(1) Peary caribou cow/calf groups were the most responsive to helicopters, and this was primarily due to the reactions of the calf (i.e., running to its mother) which then often stimulated the entire group to move. Bulls were the least reactive to the aircraft.

(2) Caribou in groups of greater than 20 individuals tended to be more responsive than caribou in smaller groups.

(3) Responses of caribou to helicopter landings, or to humans moving around a helicopter on the ground, were stronger than responses to overflights.

Gunn et al. (1985) observed the responses of maternal groups of helicopter landings during the post-calving period. They found that a helicopter overpass at 300 m (1,000 ft) followed by a landing within 300-2,000 m (1,000-6,000 ft) of post-calving aggregations resulted in a measurable displacement of these groups to at least 1-3 km (½-2 mi) from the helicopter.

3.3.2 Off-road Vehicles and Pedestrians

Off-road vehicles (as used in this report) include those vehicles that are not part of the normal stream of traffic on access roads and workpads associated with oil development. Passenger vehicles associated with roads or heavy equipment associated with construction or maintenance are included as part of the activity related to roads and other transportation corridors and are discussed in sections 3.3 and 3.4.

3.3.2.1 Heavy Equipment Off-road Vehicles

The responses of caribou to heavy equipment off-road vehicle use were observed during winter seismic exploration in the Northwest Territories of Canada (Beak Consultants 1975, Urquhart 1973). Seismic trains consisted of drill rigs mounted on large tracked carriers and assorted dozers and trucks hauling a mobile camp that supported the operation. The investigators found that in general the large vehicles did not disturb overt ongoing caribou behavior at distances greater than 1 km (0.6 mi) if people did not leave the vehicle (Beak Consultants 1975). The slow speed and relatively predictable direction of travel of these vehicles probably contributed to the low reactivity by caribou. No changes in local distribution of caribou could be related to heavy equipment use.

3.3.2.2 Small Off-road Vehicles and Pedestrians

Only a few reports have presented observations or data concerning the responses of Arctic caribou to small off-road vehicles and to pedestrians. Urquhart (1973) and Beak Consultants (1975) concluded that caribou responded much more strongly to snowmobile traffic associated with seismic operations than to the heavy equipment, probably due to the rapid movement and unpredictable course of the former. Although there have been no experiments to evaluate specifically the effects of snowmobiles on Arctic caribou, observations over a number of years have led Davis and Valkenburg (1984) to conclude that harassment caused by the use of snowmobiles during hunting is probably more disturbing to caribou than are aircraft overflights.

The responses of caribou to humans on foot varies considerably. Wright and Fancy (1980) noted that a group of CAH caribou near a drill site was frightened off by a worker approaching them within 1,250 m (4,000 ft). Roby (1978) and Cameron et al. (1979) observed CAH maternal groups fleeing from a person on foot within 800 m (2,500 ft) although most bull groups could be approached to within 50 m (200 ft). Bergerud et al. (1984) concluded that harassment by "firing lines" of hunters along road systems are far more important sources of disturbance than are behavioral barriers to caribou movements such as roads, pipelines, or other structures. Reimers (1980) concluded that disturbance of wild reindeer by hikers and hunters during summer and fall can substantially reduce the reindeer's ability to obtain sufficient forage, and could eventually reduce the animal's ability to survive through winter or to reproduce.

3.3.3 Conclusions and Discussion

Potentially deleterious effects on the utilization of habitat by caribou, such as interruptions in ongoing activity (e.g., feeding) and increases in energy-consuming escape behavior, have been documented to occur as a result of harassment; therefore, strictly speaking, aerial and ground harassment are a type of impact. However, there is considerable disagreement about the effects of harassment on caribou in terms of population productivity, and about the relative importance of different sources of harassment (i.e., aerial as opposed to ground). Deleterious effects on the utilization of habitat by caribou include movement of caribou away from sources of disturbance (e.g., temporary abandonment of habitat), interruptions in ongoing behavior (e.g., cessation of feeding), and increases in energy-consuming behavior (e.g., from feeding to running). In addition, direct effects on caribou, such as injury during panicked running in response to aircraft disturbance, are suspected. These effects, by our definition, are impacts; however, they are distinct from other impacts that we will be discussing in that the source of the harassment is temporary and often occurs unpredictably; and the significance of the impact is dependent on the season of the year, characteristics of the individual animals (e.g., sex, age, presence of other caribou, previous experience with the harassment stimulus), and source of the stimulus.

3.4 AVOIDANCE OF OIL/GAS DEVELOPMENT

One of the impacts of oil/gas development on caribou is the reduction of utilization of habitat associated with the avoidance by caribou of areas associated with such development. The behavioral response by caribou results in large areas of habitat becoming virtually unuseable by caribou even though the physical characteristics of the habitat may remain unchanged. Additionally, because the areal extent of this avoidance is usually much larger than the direct habitat loss (cf. subsection 3.2) associated with such development, the resultant reduction in habitat availability is correspondingly larger.

The following section is divided into two subsections. In the first subsection, the avoidance by caribou of "linear" developments (e.g., roads, pipelines) is discussed. Cows and calves avoid the TAPS corridor during most seasons, and the Spine Road in the Kuparuk oil field, the Prudhoe Bay oil field, and the Milne Point Road in the Milne Point oil field in summer. Human activity associated with these developments appears to be the major factor causing such avoidance. Bulls do not appear to avoid these developments to any great extent.

In the second subsection, the avoidance by caribou of "point" development (e.g., isolated drill pads or other facilities) is discussed. Caribou seasonally avoid areas around developments that are isolated from other developments. As is the case with linear developments, human activity associated with such developments appears to be a major factor in causing this avoidance.

3.4.1 Avoidance of "Linear" Developments

Unlike "point" developments, which are relatively isolated from other developments and are often temporary (i.e., are present during a few seasons of several years, or present during all seasons for a few years of less), "linear" developments often permanently connect facilities within and between oil fields and thereby create the network that is characterized by the Prudhoe Bay oil field (figure 3). The effect of linear developments is not only to expand the distance over which caribou can potentially interact with development but also to provide conditions for increased human activity such as traffic and road maintenance.

Avoidance of linear developments by CAH caribou has been documented along TAPS during most seasons except fall (rut), at the Prudhoe Bay oil field during calving and early summer, along the Spine Road during calving and summer, and along the Milne Point Road during calving and summer.

Avoidance of the TAPS corridor (which includes the Dalton Highway--figure 3) by maternal groups has been shown by several examples:

(a) Since June 1975 the percentage of calves along the TAPS corridor has been significantly lower than the calf percentage region-wide, except during the rut (Cameron and Whitten 1976, 1977, 1978, 1980b; Cameron et al. 1983, 1985; Roby 1978). Lower calf percentages along the corridor have been attributed to lower numbers of groups with calves rather than to a lower proportion of calves within groups--i.e., avoidance appears to be a group response (Cameron and Whitten 1980b, Cameron et al. 1983), an observation that is consistent with the hypothesis that maternal groups are more sensitive to disturbance (e.g., Lent 1966, Miller 1982).

(b) In contrast to that of calves, the percentage of bulls along the corridor has been higher than the percentage of bulls region-wide; however, as is the case with calves, the difference has not been significant during the rut (ibid.). Observations of caribou in the corridor have been uniformly lower in the fall than in other seasons, suggesting that bulls are leaving the corridor to join maternal groups rather than maternal groups entering the corridor and thus inflating the calf proportions there (Cameron and Whitten 1980b). The maternal groups could be away from the corridor during the rut because they are attracted to rutting areas which do not happen to occur in the corridor, or they could be avoiding the corridor itself. Carruthers et al. (1984, figure 24) have plotted locations where CAH caribou were found during the rut between 1981 and 1983. Although the areas were generally located in the northern foothills, there were no consistently used locations; therefore, it appears that maternal groups are avoiding the corridor rather than moving to a rutting area, and that the similarity in the percentage of bulls within and away from the corridor is due to bulls leaving the corridor to join maternal groups.

(c) Although the general trend of the CAH population has been an increase in calf percentages since 1975, the reverse trend has occurred along the corridor (Cameron et al. 1983, 1985). Calf percentages in the corridor have declined steadily since 1975 although the level of human activity in the corridor (mostly construction-related traffic on the Dalton Highway) has varied considerably (Cameron et al. 1983). Human activity was high during construction of TAPS in 1975-76, declined between 1977 and 1979, then increased again in 1980 as construction increased in the Kuparuk oil field, and has remained high yet below the peak of 1975-76 (ibid.). This declining trend in calf percentages in spite of changes in the intensity of human activity suggests either that once maternal groups encounter developments with high levels of human activity they avoid these areas even after the activity subsides, or that even the lower levels of activity (compared to the peak) currently occurring are higher than the threshold at which maternal groups will avoid development.

(d) Relocations of visual- and radio-collared caribou since 1975 have confirmed that cow caribou occupy and cross the corridor significantly less than do bull caribou (Cameron et al. 1983, Whitten and Cameron 1983).

These observations demonstrate that maternal groups avoid the TAPS corridor during all seasons except possibly during fall. Furthermore, this avoidance appears to have continued in spite of variations in human activity in the corridor since the peak of TAPS construction acitivity in 1975. Conversely, bulls do not appear to avoid the corridor to any significant degree. It appears that during the rut, when calf percentages are not significantly different along and away from the corridor, maternal groups remain sensitive to disturbance along the corridor and that the bulls leave the corridor to join maternal groups rather than maternal groups entering the corridor--this point cannot be conclusively shown however.

Carruthers et al. (1984) have challenged the conclusion of Cameron et al. (1983) that maternal groups avoid the TAPS corridor because of the development that has occurred there. Although Carruthers et al. (1984), during their study of the CAH between 1981 and 1983, found that the proportion of groups containing calves were under-represented along the TAPS corridor when compared with the proportion of groups containing calves region-wide, they concluded that this difference is due to the avoidance of riparian habitat by maternal groups and not to avoidance of human developments. They assert that most of the TAPS corridor is located in riparian areas of the Sagavanirktok River floodplain; therefore, bulls tend to prefer this area whereas cows and calves avoid it. If the data interpretation of Carruthers et al. (1984) are correct then calf percentages in the Sagavanirktok River drainage (i.e., TAPS corridor) should not be significantly different than those of riparian areas elsewhere; however, if the data intepretation of Cameron et al. (1983) are correct, calf percentages in the Sagavanirktok River floodplain should be lower than in riparian areas elsewhere. Carruthers et al. (1984) data indicate that calf percentages are much lower, and bull percentages much higher in the corridor than in other riparian areas (cf. Table 7, ibid.). Thus the interpretation of Cameron et al. (1983) is supported by the data of Carruthers et al. (1984). Furthermore, the ADF&G data from which regional calf percentages were derived, were obtained from aerial surveys conducted along major drainages (Cameron et al. 1985)--i.e. if any bias existed it would have tended toward equalization rather than divergence of the regional and corridor calf percentages. The most realistic interpretation of these data is that maternal groups avoid the TAPS corridor because of the human developments and/or activity associated with it.

A second example of avoidance of linear developments is the avoidance of the Prudhoe Bay oil field by CAH cows during calving and mosquito relief movements. As noted in subsection 2.2 some calving and considerable mosquito relief movements occurred in the Prudhoe Bay oil field prior to the construction of TAPS in 1975 (e.g., Child 1973, Gavin n.d., White et al. 1975). Since 1975, use of the area for calving has declined (e.g., Cameron et al. 1985, Whitten and Cameron 1985) and significant east/west movements through the oil field during mosquito season have also declined (e.g., Cameron et al. 1983; Lawhead and Curatolo 1984; Smith and Cameron 1985a, b) although some mosquito-induced movements have penetrated the oil field from the west at least as far east as the Putuligayuk River mouth (Woodward-Clyde Consultants 1983). The evidence for avoidance of the Prudhoe Bay area by parturient caribou relies not only on the small numbers of maternal groups observed in the Prudhoe Bay oil field during aerial and ground surveys during calving (summarized in Cameron et al. 1985, Lawhead and Curatolo 1984, Whitten and Cameron 1985) but also on the comparison between the density of calving caribou in Prudhoe Bay and the density of calving caribou in other CAH calving areas, and the latitudinal distribution of calving in areas adjacent to Prudhoe Bay.

During aerial and ground surveys in the Prudhoe Bay area between 1975 and 1977, the percentage of calves within the area was similar to that of regional calf percentages; however, beginning in 1978 the percentage dropped markedly and has remained low since (Smith and Cameron 1983). Maternal groups that did calve in the Prudhoe Bay area did not remain near the intensively developed area along the road system (cf. figure 3) (Cameron et al. 1979). The total numbers and percentage of calves in the Prudhoe Bay area continued to decline between 1978 and 1981 although the regional calf percentages continued to increase (Whitten and Cameron 1985). During this period the density of caribou during calving in Prudhoe Bay was less than half that of the next lowest-density calving areas (Colville River delta and Mikkelsen Bay) (ibid.). In 1983 no maternal groups were observed in the Prudhoe Bay oil field during calving (Lawhead and Curatolo 1984, figure 1). During calving in 1981 through 1983 the total number of caribou that were observed along aerial transects that passed through the Prudhoe Bay oil field fell consistently lowest among totals of all survey transects along the coastal plain (figure 15 in Carruthers et al. 1984). In addition to aerial and ground survey data, relocations of visual- and radio-collared caribou indicated a continued avoidance of the Prudhoe Bay oil field (Cameron et al. 1983). These observations indicate that calving has become almost nonexistent in the Prudhoe Bay oil field as the structural complexity and associated activity in the oil field has increased.

A second source of evidence for the avoidance of the Prudhoe Bay oil field by parturient caribou is the comparison of relative density of calving animals in the oil field with areas of similar terrain and vegetation where the CAH calves. Areas such as Mikkelsen Bay appear to be similar to the Prudhoe Bay oil field in regards to vegetation and terrain, but without oil developments, yet these areas supported at least twice the density of calving caribou between 1978 and 1981 (Whitten and Cameron 1985) and continued to support at least some calving caribou in 1983 although Prudhoe Bay had none (Lawhead and Curatolo 1984, figure 1).

The final source of evidence for the avoidance of Prudhoe Bay by calving caribou is the comparison of the latitudinal distribution of calving caribou between Prudhoe Bay and adjacent coastal plain calving areas. With the exception of the Colville River delta and Prudhoe Bay, calving on coastal plain calving areas between 1978 and 1981 occured primarily within 16 km (10 mi)--and more often within 8 km (5 mi)--of the coast (Whitten and Cameron 1985). The majority of calving in the Colville River delta area took place inland, as did the majority of calving in the Prudhoe Bay area (ibid.). The coastal portion of the Colville River delta is subject to considerable flooding and overflow ice during calving; however, no such natural feature accounts for the inland distribution of calving south of the Prudhoe Bay area which took place 24-32 km (14-20 mi) inland--i.e., well south of the development area. The only unique feature of Prudhoe Bay appears to be the intensive oil field development there.

These three sources of evidence provide strong support for the conclusion that calving has declined markedly in the Prudhoe Bay oil field, and that the decline has been in response to the development of that oil field.

Caribou of the CAH avoid the Prudhoe Bay oil field not only during calving but also during mosquito-relief movements that generally follow the coastline east and west, depending on wind direction (e.g., Child 1973, Gavin n.d., White et al. 1975). Prior to 1975 such movements were common (ibid.). However, in the past five years such movements by large groups have not been observed except for brief penetrations into the less-developed western portion of the oil field (e.g., Woodward-Clyde Consultants 1983). In other instances mosquito-harassed groups have been observed to deflect away from the oil field, presumably due to the low ground clearance (often less than one meter [3 ft]) on feeder lines and to the intensive traffic (e.g., Lawhead and Curatolo 1984, Smith and Cameron 1985a, b). Visual- and radio-collared caribou have not been relocated in the Prudhoe Bay oil field proper (Whitten and Cameron 1983).

The third example of avoidance of linear developments by caribou consists of observations of avoidance of the Spine Road/Kuparuk Pipeline complex by calving caribou, and local shifts in total caribou occupancy and proportion of calves observed along the Spine Road and Oliktok Road in the Kuparuk oil field. These changes appear to be in response to construction activity and overall development in the Kuparuk oil field. Major construction activity in the Kuparuk oil field began in 1978 with the extension of the Spine Road from the Prudhoe Bay oil field across the Kuparuk River to the west. Between 1979 and 1980 work on the Spine Road, drill pads and access roads, and construction of CPF-1 was centered in the eastern portion of the Kuparuk oil field (cf. figure 3). In winter 1980-81 the Kuparuk Pipeline was completed; this pipeline links CPF-1 with TAPS Pump Station 1. Vehicle traffic along the Spine Road increased from 11 vehicles/day in 1980 to 18 vehicles/day in 1981 (Cameron et al. 1983). In 1982 there was extensive gravel hauling and other construction activity associated with completion of CPF-2 in the western portion of the field. In 1983 and 1984 construction activity was most intensive in the western portion of the Kuparuk oil field and along the Oliktok Road (Smith et al. 1984). Overall activity in this part of the field increased dramatically during this period as indicated by the increase in Spine Road traffic levels west of CPF-1 from 31 vehicles/hr in 1983 to 55 vehicles/hr in 1984 (Murphy 1984). Even the traffic levels in 1983, which are lower than those of 1984, indicate a dramatic increase in traffic over 1980 and 1981. Some caution is advisable in interpreting these figures; however, because they reflect traffic levels primarily in midsummer when construction activity is at its peak. During the first three weeks of June (i.e., during caribou calving and post-calving) the Kuparuk River bridge, across which all traffic from Prudhoe Bay and the Dalton Highway must cross, is washed out and only local traffic is possible within the Kuparuk oil field. Changes in total caribou occupancy, maternal group occupany, and local distribution of maternal groups in midsummer in the Kuparuk oil field are summarized below:

(a) In 1979, the distribution of maternal groups along the Spine Road during calving was significantly lower within 4 km (2.4 mi) of the road than elsewhere north or south of the road (Cameron and Whitten 1980a). In 1980 and 1982 there were no calves observed within 4 km (2.4 mi) of the road (Cameron et al. 1981, Smith et al. 1984). In 1983 and 1984 there were few calves along the Spine Road or Oliktok Road according to Smith et al. (1985).

(b) The pattern of total caribou and maternal group occupancy along the Spine Road during midsummer changed between 1978 and 1983. During mid-summer 1978 and 1979 the proportions of caribou observed along the road were higher at major drainages (including the Kuparuk River) although there was some variation between years that appeared to be in response to local construction (mostly drainage structure maintenance and replacement) at these "nodes" of caribou occupancy (Cameron et al. 1983). Although the percentages of calves varied between years, within a year the percentages of calves within groups at these "nodes" were not significantly different from regional percentages (ibid.). In 1980, as overall construction increased in the eastern portion of the oil field, the pattern that was observed in 1978-79 was not apparent--there was a general shift of occupancy westward toward the end of the Spine Road. In 1982 and 1983 there was continued higher rate of occupancy in the western portion of the oil field, although occupancy in the CPF-1 area declined probably due to increased construction traffic between there and CPF-2 (Smith et al. 1984). In 1983 there was also considerable caribou (mostly cows and calves) occupancy along the Oliktok Road suggesting that maternal groups were "end-running" western part of the oil field in order to get to the Oliktok Point area (Smith et al. 1985). The Kuparuk River continued to be a "node" of occupancy and movement; however, the proportion of calves declined between 1981 and 1983 (Curatolo 1984, Smith et al. 1985). Smith et al. (1985)

attributed the decline in calf percentage at the Kuparuk River "node" to the avoidance of construction in the area by maternal groups, whereas Curatolo (1984) attributed the decline to an increase in the number of bulls using the Kuparuk River area which would have inflated the bull percentage and deflated the calf percentage. Because of the variation in the total numbers of caribou using the Kuparuk oil field among years--variations that could be unrelated to the development itself--conclusive resolution of these two interpretations is difficult. However, the interpretation of Smith et al. (1985) appears to be most likely in this case because (a) data collected prior to significant human disturbance in the Kuparuk River area (e.g., 1978 and 1979) indicate that it was a "node" of occupancy by cows and calves, and (b) that the percentage of calves in groups along the Kuparuk River did not differ from regional calf percentages (Cameron and Whitten 1980). These data suggest that prior to intensive human activity there maternal groups were not avoiding the Kuparuk River area in midsummer, and that the proportion of calves in these groups was not abnormal.

(c) The percentage of calves in groups observed along the Spine Road in midsummer declined between 1981 and 1983 but showed some signs of recovery in 1984. Calf percentages in groups observed along the Spine Road were not significantly different than regional calf percentages between 1978 and 1980; however, in 1981 and 1982 calf percentages were substantially lower than the regional percentage (Cameron et al. 1983, Smith et al. 1984). In 1983 midsummer calf percentages along the Spine Road continued to be lower than regional calf percentages (Smith et al. 1985). However, in summer 1984 calf percentages in midsummer along the road were <u>not</u> significantly different than regional percentages--the investigators suggested that caribou are habituating to local activity and man-made structures (Smith et al. 1985).

The final source of evidence for avoidance of areas of development is the distribution of calving and summer occupancy along the Milne Point Road in the Milne Point oil field (figure 3). The Milne Point oil field is located just west of the Kuparuk River and along the coast (i.e., northeast of the main Kuparuk oil field) and overlaps the eastern portion of the concentrated calving area. The Milne Point Road connects the oil field, which currently consists of several drill pads with connecting access roads, a processing facility, and 300-person camp, with the Spine Road to the south (figure 3). The 29 km (18 mi) road was constructed in winter 1981-82, and a 35 cm (16 in) diameter pipeline was constructed along it in winter 1984-85. Summer traffic along the road was considered low (less than 10 vehicles/day) in 1983 and 1984, moderate in 1982 (10-100 vehicles/day), and high in 1985 (over 200 vehicles/day) (Dau and Cameron in press). The distribution of caribou in response to the road during calving and midsummer provide evidence that caribou are avoiding the road system during these two periods. These two examples are summarized as follows:

(a) Aerial surveys of caribou distribution and numbers during calving were conducted for four years prior to construction of the road, and four years since construction. During the four years preceding construction, calving caribou encompassed the entire area now covered by the road (Dau and Cameron in press). During the four years after construction, there was a positive correlation with distance from the road up to 3 km (2 mi) and the density of parturient caribou, whereas there was no such relationship between the density of nonmaternal caribou and distance from the road (ibid.). The contrast between maternal group density prior to construction and after construction is even more vivid because prior to construction the area which the road encompasses had a higher density of parturient caribou than had areas to either side (ibid.).

(b) Since construction of the road in 1982 ground surveys of caribou occupancy along the road during summer have indicated that caribou occupancy has increased directly with distance from the road up to 4 km (2.4 mi), and that this is most pronounced during June but also occurs in July (Dau and Cameron 1985). Although the June data overlap with data during calving (ref. "a" above) they also include the post-calving period and suggest that the maternal group avoidance of the road continues into post-calving and mosquito season.

In summary, results from data gathered in the TAPS corridor, and the Prudhoe Bay, Kuparuk and Milne Point oil fields indicate that:

(a) During summer maternal groups are more reactive to linear developments than are nonmaternal groups, and will avoid areas of high amounts of human activity. This avoidance is most apparent during the calving season, when parturient caribou avoid areas with even relatively small amounts of human activity, and appears to decline somewhat as summer progresses.

(b) Although there are no studies that conclusively demonstrate that maternal groups avoid linear developments because of human activity occurring there, there is considerable circumstantial evidence of this. Maternal groups have avoided the TAPS corridor since TAPS construction, and have shifted their occupancy along the Spine Road and Milne Point Road in apparent response to the amount of human activity along these roads. However, maternal group occupancy along linear developments does not appear to be a straight relationship with the contemporary amount of human activity there--it appears that once maternal groups avoid an area because of human activity this tendency persists for several years even though the amount of human activity declines. This persistence is most noticeable during calving seasons.

(c) There are limited data on avoidance of linear developments during seasons other than summer. The few data gathered along the TAPS corridor indicate that since TAPS construction that fall calf and bull percentages in the corridor have not been significantly different than those region-wide. It appears that bulls may leave the corridor in search of maternal groups rather than maternal groups becoming less reactive to the corridor, although lowered reactivity of maternal groups during the rut cannot be ruled out.

(d) Avoidance of the Prudhoe Bay area has been demonstrated from data gathered by direct observation and location of radio-collared animals, by comparisons of maternal group density in Prudhoe Bay with other CAH calving areas, and by comparisons of the latitudinal distribution of calving in the area surrounding Prudhoe Bay.

(e) There is some evidence that maternal groups can habituate to human activity during midsummer; although the evidence is based on occupancy along the Spine Road and Oliktok Road in only one year (1984).

(f) Analysis of maternal group occupancy along linear developments suggests that "zones of avoidance" of linear developments occur at distances of 3-4 km (1.8-2.4 mi) during calving, and from "no avoidance" to up to 4 km (2.4 mi) during midsummer.

3.4.2 Avoidance of "Point" Development

"Point development" consists of isolated facilities (e.g., seismic camps, drill sites, pump stations, processing facilities), that are confined to a relatively small area. After the exploration phase it is often difficult to separate the effects of the "point" development from those of "linear" developments. For example, isolated drill pads that are supported by air transportation are commonly employed for the later stage of exploration. If these are to become production wells, roads and feeder lines are constructed to them and these linear structures and the human activity associated with them add a new dimension to the disturbance.

Caribou have been observed to avoid fall and winter seismic camps, simulated compressor stations, and drill sites. During fall and winter seismic operations on Banks Island, Peary caribou (Rangifer tarandus Pearyi) would not approach within 3.2 km (2 mi) of camps and staging areas which were located in areas of high visibility but would approach much closer in hilly terrain (Urquhart 1973). McCourt et al. (1974) observed PH caribou responses to both an inactive seismic camp, and to an active construction camp. Caribou encountered the seismic camp while on spring migration; the majority of animals skirted it by 200 m (1/8 mi). Caribou passed within 400 m (¼ mi) of the active construction camp.

McCourt et al. (1974) also observed the responses during different seasons of the year of PH caribou to the simulated sound of a 20,000 hp. gasline compressor. The sounds were at frequencies and decibel levels equivalent to those of the air intake, scrubbing, bypass, and exhaust systems of such a compressor, and these sounds were broadcast in directions similar to those of a real compressor. In the experimental situation two units, one the simulator and the other the gasoline-powered generator to supply the simulator, were located 15 m (50 ft) apart. Although the simulation did not mimic the odor, visual appearance, and human activity associated with a real compressor station, the results do provide insight into the effects of noise. Caribou were observed at two locations each during spring migration, during calving, during late July, and during fall migration. Caribou during spring and summer avoided an area within 200 m (1/8 mi) of the simulation, and during fall migration there was a suggestion that caribou avoided the area within 800 m (½ mi) (ibid.).

Two studies located within the CAH range were conducted east of Prudhoe Bay-- one at an exploratory drill site near Pt. Gordon (Wright and Fancy 1980), and the other at Drill Sites (DS) 16 and 17 on the east side of the Sagavanirktok River delta (Fancy 1982, 1983) (figure 3). The former site had no connecting road, and access for crew changes and support was by helicopter. The latter sites were connected to the Prudhoe Bay complex by a road in 1980, and by the road with an adjacent pipeline in 1981. Although a portion of caribou were observed to avoid the drill sites (refer to this section), many caribou entered the drill sites but were unable to cross the road/pipeline complex (refer to section 3.5).

At the Pt. Gordon site, observations of caribou within 2 km (1.2 mi) of the drill site were compared with observations of caribou at a control plot located 6.5 km (4 mi) east between 9 June-17 August 1980. Because of late June snowmelt and generally cool temperatures in July, fewer caribou than normal encountered the drill site. No caribou approached the drill site closer than 1,200 m (¾ mi), and few caribou came within 2 km (1.2 mi). The investigators concluded that the caribou's responses were directly attributable to the disturbance caused by the drill site. Sources of disturbance included noise from the drill rig and associated machinery including generators and compressors, and from support vehicles such as dozers and front-end loaders. Additional sources of disturbance were visible human activity such as walking around the drill pad and approaching the caribou in order to photograph them, and movement of vehicles on the pad.

At DS 16 and 17, observations were made during July-August 1980 and 1981. Several major differences between this and the Pt. Gordon study site include: (1) the presence of an access road with traffic levels averaging 24 vehicles/hr connecting DS 16 and 17 to an access road to Prudhoe Bay; (2) the presence of feeder lines elevated 1.5 m (5 ft) which ran between DS 16 and 17 and Prudhoe Bay; and (3) the proximity of DS 16 and 17 to the Prudhoe Bay complex (a few km to the west). Caribou movements in the drill site area were predominately northeast/southwest as animals moved back and forth to the delta mouth to seek relief from mosquitos. Groups which deflected away from the drill site experimental area appeared to react at up to 2 km (1.2 mi).

The results of these studies indicate that "point" developments can elicit avoidance reactions by caribou within 2 km (1.2 mi) of the development, depending on season, the visibility of the development, and the level of human activity associated with it. The influence of structures alone, as distinct from the human activity around them, was variable. During most of the year caribou often exhibited little reaction to inactive gravel drill pads although during oestrid fly harassment periods these structures appeared to be preferred. Caribou were observed to avoid an inactive camp during spring and summer; however, these observations are not directly comparable with those from other studies. It is apparent that point development having human visual and sound disturbance associated with it elicits a stronger avoidance response than development without human disturbance. The reactions of caribou to point development appear to vary seasonally; however, studies that are comparable among seasons have not been carried out.

3.4.3 Conclusions and Discussion

Investigations of the regional distribution and local occupancy of caribou indicate that under certain conditions caribou avoid "linear" and "point" developments. This avoidance can not only occur over several seasons of any given year but can persist for several years. Conditions that influence avoidance of developments by caribou include sex and age composition of group members, season of the year, the presence of external stimuli such as insects or human activity, and previous experience of the group members with developments. Avoidance of linear developments is more significant than that of point developments, not only because the distances at which avoidance may occur appear to be longer in the case of the former, but also because of the greater area of coverage by linear developments, and the more intensive (and extensive) amounts of human activity that are likely to be associated with linear developments.

Groups with calves avoid linear developments more than do groups without calves. No comparable data are available for sex or age classes that avoid point developments. This apparent reactivity that is shown by maternal groups to disturbance is higher during the calving season than later in midsummer, and appears to be oriented more toward human activity associated with developments than to the developments without human activity unless they have previously associated that development with human activity. For example, maternal groups avoid the TAPS corridor, Spine Road, and Milne Point Road during calving although the relative levels of human activity along these developments have varied over the years. It appears that once a threshold level of activity occurs during calving, and the parturient females avoid the area, the avoidance of this area persists in succeeding years even though human activity may be relatively lower. The persistence of avoidance of the TAPS corridor by maternal groups since the construction of TAPS is an example.

Seasonal influences on the reactivity of maternal groups are also evident. Although maternal groups avoided local areas of the Spine Road/Kuparuk Pipeline complex and shifted occupancy to areas of smaller amounts of human activity from year to year, they appeared to habituate to the development in midsummer 1984 when regional calf percentages and local calf percentages were similar. The data are limited and equivocal with respect to seasonal influences during other seasons. Data on the avoidance of maternal groups to the TAPS corridor in the fall indicate an increase in calf percentage to regional calf percentages; however, it appears likely that this increase in calf percentage is more a function of bulls leaving the corridor during the rut than of calves entering the corridor.

The presence of insects and human activity are opposing stimuli in regards to affecting caribou occupancy along developments in the Prudhoe Bay and Kuparuk oil fields. During mosquito season caribou probably inhabit and move through the Kuparuk oil field and elsewhere on the coastal plain because of the proximity of these areas to important mosquito relief habitat and to sufficient forage supplies. In spite of this general tendency toward a coastal distribution, caribou maternal groups also respond to increased local levels of human activity by avoiding them. During the midsummer period however, when mosquito and oestrid fly activity increases, there appears to be a reduction in maternal group reactivity to human activity compared to the calving season.

3.5 DISRUPTION OF MOVEMENTS

In the preceding section, the effects of linear and point developments that resulted in caribou avoiding localized portions of habitat which are associated with development were discussed. In this section the disruption of caribou movements through or within an oil field is discussed. Avoidance of development and disruption of movements are somewhat interrelated and difficult to empirically isolate from each other because they are both part of the dynamic process of caribou movements and distribution. We have considered avoidance to be measured by changes in occupancy, whereas disruption of movements is considered to be measured by changes in movement patterns. Changes in movement patterns include changes in widespread caribou movements, which are often difficult to distinguish from avoidance, and specific changes in movement patterns that for the most part have been determined by studies focussing on the success of caribou in crossing linear developments such as roads or pipelines.

Some examples of disruption of general movements have been mentioned in subsection 3.4.1 in association with avoidance of portions of the Kuparuk oil field where construction activity was intensive. These examples include the "end-running" of the western portion of the Spine Road/Kuparuk Pipeline complex during the summers of 1982 and 1983; and the deflections of large, mosquito-harassed groups when they encountered the low feeder lines and human activity associated with the Prudhoe Bay oil field. There are additional examples of disruption of caribou movements through the Kuparuk oil field. In 1982 and 1983 large groups of caribou which were moving southward from the coast as the intensity of mosquito harassment declined were observed to swing westward as they approached to within 1-2 km (½-1 mi) of the Spine Road (Smith and Cameron 1985a). Although other groups of caribou were observed to move southward across the Spine Road/Kuparuk Pipeline complex with no apparent problem during the same season (e.g., Cameron pers. comm., 1985; Curatolo and Murphy 1983) the aforementioned large groups appeared to be reacting to construction-related disturbance along the Spine Road (Smith and Cameron 1985a). In 1984 no such "deflections" were observed--caribou moved southward across the complex between the Kuparuk River and CPF-1 (Smith et al. 1985).

General changes in movements of caribou in response to manmade linear "features" (not really "developments" in the sense we use it here) such as winter seismic lines and cutlines have been observed by Urquhart (1973) and Banfield (1974). The majority of Peary caribou reacted to new winter seismic lines by paralleling them several hundred yards then either crossing in areas of less snow or turning away; however, maternal groups appeared to react more strongly than other groups. Caribou appeared to be reacting to the physical novelty of the line, and reacted very little to lines over three weeks old (ibid.). Banfield (1974) noted that migrating caribou of the PH followed cutlines through forested areas as long as the cutline generally followed the caribou's original direction of travel. Some deflection did occur. Concern was expressed over the effects of such deflections if they interrupted the northward movement of pregnant cows migrating to the calving areas; however, there has been no conclusive evidence to suggest an effect (ibid.).

The specific responses of caribou attempting to cross linear developments have been discussed in regards to simulated pipelines at Prudhoe Bay (Child 1973) and the Seward Peninsula (Child and Lent 1973); to operational pipelines at drill sites 16 and 17 (Fancy 1982, 1983; Fancy et al. 1981); the Kuparuk Pipeline and Spine Road complex (Curatolo 1984; Curatolo and Murphy 1983; Curatolo et al. 1982; Murphy 1984; Smith and Cameron 1985a, b), and drill sites 2X and 2D (Murphy 1984) in the Kuparuk oil field; and to roads such as the Dempster Highway in northern Yukon Territory (Horejsi 1981, Miller 1985) and the Spine Road in the Kuparuk oil field (Cameron and Whitten 1978, 1979; Cameron et al. 1983; Smith et al. 1984). These investigations indicate that the success with which caribou cross developments is affected by several factors including the type and configuration of the structure to be crossed (i.e., a road by itself, a pipeline by itself, or road and a pipeline), the season, the type and amount of insect harassment, the size of the group, the human activity accompanying the development, and the presence of structures within the development that are built to enhance caribou crossing success (e.g., ramps, elevated sections of pipeline). The results of these investigations are not always directly comparable because of differences in methods used in each study, criteria for a crossing attempt and for crossing success, type of structure being investigated, and study location (i.e., tundra vs. forested location). The following discussion is organized by type of structure.

Roads. Investigations of behavior of caribou encountering a road without an adjacent pipeline have been carried out during late winter and spring in forested areas of the PH's range along the Dempster Highway, and during summer in the Kuparuk oil field. Conclusions from these studies reveal that:

(1) Roads without traffic are not normally physical or behavioral barriers to caribou movements. Cuts and fills along roads that meet normal engineering standards are not usually physical barriers unless they are placed along cliffs or rivers that are impassable by caribou. Caribou apparently regard isolated roads as natural features of their environment and will cross or traverse them if they follow "paths of least energetic resistance" (cf. Jakimchuk 1980, Bergerud et al. 1984).

(2) In semi-open terrain caribou appear to select sites which have good visibility at a distance from the road of several hundred yards. These sites usually occur in upland areas. Caribou will also use gravel ramps that are constructed in riparian areas. The selection of crossing locations with these features appears to be an adaptation for predator avoidance (Miller 1985).

(3) CAH caribou approaching roads without traffic were almost completely successful in crossing these roads (Curatolo and Murphy 1983, Smith and Cameron 1985a).

(4) Traffic on roads can cause these roads to become "behavioral barriers" because approaching caribou will be deflected or turned back

for periods of time ranging from a few minutes to several hours (Curatolo and Murphy 1983, Horejsi 1981, Smith and Cameron 1985a, b). Caribou that are turned back or deflected often require several minutes to re-group and attempt to cross again. If the interval between vehicles is not sufficiently long to allow these caribou to re-group and cross, even caribou strongly motivated to cross (such as those harassed by insects) will be unable to. Traffic levels of only 15 vehicles/hr disrupted caribou crossing success along the Spine Road (Curatolo and Murphy 1983).

Pipelines. Investigations of pipelines without accompanying roads include those of simulated mainline and feeder line pipelines in the Prudhoe Bay oil field (Child 1973), a simulated mainline pipe on the Seward Peninsula (Child and Lent 1973), and the Kuparuk Pipeline in the Kuparuk oil field (Curatolo and Murphy 1983, Curatolo et al. 1982). The methods and study pipelines were dissimilar enough to warrant a further description. The Prudhoe Bay simulated mainline pipeline consisted of a 105 cm (48 in) strip of burlap raised 50 cm (24 in) above the tundra except where sections were elevated as "overpasses" to allow caribou to cross underneath, and at gravel ramps that crossed over the "pipeline." The feeder line simulation consisted of small-diameter pipe elevated 50 cm (20 in) above the tundra except at "overpasses" elevated 2-3 m (6-8 ft), and at gravel ramps. Child (1973) defined group crossing success as 100% of the individuals crossing the simulation either under the pipe or across the ramps; he found that individual crossing success was 34% at the mainline simulation and 10% at the feeder line simulation. Most animals elected to either skirt the simulation or to reverse direction. He found group crossing success declined as the size of the group increased--i.e., larger groups had more trouble crossing than smaller groups. Insect density was determined to be more important in influencing the success of crossing by caribou than was previous experience with the simulation (ibid.).

The reactions of semidomesticated herded and unherded reindeer to a mainline pipeline simulation were studied during all seasons of the year by Child and Lent (1973) on the Seward Peninsula. In this simulation, the pipe was elevated 50 cm (20 in) over most of its length except for a 100 m (300 ft) section that was elevated 4 m (12 ft), and an adjacent gravel ramp. The only successful crossing recorded was during winter when drifted and compacted snow created a "bridge" over the lower sections of pipe--i.e., a snow ramp.

Curatolo (1984), Curatolo and Murphy (1983) and Curatolo et al. (1982) studied the crossing success of CAH caribou groups along the Kuparuk Pipeline just west of the Kuparuk River where it is separated from the Spine Road by 3 km (2 mi) (figure 3). Along this section the pipeline is elevated a minimum of 1.5 m (5 ft) and contains a short buried section (effectively, a ramp). Although there are no overpasses, the height of the pipeline varies from 1.5 to 4 m (5-14 ft). The investigators established a control site located 2.5 km (1.5 mi) south of the experimental site and crossing success at the "pipe site" was compared with that at the control site. Group crossing success in these studies was defined as more than 50% of the individuals of a group crossing the pipeline. From their data gathered during summers of 1981 through 1983, they reached the following conclusions:

(1) During the pre-calving and calving period in 1982 and 1983, the success of groups crossing the pipeline was much lower than that during the mosquito and oestrid fly season. During the mosquito and oestrid fly seasons there was no significant difference in overall crossing success (80%) of groups at the "pipe site" than at the control site; however, the data included a large number of groups that crossed at the buried section (see "2").

(2) Caribou strongly preferred the buried section for crossing--although the buried section comprises only 1% of the pipeline length in this section, the frequency of group crossings was 18 and 16% in 1981 and 1982 respectively.

(3) Within the range of pipe heights available crossings were significantly more numerous at pipe heights of 2.5 m (8 ft) and over in 1981, but were not so in 1982.

(4) The success of large groups of caribou (i.e., those with more than 100 individuals) was lower than smaller groups in 1981 (when the large group crossing success was 33%), but was not significantly different in 1982 or 1983.

Pipelines and Roads with Traffic. The success of CAH caribou in crossing roads and adjacent pipelines has been investigated at drill sites 16 and 17 just east of Prudhoe Bay (Fancy 1982, 1983; Fancy et al. 1981) (figure 3), and along the Kuparuk Pipeline/Spine Road complex (Cameron et al. 1983, Curatolo 1984, Curatolo and Murphy 1983, Curatolo et al. 1982, Smith and Cameron 1985a, b) and at drill sites 2X and 2D (Murphy 1984) in the Kuparuk oil field. In all these cases, the pipeline was elevated a minimum of 1.5 m (5 ft) above the terrain, and a road with variable frequencies of vehicles was adjacent (generally within 50 m [150 ft]). Observations of the success of crossing by caribou were made from stationary blinds in drill sites 16 and 17 and 2X and 2D studies, and along the Kuparuk Pipeline/Spine Road study by Curatolo (1984), Curatolo and Murphy (1983), Curatolo et al. (1982). Observations by Cameron et al. (1983) and Smith and Cameron (1985a) were made during twice daily trips by pickup along a predetermined route on the Spine Road. Smith and Cameron (1985a) have compared the drill site 16 and 17 and Kuparuk Pipeline/Spine Road studies. Their conclusions are as follows:

(1) Caribou are less successful in crossing multiple structures when traffic is present, although all the quantitative and qualitative features of the traffic that cause a reduction in crossing success by caribou have yet to be identified.

(2) Caribou in groups of more than 100 individuals have a much lower rate of success in crossing road/pipeline complexes than do smaller groups. Of the 27 large groups which were observed to approach a complex in these studies, only 1 was successful in crossing it. Several groups numbering in the thousands were unable to successfully cross the Kuparuk Pipeline during severe insect harassment periods in 1981 and 1982, and deflected along the pipeline for distances of up to 32 km (19 mi) (Smith and Cameron 1985b).

(3) Caribou crossing success was greater during periods of oestrid fly harassment than during mosquito harassment.

(4) When the effect of a buried section along a road/pipeline complex was evaluated in regards to facilitating caribou crossing of that complex the results were inconsistent. Smith and Cameron (1985a) noted that their limited data did not indicate that a buried section along the Kuparuk Pipeline/Spine Road was used preferentially, whereas Curatolo and Murphy (1983) found that this section comprised only 1% of the pipeline length in their study area but was the location of 6% of the total successful crossings. The investigators agree that this particular buried section was not an ideal design to facilitate caribou crossing.

The investigation of caribou crossing success at drill sites 2X and 2D (Murphy 1984) are particularly interesting because they were the first attempt to evaluate the effectiveness of ramps in enhancing caribou movements across a road/pipeline complex. The ramps, due to their design and siting, were constructed specifically to facilitate caribou movements across the drill site 2D feeder line/access road and across the Kuparuk Pipeline/Spine Road. The results from these two areas were then compared with the results from a nearby drill site (2X) that had no ramp along its access road/feeder line complex. Pipeline height along all pipelines was a minimum of 1.5 m (5 ft). Factors beyond the investigators' control--such as the unusually low number of animals passing through the study area during the years of investigation, and the proclivity of road maintenance vehicles to use the ramps as unauthorized parking areas--limit the conclusions that can be drawn from the first year of the study; nevertheless, several conclusions are noteworthy:

(1) Caribou group and individual crossing success was much higher along both drill site complexes than along the Kuparuk Pipeline/Spine Road complex because of the quantitative and qualitative differences in traffic along the latter. Traffic on the Spine Road averaged 55 vehicles/hr in 1984 and 31 vehicles/hr in 1983; whereas traffic on the 2D road averaged only 6 vehicles/hr. Large vehicles (e.g., gravel trucks, graders) appear to be more disturbing to caribou than small vehicles (e.g., pickup trucks), possibly because of the larger amount of noise, dust, and flying gravel associated with the former.

(2) Caribou crossing success was higher for the 2D complex (ramp present) than for the 2X complex (no ramp present).

(3) During periods when mosquitoes were present in 1984, caribou group size remained much lower than is usually the case when mosquitoes are present. Group and individual crossing success over the Spine Road/Kuparuk Pipeline was extremely high during this period. At other times when mosquitoes were present, or when mosquitoes and oestrids were both present, crossing success was very low.

Murphy (1984) could not determine whether ramps actually increase the frequency of crossing by caribou which would not otherwise cross a road/pipeline complex, or whether ramps merely provide a preferred alternative to caribou which would have crossed anyway. However, he did point out that "if large groups consistently use ramps [as his data suggest], this represents one of the most compelling justifications for the use of ramps as a mitigative strategy in areas where pipelines are not separated from roads."

Alaska Biological Research is investigating the comparative effectiveness of ramps with sections where above-ground pipelines are separated from adjacent access roads by several hundreds of meters. The first field season was summer 1985 and results are not yet available. The department began investigating the use of ramps along the Milne Point Road/Milne Point Pipeline complex in summer 1985; their results are also not yet available.

Conclusions and Discussion. Oil and gas development has been shown to disrupt summer movements of CAH caribou on two scales--changes in general movements in response to localized human activity in the oil field, and the ability of caribou to negotiate linear developments within the oil field. Changes in general movements have been linked with localized human activity on the one hand, and to facilities and human activity in concert with insect pests such as mosquitoes on the other hand. However, there is preliminary evidence that some accommodation to development occurred in 1984.

Specific changes in movement patterns have been studied in the context of the ability of caribou to successfully cross linear facilities such as roads and pipelines that are associated with oil fields. Several factors have been identified that influence the success by which caribou cross linear facilities. These factors include the type and configuration of the facility (e.g., isolated roads or pipelines, or roads and pipelines adjacent to each other), season of the year (especially calving), size of the group, and presence of other external stimuli such as harassment by insect pests or presence of human activity such as vehicular traffic. These factors do not all act independently. Although there have been numerous studies in the CAH range, differences in such features as study design, location, and criteria for inclusion in the data set complicate drawing meaningful conclusions. Nevertheless, there appears to be general agreement on several points:

(1) There is a general ranking of severity of the type of linear development in terms of its effects on caribou crossing success from the least severe--isolated roads--to the most severe--road with a pipeline. Isolated roads with no traffic appear to be selected by some caribou during oestrid fly harassment periods for example, and to be treated as just another topographic feature in other cases. However, the presence and amount of traffic can modify the severity. For example, a pipeline by itself is probably less disturbing to caribou attempting to cross it than is a road with levels of traffic exceeding 15 vehicles/hr. However, if the traffic levels dropped considerably, and mosquito harassment caused large groups to start moving toward the coast, a pipeline by itself could cause more disruption to these groups than would low levels of traffic. Speaking generally, however, caribou appear to respond to the complexity of the structure as well as to the associated human activity. Certain structural changes can be made, such as ramps and sections where pipes are elevated higher than surrounding pipe, that enhance the crossing success of caribou even in the face of stimuli that would normally depress their success. Evaluation of the effectiveness of these structural changes is

currently being undertaken; however, at least one change has already occurred in all pipelines subsequent to the Prudhoe Bay oil field construction. Minimum pipe height in the Prudhoe Bay oil field ranged from 0.4-1.1 m (1.3-3.6 ft) (Smith and Cameron 1985a); pipelines at these heights are virtually a physical barrier to caribou movements. More recent pipelines are required to have a minimum pipe height of 1.5 m (5 ft)--this height allows caribou to physically pass during most conditions although it can become a physical barrier in early spring due to drifting snow (ibid.).

(2) Traffic was alluded to in #1 as being a significant factor in crossing sucess. Vehicles at intervals averaging only 15/hr have been associated with reduced crossing success during midsummer.

(3) Season appears to be an important consideration although its effect may be due more to changes in group composition or other variables such as insects. The success of crossing linear facilities during the pre-calving and calving season in the Kuparuk oil field is lower than the midsummer period. During the pre-calving and calving seasons, mostly maternal groups are present in this area, whereas by midsummer other sex and age classes have joined the maternal groups as insect harassment increases. Maternal groups appear to have heightened reactivity to human disturbance during calving and early summer especially (refer to section 3.4), and the reduced crossing success in early summer may be due to that. This suggestion would be in line with results from studies along the Kuparuk Pipeline where it is isolated from the Spine Road--the increase in overall crossing success between 1981 and 1983 occurred as the proportion of maternal groups crossing the pipeline declined from over 50% to less than 30%.

(4) The type and intensity of insect harassment has a strong influence on crossing success. In general, as mosquito harassment increases the size of groups also increases and crossing success declines--notable exceptions occurred along the Kuparuk Pipeline "pipe site" study area near the Kuparuk River; however, this could have been due to the increased proportion of bulls in that site. At lower levels of mosquito harassment, crossing success increases over that when no insects are present; however, in most cases, crossing success is increased even further as oestrid fly harassment increases.

The results of these studies, which do show an effect on caribou movements in the oil field, can be compared with studies of the effects of TAPS on Nelchina Caribou Herd (NCH) movements in the forested terrain of south-central Alaska. NCH animals cross TAPS enroute to winter and summer ranges. TAPS bisects the NCH range in a north/south direction, similar to its orientation in the CAH range; however, the NCH caribou encounter TAPS while they are moving eastward to winter range in the fall or westward to summer range in the spring (Carruthers et al. 1984, Eide et al. In Press). Two special refrigerated buried pipeline sections are located in known areas of historical NCH migration and these buried sections are used extensively by caribou (ibid.). Other special big game crossing structures including short (less than 18 m [59 ft]) buried sections and sections of above-ground pipe elevated at least 3 m (10 ft) above the ground are available although they were often not located in areas of known caribou movement. Results of these studies indicated that once caribou made the decision to approach the TAPS they would cross wherever they encountered the pad, although Eide et al. (In Press) found that caribou appeared to select against elevated sections of pipeline that were less than 2.5 m (7 ft) in height above the pad. Nevertheless both sets of investigators concluded that TAPS has not adversely affected movements of the NCH. There are obvious differences between TAPS in the NCH range and the oil development in the CAH range. For one thing, TAPS runs only through a migration zone in the Nelchina whereas the oil field has been developed on a major seasonal range of the CAH. Second, the NCH inhabits a mixture of forested and nonforested areas, and their wariness toward structures that are located in areas of limited visibility may be much less than that of CAH caribou which can see and hear facilities and human activity at a greater distance.

One limitation of the data available on the effects of linear developments in disrupting CAH caribou movements is that no attempts have been made to translate the paralleling and deflecting behavior of CAH caribou along pipeline/road complexes into energetic costs to the individual. The effects of relatively short-term and short distance deflections probably are minor; however, the deflections of large numbers of animals for many kilometers along the Kuparuk Pipeline could easily represent a significant energetic cost if they occurred often. Jakimchuk (1980) and Bergerud et al. (1984) argue that paralleling and deflecting are a normal part of caribou behavior when encountering natural obstacles such as mountain ranges, gravel bars, and eskers. Banfield (1974) observed that in taiga areas, migrating caribou will deflect and follow along cutlines as long as they are in general alignment with the direction of travel, but will leave them when the lines diverge significantly from the original direction of travel. The effect of deflections and delays caused by structures should likely be most apparent during mosquito season, and that may be the time to investigate effects first.

3.6 INCREASED PREDATION OR HARVEST

Bergerud (1983) and Bergerud et al. (1984) have presented evidence that in a number of cases the most important impact of increased linear developments (especially roads) is to increase the susceptibility of caribou to predation or overharvest.

Although there have been a few observations in which wolves were suspected to have ambushed caribou along the Dalton Highway (Roby 1978) there has been no confirmation or further published reports of this. In fact rather than an increase in predation by wolves, construction of the Dalton Highway and TAPS has led to an increase in harvest of wolves by man. In 1977 and 1978 over 60 wolves were taken in the range of the CAH by aerial hunters and trappers along the Dalton Highway (Carruthers et al. 1984). Since that time the wolf population has been kept at very low levels by continued hunting and trapping (Barnett 1983).

Brown bears have also been affected by construction of TAPS and the Dalton Highway. Follmann et al. (1980) reported that between 1975-79 13 brown bears were killed in defense of life and property at TAPS construction sites. The proportion of these bears taken on the North Slope portion of the project was not reported; however, camp bear problems were most acute between the Yukon River and Atigun Pass (ibid.). Since construction of TAPS a few brown bears have been attracted to the Dalton Highway to "panhandle" from passing motorists and truckers (pers. obs., ADFG files). Between 1978 and 1981 bears were most common along the North Slope portion of the Dalton Highway in the Atigun Pass to Pump Station 4 area, and around Pump Station 2 (pers. obs.). The effects of removal of problem bears or the potential changes in food habits of "panhandlers" to the overall bear density in the central Arctic region is unknown; however, mortality of CAH caribou due to bear predation is thought to be a relatively insignificant source of mortality.

Hunting is also considered to be a minor source of mortality of the CAH. Residents of the Inupiat villages of Anaktuvuk Pass, Nuiqsut, and Kaktovik all occasionally hunt CAH caribou, but these villages are on the periphery of its range and are thought to take no more than 50-100 caribou a year (Barnett 1983). Although the North Slope portion of the Dalton Highway is technically open only for commercial travel, a number of sport hunters gain access in the fall and hunt caribou. However, the closure of all big game hunting within 8 km (5 mi) either side of the Dalton Highway prior to 1980, and the opening of this corridor to bowhunting only after 1980 has served to limit the number of sport hunters to less than 200 occasionally, and usually to less than 100 (ibid.). The annual sport harvest has been 50-100 until 1984, when 170 were taken. Use of the Dalton Highway (as opposed to fly-in hunting) increased from 1982, when half the hunters drove the highway, to 1983 when 2/3 of the hunters drove to the area (ibid.). Although the Dalton Highway does provide physical access to the central Arctic region its continued use primarily as an industrial road and the implementation of hunting restrictions along the road have been effective in minimizing harvest of the CAH.

3.7 CONCLUSIONS AND DISCUSSION

The impacts of direct habitat loss, avoidance of development, and disruption of movements have been documented to affect caribou of the CAH. Potential impacts such as harassment by aircraft, off-road vehicles, and pedestrians, and increased predation or harvest may also occur; however, the occurrence of these has not been sufficiently documented to provide a basis for a conclusion.

Direct habitat loss as a result of gravel overlay of vegetation during road construction is conservatively estimated at 8,000 ac (3,200 ha). This loss is a permanent but proportionally small impact on caribou habitat relative to the amount of habitat available to the CAH, and relative to the amount of habitat that could become unavailable because caribou maternal groups avoid developments. The "zone of avoidance" by maternal groups may be up to 4 km (2 mi) from a point or linear development (e.g., the Kuparuk Pipeline/Spine Road) during the calving season. In the worst case, this avoidance may result in an 8 km (5 mi) wide band of habitat around a development that is essentially unavailable to maternal groups.

This "zone of avoidance" during calving appears to be a response by parturient caribou primarily to human activity associated with a structure rather than to the structure itself. Avoidance of the development can persist even after the human activity associated with it has declined.

Avoidance of the Spine Road and Milne Point Road by maternal groups has persisted in spite of drastic variations in the amount of traffic associated with them. Furthermore, even low or moderate levels of traffic (10-100 vehicles/day in the Milne Point study) can result in maternal groups avoiding the development during calving.

During midsummer, there does not appear to be a continuous "zone of avoidance" by maternal groups around facilities, although shifts in maternal group occupancy along the Spine Road and Oliktok Road were negatively correlated with local areas of intensive oil field construction and traffic. These data, and the data on avoidance of drill pads east of Prudhoe Bay, suggest that human activity continues to influence maternal group occupancy in midsummer but that the influence is not as strong then as during calving. Furthermore, there is some suggestion from the distribution of maternal groups along the Spine Road in midsummer 1984 that maternal groups may be adjusting to structures and activity there. Such adjustment to developments has not been demonstrated in the Prudhoe Bay oil field--maternal groups continue to avoid that area even during midsummer. Historical observations indicate that movements and occupancy of large numbers of caribou, including maternal groups, were common in Prudhoe Bay prior to the development of the oil field there.

Disruption of movements of caribou into and around the Prudhoe Bay and Kuparuk oil fields has also been shown to occur as a result of oil and gas development. Movements by significant numbers of caribou into the Prudhoe Bay oil field have virtually ceased, probably due to the intensity of human activity and the low ground clearance of pipelines there. General patterns of movements by caribou in the Kuparuk oil field have also been disrupted during mosquito season; however, there is some evidence from 1984 that the pattern of movements is returning to those prior to intensive development there.

Disruption of movements has also been investigated in terms of caribou behavior (especially success of crossing) in response to encounters with linear developments.

The success of caribou crossing linear structures depends on a number of factors such as the configuration of the structure, season, size of the group attempting to cross, presence of human activity along the structure, and type and intensity of insect harassment. These factors interact considerably and therefore are difficult to isolate empirically. There are two factors that influence not only the success by which caribou cross linear structures but also avoidance of developments. Traffic and human activity are two of these, and insect harassment is a third. Caribou maternal groups avoid areas of intensive human activity during calving and midsummer. Caribou attempting to cross road/pipeline complexes are deflected or turned back by traffic along roads when the interval between vehicles is too short to allow the animals to re-group and attempt to cross again. Other animals may not even approach closely enough to attempt to cross because of the disturbance from traffic.

The effects of insects on caribou movements have the opposite effect from that of traffic. During periods of increasing mosquito harassment caribou begin to move toward insect relief habitat along the coast. Harassment by mosquitoes and oestrid flies appears to overcome the general wariness even of maternal groups and enhances success of caribou in small or moderately-sized groups in negotiating linear structures as long as these structures do not constitute physical barriers (such as pipelines with low ground clearance). The enhancement due to mosquito harassment continues apparently until group size becomes large. Large groups have had low rates of crossing success. The inability (or unwillingness) of these large groups to cross structures such as elevated pipelines with or without adjacent roads may be due to the dynamics of group behavior rather than to the intensity of mosquito harassment. In some instances, large post-calving groups have formed prior to mosquito emergence, and these have had lower success in crossing linear structures than have the moderately-sized groups under moderate mosquito harassment. Conversely, in a few situations moderately-sized groups under conditions of severe mosquito harassment have had high rates of success in crossing linear structures. Although these data are not conclusive they suggest that under certain conditions the dynamics of group behavior rather than the absolute level of mosquito harassment may affect crossing success. No such differential response has been observed when caribou are harassed by oestrid flies--the success by caribou of crossing elevated pipelines increases directly in proportion to the severity of harassment by oestrid flies. Although the size of caribou groups during periods of severe fly harassment is characteristically low, there are insufficient data to suggest that the enhanced crossing success during this period is due to anything more than the distracting stimulus of fly harassment.

The configuration of the development is an important aspect of the success by which caribou cross it. There are no true buried sections in the Prudhoe Bay or Kuparuk oil field. Because of engineering constraints due to permafrost soil conditions on the coastal plain, pipelines must either be elevated or placed in short sections of gravel berm. Most of the mainline and feeder line pipelines are elevated in the oil fields. Buried sections occur in special areas such as road crossings. Although in the Prudhoe Bay oil field, pipelines are generally elevated only 0.5-1 m (1½-3 ft), since 1979 the State of Alaska has required that all pipelines on state land on the North Slope be elevated a minimum of 1.5 m (5 ft) above-ground. This elevation is sufficient to allow physical passage by caribou during summer, although drifting snow under the Kuparuk Pipeline created a barrier during spring 1982. There are insufficient data from which to conclude that pipelines elevated 1.5 m (5 ft) will not disrupt caribou movements; however, the data suggest that this elevation is sufficient under most circumstances. There are no studies in which elevated pipelines alone (no traffic and no ramps) have been studied during all seasons from pre-calving to August dispersal. Investigation of the Kuparuk Pipeline where it is separated from the Spine Road strongly suggest that a pipeline separated from a road by a considerable distance may not be a behavioral barrier; however, the data are inconclusive because there appears to be selection for the higher pipeline heights (2.5 m, 8 ft) by crossing groups, and because a number of successful crossings occurred at a "ramp." The data from several sites do suggest that the success of caribou in large groups crossing pipelines elevated 1.5 m (5 ft) is low, and that during the oestrid fly season pipelines elevated at such a height do not disrupt movements. Data are currently being gathered on the behavior of caribou attempting to cross elevated pipelines in areas where the pipelines are separated from the Oliktok Road by up to 300 m (1,000 ft). These data should be available in the next few years.

Although data are still being gathered on the effectiveness of ramps in enhancing crossing success and on design considerations that may increase the effectiveness of ramps, there are preliminary data that indicate ramps are effective in enhancing the success by which large groups cross elevated pipelines and road/pipeline complexes. Combinations of elevated pipeline, ramps, and separations of roads and pipelines may be the key for providing adequate caribou movements through oil fields in the future.

4.0 DISCUSSION

The superimposition of oil and gas development over a portion of the summer range of the CAH has provided a unique opportunity to examine the impacts of such a development on caribou. The vast majority of available information about the interactions between caribou and oil development has been gathered in the Prudhoe Bay, Kuparuk, and Milne Point oil fields. Several important lessons have been learned during this process. One of the major lessons is that some features of oil field development are more responsible for deleteriously affecting caribou--habitat relationships than are other features. For example, buried pipelines, roads, and in certain situations, elevated pipelines (if sufficiently elevated above the terrain) do not appear to affect caribou movements or distribution unless caribou associate them with human activity. Even aboveground pipelines can apparently be modified with ramps or possibly sections of higher elevation pipe to enhance caribou passage. These findings are encouraging because they suggest that even though engineering restrictions on the coastal plain preclude options such as pipeline burial other options may be available to minimize the effects of structures on caribou movements.

Another example of a feature that is one of the major influences causing an impact to caribou is the human activity associated with development. Again, this is an encouraging finding because although some aspects of human activity (e.g., general levels of noise, smoke, odors) cannot be effectively controlled, one of the major components of human activity--traffic along the road systems--can be controlled in such a manner that effects on summer movements of caribou can be minimized.

On the other hand, one lesson is not as encouraging. Maternal group sensitivity to developments, especially during the calving season, has been demonstrated to occur at relatively low levels of traffic, and to persist beyond the years in which the original avoidance occurred even if human activity declines. This reactivity of maternal groups to developments appears to be an extension of the natural sensitivity of parturient caribou during the calving and early post-calving period. The inferences of this sensitivity by maternal caribou are that developments in a major calving area can potentially disrupt calving caribou to the point that they will avoid the area if the density of developments reaches a threshold. However, once the calving and post-calving season has passed, the reactivity of maternal groups declines somewhat possibly in response to insects and social factors. This decline in sensitivity is not complete--maternal groups avoid areas of intensive human activity but appear to be able to adapt to a greater level of disturbance during midsummer than during calving.

The final lesson is that the current oil and gas development on the coastal plain is a victim of its geography. Several features of oil development in the Prudhoe Bay and Kuparuk areas - for example, its proximity to a concentrated calving area and to coastal mosquito-relief habitat, and its location in soil conditions that preclude pipeline burial - have resulted in impacts to the CAH that may not be relevant to other North Slope herds when these features do not exist.

Relevance of CAH Findings to Other Herds

Although this synthesis focuses on the CAH, some of the findings should be relevant to other North Slope caribou herds, especially herds such as the TLH which occupy similar coastal plain habitat. Responses to linear structures are likely to be similar. However, the TLH may be subject to more hunting, therefore the reactivity to traffic and off-road vehicles may be greater for animals of the TLH than that of the CAH.

Relevance to the PH and WAH is more difficult to evaluate. Both herds are not only much larger, and with more pronounced seasonal migrations, but both are also hunted more heavily than the CAH and thus may be more reactive to development. The WAH has pronounced north/south seasonal movement, and would encounter perpendicularly an east/west transportation corridor during fall and spring. Reactions of caribou to structures which they encounter during spring or fall have not been investigated. However, contact between animals of the WAH and oil development would most likely occur in the foothills, where topographic relief would allow more options for reducing the visibility of structures and for allowing use of long sections of buried pipeline because soil conditions may be suitable for pipeline burial. The PH would most likely encounter an east/west transportation system during calving and post-calving (i.e., perhaps the most sensitive times in their annual cycle). The reactions of extremely large (tens of thousands) mosquito-harassed groups are unknown.

Research Recommendations

(1) The determination of whether a change in habitat utilization of caribou has occurred in response to development can only be made in relation to data gathered prior to the development, or to data gathered in another similar location and under similar conditions. Baseline distribution, abundance, and especially movements and habitat utilization information should be gathered for other herds which are likely to be affected by oil development. Intensive use areas such as calving areas and movement areas (migrations as well as pronounced and repeated local movements) are especially important and should be identified.

(2) If oil reservoirs in NPR-A are developed, an east-west pipeline across the foothills between NPR-A and TAPS is likely to be constructed. There is little information about the response of caribou to pipelines during winter. Although the logistics of gathering such data are formidable, caribou responses to a simulated pipeline during winter should be investigated. Such a simulation should include state-of-the-art structures for enhancing caribou crossing success (such as ramps) and simulated construction traffic.

(3) The effectiveness of various ramp designs should continue to be investigated. In particular, the effectiveness of these designs in enhancing the success by large caribou groups in crossing road/pipeline complexes should be investigated.

(4) The effectiveness of deliberately separating roads and pipelines as a measure to enhance caribou crossing success should also be evaluated. Variations in the distance of separation is a variable that should be addressed comprehensively, and separation distance should not be limited to 300 m (1,000 ft) as is currently the case.

(5) To date, research on caribou responses to pipelines or to road/pipeline complexes have only investigated situations with single or double pipelines. As development in the Kuparuk field continues, multiple feeder ilnes (up to 6) will be placed on the same supports. Caribou may view this array as a "tunnel" rather than a pipe. Systematic observations should be conducted in order to develop different techniques for mitigation if such techniques become necessary.

(6) Although the attention of investigators is often focussed on animals which avoid or respond strongly to facilities, more effort should be addressed at determining why some animals are able to accommodate to development, and to determine what steps can be taken to increase accommodation. For example, if all ramps in the CAH range were identical in size and shape, perhaps caribou would learn to identify them as crossing locations. Practical research should focus on the mechanisms of accommodation, and methods which can foster accommodation.

(7) Although we have focused on the importance of maintaining access by the CAH to mosquito relief habitat, habitat utilization between periods of mosquito harassment may be equally important in the summer nutrition of CAH caribou. Observations of the habitat utilization by eastern portion of the CAH could be useful in assessing this--they are subjected to similar wind conditions and occupy similar habitat; however, they do not normally encounter human development.

5.0 LITERATURE CITED

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6.0 ANNOTATED BIBLIOGRAPHY OF SELECTED REFERENCES
IMPACTS OF OIL AND GAS DEVELOPMENT ON THE CENTRAL ARCTIC HERD

References in the enclosed annotated bibliography have been selected because of their relevance to identification and/or mitigation of impacts of oil and gas development on the Central Arctic Herd. Not all references related to the Central Arctic Herd have been included. Those references have been included which reflect major research programs (especially multiyear programs), historical interest, or other relevant discussion.

In each annotation, relevant material from the report is presented as the original author's (authors') conclusions and observations, either paraphrased or as a direct quote. Comments by the reviewer are enclosed in brackets [ ] and if the comments are more than a few words, are often preceded by "Reviewer's note" ([Rev. note: ...]).

Banfield, A.W. 1974. The relationship of caribou migration behavior to pipeline construction. Pages 797-804 in V. Geist and F. Walther, eds. The behavior of ungulates and its relation to management. I.U.C.N. New Series No. 24. I.U.C.N., Morges, Switzerland. 941 pp.

The author summarizes field research on the Porcupine Herd by the Arctic Gas project and includes information from available literature, as well as his personal observations. In addition to briefly summarizing the status of the Porcupine Herd (as of 1973), the author presents the following relevant conclusions:

(1) During studies of caribou east of the Mackenzie valley, migrating caribou utilized frozen lakes in winter and gravel eskers at any season. In mountainous terrain, steep mountain slopes are often used, either because of the shallow snow areas they provide or to avoid predators.

(2) Migrating caribou have been observed to follow cleared seismic lines in taiga areas, especially when the lines are parallel to the general direction of travel; however, when the lines are oriented tangentially to the direction of travel, caribou eventually will turn off in the original direction. Concern has been expressed about the effects of this deflection, especially as regards the delay of pregnant cows in reaching calving areas. Concern has also been expressed about the potential risk of increased predation on caribou following the lines. The effects of buried pipe lines may be similar to those of seismic lines.

(3) The effects of noise disturbance caused by compressor stations were being studied as part of the Arctic Gas project.

(4) The effects of aircraft disturbance or caribou were being studied.

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Beak Consultants. 1975. Seismic activities and muskoxen and caribou on Banks Island, N.W.T. Unpubl. rept. to Panarctic Oil, Ltd. 18 pp. + figs.

This study summarizes research about the effects of winter seismic operations on muskoxen and, to a lesser degree, caribou on Banks Island. Observations of these animals' responses to seismic operations were made by biologists accompanying the seismic trains. Although some aerial surveys were conducted, most of the data were gathered while the investigators were riding in tracked vehicles with the drill crews or accompanying the trains at a distance on snowmobiles and observing the animals' reactions. Caribou behavior was not specifically monitored.

Relevant observations and conclusions include the following:

(1) Observations suggest that seismic operations conducted with Nodwell tracked vehicles do not disturb ongoing behavior of muskoxen and caribou

in winter when the separating distance is greater than one kilometer (0.6 mi); snowmobiles, however, appear to alter ongoing activity at greater distances. The investigators conclude that the responses by the caribou to snowmobiles do not differ significantly from those shown by caribou toward wolves.

(2) No changes in habitat use by either muskoxen or caribou were observed.

(3) The investigators noted that one limitation of the study was that they could not record departures from ongoing activity unless animals were within one kilometer of the observer.

[Rev. note: This report provides information on the reactions to seismic activity primarily by muskoxen but also provides some information regarding the reactions of caribou to seismic activity. The conclusion (#2) regarding habitat use should be considered preliminary because the investigators did not specifically test for differences in habitat use.]

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Bergerud, A.T., R.D. Jakimchuk, and D.R. Carruthers. 1984. The buffalo of the North: caribou (Rangifer tarandus) and human developments. Arctic 37(1):7-22.

In this review, the authors discuss the effects of various types of human developments (e.g., roads, pipelines), land use (e.g., logging), and other activities (e.g., hunting) on the demographics of seven North American caribou herds and the Snohetta wild reindeer herd in Norway. The reactions of caribou to disturbance from human and predator harassment and to linear features (natural as well as man-made) are also discussed. The effects of predation in sensitizing caribou to disturbance are also discussed.

Relevant observations and conclusions include the following:

(1) There is considerable uncertainty in the literature regarding the effects of human disturbance on large ungulates. This uncertainty is due to the extrapolation from observations on individuals or small groups to effects at the population level, to the great variation in the quality of the information available, and to the use of correlational reasoning rather than hypothesis testing.

(2) The effects of transportation corridors, primarily roads, on the Fortymile, Nelchina, British Columbia, Central Arctic, Newfoundland and Kaminuriak herds were discussed. The authors concluded that the major impact of transportation corridors has been to increase access by hunters, resulting frequently in overharvest. Demographic changes were the result, and these changes have been incorrectly attributed to the effect of the corridor itself rather than to the increase in hunting along the corridor. In other instances, major distributional changes have been incorrectly attributed to disturbance associated with transportation corridors when in fact the distributional changes were more likely the

herd's natural response to changing abundance. The authors conclude that in none of the herds mentioned above have permanent declines occurred.

(3) The authors discuss the Snohetta Herd case history in some detail. They argue that although earlier authors had emphasized the observation that the disturbance and facilities associated with construction of a railroad was responsible for the cessation of migration between the Knutsho and Snohetta ranges, the actual reason was merely that the herd was naturaly responding to lower population levels resulting from overhunting along the railroad and road corridor.

(4) The authors present cases in which severe aircraft or vehicle harassment occurred during caribou tagging studies in Newfoundland, Manitoba, and Alaska. Tagging operations were conducted during the immediate postconception period and during calving, yet calf production and survival were unaffected. The authors conclude from these and several other examples that although harassment is neither unimportant nor acceptable, caribou "can withstand periodic severe disturbance without adverse effects on productivity and survival."

(5) Caribou have been observed to parallel and deflect around natural features (e.g., rivers, lakes, mountains) just as they have been observed to climb steep slopes. This behavior is attributed to caribou moving in response to "paths of least energetic resistance." Observations of paralleling or deflecting from man-made structures such as road berms and fences should not be construed as abnormal responses.

(6) Caribou reactions and sensitivity to disturbance should be evaluated in the context of *Rangifer's* co-evolution with wolves. There are several examples in which caribou, following habituation to humans, may have actually sought human-altered habitat (e.g., around settlements). Conversely, new roads, seismic lines, etc., may provide opportunities for wolves to enter caribou habitat that was previously unavailable to them.

(7) The major environmental variable that caribou need is space - space that will provide habitats where caribou have an advantage (such as mobility) over predators. Much as the buffalo, caribou have the problems of overharvest and need for space. Caribou populations must not be dissected into small discrete units so that they lose their ultimate adaptation - mobility to escape predators.

[Rev. note: This is an extremely thought-provoking article and deserves a critical review that is beyond the scope of this annotation - a more detailed review will be provided in the text of the report to which this bibliography is appended. Many of the examples the authors cite involve caribou populations that encounter linear developments, such as transportation corridors, during fall or spring migration. One questions whether responses to these corridors would be the same if they were placed in calving grounds or winter range, where caribou are relatively sedentary. At least one of the authors (Bergerud 1978, p. 100) has recommended that harassment by humans should be prevented near calving grounds.]

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Cameron, R.D., and K.R. Whitten. 1976. First interim report of the effects of the Trans-Alaska Pipeline on caribou movements. Spec. Rept. No. 2, Joint State/Fed. Fish and Wildl. Advis. Team, Anchorage. i+38 pp. + appendix.

The results of aerial and ground surveys in 1974-75 to determine the effects of the Trans-Alaska Pipeline System (TAPS) on CAH caribou are summarized in this report. [Construction of the Haul Road to Prudhoe Bay began in spring 1974; construction of the pipeline workpad began in summer 1975.] Periodic aerial surveys were conducted from a Cessna 180 or 185 along the Arctic coastline and selected North Slope drainages at 60-120 m (200-400 ft) AGL. Classification of individual sex and age classes was made if possible; however, often only calves and adults (i.e., older than calves) could be determined. Direct observation and radiotelemetry were used. The latitude/longitude coordinate for each aerial observation was plotted, and from the observations from each survey a mean "center of caribou occupancy" was determined. The "center of caribou occupancy" was compared with a calculated "center of survey coverage" to relate the observed caribou distribution with an assumed uniform distribution.

Ground surveys were conducted from a light truck along the Haul Road, commencing in September 1974. Surveys were conducted twice during each two-week period, covering the area between Pump Station 4 and Prudhoe Bay. Observations of caribou in the vicinity of the Haul Road, caribou crossing locations, and physical characteristics (e.g., berm height, snow depth and hardness in the vicinity) of the Haul Road at crossing locations were made. The physical characteristics of crossing locations were compared with physical characteristics of the Haul Road at 1.6 km (1 mi) intervals between Pump Station 3 and Galbraith Lake, in order to determine if specific characteristics of the Haul Road were selected by caribou at crossing locations.

Relevant observations and conclusions include the following:

(1) Except for the September (rut) survey period, regionwide aerial surveys indicated that groups with calves occupied higher latitudes (i.e., nearer the coast) than other groups. Movement patterns of the two types of groups were similar, but there was approximately a 50 km difference in the centers of occupancy.

(2) Haul Road surveys indicated that, except during rut, groups with calves were observed near the TAPS corridor proportionately less often than they were elsewhere during aerial surveys.

(3) Once above-ground pipe was in place (winter 1975-76), observations of crossings indicated that more bulls than cows or calves crossed under the pipe, and most observed crossings occurred during the oestrid fly season. However, the total number of observed crossings was small.

(4) Observations during aerial surveys indicated that most calving occurred between approximately 70° north latitude and the coast [Rev. note: inclement weather precluded an aerial survey during what we now know was the peak of calving - early June].

[Rev. note: Although this report covered the first year of an ongoing study, several conclusions (i.e., nos. 2 and 4) that would have been considered somewhat tentative in 1976 were subsequently confirmed.]

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Cameron, R.D., and K.R. Whitten. 1978. Third interim report of the effects of the Trans-Alaska Pipeline on caribou movements. Spec. Rept. No. 22, Joint State/Fed. Fish and Wildl. Advis. Team, Anchorage. ii + 29 pp.

This report summarizes results of the 1977 portion of the ongoing study of the effects of the Trans-Alaska Pipeline System (TAPS) on CAH caribou distribution and movements. Methods are identical to those reported in Cameron and Whitten (1976, 1977), with the addition of a June 30 fixed-wing survey over a 45 km section of the corridor area beginning at Pump Station 1 and extending westward approximately 20 km. Ten east/west transects were flown at 50 m (150') AGL, and group size and number of calves were recorded in this "avoidance area" survey.

Relevant observations and conclusions include the following:

(1) Results of aerial surveys indicate that "centers of occupancy" did not change greatly for similar survey dates in 1975-77, except that in 1977-78 the majority of caribou wintered on the coastal plain. Later initiation and lower depth of snowfall on the coastal plain in 1978 may have resulted in more caribou wintering there.

(2) Calving occurred more or less uniformly throughout the coastal region between Oliktok and Bullen points, and no regional concentration areas were identified. Calving peaked June 6-8. Calving in the Prudhoe Bay development area was extremely scarce (or absent), and no calves were observed during aerial surveys.

(3) Summer calf percentages in the TAPS corridor continued to be lower than corresponding regional percentages, and the percentage continued to decline relative to that of previous years (cf. Cameron and Whitten 1976, 1977). Fall calf percentages from the TAPS corridor followed a similar trend, except for 1975.

(4) Caribou latitudinal distribution within the TAPS corridor study area (fig. 1) indicated that during summer, of those caribou in the TAP corridor, relatively greater numbers were found in the region just south of the Prudhoe Bay development area (survey region 3) than in the region encompassing Prudhoe Bay (survey region 4), whereas in areas away from the corridor relatively lower numbers were found in survey region 3 than in survey region 4. These data reflected an avoidance of Prudhoe Bay by caribou and suggested displacement into survey region 3.

(5) Of 109 caribou fitted with visual collars, 5% emigrated to the WAH and 1% emigrated to PH; 68% of those collared were resighted. [Rev. note: J.L. Davis (pers. comm. 1985) has noted that some of these caribou were collared on winter range and therefore that these movements may not have

been true emigrations.] By the end of 1977, a total of at least 70 crossings of the TAPS corridor had been made by at least 29 collared caribou. Most crossings of the TAPS corridor occurred during northward spring migration, the majority between Sagwon and the checkpoint just south of Prudhoe Bay (i.e., south of most of the Prudhoe Bay development area).

(6) Of the 30 cows fitted with radiocollars, 90% have been relocated in the CAH. Of the remaining 10%, known emigration accounted for 3%, and suspected emigration or transmitter failure accounted for the rest. Mortality was at least 10% within two years of collaring.

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Cameron, R.D., and K.R. Whitten. 1979. Distribution and movements of caribou in relation to the Kuparuk Development Area. First interim rept., ADF&G, Fairbanks. 32 pp. (mimeo).

Observations of CAH caribou during summer 1978 are summarized, and the relationship of CAH caribou movements with oil development activities and insect densities is explored. Guidelines are presented for the mitigation of potential impacts to caribou that may be caused by further oil development in the Kuparuk Development Area (KDA).

Aerial surveys were flown in a Bell 206-B helicopter during calving (11-14 June) and, in a separate study, by fixed-wing aircraft during the postcalving aggregation period. Ground surveys along the West Sak Road (also called the "Spine Road") were conducted between 18 July-18 August. Direct observation and radiotelemetry were used.

Calving surveys consisted of helicopter flights at 30-50 m (100-200') AGL, following north/south transects located on section lines and spaced approximately 3.2, 4.8, or 9.7 km (2, 3, and 6 mi, respectively) apart, in an area between roughly Oliktok Point and Bullen Point and north of 70° north latitude. Ground surveys consisted of observing from a truck all caribou within 1.6 km (1 mi) either side of the West Sak Road from the Kuparuk River on the east to Well Site 12 on the west. Fixed-wing aerial survey methods are reported in Cameron and Whitten (1978).

Relevant observations and conclusions include the following:

(1) Calving densities were highest west of the Kuparuk River (minimum = 38 caribou/100 km^2) and near Bullen Point on the east, although some calving occurred at Franklin Bluffs also. Because survey coverage ended at Bullen Point, where high densities began to be encountered, the authors suspected that another high-density calving area was located near the Canning River delta. The density of calving caribou and the percentage of calves was extremely low in the Prudhoe Bay development complex. The authors conclude that the underrepresentation of calving caribou in the Prudhoe Bay complex was due to avoidance by maternal pairs of the Prudhoe Bay area because of oil development activity.

(2) During July-August, calf percentages along the West Sak Road were similar to those obtained in other areas (i.e., ca. 25%), except in Prudhoe Bay, and there was no difference among calf percentages at intervals of 0-500, 600-1,000, and greater than 1,000 m from the road.

(3) Most caribou movements in the West Sak Road area during insect season were through three major zones, located 0-4, 8-12, and 28-32 km from the Kuparuk River. These zones corresponded to the three major drainages crossing the West Sak Road - the Kuparuk, Sakonowyak, and Ugnuravik rivers, respectively. The preponderance of movements were northward toward the coast during insect harassment periods. The authors felt that the absence of southward crossings was due to weather and insect conditions during the period, which resulted in caribou remaining near the coast.

(4) The authors observed that during particularly severe insect harassment periods, caribou tended to aggregate on river deltas, prominent points, and in shallow lagoons; during less severe (but still severe) periods, the entire beach zone was used.

(5) Heavy traffic rates (20 vehicles/hr) along the West Sak Road occurred at the same time as severe insect harassment periods; low or medium rates of traffic were associated with a wide range of frequency of caribou sightings; therefore, the authors were unable to reach any conclusions about the effects of traffic.

(6) The authors present several recommended guidelines, including the following:

(a) Seasonal restrictions on aerial and ground traffic in the Kuparuk Development Area should be established, including restrictions on ground traffic (e.g., road maintenance) and a ban on construction activity during the calving period.

(b) Nonessential facilities should be located out of major movement zones; temporary facilities should be located with permanent ones.

(c) Feeder lines should be buried, except where other requirements (e.g., geotechnical constraints) mandate above-ground sections. The latter should be located only in nonsensitive areas, and appropriate crossing facilities should be provided.

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Cameron, R.D., and K.R. Whitten. 1980a. Distribution and movements of caribou in relation to the Kuparuk Development Area. Second interim rept., ADF&G, Fairbanks. 35 pp. (mimeo).

This report summarizes observations of CAH caribou during summer 1979. Methods were identical to those reported in Cameron and Whitten (1979). The calving grounds were surveyed by helicopter 11-13 June; the West Sak Road ("Spine Road") was surveyed from a light truck 26 June-21 August.

Relevant observations and conclusions include the following:

(1) Calving distribution was similar to that of 1978 (cf. Cameron and Whitten 1979); however, the total number of caribou more than doubled in 1979. Calving percentages and initial production were similar for both years, although proportionally more bulls and fewer yearlings were present on the calving ground in 1979 than in 1978. The Prudhoe Bay area continued to be avoided by maternal groups during calving.

(2) There was a slight shift inland of the dense calving area west of the Kuparuk River; in 1978, over 70% of all caribou calving west of the Kuparuk River were observed within 16 km (10 mi) of the coast, whereas in 1979 70% were located between 8 and 24 km (5 and 14 mi) from the coast.

(3) As was the case in 1978, there was no detectable avoidance of the West Sak Road by maternal pairs during the summer. The percentage of calves near the road did not differ significantly from that regionwide.

(4) Although major drainages appeared to be used as movement zones across the West Sak Road during the summer, the pattern in 1979 suggested that construction-related disturbance could be affecting movements. In 1978, major movement zones across the road appeared to be at 0-4, 8-12, and 28-32 km from the Kuparuk River. In 1979, movement zones were found at 0-4, 4-8, and 16-20 km from the Kuparuk River. Heavy construction activity along the West Sak Road in 1978 occurred at 16-20 km, and this area was used heavily during movements in 1979 when there was little human activity present. Likewise, the area at the Ugnuravik River (28-32 km from the Kuparuk River) was used heavily by caribou in 1978 but not in 1979, when heavy construction activity was occurring.

(5) Although the general pattern of movements (i.e., predominantly northward) across the West Sak Road was similar in 1978 and 1979, weather conditions and the appearance of large numbers of caribou south of the road in 1979 suggested that southward "drift" during periods of low or no insect harassment occurred at night or at intervals between road surveys. The authors conclude that road surveys are useful for determining the locations of caribou crossings but should not be used to determine chronological patterns or the magnitude of total crossing activity.

(6) Recommended guidelines are included. Guidelines are similar to those presented in Cameron and Whitten (1979), although seasonal guidelines are expanded.

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Cameron, R.D., and K.R. Whitten. 1980b. Influence of the Trans-Alaska Pipeline corridor on the local distribution of caribou. Pages 475-484 in E. Reimers, E. Gaare, and S. Skjenneberg, eds. Proceedings of the second international reinder/caribou symposium, Røros, Norway. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

The results of the ongoing study of the effects of the Trans-Alaska Pipeline System (TAPS) and Prudhoe Bay oil development area on CAH caribou are summarized for the period 1975 through 1978. Methods were described in Cameron and Whitten (1976, 1977, 1978, 1979) and in Cameron et al. (1979). Additional data analysis in this report includes a comparison of quarterly changes in human disturbance from 1975 through 1978 (as indicated by air operations and employment figures for the Prudhoe Bay field) with caribou group composition along TAPS.

Relevant observations and conclusions include the following:

(1) Between 1975 and 1978, the mean calf percentage observed in the TAPS corridor from the Haul Road was lower than that observed during aerial surveys over the entire CAH region. During the same period, the percentage of calves observed from the Haul Road declined, whereas regionwide calf percentages increased.

(2) Between 1975 and 1978, the mean bull percentage observed in the TAPS corridor from the Haul Road was higher than that observed during aerial surveys over the CAH region. During the same period, the mean percentage of bulls observed from the Haul Road increased.

(3) The caribou sighting frequency and corridor-crossing rate within the TAPS corridor declined in 1976, then increased between 1977 and 1978. These indices suggest that caribou density within and movements across the TAPS corridor declined during TAPS construction, then partially recovered as construction activity decreased in 1977-78. The partial recovery in 1978 was attributed to an increase in summer occupancy by nonmaternal groups.

(4) Local avoidance by caribou of the intensive oilfield and support facility development in the Prudhoe Bay area was documented. The percentage of calves in survey region 4, which encompasses the Prudhoe Bay area, was lower than corresponding calf percentages in that same region away from the corridor [cf. Cameron and Whitten 1978].

(5) In spite of decreased construction-related activity along the TAPS corridor between 1975 and 78, there was no corresponding increase in the calf percentage along the corridor.

(6) Because of the influence of traffic and other construction activity along the TAPS corridor, the relative effectiveness of pipeline crossing facilities or construction mode (e.g., elevated vs. buried) could not be realistically evaluated.

[Rev. note: This report is one of the primary references for evaluating the impact of linear developments (pipeline and road) on caribou movements and distribution. Recently, the assertion that maternal groups have avoided the TAPS corridor because of construction-related activity has been challenged (cf. Carruthers et al. 1984, and text). Although there is still some disagreement that the Prudhoe Bay field had been an important calving area, continued avoidance of the Prudhoe Bay field by maternal groups has been documented (cf. text).]

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Cameron, R.D., K.R. Whitten, W.T. Smith, and D.D. Roby. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. Can. Field-Nat. 93(2):155-162.

This report summarizes field research conducted on the CAH during 1975. Some of the report overlaps Cameron and Whitten (1976); however, additional data analysis and conclusions are included.

Relevant observations or conclusions additional to Cameron and Whitten (1976) include the following:

(1) During summer, the mean latitudinal position of groups with calves (maternal groups) was higher than that of nonmaternal groups (mostly bulls) region-wide. In the TAPS corridor, the mean latitudinal position of all groups (maternal and nonmaternal) was farther south than that of all groups regionwide. In addition, during the fall when the calf percentage in the corridor was similar to that of the regionwide percentage (i.e., when all animals are mixed during the rut), the mean latitudinal position of combined groups in the corridor was farther south than the regionwide position. These results were interpreted to indicate that not only was the corridor influencing local distribution of maternal groups (cf. Cameron and Whitten 1976) but also that there were other influences in the corridor causing local abnormalities in overall caribou distribution.

(2) The group size of maternal groups regionwide was higher than that of nonmaternal groups. The mean group size within the TAPS corridor was smaller than the corresponding group size regionwide. Avoidance of the corridor by larger groups and/or group fragmentation were suggested as possible reasons for this.

(3) Analysis of the distribution data in four sample regions along the TAPS corridor indicated that in summer 1975 caribou away from the corridor were distributed in a pronounced north/south gradient, with highest densities at the north (coastal) end. In contrast, within the corridor highest densities were in the region just south of the Prudhoe Bay intensive development area. From these data as well as from the observation that there were no neonatal calves noted from the Haul Road in the Prudhoe Bay developed area, the authors concluded that caribou, and especially cows and calves, were avoiding the Prudhoe Bay development area.

(4) During fall (i.e., rut), the percentage of calves near and away from the TAPS corridor was similar, suggesting a decreased sensitization to the TAPS corridor by maternal groups or the influence of rutting bulls on group activity. [Rev. note: this phenomenon could also be due to bulls leaving the immediate corridor to search for cow/calf groups that remain distributed away from the corridor - no density data were available to test this.]

[Rev. note: This report is the first report in the formal literature about maternal group avoidance of the TAPS corridor and general avoidance of the Prudhoe Bay development area. It would have been helpful if the authors had provided a discussion of aerial survey methods equivalent in detail to that of the Haul Road surveys. In addition, the lack of statistical analysis (e.g., of group size differences) creates some problems in determining the significance of the differences in the data the authors discussed. For example, a casual inspection of group size differences (fig. 2) does not allow one to draw many conclusions, and indeed, this aspect of the analysis was not discussed in subsequent publications by the authors. In spite of these examples, conclusions regarding the avoidance of the TAPS corridor by maternal groups and avoidance of the Prudhoe Bay development area were not only verified by subsequent research but have become strengthened by observations of more pronounced differences in subsequent years.]

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Carruthers, D.R. 1983a. The Central Arctic Herd myth. Unpubl. MS. presented to first N. Am. caribou workshop, Whitehorse, Y.T. 36 pp. [Received from ARCO Alaska, Inc.]

In this report, the author summarizes some of the literature regarding the concepts of "herd," "tradition," and "calving grounds," and discusses these concepts in the context of the CAH. Relevant conclusions include the following:

(1) Caribou biologists' belief in the concept of a caribou herd borders on dogmatism. We have tended to think of herds as spatially and temporally discrete units, largely because of our short period of scientific acquaintance with caribou, relative to the period of time over which caribou have evolved.

(2) Two criteria, use of a spatially unique calving ground and tradition (or fidelity) to the calving ground, are currently used to describe a caribou herd. These concepts were developed in the 1960's and have had insufficient testing since.

(3) As the size of caribou herds has declined, the number of calving areas has increased. For example, four "new" herds have been "discovered" in the range of the WAH since the herd began to decline in the early 1970's. These "new" herds were defined because of the discovery of "new" calving areas in the region. A figure was presented that graphically portrays that the number of calving areas of the WAH and Fortymile Herd was inversely correlated with the total numbers of animals in the herds.

(4) The CAH has only recently been defined, and this definition occurred during a low period in the WAH numbers. Historically, the region of the CAH has been an overlap zone between the WAH and PH.

(5) Because the CAH is not really a herd at all, the effects on the herd caused by "fragmentation" [i.e., by TAPS or Prudhoe Bay] and "displacement" (i.e., from the Prudhoe Bay developed area or the Kuparuk oilfield

area) cannot be isolated from normal variations in use of the area as an overlap between adjacent herds.

[Rev. note: Although this is a thought-provoking review of one of the shibboleths of caribou biology, the author fails to address the fact that our understanding of numerous aspects of caribou biology has increased tremendously since the 1960's; therefore, it is not surprising that more calving areas and herds have been discovered. These discoveries have occurred during the same period of time that several Alaskan and Canadian herds have declined - a contemporary but not necessarily causal relationship. Furthermore, the subsequent dramatic increase of the WAH has not lead to the disappearance of the "new" herds. The author overstates the extent to which caribou biologists view "herds" as discrete entities, and he does not address the practical benefits for agencies to manage caribou herds as discrete entities. The author also fails to adequately give credit to the fact that, for example, in spite of dramatic population fluctuations, WAH caribou have calved in the Foothills in the general area of the upper Utukok River since at least the 1960's. WAH calving has not been scattered over other portions of its range (e.g., Kobuk Valley, Anaktuvuk/Chandler River foothills), which may have been equally accessible; therefore, the concept that calving occurs where caribou pause in their seasonal use of range (p. 7) does not appear to be a sufficient explanation for why caribou have returned to the same area for at least 20 years.]

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Carruthers, D.R. 1983b. Overlap of central and western arctic caribou within the current range of the Central Arctic Herd. Rept. to ARCO, Alaska, Inc. by Renewable Resources Consulting Services, Ltd., Sidney, B.C. vi + 20 pp.

In this report, a literature summary of the historic winter distribution of the CAH and the results of aerial surveys over the CAH range in late winter/-spring of 1983 are presented. Aerial surveys were conducted using fixed-wing aircraft (Heliocourier) flying at 120 m AGL along north/south flight lines spaced 20 km apart. An observer on each side of the aircraft counted all caribou within 1 km. The data from the transects were extrapolated to the remainder of the range.

The author's relevant observations and conclusions include the following:

(1) Caribou (mostly females) in late winter 1983 were concentrated primarily in the southwestern quarter of the CAH range, especially between the Colville and Itkillik rivers; a much smaller concentration was located within 30 km (20 mi) of the coast between the Colville and Kuparuk rivers.

(2) Densities averaged 110 caribou/100 km^2 in the southwestern portion, whereas within 40 km (24 mi) of the coast densities averaged only 14 caribou/100 km^2;

(1) Male and cow/calf groups had distinctive seasonal habitat preferences that affected their distribution over the CAH range. Cow/calf groups were found farther from riparian habitat than were bull groups during most seasons of the year. During the mosquito season, both types of groups used similar habitat types, including riparian areas. This practice was apparently due to utilization of mosquito relief habitat associated with riparian areas. River deltas and coastal beach areas were used extensively by female groups, whereas male groups made more use of river valley gravel bars. During the rut, differences in habitat use were reduced.

(2) The CAH distribution and movements were similar between 1981-1983 and were similar to those described by earlier TAPS studies (e.g., Gavin n.d.).

(3) Although discrete calving grounds were not evident, higher densities of female caribou were found near Oliktok and Bullen Points.

(4) Influxes of up to 20,000 WAH caribou were found in the range of the CAH in fall and late winter, and influxes appear to be increasing in size and regularity in recent years. Influxes from the PH and WAH are anticipated as these adjacent herds continue to increase.

(5) No major changes in activity pattern (e.g., lying, feeding, walking, running) were found between caribou adjacent to and away from TAPS.

(6) Along the northern section of TAPS where it is separated from the Dalton Highway and the Sagavanirktok River, "... the percent calves in the surveyed population was similar to regional estimates."

(7) The low representation of cows and calves adjacent to the TAPS corridor was a result primarily of their natural avoidance of riparian habitat. In contrast, bulls preferred riparian habitat and were common in the Sagavanirktok River valley and adjacent to TAPS. Thus the differences in calf percentage attributed to the TAP corridor by other authors was due to habitat selection differences between bull groups and cow/calf groups and not to the effects of the TAPS corridor itself.

[Rev. note: This report provides a considerable amount of information about habitat use, distribution, and behavior of CAH groups over a 2½-year period. The results section is very detailed and extensive and deserves a much more expansive review than can be covered here. Several of the conclusions reached by the authors (especially their conclusion that the distribution of caribou was independent of the presence of TAPS) are in direct contradiction to conclusions of other researchers (e.g., Cameron and Whitten 1980, Cameron et al. 1979, Smith and Cameron 1983, Whitten and Cameron 1985) and to data presented in this report. For example, table 7 presents data that indicate that calf percentages in and near to riparian habitat in the TAPS corridor are lower than calf percentages in riparian habitat regionwide. These data appear to conflict with the authors' statement on p. 127 that "during the present study it was found that normal patterns of sexual segregation, seasonal movements, and habitat preferences account for the differences in the distribution and density of cow-calf groups adjacent to TAPS."

(3) In late May 1983, caribou concentration areas were between the White Hills and the coast but farther inland than in the late winter and within 40 km (24 mi) of the coast between the Shaviovik and Canning rivers. Both of these concentration areas had 95% females and short yearlings; densities were lower than those in late winter.

(4) The author concludes that the southwestern portion of the CAH range is a likely area where WAH and CAH caribou herds overlap in winter because (a) very high densities of caribou were present there in late winter, and in late May there were few caribou there but no comparably high densities elsewhere in the CAH range; and (b) estimates as well as actual counts over the entire study area decreased by 67% between late winter and spring - this amounts to a loss of 9,750 caribou from the area.

(5) The CAH and WAH are both increasing and therefore may again [emphasis added] coalesce to form one subpopulation.

[Rev. note: Although the author's conclusions may be correct, the substantiation of these conclusions from the 1983 surveys is questionable because of the methodology used. The author did not discuss key assumptions in the Methods section. The validity of age/sex composition counts (e.g., cows, calves, bulls, yearlings) from fixed-wing aircraft is questioned by knowledgeable caribou biologists. The statistical validity of extrapolating from 10 km^2 survey strips to 100 km^2 blocks, without prior stratification of the survey area, was not discussed, yet this extrapolation is a key argument for the author's conclusion.]

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Carruthers, D.R., R.D. Jakimchuk, and S.H. Ferguson. 1984. The relationship between the Central Arctic Caribou Herd and the Trans-Alaska Pipeline. Rept. to Alyeska Pipeline Serv. Co. by Renewable Resources Consulting Services, Ltd., Sidney, B.C. xvii + 207 pp.

This report summarizes research on caribou of the CAH conducted between June 1981 and October 1983. Transect aerial surveys were flown with fixed-wing aircraft along north/south flight lines at intervals of 6.7 km and 20 km apart, depending on the level of coverage desired. Block surveys were flown by fixed-wing aircraft over 182-850 km^2 blocks located along the strip surveys. The strip surveys were designed to provide a 10% sampling intensity, which was then extrapolated to cover 100% of the region in order to determine caribou distribution and population trends. Greater survey coverage (30%) was flown in late winter 1982 and during calving in 1981-83. The block surveys were flown at 100% coverage in order to compare distribution and habitat selection of caribou within the Trans-Alaska Pipeline System (TAPS) corridor to that of caribou away from the corridor (i.e., control areas). Composition (i.e., male, female, yearling, calf, unidentified), group activity, and habitat use of caribou groups were also noted. Ground observations of caribou behavior were made June-October 1981 and July-August 1982 along the TAPS corridor and in control areas away from the corridor.

Relevant observations and conclusions include the following:

Additionally, the analysis of data by group types obscures the actual relationship between habitat utilization by individuals - e.g., a small number of large groups would underestimate utilization of a particular habitat type, and vice versa. Analysis based on individuals (e.g., table 7) shows that calf percentages were similar in both riparian and nonriparian areas.

As another example of the conclusions not following from the results, conclusion #10 (p. 14) states that "no major differences were found between the activity patterns of caribou adjacent to and away from TAPS." However, on p. 101 (and in fig. 39) the authors present results indicating that during two (i.e., postcalving and August dispersal) of three periods during which activity patterns were measured, there were substantial differences between caribou in the TAPS area and the "control" areas in patterns of feeding (32% vs. 47% during postcalving; 32% vs. 54% during August), moving (26% vs. 15% during postcalving), and standing (29% vs. 11%, during August dispersal).

A potentially more important consideration, however, is that most caribou biologists believe that it is not possible to accurately determine sex/age composition data (i.e., calves, yearlings, cows, bulls) from a fixed-wing aircraft. Because data gathered in this manner form the basis for the authors' conclusions regarding habitat utilization, distribution, and population trends, it must be recognized that the confidence limits on the data and conclusions are very broad.

In summary, although a considerable amount of data are presented, it is difficult to arrive at the same conclusions as the authors from an analysis of the results presented. The same results (but not conclusions) can be used to support other researcher's conclusion that caribou cows and calves avoid the TAPS corridor.]

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Carruthers, D.R., R.D. Jakimchuk, and C. Linkswiler. 1984. Spring and fall movements of Nelchina caribou in relation to the Trans-Alaska Pipeline. Rept. to Alyeska Pipeline Serv. Co. by Renewable Resources Consult. Serv. Ltd, Sidney, B.C. xi + 101 pp.

This report summarizes field research conducted on the Nelchina Caribou Herd (NCH) in Southcentral Alaska between April 1981 and November 1983. The study area was along the Trans-Alaska Pipeline System (TAPS) between Paxson and Glennallen. [Rev. note: see also Eide et al. 1985.] Within the study area, TAPS is less than 2 km (1 mi) from the Richardson Highway [a major all-weather highway] over 88% of its length and less than 400 m (0.25 mi) from the highway over 25% of its length. Objectives of the study were to (a) document caribou crossings of TAPS, (b) determine characteristics of the crossing areas, and (c) describe behavior of caribou when they encountered the pipeline. A combination of observation of animals and track interpretation was used. Regional surveys were conducted by small aircraft; corridor surveys were conducted by truck or snowmachine.

Relevant results and observations include the following:

(1) Nelchina caribou encountered TAPS primarily during two periods of the year: in fall (peaking in November), when animals were migrating eastward to winter ranges, and again in spring (peaking in April), when animals moved westward from winter range to summer range. Movements eastward of the area now including the TAPS corridor and including the Richardson Highway began sometime between 1960 and 1965 during maximum population levels. Regional surveys indicated that such movements have continued to the present, even during periods of low population in the 1970's. Areas of intensive movement have also remained similar since 1960-65. Most movements through the study area were between Paxson and Sourdough. During fall migration, most caribou crossed over a 20 km (12 mi) section north of and including Hogan Hill in areas consisting of upland and sloped topography. During spring migration, most caribou crossed over a 20 km (12 mi) section south of Hogan Hill in lowland areas that were contiguous on either side of TAPS and that included a high density of small lakes.

(2) TAPS is above ground for 61% of the study area, with 92% of the above-ground portion higher than 1.8 m (6.0 ft) from the bottom of the pipe to the top of the pad ("BOP-TOP"). TAPS is buried for 39% of the study area; most of the buried portion is located near Sourdough. Two buried sections were specifically constructed as crossing sites for caribou in known areas of migration. Additional buried sections, including short (18 m, 60 ft) "sag bends," and sections buried because of geotechnical reasons, comprise the remainder. Spring crossing sites were located in areas with a high proportion (76%) of above-ground mode, whereas fall movements were where TAPS was mostly (65%) buried mode. No selection by caribou for either mode was apparent, even in the 32 km (20 mi) section where both modes were available to caribou.

(3) The use of special big game crossing structures was also evaluated. The two special refrigerated burial sections, each 2.9 km (1.8 mi) long, were designed to specifically provide caribou passage and were located in areas of known historical movements at the north end of the southern third of the study area. Of the 29% of the estimated caribou that crossed TAPS at any big game crossing structure, 93% did so at the refrigerated burial sections. Two additional types of crossing structures, "sag bends" (18 m [60 ft] buried sections) and Designated Big Game Crossings ("DGBC's," or 18 m [60 ft] sections elevated to at least 3 m [10 ft] above the pad), were used very little because most of them were located outside of major caribou crossing zones. All structures were used less in fall than in spring.

(4) The angle of caribou trails approaching within 20 m (64 ft) of the edge of the 46 m (150 ft) cleared TAPS right-of-way and the subsequent angle leaving the opposite side were measured in order to indicate "deflections" by caribou encountering TAPS. Additional foot surveys 500 m (1,650 ft) away from TAPS were used as controls in order to determine if deflections were occurring farther than 20 m (64 ft) from the edge of the cleared right-of-way. Results of these surveys indicated that TAPS is seldom visible to human observers more than 125 m (410 ft) from the right-of-way and that caribou did not appear to significantly deflect within 500 m (1,650 ft) of TAPS.

(5) Although wolves and wolf sign was observed throughout the study area, there were no indications that wolves were using TAPS to ambush prey or that wolves were concentrating in the vicinity of TAPS.

(6) Based on the above, it appears that population size and seasonal distribution of the NCH are independent of the presence of TAPS. Virtually all caribou that encountered TAPS crossed successfully, without significantly changing their direction of travel.

[Rev. note: The results and conclusions of this report are in general agreement with those of Eide et al. (1985), with the exception that Eide et al. (1985) found that caribou tended to avoid crossing above-ground pipe at BOP-TOP's of less than 2.1 m (7 ft). Carruthers et al. (1984) concluded from their own data that there was no such selection and, further, that Eide et al. (1985) used a less appropriate analysis technique. Although a statistical comparison between the two reports is beyond the scope of this review, at least two factors should be considered. First, Eide et al. (1985) conducted their study in 1977, immediately postconstruction. In the intervening period between 1977 and 1981, there is the possibility that caribou could have accommodated to elevated pipe. Second, Carruthers et al. (1984) analyzed their data as one set for the total length of TAPS within the study area, whereas Eide et al. (1985) divided the study area into three segments and analyzed each of these segments independently (as well as analyzing the total length).

Carruthers et al. (1984) provided several recommendations for future construction projects similar to TAPS. Two of these are noteworthy: (a) human hunting activity in proximity to pipelines should not be permitted, and (b) DGBC's and sag bends are not necessary as design features to facilitate caribou passage across pipelines.]

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Child, K.N. 1973. The reactions of barren-ground caribou (*Rangifer tarandus granti*) to simulated pipeline and pipeline crossing structures at Prudhoe Bay, Alaska. Completion rept. to Alyeska Pipeline Service Company by Alaska Cooperative Wildlife Research Unit., Univ. Alaska. 50 pp.

The reactions of free-ranging caribou to various types of simulated pipelines and crossing structures in the Prudhoe Bay area were studied in a field experiment during the summers of 1971 and 1972. The author summarizes historic and current (as of 1973) distribution and movements of caribou in the Prudhoe Bay area and extensively discusses summer movements, especially as related to insect densities. The author dye-marked caribou in three areas adjacent to Prudhoe Bay in order to determine movements into the area.

The experimental pipelines were intended to simulate a 48" diameter pipeline (e.g., the Trans-Alaska Pipeline) and smaller diameter pipelines (e.g., feeder lines within the oil field) and proposed big game crossing structures such as "underpasses" (sections of pipe elevated above ground higher than adjacent pipe) and ramps. Modifications (e.g., diverter "wings") to discourage caribou from going around the simulations or to test different characteristics of the pipeline design (e.g., changes in ramp design) were made between the 1971 and 1972 study periods. The TAPS pipe simulation consisted of 2 mi of 4-ft-high burlap and snowfence "pipeline" elevated 20" above terrain and included four underpasses and two ramps. The 1971 "feeder line" simulation consisted of ca. 3,600 ft of 24" CMP on oil drums, with underpasses of 24" CMP on 6-8 ft pilings. In 1972, an additional "feeder line" of 3,600 ft of 10" diameter "pipe" on drums, and with a gravel ramp, was added. The TAPS simulation was located adjacent to the Sagavanirktok River floodplain in an area where caribou movements were predominately east/west during the mosquito season. The author did not specify the location of the feeder line simulation.

The reactions of free-ranging caribou were observed as they encountered the experiment. Most encounters occurred as caribou were moving east-west during alternating periods of mosquito harassment and relaxation from harassment.

Child's relevant conclusions are as follows:

(1) Animals marked west of Deadhorse, between the Kuparuk River and Put River, were later observed in Prudhoe Bay more frequently than those marked south and southeast of Prudhoe.

(2) Individual crossing success (defined as the number of animals crossing under the pipe or using the crossing structures, regardless of the time required to cross) was low (25% for both years and both simulations). Of those that failed to cross, 34% and 10% at the TAPS and feeder-line simulations, respectively, reversed direction; the remainder of the animals skirted the simulation.

(3) Of those individuals that crossed successfully, a greater proportion used the ramps than the underpasses or adjacent pipe.

(4) Generally, as the size of the group increased, group crossing success (defined as all members of a group crossing under the pipe or using the crossing structures, regardless of the time required to cross) of the TAPS experiment decreased; individuals (i.e., group size = 1) had crossing success of 62%, whereas the average crossing success of groups of size 2-1,500 was 25%; none of the 15 groups of size greater than 50 successfully crossed the TAPS line.

(5) Group crossing success was also related to sex of the group leader: crossing success of groups led by bulls was less than that of groups led by cows; bulls tended to detour widely around the simulation, whereas groups led by cows tended to remain near the crossing facilities, and even if they did not cross, they did investigate the facilities.

(6) Crossing success was greater during periods of insect harassment; insect harassment was a more important influence on crossing success than were the advancing season or experience with the simulation.

[Rev. note: Together with White et al. (1975), this study provides background information on prepipeline summer distribution and habitat utilization of the Central Arctic Herd. The study also provides important insight into the reactions of relatively "naive" caribou encountering pipelines and crossing facilities during the summer. In retrospect, interpretation of the data could have been more meaningful if the analysis had accounted for differences in caribou reactions during periods of varying harassment by mosquitos and by oestrid flies, respectively, such as has been done by Curatolo and Murphy (1983).]

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Child, K.N., and P.C. Lent. 1973. The reactions of reindeer to a pipeline simulation at Penny River, Alaska. Interim rept., Alaska Cooperative Wildlife Research Unit, Univ. Alaska. 29 pp.

The reactions of free-ranging and herded semidomestic reindeer to a simulated pipeline were observed between March 1972 and May 1973 on the Seward Peninsula. The simulation consisted of ca. 7,000 ft of 32" diameter dredge pipe placed on prone oil drums (24" ground clearance) running east and west from the floodplain of the Penny River. Hogwire fence diverter "wings" ran an additional 2,000 ft from each end of the pipe. A 320 ft long overpass (ground clearance of up to 12 ft in center) was placed adjacent to a gravel ramp over the pipe. These crossing structures were just uphill from riparian willow stands along the river.

Although the intent was originally to isolate a group of reindeer from the herd in order to test the effects of repeated seasonal encounters with the simulation, the investigators were prevented from meeting this objective.

Responses of reindeer were observed in 1972 during March (late winter), May (postcalving), July (insect season), September (prerut), November (early winter postrut), and May 21-23, 1973.

The authors conclude:

(1) Reindeer, even when herded, reversed direction or diverted around the simulation in almost all instances. Crossings were observed under two sets of conditions: (a) during late winter when stretches of drifted and compacted snow formed bridges over the pipe, and (b) in May 1973 (but not in May 1972), animals harassed by insects were observed to use the ramp.

(2) Animals would approach the pipe to within 50 m but remain at least 125-150 m from the overpass. Because the overpass was supported by numerous angle braces, the avoidance of this structure by the reindeer was thought to be due partially to its optical complexity.

(3) The reindeers' initial experience with the simulation was not modified by short-term experience. In some cases, reindeer bedded and were held for up to several days near the simulation but showed no inclination to cross.

(4) Leadership of mixed as well as segregated groups avoiding or escaping the simulation was often by adult bulls.

(5) The responses of reindeer to this simulation were similar to those of caribou at the Prudhoe Bay simulations.

[Rev. note: Several studies noted elsewhere in the present review have dealt with caribou or reindeer responses to structures during summer; this report provides essentially the only information on responses during other seasons. Unfortunately, the experimental facility itself, especially the underpass and the proximity of the crossing structures to a riparian area, likely biased the results somewhat, as the investigators note. Another potential source of bias, the extent of which is unknown, is the effect of herding the animals to the facility, as opposed to allowing free-ranging animals to encounter the facility as part of their normal movements.]

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Curatolo, J.A. 1984. A study of caribou response to pipelines in and near the Eileen West End, 1983. Final rept. to Prudhoe Bay owners for SOHIO Alaska Petroleum Co. by Alaska Biological Research, Fairbanks. vi + 32 pp.

This report presents results from the summer 1983 continuation of the 1981 and 1982 studies (cf. Curatolo et al. 1982 and Curatolo and Murphy 1983). Methods were similar to those of 1982, except that in 1983 observations were made at the SOHIO "S Pad" pipeline which runs on the north side of the West Sak Road (WSR), also called the "Spine Road," across the Kuparuk River to the Prudhoe Bay oil field. The S Pad pipeline is located 2.5 mi north of the pipe site. The S Pad pipeline is elevated higher than 6 m (20 ft) in the study area, so pipe height at each crossing location was not noted. The pipe/road site, used in 1981-82, was not evaluated.

Field work was conducted between 25 June-29 July 1983.

Relevant observations and conclusions include the following:

(1) Composition of the caribou in the study sites changed between 1981-1983; calf percentage declined from 20% in 1981 to 11% in 1983. The decline in calf percentage was due to an increase in the proportion of bulls in the study sites (from 36% in 1981 to 64% in 1983) rather than a decline in cow/calf numbers. The authors attributed the proportional increase in bulls to the preference by bulls for riparian habitat.

(2) Mosquito harassment in 1983 was less intensive than in 1981 or 1982.

(3) During the period of time when insects were absent, caribou group crossing success in 1983 was 30% at the pipe site and 23% at the S Pad site. [Rev. note: The results for the control were not reported. Crossing success at the pipe site presumably includes that at the buried section.]

(4) During the period when both oestrids and mosquitos were present, group crossing success in 1983 was 63% at the pipe site and 65% at the S Pad site. [Rev. note: The results from the control site were not reported. Crossing success at the pipe site presumably includes that at the buried section. Because crossing success has been generally higher during oestrid season than during mosquito season - Curatolo and Murphy (1983) -

the 1983 values may be higher than that of "normal" crossing success during the mosquito season.]

(5) The frequency of pipeline crossings by caribou was similar for all group types and group sizes investigated. [Rev. note: Inspection of table 5 reveals that this conclusion appears to be supported by the data. Although crossing success differences of up to 15% existed between differently sized groups, there were no apparent trends, except that individuals (group size = 1) had very low success and constituted a small sample size at both sites.]

(6) There was no apparent decline in crossing frequency associated with caribou having to cross the two pipelines. [Rev. note: The relevance of this conclusion is difficult to evaluate because of the lack of serial observations - i.e., the investigators could not determine if the same animals that encountered the first pipeline also encountered the second.]

(7) At the pipe site, there was no significant difference between the pipe height at the crossing location selected by caribou groups and the distribution of pipe heights within 1/8 mi of the group before crossing.

[Rev. note: Although this report contained a large amount of useful data, it did not provide the detail and data analysis at the level of the two previous reports (i.e., Curatolo et al. 1982, Curatolo and Murphy 1983). Particularly problematic was the lack of the pipe site control in 1983, for comparison with data from previous years and within the pipe site.]

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Curatolo, J.A., and S.M. Murphy. 1983. Caribou responses to the pipeline/road complex in the Kuparuk oil field, Alaska, 1982. Final rept. to ARCO Alaska, Inc. by Alaska Biological Research, Fairbanks. x + 81 pp.

Results from the 1982 continuation of the 1981 study (cf. Curatolo et al. 1982) are presented in this report. Data were collected between 4 June and 1 August. Methods were identical to the 1981 study, with the addition of a fifth study site, called the "river-road site" along the West Sak Road (WSR), also called the "Spine Road," at the Kuparuk River.

Relevant observations and conclusions include the following:

(1) In 1982, fewer caribou were observed to enter the study area than in 1981, in spite of the longer field season in 1982. The proportion of calves overall in the study areas was 23%, although there were fewer cow/calf groups in 1982 than in 1981, especially at the Kuparuk River sites. [Rev. note: Considering that the 1982 field season started during calving season, one would have expected a larger proportion of cow/calf groups in the sites in 1982 than in 1981.]

(2) During the mosquito season, caribou group crossing success was significantly lower at the pipe-road site (35%) than at the pipe site (80%),

river-road site (89%), or the control sites (82% and 84%). [Rev. note: Data from the two pipeline sites include crossings at buried sections.]

(3) During the 1982 oestrid fly season, there was no significant difference in crossing frequency between sites.

(4) During the calving/postcalving season, caribou group crossing success was lower in the pipe site (33%) than in its respective control (60%) but identical between the pipe-road site (25%) and its control. [Rev. note: Similar data were not gathered in 1981. Again, these data presumably include crossings at buried sections.]

(5) Crossing frequency overall was lowest during the calving-postcalving season; this observation could have been due to the fact that caribou were relatively sedentary during this period.

(6) Proportions of cow/calf groups that crossed the pipelines were similar between sites for both 1981 and 1982.

(7) Crossing success for differently sized groups was similar within each site. [Rev. note: This conclusion is supported by data for the pipe site; however, no groups larger than 100 were successful at the pipe-road site (table 4). Conversely (and in contrast to 1981 data), at the pipe-road site groups of 41-100 individuals were completely successful in crossing the pipeline (vs. 0% success in 1981).]

(8) Caribou showed a strong selection for crossing at buried sections of the pipeline. Crossing success at buried sections in the pipe site and pipe-road site were 16% and 6%, respectively, although these sections comprise less than 1% of the total length. [Rev. note: Note that the buried section in the pipe-road site has several features that were anticipated to make it less desirable as a crossing location - see Curatolo et al. 1982.]

(9) Caribou selected higher pipe heights (i.e., over 100") at the pipe site when insects were not present. This selection did not occur when insects were present at the pipe site nor at anytime at the pipe/road site. The authors conclude that "...pipe height (in the range examined) was not a factor that affected caribou in selecting pipeline crossing sites" (p. viii). [Rev. note: This conclusion is in apparent contradiction with results of the statistical tests provided in Appendix B, in which, at the pipe site, crossing success was significantly related to pipe height at the p=.05 and p=.01 levels. However, the authors (pers. comm.) believe that this apparent relationship is an artifact of the distribution of higher pipe heights nearest to the area of greatest caribou movement (i.e., the Kuparuk River). Dialog on this topic is continuing.]

(10) Recommendations for mitigation included the following:

   (a) Initiation of a regionwide analysis of caribou movements, distribution, and habitat use in order to determine the most effective locations and methods by which to facilitate caribou movements through the oil field.

(b) Facilitate caribou movements through the pipeline/road complex by separation of pipelines from heavily travelled roads, and construction of ramps at strategic locations over elevated pipelines.

[Rev. note: This is a thorough, well-documented study that is the best source of information detailing caribou responses to the pipeline/road complex in the Kuparuk oil field. Although there are some differences of opinion over interpretation of the results, this report is a good source of information. It should be noted that only the most important results and/or conclusions have been presented here. The study approach of intensive, systematic research conducted at selected locations complements well the more geographically extensive research conducted by the ADF&G (e.g., see Smith and Cameron 1985a) and vice versa.

There are, however, several areas in which caution should be exercised in accepting the conclusions. For example, analysis of crossing success based on groups rather than individuals can obscure the potential effects on the entire population. These effects would be more directly influenced by individual rather than group success.]

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Curatolo, J.A., S.M. Murphy, and M.A. Robus. 1982. Caribou responses to the pipeline/road complex in the Kuparuk oil field, Alaska, 1981. Final rept. to ARCO Alaska, Inc. by Alaska Biological Research, Fairbanks. x + 64 pp.

This report presents results of field research on CAH caribou conducted in the Kuparuk oilfield between July 1 and August 5, 1981. The behavior of caribou was examined at the Kuparuk Pipeline (KP), both isolated from and near to the West Sak Road (WSR - also called the "Spine Road"), and in nearby control areas. Observations of caribou behavior were made from 3 m high towers located in four study sites - the "pipe site" and the "pipe/road site" and their corresponding controls. The pipe-site was a 1.7 km^2 (0.6 mi^2) area along the KP near the west bank of the Kuparuk River, where the KP is separated from the WSR by 3.3 km (2 mi). The 1.1 km^2 (0.4 m^2) pipe control site was located 3.7 km (2.25 mi) south. The 2.5 km^2 (0.9 mi^2) pipe/road site was located approximately 6 km (3.6 mi) west of the pipe site along the Sakonowyak River in an area where the KP and WSR are separated generally by less than 30 m (100 ft). A 1.7 km^2 (0.6 mi^2) control was established 2.5 km (1.5 mi) to the south.

Data gathered included caribou movement and activity patterns, responses to structures and group size. Insect levels, traffic patterns, and weather information were also noted. The data were separated into mosquito season (2 July-19 July) and oestrid fly season (20 July-5 August).

Relevant observations and conclusions include the following:

(1) Group composition was relatively similar among all four study sites; calves averaged 22% for all four sites (range = 20-24%).

(2) During mosquito season, the proportions of groups crossing the pipe site and pipe/road site were 60 and 29%, respectively; the proportions crossing the respective controls were 68 and 75%. [Rev. note: These data presumably include crossings at buried sections.]

(3) During oestrid fly season, the proportions of groups crossing the pipe site and pipe/road site were 69 and 46% respectively; the proportions crossing the respective controls were 67 and 66%. [Rev. note: These data presumably include crossings at buried sections.]

(4) The variable responsible for reduced crossing success at the pipe/road site appeared to be traffic on the road.

(5) There was no apparent selection by caribou groups for crossing at specific pipe heights at the pipe/road site; however, at the pipe site a significantly greater percentage than expected crossed at pipe heights between 3.3 and 4.3 m (130-170").

(6) There was a strong selection for buried sections of the KP, especially at the pipe site (which had a buried road crossing over the pipe).

(7) Group speed and east-west travel [i.e., paralleling the KP] were significantly greater at the pipe site and pipe/road site than at the controls.

(8) Repeated, or multiple, crossings of the KP occurred, especially during oestrid fly harassment. This was at least partially attributable to caribou selecting the road, pipeline, and pipeline workpad for shade and fly relief habitat.

(9) The proportion of successful crossings by all group types (cow/calf and bull) was similar within each site. [Rev. note: According to the authors' criteria, "bull groups" consisted of more than 50% bulls, or, conversely, up to 49% cows/calves; and "cow/calf groups" consisted of more than 50% cows/calves, or up to 49% bulls.]

(10) The proportion of caribou groups crossing the KP was similar by group sizes within each site, although success was different between sites. [Rev. note: This conclusion does not appear to be supported by data in table 4. At the pipe site, success of groups larger than 100 was 33%, compared to the next lowest success rate of 63% (size 2-10). At the pipe-road site, success of groups of size 41-100 was 0%, compared to the next lowest success of 33% (for individuals - i.e., group size = 1 - and groups larger than 100)].

(11) Caribou reactions to roads without traffic varied from no observable reaction to selection for fly relief habitat during the oestrid fly season.

(12) Among the mitigation recommendations provided by the authors are the following:

(a) Vehicular traffic, especially during the mosquito season, should be restricted, although alternatives to blanket restrictions could be more effective. These alternatives include (aa) limiting the number of vehicles on a road to allow for lulls in traffic, (bb) restricting heavy traffic to nighttime hours when mosquito levels are low, and (cc) consolidating work in local areas.

(b) Pipeline and road systems should be routed so that they are separated by at least 1 mi. [Rev. note: Areas of separation of flowlines from roads by 300-1,000 ft will be evaluated for caribou crossing success beginning in summer 1985. The North Slope Borough has placed restrictions on separation distances, allowing flowlines to be placed no farther than 1,000 ft from a road - for oil spill observation considerations.]

[Rev. note: This report provides a large amount of well-quantified data, gathered in a systematic manner, regarding the reactions of caribou to roads and pipelines and is a significant source from which to develop mitigative guidelines. Aside from a few minor discrepancies, the conclusions are supported by the results. For further discussion, see annotations for Curatolo and Murphy 1983 and Curatolo 1984.]

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Dau, J.R., and R.D. Cameron. 1985a. Effects of a road system on caribou distribution during calving. Address at fourth international reindeer/-caribou symposium, Whitehorse, YT. August 22-25, 1985. 18 pp.

This report summarizes research conducted in the Milne Point area near the Kuparuk oilfield, west of Prudhoe Bay, Alaska. Research focussed on the effects of the 29-km Milne Point road on calving distribution (this report) and on distribution and use of the area during the remainder of the summer (Dau and Cameron 1985b). The road was constructed during winter 1981-82. Calving distribution was determined by flying strip censuses at elevations of 100-175 m with a helicopter. Data were analyzed according to calf and total caribou distribution within each of 40 quadrats of 1036 ha each and also within six 1-km-wide intervals from the road. Data for the four-year period (1978-81) prior to road construction were compared with the four-year period (1982-85) after road construction.

Relevant observations and conclusions include the following:

(1) Human activity and traffic levels in the Milne Point area were low (less than 10 vehicles/day) in 1983 and 1984, moderate (10-100 vehicles/day) in 1982, and high (more than 200 vehicles/day; 3 active drilling rigs; 35-cm diameter above-ground pipeline constructed along the road in winter 1984-85; 300 person housing unit) in 1985.

(2) Prior to construction of the road, the seven quadrats surrounding the road system contained 18% of total caribou and 17% of calves observed during calving. After the road was in place, these same quadrats contained only 2% of all caribou and 0.2% of calves observed during calving.

(3) Analysis of the density of maternal (greater than 25% calves) and nonmaternal (less than 25% calves) groups in comparison to the road location (i.e., 1982-85) indicated that there was not a significant correlation between nonmaternal group density (i.e., groups/km^2) and distance from the road, whereas there was a significant positive correlation between maternal group density and distance from the road. A comparison between nonmaternal and maternal group density in 1978-81 and the future location of the road superimposed over the sample area indicated that there was no significant correlation between group density and the future road location. Although correlations were not significant, inspection of the observed and expected values for caribou distribution in comparison to the road location indicates that prior to road construction more caribou than expected were located 1-3 km from the future road location and that fewer than expected were located 4-6 km. After road construction the reverse occurred - fewer caribou than expected were located within 3 km of the road.

(4) Comparison of the density of total individual caribou and of calves (as opposed to groups as in #3) with the road location produced results similar to #3 - i.e., a significant correlation between distance from the road and caribou density only for the period after road construction. However, in the case of analysis of density of individuals, not only calf but also total caribou density demonstrated such a correlation. The authors point out that because of the preponderance of female caribou accompanied by calves in the area, a comparison of distance from the road with density based on individuals rather than groups would yield results more similar between calves and total caribou than would a comparison based on maternal vs nonmaternal groups.

(5) A synthesis of results discussed in nos. 2-4 above indicates that prior to road construction maternal and calf caribou selected the area influenced by the current road. After the road was present, however, maternal and calf caribou have avoided the area within 3 km of the road. The authors speculate that a dense network of roads in important calving areas could cause widespread displacement of parturient caribou unless calving caribou develop a tolerance to human activity and structures - a tolerance that so far has not been demonstrated.

[Rev. note: This report is especially important for two reasons. First, this is the first caribou calving study incorporating data gathered prior to development with data gathered after development. Second, the apparent sensitivity of maternal caribou to moderate levels of human activity (e.g., 10-100 vehicles/day immediately after construction) and the apparent continuation of this sensitivity into years of low levels of human activity is striking.]

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Dau, J.R., and R.D. Cameron. 1985b. Responses of barren ground caribou to petroleum development near Milne Point, Alaska. Interim rept. to CONOCO - Alaska Operations, Anchorage. 11 pp.

This report summarizes research on summer 1984 caribou distribution in the Milne Point area, near the Kuparuk oilfield west of Prudhoe Bay, Alaska. Research focussed on the effects of the 29-km Milne Point road (constructed in winter 1981-82) and associated facilities on caribou summer distribution (see Dau and Cameron 1985a for further discussion). Aerial surveys were conducted by helicopter during calving. During the remainder of the summer, ground surveys were conducted from a pickup truck along the road system. Results from summer 1984 were compared with those of summers 1982 and 1983.

Relevant observations and conclusions include the following:

(1) Two areas of relatively high use during calving were discernible in 1982, 1983, and 1984. These areas were located on either side of the Milne Point road system. In 1978-81 (prior to road construction), the high-use areas during calving encompassed the area currently affected by the road. Prior to road construction, the proportions of total caribou and calves during calving within the area through which the road was built were 18 and 17%, respectively; in 1982-1984, the proportions were 6 and 5%, respectively.

(2) Data from road surveys indicate that during summers of 1982, 1983, and 1984, the distribution of total caribou and of calves increased with their distance from the road, up to 4,000 m, which was the outside boundary of the survey area. This pattern was not apparent in the comparison of summer distribution and the superimposed road location prior to construction (1978-81). [Rev. note: The observed difference in summer distribution can be attributed to the effects of the road and not to some natural feature such as vegetation or topography.]

[Rev. note: Although this report is a spartan treatment and discussion of very relevant data, a final report (summarizing eight years of data) is being prepared and will be available in late fall 1985 (Dau, pers. comm.). This report provides support for the authors' conclusions that the road system and human activity associated with it are responsible for avoidance not only during calving (cf. Dau and Cameron 1985b) but also during the remainder of the summer and furthermore that this trend has continued since summer 1982 (the first summer after road construction).]

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Davis, J.L., and P. Valkenburg. 1979. Caribou distribution, population characteristics, mortality, and responses to disturbance in northwest Alaska. Pages 13-52 in P. Lent, ed. Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR-A 1977-1978. National Petroleum Reserve-Alaska Work Group 3, Field Study 3. USDI, NPR-A 105(c) Land Use Study, Anchorage. xxxiii + 226 pp.

This report summarizes the distribution, movements, population estimates, and reactions to aircraft disturbance of Western Arctic Herd (WAH) and Teshekpuk Lake Herd (TLH) caribou in 1977-1978. Distribution, movements, and some population data were gathered during fixed-wing and rotorcraft aerial surveys, and sex/age composition from ground surveys. Population estimates for the WAH were derived by the Air Photo Direct Count Extrapolation technique. Although the primary study area was National Petroleum Reserve-Alaska (NPR-A), data from the remainder of the WAH range were also included. During aerial surveys in spring 1978, responses of caribou to fixed-wing and rotor-wing aircraft were evaluated, using the techniques and disturbance criteria of Calef et al. (1976) (see Calef et al. 1976, this review, for details).

Relevant observations and conclusions include the following:

(1) Although the peak of calving for the WAH in 1978 (June 6-8) was a few days earlier than that of 1977 (June 10), the patterns of use of the Utukok calving grounds were identical. In 1978, the "core" calving area, with densities of approximately $19/km^2$, was surrounded by a "peripheral" calving area.

(2) The TLH calving area in 1978 appeared to be east of Teshukpuk Lake, between Harrison Bay and Cape Halkett. [Rev. note: prior to 1978, the TLH had not been surveyed separately and was considered to be a portion of the WAH.]

(3) Overwintering calf survival was lower for that portion of the WAH wintering near Pt. Lay than for other portions of the herd wintering elsewhere. Predation did not appear to be a factor, but several dead or moribund animals with extremely high infestations of warble and/or nose bot larvae were found, suggesting that an unusually heavy insect infestation could be at least partially responsible.

(4) Although there were no clear-cut differences between the responses of caribou to fixed-wing and rotor-wing aircraft in April 1978, there was a direct correlation between the altitude of the aircraft and the severity of the caribou's reaction. Differential responses among different group sizes could not be clearly determined from the data, although the data suggest that the larger groups reacted more strongly [especially south of the Brooks Range; see fig. 2-8 and table 2-5].

(5) From literature review and analysis of their own data the authors suggest several guidelines, including (but not limited to) the following:

    (a) Until more is known about the effects of development on caribou during calving or on the calving habitat, increased human activity and development should be prohibited on or adjacent to calving areas.

    (b) Aircraft flights at altitudes of less than 160 m (500 ft) over caribou should be minimized; during May to August, minimal flying height should be 660 m (2,000 ft).

    (c) Because caribou may respond more to people on the ground, ground crews and/or vehicles should not approach caribou to within 1,000 m (3,000 ft) during calving.

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Eide, S.H., S.D. Miller, and M.A. Chihuly. 1985. Oil pipeline crossing sites utilized in winter by moose and caribou in southcentral Alaska. Can. Field-Nat. (in press).

This field research study, which was conducted during the period October 1977 through April 1978, investigated the crossing sites selected by moose and caribou along a 145 km segment of the Trans-Alaska Oil Pipeline in southcentral Alaska. Specifically, the study was designed to (a) evaluate the use of crossing structures specifically designed to permit the free passage of moose and caribou across the pipeline corridor and (b) to evaluate where animals chose to cross the pipeline at sites that were not specifically designed to facilitate crossings. This segment of the pipeline between Meiers Lake and Squirrel Creek is crossed by the Nelchina caribou herd (numbering approximately 14,000 animals in 1977) in early winter on its way to wintering areas and again in late winter-early spring while on its way to the calving grounds. Within this geographic reach, both elevated and buried segments of pipeline are crossed by this herd.

The terrain in the study area is gently sloping except where watercourses have cut steep banks through rolling hills. Vegetation within the study area was a mixture of white and black spruce, birch, willow, aspen, and balsam poplar interspersed with sedge meadows, shallow lakes, and riparian habitats. The presence of caribou tracks after fresh snowfalls was used to determine crossing site locations and crossing success. Physical parameters of the crossing sites were also measured (see also Carruthers et al. 1984).

Relevant observations and conclusions for caribou include the following:

(1) Seventy percent of caribou encounters (n=4,383) with the pipeline recorded during this study were of caribou moving eastward during fall migration. The majority of the caribou moving west in the spring apparently crossed the pipeline in late April when snow conditions were inadequate to record tracks. The near unidirectional orientation of tracks, except during December, suggested that the majority of encounters were by migratory caribou.

(2) Caribou selected buried sections of pipeline as crossing sites from 2.2 to 4 times greater than expected values would have predicted. [Rev. note: Approximately 17 percent of the pipeline within the study area, excluding road and stream crossings, was buried. The 10 buried segments averaged 2.2 km in length.] Because these buried sections were not randomly located along the pipeline, selection per se of these buried segments as crossing sites is not necessarily indicated. Except for buried river and highway crossings, buried pipeline was placed at locations where caribou traditionally crossed the pipeline corridor. The observed selection by caribou for crossing buried pipeline instead of above-ground sections may indicate continued use of traditional movement corridors rather than active selection; at the very least sections of pipeline that were buried to facilitate caribou crossings were buried in the correct location.

(3) Data indicated that at elevated sections of pipeline caribou selected against crossing sites with pipe-to-ground clearances of less than 7 ft (2.1 m). There appeared to be a tendency by caribou to select for

pipe-to-ground clearances greater than 8 ft (2.4 m). Analysis of subsections of above-ground pipeline, where crossings were most concentrated, indicated that caribou showed a negative selection for the lowest pipe-to-ground clearance categories occurring in that subsection and a generally positive selection for the higher pipe-to-ground clearance categories.

(4) Caribou crossed elevated sections of pipeline under VSM cross members on 30 occasions (1.4% of total crossings of elevated pipeline), 13 of which were at measured vertical clearances of less than 4.0 ft. The lowest caribou crossing measured had a vertical clearance of 3.2 ft.

(5) Caribou showed no selection for specially designed short elevated crossing sites ("DBGCs") and specially designed short buried crossing sites ("sagbends"). [Rev. note: DBGCs exceeded 10 feet in clearance from the bottom of the pipe to the top of the pipeline pad throughout each segment (generally 60 feet). Sagbends were effectively quite short; the buried portion was typically less than 60 feet. Both types of special crossings were located in areas known to be regularly used by big game species and in areas thought to have a high probability of use based on traditional movements or habitat characteristics.] The authors suspected caribou might select for sagbend crossings if sagbends were more frequent in occurrence and were longer in extent.

(6) Deflections (tracks that did not cross the pipeline) were recorded for 2.7% of the caribou encounters with the pipeline. Ninety-nine percent of the deflections occurred at elevated sections of pipeline. Deflections were observed for all pipe-to-ground clearance categories except for those less than 5 ft or greater than 12 ft, most likely due to the infrequent occurrence of these categories.

(7) The authors, during an October aerial survey, observed an eastward-moving group of 300-1,000 caribou tracks that deflected about 30 m from the pipeline, paralleled the pipeline for 1-2 miles, and then turned away from the pipeline without crossing. [Rev. note: Because of the forested terrain, observations of deflections farther away from the pipeline than the cleared right-of-way could not be made. Therefore, caribou that deflected at greater distances would not have been included in the analysis.]

(8) Since the construction of the Trans Alaska Pipeline, the pattern of the spring and fall migration of the Nelchina caribou herd has not changed from preconstruction patterns and herd size has grown from approximately 14,000 in fall 1977 to approximately 25,000 in fall 1983.

[Rev. note: As mentioned in this paper, snow depth in the study area during the winter of 1977-78 was in the lower third of winters from 1960-1982. A year of high snow accumulation could produce substantially different results in terms of caribou crossing-site selection and the ratio of successful crossings to deflections. For a comparison between results of this study and that of Carruthers et al. 1984, see Carruthers et al. 1984.]

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Fancy, S. 1982. Movements and activities of caribou at Drill Sites 16 and 17, Prudhoe Bay, Alaska: the second year. Final rept. by LGL Alaska Research Associates to Prudhoe Bay Unit Owners. ix + 48 pp.

This report summarized data gathered at Drill Sites (DS) 16 and 17 between 1 July and 10 August 1981 and compared these results with those obtained in the 1980 field season [cf. Fancy et al. 1981]. Methods were similar between years, except that in 1981, a 9 km^2 control site was established approximately 4 km south of DS 17. Vegetation and other features were similar between the control and drill sites, except for the drill rigs, pads, roads, flowlines, and human activity at the latter. Traffic levels averaged 24 vehicles/hour during randomly selected one-hour periods between 15 July and 6 August. An active drill rig was located at DS 17 throughout the study, whereas a drill rig was active at DS 16 only between 1 and 15 July (after which it was removed by 18 July). Flowlines (elevated 2 m above the tundra) connected the drill sites to the Prudhoe Bay oil network.

During the 1980 study, oestrid fly intensity was not isolated; however, in 1981 oestrid fly intensity was determined by observation of caribou fly escape behavior. The 1981 behavioral data were than analyzed according to the intensity of mosquito and oestrid fly harassment, respectively.

Relevant observations and conclusions include the following:

(1) Rates of caribou movement across each site were not significantly different except during periods of severe mosquito harassment, when groups moved faster across the experimental site than across the control site.

(2) During periods of low and moderate/severe mosquito harassment, but not oestrid harassment, groups on the experimental site spent significantly less time lying and feeding than those on the control site. However, there was no significant relationship between distance to a structure and time spent in lying or feeding.

(3) Of the 105 groups that approached within 500 m of a structure, 56% of the groups with calves and 31% of the groups without calves detoured around the structure or reversed direction.

(4) Small groups (i.e., less than 10 individuals) did not cross structures differently than large groups. [Rev. note: see Smith and Cameron 1985a and b and Curatolo and Murphy 1983 for a review of the effects of group size on crossing success.]

(5) The relationship between the crossing pattern of the groups within 500 m and the level of insect harassment was not statistically significant. During periods of high oestrid fly harassment, 71% of the groups crossed the structures directly. During periods of low insect harassment, 56% of the groups crossed a structure directly.

(6) Although localized avoidance of the drill pads was observed, many of the groups that reversed direction upon encountering the structures (roads and pipelines as well as drill pads) were later observed to detour around the structures, in or outside of the study area.

[Rev. note: Because this study was a continuation of the 1980 study (cf. Fancy et al. 1980) the same comments with regard to the study area configuration are applicable. In addition, the author never stipulated whether the "crossing pattern" referred to crossing more than one structure (i.e., road and flow line) or just to the first structure the group encountered.

Because of the individual variability in response to the structures it would be useful to know the proportion of groups during both years that entered the experimental site and then did not approach within 500 m of a structure. "Crossing pattern" is based on those groups that at some earlier point had already decided to approach within 500 m; other groups apparently decided not to approach.

Given the apparent difference in crossing success between large, mosquito-harassed groups (cf. Smith and Cameron 1985a and b) and smaller groups, an explanation of the number of groups in different size categories, as was given in Fancy et al. (1980), would be useful.]

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Fancy, S.G. 1983. Movements and activity budgets of caribou near oil drilling sites in the Sagavanirktok River floodplain, Alaska. Arctic 36(2):193-197.

Movements and activity patterns of CAH caribou were studied near two active drilling sites in the Sagavanirktok River floodplain east of Prudhoe Bay during July-August 1981. Two 9 km^2 study sites, one surrounding the area of the two drill sites and one a control, were established. Grids were set up around the sites and observations made from 12 ft high towers every two minutes between 0700-1700 hours. The time that caribou spent lying and feeding and the proportion of calves in each group were especially emphasized in the analysis. (See Fancy 1982 and Fancy et al. 1981 for additional details.)

Relevant observations and conclusions include the following:

(1) On both sites, groups harassed by insects (mosquitos and/or oestrid flies) moved significantly faster than groups not harassed; caribou spent only 34% of the time lying and feeding during high insect levels as opposed to 72% during low insect levels.

(2) The proportion of time spent lying and feeding at the drill site was not significantly different from that at the control site. [Rev. note: this contradicts Fancy 1982, table 5, in which the author concludes that caribou spend significantly less time lying and feeding at the drill site during mosquito harassment but not during oestrid harassment.]

(3) During oestrid fly season, caribou were attracted to pads and other structures for fly relief and possibly for relief from the heat, even though fly-relief habitat is widespread in the delta.

(4) Observations of caribou that were within 500 m of a road, pipeline, or drill pad indicated that approximately 29% of the groups that encountered one of these structures either reversed direction or deflected around the structure. Several of the groups that detoured around DS 16 appeared to alter their direction of movement up to 2,000 m away.

(5) Calf percentages of groups encountering the study site in 1980 (when there was no control site) were similar to regional calf percentages (23.9 and 21%, respectively). In 1981, however, calf percentages were 10.5 and 12.5% for the control and drill sites, respectively, as compared to regional calf percentages of 28%. There was more construction activity in 1980 (a year when regional and local calf percentages were equivalent) than in 1981. Although the author did not dismiss the possibility that cows that had encountered the area in 1980 had learned to avoid the construction activity and therefore did not enter the study area in 1981, he believed that the lowered 1981 calf percentage was more likely due to natural variation in use of the area.

[Rev. note: see comments in annotation for Fancy 1982.]

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Fancy, S.G., R.J. Douglass, and J.M. Wright. 1981. Movements and activities of caribou at Drill Sites 16 and 17, Prudhoe Bay, Alaska. Final rept. by LGL Alaska Ecological Research Associates to Prudhoe Bay Unit owners, Contract No. AR64048. ix + 48 pp.

The movements and activity of CAH caribou near two drill sites in the Sagavanirktok River floodplain were studied between 1 July and 15 August 1980. The 9 km² study area included Drill Sites (DS) 16 and 17. Direct observations of caribou group responses (e.g., direction and rate of movement, activity type, and crossing frequency) to structures (e.g., drill rig, roads, work pads) were made by observers in two towers, primarily between 0700-1700 ADT. Although the original intent of the research had been to study the responses of caribou to structures without associated human activity, this intent was frustrated because intensive construction of flowlines, operation of an active drill rig at DS 17, and traffic levels averaging 340 vehicles/day occurred during the study period. Mosquito levels were subjectively assigned to one of four categories. Experimental attempts to assess oestrid fly levels were unsuccessful.

Relevant observations and conclusions include the following:

(1) The composition of the caribou that entered the study site was as follows: 12.7% bulls, 22.7% cows, 18.6% calves, 2.6% yearlings, and 39.7% unknown.

(2) Eighty groups entered the study area, of which 35 approached within 500 m of a structure. Of these 35 groups, 43% crossed at least one structure directly, 26% crossed after turning at least 90° from their original path of travel, 20% detoured completely around the structure, and 11% reversed direction.

(3) Analysis of the data for those groups that approached within 500 m of a structure revealed that there was no statistically significant relationship between the crossing pattern (e.g., reversal, detour, direct crossing) and sex/age composition or size of the group and that there was almost a statistically significant relationship (p=.05) between crossing pattern and the group's location of entry onto the study area. Groups entering the study area from the south [which is a typical pattern during mosquito harassment periods] had a greater proportion of direct crossing than groups entering from the north (52% of former vs. 20% of latter), and groups entering from the south had a greater proportion of reversals than groups entering from the north (30% of former vs 4% of latter).

(4) Human activity may be as important as structures in affecting caribou movements and behavior. Because caribou groups were often closer to areas of human activity than to structures, the comparison between distance to a structure and caribou movements or behavior was of questionable value. An additional confounding factor is that the authors observed that some groups entered the study area moving rapidly but slowed as they approached within 400-800 m of a structure and then speeded up again as they approached the structure. This "nonlinear" movement pattern was attributed to "displacement behavior," an ethological term that applies when animals exhibit an unrelated behavior (such as feeding or lying down) in response to competing motivational stimuli (e.g., flight vs. approach). Many groups also hesitated and moved laterally at distances of 400-800 m from DS 16 when construction activity was high there.

(5) The rate and direction of movement of caribou on the study area was directly and significantly related to the level of mosquito harassment.

(6) Unlike other studies, this study found no relationship between group size and level of mosquito harassment.

(7) Caribou movements were concentrated near DS 16, which had no active drill rig in place.

(8) Weather during this study was colder and windier than normal.

[Rev. note: Although this study has provided a considerable amount of useful data with respect to caribou responses to structures, the authors acknowledge that some of the results are difficult to interpret because of the unplanned amount of human activity associated with the structures. An additional source of confusion could have been the inability to isolate data gathered during periods of high mosquito density vs. high oestrid fly density - the authors did not clearly explain whether data from the two situations were combined or whether the oestrid data were not included in the analysis (see p. 9).

Two factors (the study area location and the time of observation) render the study more valuable for characterizing behavior of caribou during northward movements as opposed to southward movements. Because of the location of the northeastern study area boundary, caribou did not enter the study from the north until they were within ca. 200 m of a structure; however, caribou entering the study area from the south (usually under conditions of mosquito harassment) could remain up to 2,000 m from the nearest structure. In addition, most observations were conducted during the day, when mosquito-harassed groups would be more likely to encounter the study area from the south, while enroute to the coast. The study area configuration would not affect the analysis of "crossing pattern," however, because that analysis considered only those animals already within 500 m of a structure. Comparisons between results from this year's (1980) study and the 1981 study are discussed in the annotations for Fancy 1982, 1983.]

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Fleck, E.S., and A. Gunn. 1982. Characteristics of three barren-ground caribou calving grounds in the Northwest Territories. Progress rept. No. 7, N.W.T. Wildlife Service, Yellowknife. x + 158 pp.

This report summarizes the literature review and field study of the use of calving grounds of three caribou herds: the Bathurst, Beverly, and Kaminuriak herds. This is the first report of an ongoing study. Historic utilization of the calving grounds (defined as "... the area where pregnant cows concentrate during calving"), topographic and surficial geologic factors, snowmelt patterns, and predator abundance/distribution were summarized from literature, remote sensing data, and mapped information. Vegetation, snowmelt patterns, and topographic/geologic features were also observed on reconnaissance flights and ground inspection.

Relevant observations and conclusions include the following:

(1) Recent studies of the three herds confirm that parturient caribou in all three herds have returned to the same general calving grounds over the past 15 years of record, and evidence from the archaeological record suggests that these calving grounds may have been used since prehistoric times as well. The authors also point out that not all calving occurs in these areas and that the exact boundaries of calving grounds have not been consistently defined by investigators (see figs. 2, 4, and 6).

(2) The authors examined the hypothesis that calving grounds are selected by parturient cows because of the variety of topographic relief, which in turn results in a microhabitat offering shelter for neonatal calves as well as phenological variation in vegetation. All three calving grounds are characterized by varied topography; however, it is most pronounced on the Bathurst and Kaminuriak calving grounds. On the Beverly calving grounds, not only is topographic relief less pronounced than that of the other two calving grounds, but it is also not unique from some other areas in the Beverly herd's range.

(3) All three calving grounds are in areas that appear to be in the coolest sector of the region and hence among the latest to develop newly green vegetation. The vegetation composition is not unique, compared to surrounding areas. Presence of greening vegetation during the <u>peak</u> of calving is not characteristic of, at least, the Bathurst and Beverly calving grounds; however, within two to three weeks of calving, newly emergent vegetation does become available.

(4) Snowmelt patterns are different for each of the calving grounds. From inspection of LANDSAT imagery and snow records, the authors found that the Kaminuriak and southern Beverly calving grounds were consistently snow-free earlier than the Bathurst and northern Beverly calving grounds.

(5) Although no predator surveys were flown over the calving grounds, examination of records and literature yielded conflicting results concerning the densities of predators on calving grounds and on the remainder of caribou winter and summer range. Wolves, wolf dens, and bears appear to be uncommon on calving grounds; however, the authors caution that this conclusion is based on limited evidence.

(6) The authors conclude that "the most obvious characteristic of the calving grounds is that cows traditionally return there to calve." No other single characteristic of the three calving grounds appears to be universal, nor do any appear to be unique as compared to surrounding areas; however, the available data are inadequate. The authors suggest numerous areas that should be explored more thoroughly during further hypothesis testing about the selection and utilization of calving grounds by parturient caribou.

[Rev. note: It would have been helpful if the authors had discussed the "primary calving areas" identified in several of the maps of calving areas - e.g., figs. 12 and 16 - and discussed characteristics of these areas in greater detail. Presumably, these "primary calving areas" are roughly equivalent to "core calving areas" (cf. Davis and Valkenburg 1979 for the WAH) and therefore may share some characteristics that are different not only from areas not in the calving grounds but also from other areas of the calving grounds. Nevertheless, considering the limited data available from which to describe biotic and abiotic characteristics of these calving grounds, and our poor understanding of how and why caribou use these areas, the authors have admirably summarized the situation.]

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Gavin, A. N.d. [1978?]. Caribou migrations and patterns, Prudhoe Bay region, Alaska's North Slope (1969-1977). Unpubl. rept. to ARCO Alaska, Inc. 57 pp.

This report summarizes observations of caribou distribution, movements, and abundance between 1969 and 1977. The geographic area generally covered was between the Colville and Canning rivers and between the coast and the Brooks Range. Incidental observations and survey results are included. North-to-south surveys were generally conducted along the main drainages. East-to-west surveys were conducted up to 20-30 mi inland between the Colville and Kuparuk rivers, and up to 10 mi inland between the Sagavanirktok and Canning rivers.

Relevant observations and conclusions include the following:

(1) During the earlier (ca. 1970) portion of the report period, there was geographic and temporal overlap of range between the Central Arctic, Western Arctic, and Porcupine herds.

(2) The coastal area now included within the Prudhoe Bay complex (i.e., between the Kuparuk and Sagavanirktok rivers) was utilized year-round by only a small number of caribou (less than 100). Seasonal influxes, especially during the summer, of up to thousands of animals were reported.

(3) The immediate Prudhoe Bay area was not a major calving area; major calving areas were between the Kuparuk and Colville rivers in the west and between the Canning and Kadleroshilik rivers in the east.

(4) Calving in 1971, and probably in 1972, occurred in the foothills rather than along the coast, because of heavy snow along the coast.

(5) Coastal areas and especially the Colville, Kuparuk, Sagavanirktok, and Canning river deltas were utilized heavily as insect relief habitat.

[Rev. note: Although the coverage was spotty and survey lines and techniques not well defined, this report has historical value, especially for the early half of the report period. Gavin's observations of movement areas and general distribution in the Prudhoe Bay area are likely fairly accurate. His abundance figures, however, especially for large groups, have been questioned by knowledgeable biologists, and his interpretation of seasonal movements outside of the summer season are not based on sufficient survey information to justify his conclusions.]

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Klein, D.R. 1980. Reactions of caribou and reindeer to obstructions - a reassessment. Pages 519-527 in E. Reimers, E. Gaare, and S. Skjenneberg, eds. Proceedings of the Second International Reindeer/Caribou Symposium., Røros, Norway. Direktoratet for vilt og ferskannsfisk, Trondheim. 799 pp.

This overview of reactions of Rangifer to obstructions (e.g., roads, pipelines, and winter trails) summarizes reports and studies from the Soviet Union, Fennoscandia, and North America. The author also provides an update (as of 1979) about the effects on wild reindeer in Taimyr of a railroad/gaslines/road complex near Norilsk. This complex resulted in delay, deflection, and in some cases an absolute block to movements along a traditional migration route used by 100,000 reindeer. Mortality from collision with trains, separation of cows from their calves, and localized destruction of range was also attributed to the complex.

The author identifies several patterns of reaction by Rangifer to obstructions. These patterns include the following: (1) structures such as roads, pipelines, or altered watercourses can block, delay, or effect movements independent of other human activities; (2) the level and type of traffic and other human activities also affects caribou/reindeer reactions; (3) seasonal influences on the reactions of caribou/reindeer are apparent; (4) age, sex, and size of caribou groups influence reactions; (5) responsiveness varies, depending on whether the animals are resident in the area or seasonally encounter the structure; and (6) habituation to disturbances (structures as well as activity) occurs more readily in unhunted than in hunted populations and in populations free from predators.

[Rev. note: the significance and interpretation of observations in this report have recently been challenged - see Bergerud et al. 1984.]

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Kuropat, P., and J.P. Bryant. 1980. Foraging patterns of cow caribou on the Utukok calving grounds in Northwestern Alaska. Pages 64-70 in E. Reimers, E. Gaare, and S. Skjenneberg, eds. Proceedings of the Second International Reindeer/Caribou Symposium, Røros, Norway. Direktoratat for vilt og ferskvannsfisk, Trondheim. 799 pp.

The results of field research in 1977-78 on WAH maternal cow caribou on the Utukok calving grounds are reported. Caribou were observed directly while feeding on the calving grounds and in nearby areas immediately following calving. Observations of feeding groups as well as detailed observations of individuals feeding were made, and forage samples were collected and analyzed.

Relevant observations and conclusions include the following:

(1) Geologic factors and meteorologic conditions resulted in earlier snow ablation in this area than in other parts of the North Slope. This situation in combination with the phenological development and the unique growth form of Eriophorum vaginatum (cotton grass) tussock tundra result in an early and highly nutritious source of forage for calving and lactating female caribou. In addition to Eriophorum vaginatum flowering heads, parturient cows also selected fluvial shrub areas to feed on newly emergent willow catkins.

(2) Following the antheses of Eriophorum, approximately two weeks following snow ablation, caribou changed to feeding on nearby dry upland areas where Lupinus arcticus (arctic lupine) is abundant.

(3) During the remainder of the postcalving period, maternal cows follow local variations in microhabitat and select forage species and plant parts that provide the most nutritious forage.

[Rev. note: This research provides an important link in our understanding of why some areas may be selected for calving; however, no such relationship has been found in other caribou herds' calving areas (cf. Fleck and Gunn 1982). The observation that maternal caribou feed in riparian areas soon after parturition indicates that maternal caribou do not necessarily avoid riparian areas, as has been suggested by some authors (cf. Carruthers et al. 1984.)]

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Lent, P.C. 1980. Synoptic snowmelt patterns in Arctic Alaska in relation to caribou habitat use. Pages 71-77 in E. Reimers, E. Gaare, and S.

Skjenneberg, eds. Proceedings of the Second International Reindeer/ Caribou Symposium, Røros, Norway. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

Mapping of gross features of snow accumulation and progressive snowmelt over Arctic Alaska from 1975 through 1978 by the use of LANDSAT imagery is reported. Inspection of LANDSAT imagery revealed that suspected areas of early snow ablation corresponded to the Foothills/tussock tundra zone typical of calving areas of the WAH and PH, and to routes regularly used by caribou migrating to the calving areas. Annual variations in the extent of early snow ablation were also determined, and these generally correlated to caribou calving use. The author does not conclude that snowmelt alone is responsible for the location of calving areas; however, other related factors such as vegetation phenology may be.

The area of early snow ablation in the CAH range was far south of the CAH calving area, although a small area near Prudhoe Bay was snow-free in 1976, when the remainder of the area was still under snow.

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Murphy, S.M. 1984. Caribou use of ramps for crossing pipe/road complexes, Kuparuk oil field, Alaska, 1984. Final report to ARCO Alaska by Alaska Biological Research, Fairbanks. 61 pp.

This report presents results of a field evaluation of the effectiveness of caribou ramps in providing passage for caribou through pipeline/road complexes in the Kuparuk oil field during July 1984. The study area was located in the Ugnuravik River drainage in the southwest portion of the field. The study area contained three ramps--one on a drill site road/pipeline complex (the "2D complex") and two on the main Spine Road/Kuparuk Pipeline complex ("Spine Road complex") linking CPF-2 to the Prudhoe Bay area. Another portion of the study area--the drill site 2X road/pipeline ("2X complex") had no ramps. The Spine Road complex is oriented approximately northeast/southwest, while the 2D complex is oriented approximately north/south for 1/3 of its length and east/west for 2/3 of its length (cf. figure 2). The 2X complex is oriented approximately north/south. Ramps in the study area consisted of 30 m x 30 m (100 ft x 100 ft) gravel pads that extended from the road across the adjacent above-ground pipeline and were sloped at 20:1 from the pipeline to the ground. The ramps covered approximately 30 m (100 ft) of pipeline.

Caribou were considered to have attempted to cross the Spine Road complex if they approached within 0.8 km (½ mi) of it, and to have attempted to cross the 2D complex if they approached within 0.4 km (¼ mi) of it. A successful group crossing was defined as over 50% of the group crossing both the pipeline and road.

Results from 1984 are compared with those of 1982, when only the Spine Road was present, and of 1983, the first year after construction of the Kuparuk Pipeline. The study area in 1984 was increased to four times that of 1983 in order to increase the number of observations.

Relevant observations and conclusions include the following:

(1) The pattern of caribou movements through the study area was similar in 1984 to that of 1982 and 1983. Caribou moved generally northward and eastward through the study area when mosquitoes were present and southward when mosquitoes were absent.

(2) The frequency and type of traffic on the Spine Road was different in 1984 from what they were in 1983. In 1984, there was a vehicle every 1.1 minutes (55 vehicles/hr), whereas in 1983 there was a vehicle every 1.9 minutes (31 vehicles/hr). In spite of the larger amount of traffic in 1984, the intensity of disturbance may have been less than in 1983 because the proportion of large vehicles (e.g., gravel trucks, tankers, graders) was greater in 1983 than in 1984, and the frequency of such vehicles parking near or on the ramps was also greater in 1983. [Rev. Note: Inspection of table 6 reveals that the number of large vehicles/hr was very similar between years--16/hr in 1983 vs. 18/hr in 1984; however, the proportion of time in which vehicles were parked on the ramps was very different between years--16% in 1983 vs. 1% in 1984.] Large vehicles appear to disturb caribou at greater distances and frequently elicit a more severe reaction from the caribou that encounter them than do small vehicles (i.e., pickup trucks). Traffic on the 2D road was one vehicle every 10 minutes (6 vehicles/hr).

(3) Over 50% of the reactions of caribou crossing elevated pipelines were classified as moderate or severe. Over 90% of the severe reactions occurred within 100 m (300 ft) of the road /pipeline complex. Caribou showed few moderate or severe reactions to ramps.

(4) The proportion of total successful crossings of the Spine Road complex by individual caribou was significantly higher in 1984 (34%) as compared to 1983 (5%) and was not significantly different from that of the Spine Road in 1982 (24%).

(5) In 1984, the rate of success of individuals crossing the Spine Road complex when mosquitoes (and no oestrid flies) were present was 93%. This crossing rate was higher than for any insect or insect-free condition in 1984 or any other year. The average group size when mosquitoes were present in 1984 was lower than when mosquitoes (only) were present in other years, and it was relatively low when compared with group size in other years even when mosquitoes were not present. In contrast, when mosquitoes and oestrid flies were present in 1984 group size was large and individual crossing success was extremely low (4%). These data confirm the tendency for smaller groups to have increased success over large groups in crossing road/pipeline complexes. [Rev. note: Previous studies--e.g., Child 1973, Curatolo and Murphy 1983, Fancy 1983--did not distinguish between group size and the intensity of mosquito harassment when evaluating the ability of large groups to negotiate pipelines or pipeline/road complexes. The data reported here suggest that group size *per se* influences crossing success because even though mosquitoes were present in 1984, group size remained small and the proportion of individuals successfully crossing the Spine Road complex was notably high.]

(6) Group and individual success in crossing the 2X and 2D complexes combined was much higher than success in crossing the Spine Road. Seventy-six per cent of groups and 98% of individuals encountering these complexes crossed them; however, crossing success of the 2X complex (no ramp) was lower than that of the 2D complex (ramp present). The author attributes the greater success by caribou in crossing these two complexes as opposed to the lower success in crossing the Spine Road complex to the more frequent traffic on the latter. The author notes that differences in ramp design and siting could also have affected the rate of successful crossings.

(7) Comparisons of crossing frequencies between sections of the Spine Road complex with and without ramps indicated that total group crossing success in the section with ramps (47%) was not significantly different from that of the section without ramps (25%), but individual crossing success was significantly higher (37%) in the section with ramps than in the section without ramps (29%). [Rev. note: Although there was statistically no significant difference in group crossing success, the test statistic and critical value (at $p=.05$) were extremely close, suggesting that there may be a real difference in group success between the two test situations.]

(8) The author concludes that "the question of whether ramps actually increase crossing frequency or merely provide caribou that are intent on crossing with a preferred alternative remains unresolved." He mentions several factors that preclude drawing firm conclusions. These include small sample size, less than optimal ramp design and siting, unauthorized parking of maintenance vehicles on the ramps, and the potential contribution of habituation by caribou to the road/pipeline complexes. He also concludes that "if large groups consistently use ramps [as the data suggest], this represents one of the most compelling justifications for the use of ramps as a mitigative strategy in areas where pipelines are not separated by roads."

[Rev. note: This study is one of the few that specifically evaluate the effectiveness of ramps in providing passage through a road/pipeline complex. The conclusion concerning the effectiveness of ramps in passing large groups over these complexes is especially relevant to the CAH and to other arctic herds where industrial development is planned near important mosquito relief habitat, because large groups often occur in response to severe mosquito harassment (although not always, as this report mentions). It is unfortunate that the ramp design and siting and unauthorized use of the ramps as parking areas (over which the author had no control) was not optimal because these two factors, as the author mentions, can alter the amount of ramp usage and interfere with an accurate evaluation. Ongoing research on the effectivness of ramps adjacent to and away from the Oliktok Road in the Kuparuk oil field and along the Milne Point Road in the Milne Point field will hopefully resolve these questions.]

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Reynolds, P. N.d. [1981?]. Preliminary report on the status of the Teshekpuk Lake Caribou Herd. Unpubl. rept., USDI, BLM, Fairbanks. 20 pp.

This report summarizes present and historic distribution and current abundance of the Teshekpuk Lake Caribou Herd (TLH). Current data were obtained from visual observations and from relocations of radio-collared individuals during aerial surveys in 1981.

Relevant observations and conclusions include the following:

(1) The TLH was estimated to consist of approximately 3,000 animals, 835 of which were calves.

(2) In June, females moved to the calving area mostly between Teshekpuk Lake and Harrison Bay. This area has been used as a calving area since at least 1977.

(3) During the insect season, caribou of the TLH (bulls as well as cow/calf pairs) moved to the coast on warm, calm days and drifted inland on cool, windy days.

(4) Several radio-collared Western Arctic Herd (WAH) [presumably] caribou were present on the Teshekpuk Lake study area in August and October 1981. No CAH radio-collared caribou were located in the study area in 1981, but several have been observed there in the past. [Rev. note: R. Cameron (pers. comm. 1985) noted that all these animals were collared on the winter range and that the herd membership of these animals was equivocal.]

(5) Seasonal distribution is mapped.

[Rev. note: This report provides a good summary of seasonal distribution in 1981. The calving composition data, which were gathered from a fixed-wing aircraft, should be treated with caution.]

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Robus, M.A. 1983. Caribou movements in the CPF 2 - Oliktok Region, Kuparuk oil field, Alaska, 1982. Final rept. to ARCO Alaska, Inc., by Alaska Biological Research. v + 74 pp.

This study summarizes field research on CAH summer distribution, movements, and age/sex composition in the Kuparuk oil field between May 31 and August 4, 1982. Caribou distribution and movements were determined by observation from three blinds located in a study area along the Central Processing Facility 2 road and one along the Oliktok Point road, by daily road surveys, and from miscellaneous observations from other investigators. Insect densities were also estimated. [Rev. note: although the method of estimation was not given in this report, one can assume that it is the same as that used by Curatolo et al 1982]. The investigators identified major caribou movement zones and recommended locations along the CPF-2 and Oliktok roads where adequate provision for caribou passage across pipelines should be located. Detailed maps of caribou movements during periods of insect-free and insect-harassment conditions are provided. The report discusses the relationship between the detailed movements in the study area and those of the CAH in the rest of its summer range.

[Rev. note: see also Robus and Curatolo 1983.]

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Robus, M.A., and J.A. Curatolo. 1983. Caribou movements along the Oliktok Road and in the Kalubik Creek region, Kuparuk oilfield, Alaska, 1983. Final rept. to ARCO Alaska, Inc., by Alaska Biological Research, Fairbanks. vii + 61 pp.

This study was a continuation of that reported in Robus 1983, except that two areas were added to the 1982 study area (see Robus 1983). In 1983, caribou crossing areas along the Oliktok Road were similar to those reported for 1982. However, general caribou movements in the area were different in that the greater number of days with moderate/severe insect harassment resulted in animals remaining near the coast during more of July. Caribou generally did not move south of the Spine Road in 1983, as compared to 1982, and this was attributed to their response to insect harassment rather than response to industrial development in the Kuparuk area. Caribou in 1983 also tended to move east/west along the coast more often than had been the case in 1982, and this was also attributed to insect densities.

As was the case in Robus 1983, specific caribou movements were mapped, and several suggestions for mitigation are provided. These suggestions include the following:

(1) Placement of feeder pipelines on the west side of the Oliktok Road would increase the likelihood that caribou moving northeastward under insect harassment would encounter the pipeline before they would encounter traffic on the road.

(2) Separation of feeder lines should be placed at least 1,000 ft from the road, in order to facilitate caribou crossing of both facilities.

(3) Traffic should be restricted along the Oliktok Road during periods of major caribou summer movements.

(4) Crossing ramps should be placed where separation of road and pipelines is not feasible.

[Rev. note: As is the case with Robus 1983, this report is an excellent source for detailed movements information in the western part of the Kuparuk oilfield.]

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Skogland, T. 1985. The effects of density-dependent resource limitation on the demography of wild reindeer. J. An. Ecol. 54:359-374.

The author compares population characteristics of eight Norwegian wild reindeer herds that live on winter ranges of varying quality. Seven of these herds consist of wild mountain reindeer (Rangifer tarandus tarandus) living on alpine or subalpine tundra in southern Norway. One herd consists of Spitsbergen reindeer (R. t. platyrynchos) on arctic tundra on the island of Svalbard. No wolves or other large mammalian predators (other than man) are present on these herds' ranges.

Data were gathered between 1979 and 1981, although comparisons between the recent data and that gathered as early as 1969 are also made. Population characteristics that are compared among herds of different densities include fecundity, calf and adult survival, and recruitment.

Relevant observations and conclusions include the following:

(1) Herd densities varied from 0.5 to 5.0 reindeer/km^2 of total vegetated habitat available. Ratios of winter:summer grazing area varied from 0.15 to 2.35.

(2) Comparison of adult reindeer fecundity and survival among herds of different densities indicated no significant relationship between these parameters and herd density.

(3) Comparisons of recruitment among herds indicated a significant inverse relationship between this parameter and density. This relationship was most significant when compared to density on late winter range; winter food limitation was considered to be the most important contributor to changes in recruitment. The difference in recruitment between the least and most productive herds was almost fourfold.

(4) Two aspects of recruitment, calf survival and age-specific fecundity, were examined. Although there was no significant relationship between density and adult fecundity, there was a significant inverse relationship between density and subadult (cows less than 2.5 years old) fecundity.

(5) The major contributor to the decline of recruitment as population density increased was calf mortality, and primarily neonatel calf mortality. Again, population density on the late winter range was highly and inversely correlated with neonatal calf mortality. Furthermore, mortality of older calves during their first summer and the following winter was only recorded in those herds having significant neonatal mortality - i.e., cows on limited late winter food supplies not only had higher neonatal calf losses but also apparently had older calf losses due to adverse summer or winter weather conditions. Herds that had sufficient late-winter range had high neonatal and later calf survival.

(6) The author concludes that density-dependent effects, such as lowered recruitment due to lower availability or quality of winter forage, can control wild reindeer populations but only at population densities near or above one-half the ecological carrying capacity of the habitat in question.

[Rev. note: This study is an important link in the substantiation of the relationship between resource limitation and lowered productivity of Rangifer populations. However, it is important to note that even the lower-density herds (0.5 reindeer/km^2) discussed here are higher than many mainland North American caribou herds and that therefore density-dependent effects similar to those discussed in this report are unlikely to occur at many current North American caribou population densities.]

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Smith, W.T., and R.D. Cameron. 1985a. Factors affecting pipeline crossing success of caribou. Pages 40-46 in A.M. Martell and D.E. Russell, eds. Proceedings of the First North American Caribou Workshop, Whitehorse. Canadian Wildlife Service Special Publication, Ottawa. 68 pp.

The results of data on the reaction of CAH caribou to the West Sak Road (WSR) ("Spine Road") and Kuparuk Pipeline (KP) complex in the Kuparuk oilfield were presented and compared with data gathered by Child (1973), Curatolo and Murphy (1983) and Fancy (1982, 1983). The survey period covered the summers of 1981 and 1982. The original observations discussed in this report were made during daily road surveys along the WSR, and additional observations were made outside of the specific road survey periods. Observations from Child (1973), Curatolo and Murphy (1983), and Fancy (1982, 1983) were made from fixed observation towers. Variables that could influence caribou crossing success and were discussed in this report included group size/composition, topography, insect activity, human activity (e.g., traffic levels, construction), and pipe/road configuration. The difference between crossing success when analyzed in terms of groups of caribou, as opposed to individual animals, was discussed.

[Rev. note: Although the survey period for original data presented here was not mentioned in this report, it was given in Smith and Cameron (1985b) as 15 June-7 August 1981, and 1 July-5 August 1982.]

Relevant observations and conclusions include the following:

(1) The majority of caribou observed were in large groups (greater than 40 individuals). This was because most groups were seen during periods of expected movement (i.e., movements affected by mosquito harassment), and therefore these observations contributed disproportionately to the results. [Rev. note: A related factor is that the survey periods for both years occurred primarily during the mosquito season - vs. precalving or oestrid fly season.] Likewise, large groups contributed disproportionately to the number of attempted crossings of the KP, WSR, or both. It was noted also that during precalving and calving in 1982, parturient cows apparently moved into the calving area from the west, bypassing the WSR. [Rev. note: This could also have been because, as the authors stated earlier in the report, "...In late spring, 1982 ... drifting snow accumulated beneath the Kuparuk Pipeline (KP) for much of its length, creating an impassable barrier."]

(2) A comparison between group and individual crossing success was made, using original data as well as data from the investigators mentioned above, after all the data had been standardized. Trends were somewhat obscure, but one conclusion was consistent among all four studies: caribou in large groups (greater than 100 individuals) have low success in crossing elevated pipelines. Group success was extremely low - only one of 27 groups was successful. Individual success was higher, ranging from 23 to 49.9% for the other studies, whereas the authors found 20 and 0% for 1981 and 1982, respectively. The authors discuss biases in their data that explain the lower individual success they noted.

(3) When one group was deleted from the calculations (because it was deterred by unusually heavy local traffic) success in crossing the WSR was greater than 90% for caribou individuals and groups, based on data from the authors and Curatolo and Murphy (1983).

(4) In all situations in which there were buried pipeline crossings not associated with road traffic, caribou crossed the pipeline at these sites preferentially. However, the authors found that two buried sections (road crossings) of the KP where it was next to the WSR were <u>not</u> preferentially selected as crossing sites. Therefore, design of the crossing structure could not be separated from associated traffic in isolating factors affecting caribou use of buried sections.

(5) During oestrid fly season, the ability of caribou to cross the KP and WSR increased markedly.

[<u>Rev. note</u>: Although this report provides a valuable comparison among studies, it would have been helpful to provide additional discussion concerning their standardization of data from other studies. For example, Fancy (1981, 1982, 1983) analyzed crossing success for only those animals that approached within 500 m of a structure - the authors provided no comparable criteria from their own or the additional studies, nor a discussion of why they did not. Nevertheless, this report, together with those of Fancy (1982, 1983), Curatolo (1984), and Curatolo and Murphy (1983) provide an important contribution to understanding caribou responses to a pipeline complex.]

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Smith, W.T., and R.D. Cameron. 1985b. Reactions of large groups of caribou to a pipeline corridor on the Arctic Coastal Plain of Alaska. Arctic 38(1):53-57.

The reactions of two large groups of caribou that encountered the Kuparuk Pipeline corridor in summer 1981 and 1982 are described in detail. In both cases, groups approached the Kuparuk Pipeline/West Sak Road ("Spine Road") corridor from the south, and portions of the initial group crossed under the pipeline and over the road, deflected eastward (toward Prudhoe Bay), or reversed direction. The Kuparuk Pipeline is elevated a minimum of 1.5 m (5') above the tundra, and runs east-west 44 km between Central Processing Facility-1 (CPF-1) in the Kuparuk oilfield to TAPS Pump Station No. 1 in the Prudhoe Bay oilfield. The West Sak Road (WSR) parallels the pipeline for ca.

30 km. There are three short (ca. 21-32 m) buried sections where the pipeline arcs toward the ground surface and is covered with a gravel berm (road crossing). Traffic on the WSR averaged 20 vehicles/hr during the 1981 observation and 21 vehicles/hr during the 1982 observation.

Relevant observations and conclusions include the following:

(1) On July 18, 1981, a group of 917 caribou approached the pipeline from the south near CPF-1. During 12 hours of observation, of the original 917 caribou, 46% crossed elevated sections without recrossing, 13% crossed at buried sections, 22% trotted or ran parallel to the pipe for 32 km without crossing, and 19% split from the main group and could not be accounted for. Overall, less than 60% of the original group were known to have crossed the pipeline/road complex.

(2) On July 13, 1982, a group of 515 caribou was observed milling on the south side within 20 m of the pipeline, 5 km east of CPF-1. After four unsuccessful crossing attempts, and the addition of more caribou as the original group moved eastward, a group of 655 caribou continued eastward. During eight hours of observation, 64% of the group crossed the pipeline - 26% under the elevated portion and 38% at a buried section. Thirty-six percent separated from the main group, and their fate was not determined.

(3) The authors concluded that large, mosquito-harassed groups do not readily cross beneath elevated pipelines. Deflections of up to 32 km, during which the caribou trotted or ran, were observed.

(4) Caribou were more successful in crossing buried sections, especially the widest buried section, than the elevated portion. For both years combined, 24% of the caribou crossed at buried sections, which comprise less than 1% of the pipeline.

(5) Well-designed buried crossings, especially those isolated from human activity, enhance caribou crossing success.

[Rev. note: Although this report documents a combination of circumstances (e.g., severe mosquito harassment when the animals are in contact with a road/pipeline complex) that occurs during a limited time relative to the annual life cycle of the entire CAH, the importance of the effect with respect to the large numbers of animals involved during the season when caribou need to maximize nutritional intake suggests that repeated occurrences could have severe consequences. For discussion of the effects of structures on crossing success of smaller groups, see Curatolo 1984, Curatolo and Murphy 1983, Fancy 1982, 1983 and Smith and Cameron 1985a.]

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Urquhart, D. 1973. The effects of oil exploration activities on the caribou, muskoxen, and arctic foxes on Banks Island, N.W.T. Appendix II in N. Simmons and T. Barry, preparers. Oil Exploration and the Bankslanders. Canad. Wildl. Serv. [no further information available].

This field study of the effects of winter seismic exploration on Banks Island consisted of observations on the ground and from the air of caribou reactions as they encountered seismic lines, camps, and "cat trains", and the distribution and density of caribou in response to seismic activity. Caribou distribution/density in relation to seismic activity was investigated by replicate surveys over a predetermined survey course. The study was conducted during fall and winter 1970 and fall (until November) 1971.

Relevant observations and conclusions include the following:

(1) Reaction to seismic camps: (a) When camps were located in areas easily visible for several miles, caribou in fall seldom approached within less than 2 mi, although they would graze within sight. This reaction was also observed with respect to staging areas and drill sites. Visibility, audibility, and odor of the source are important variables; however, these could not be evaluated independently. (b) Reactivity of caribou groups, as measured by response to snowmachines, varied. In October, mixed and bull groups could be approached closely, but in November all groups fled.

(2) Reactions to seismic lines: (a) The majority of caribou bands that encountered recent seismic lines in the winter paralleled for distances of several hundred yards to a mile or more, then turned away. (b) Groups that crossed the seismic lines did so in areas of noticeably less snow. (c) The author made some observations during November (period of normal migrations), in which caribou crossed without hesitation a seismic line three weeks old. (d) Cow/calf groups were observed to be more reactive to seismic lines than bull or mixed groups. (e) Although seismic lines affect caribou movements in the winter, the effects last only two to three weeks, depending on snow and wind conditions. (f) The disturbing factor of seismic lines appears to be the physical novelty (e.g., snow ridge with clumps of sod attached).

(3) Caribou distribution in relation to seismic grid: Although the results had not been subjected to a statistical analysis, the author's preliminary conclusion was that the effects of a seismic line grid with lines spaced at over 6 mi apart did not seriously affect caribou distribution.

(4) The author proposes several guidelines, including seasonal restrictions (i.e., during calving and fall and spring migration) and reduction of snow drift height created along the edge of the line by driving a tracked vehicle over it.

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White, R.G., B.R. Thomson, T. Skogland, S.J. Person, D.E. Russell, D.F. Holleman and J.R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. Pages 102-113 in J. Brown, ed. Ecological investigations of the Tundra Biome in the Prudhoe Bay region, Alaska. Univ. Ak. Biol. Pap., Spec. Rept. No. 2.

Summer feeding ecology of caribou of the Central Arctic Herd (CAH) was studied during 1972 and 1973 on the arctic coastal plain between the Kuparuk and Sagavanirktok rivers. Field research consisted of systematic observations of free-ranging caribou; observations of forage selection by tethered, tame reindeer; collection of esophogeal ingesta of fistulated reindeer and rumen contents of fistulated caribou; and collection of plant-composition data in the study sites. Field data were used to develop a preliminary Rangifer grazing model for the Tundra Biome portion of the International Biological Program. Together with that of Child (1973), these studies provide the major references about the ecology of Central Arctic Herd caribou prior to major oil development at Prudhoe Bay. Although most of the conclusions are tentative or are too esoteric to be used directly in impact appraisal or mitigation, the following conclusions are relevant:

(1) In the early 1970's, the Prudhoe Bay region supported a resident population of approximately 300 animals, although influxes of up to 3,000 have been recorded, primarily during the mosquito-relief season.

(2) Although the Prudhoe Bay region appears to be of minimal importance to the CAH as winter range, it is highly utilized during summer, especially when caribou move into the coastal area for relief from mosquitos.

(3) From data generated during computer simulations, it appears that nutrients in Prudhoe Bay forage are sufficient to provide growth and fattening to resident caribou only in the month of July, and because caribou are likely to spend at least one week of July avoiding mosquitos, only three weeks are actually available. The importance of this period to calves is such that "any restriction in nutrition during this stage of rapid growth may lower the likelihood of surviving the winter."

(4) Lactating cows graze more intensively than other age/sex classes and consume an amount of forage equivalent to that of adult bulls (which are much larger in body size). Values for adult bulls were estimated because of the small sample size.

(5) Insect densities (hence intensity of harassment) can be predicted by comparing ambient temperature and wind speed (see fig. 4 in report). Mosquito harassment not only increased the energy requirement by increasing locomotion, with a consequent decrease in grazing and resting time, but also caused avoidance of habitats associated with higher mosquito densities. Carex marshes and lake margins and Dupontia meadows, e.g., although nutritionally superior to other habitats, were avoided in July because of their increased mosquito densities. [Rev. note: Unfortunately the authors did not always state the distinction between mosquito and fly effects; therefore, some of the discussion was confusing.]

(6) Estimates from the model suggest that less than 2% of the primary production in the area is utilized annually. Therefore, although the area is only "moderately productive," there is an adequate biomass buffer to accommodate short-term influxes of large numbers of animals during insect-harassment periods. During extended (i.e., several days) periods of insect relief, caribou that entered the area drifted southward and out of the area (but not out of CAH summer range) until the next insect-harassment period.

(7) Caribou forage species preferences were influenced by the phenological stage of vegetation (i.e. the *Dryas*/snowbed community in early summer contains a mixture of calciphilic species), avoidance by caribou of high-density insect habitat (e.g., *Carex* marsh), and widespread availability of less-preferred communities (e.g., *Eriophorum* meadow).

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Whitten, K.R., and R.D. Cameron. 1983. Movements of collared caribou, *Rangifer tarandus*, in relation to petroleum development on the arctic slope of Alaska. Can. Field-Nat. 97(2):143-146.

The results of relocating radio- and/or visual-collared caribou of the CAH are presented. Between April 1975 and May 1978, 160 caribou were collared generally within 20 km of the TAP corridor. All caribou were located incidentally to other road and aerial surveys (see Cameron and Whitten 1976, 1977, 1978 for details); however, flights specifically for locating radio-collared animals were also made.

Relevant observations and conclusions include the following:

(1) At least 59% of 124 visual-collared caribou were resighted in the CAH range during the following four to five years. At least six visually-collared cows emigrated to either the WAH or PH. Only 61% of 36 radio collared caribou were seen without the aid of tracking equipment, which is similar to the resighting rate for visual collars; however, at least 92% actually remained in the study area, based on tracking results.

(2) The rate of resighting of bulls from the Haul Road in the TAP corridor was significantly greater than that of cows, although away from the TAP corridor, differences between the respective rates of resighting during aerial surveys were not significant.

(3) A significantly higher number of TAP corridor crossings by bulls than cows was found; however, some of this difference was due to repeated recrossings by groups of bulls that remained near the corridor. Therefore no real conclusions regarding bull and cow crossings could be made.

(4) Although caribou movements through the Prudhoe Bay field had been documented, especially during insect relief season, as recently as the early 1970's (i.e., prior to intensive oil field development), no collared caribou have been observed to move through the oil field in mid summer since 1975. In several instances, large postcalving groups containing collared animals approached the Prudhoe Bay oilfield complex from the east or west but fragmented and dispersed. Only a few individuals (mostly bulls) actually entered the field.

(5) In general, the results from studying movements of collared caribou support previous evidence of maternal group avoidance of the TAP corridor and the Prudhoe Bay oilfield complex.

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Wright, J.M., and S.G. Fancy. 1980. The response of birds and caribou to the 1980 drilling operation at the Pt. Thomson #4 Well. Final rept. by LGL Ecological Research Associates, Inc., to EXXON Company USA. vii + 62 pp.

The responses of birds and CAH caribou that encountered an exploratory drilling operation at EXXON's Point Thomson #4 well were studied during summer 1980. The experimental site was an exploratory well east of the Canning River, 75 km (45 mi) east of Prudhoe Bay and 1 km SSE of Pt. Gordon on the Beaufort Sea coast. A control site was located 6.5 km (4 mi) east of the drill site. Both sites, primarily wet sedge meadow, were similar, although lakes and ponds were more numerous in the control site. Observations were made during three trips on 18 June-1 July, 14-21 July, and 12-17 August.

Observations of caribou locations and activity, environmental conditions, and vegetation types used were made at 2- to 10-minute intervals for all caribou within 2 km (1.2 mi) of the sites. Group movement rates were measured for groups that remained in the study area at least 20 minutes. Decibel levels of drilling operations and support helicopter (Bell 212) flights were measured at the drill site and control.

Relevant observations and conclusions include the following:

(1) Late snowmelt in June and cool temperatures in July resulted in CAH caribou calving further inland and utilizing coastal insect relief habitat less than in other years.

(2) Fewer groups of caribou came within 2 km of the drilling site than the control site; no caribou came closer to the drill site than 1,200 m. These observation were attributed to disturbance associated with the drill site.

(3) Although sound pressure levels measured at 1,500 and 2,000 m from the drill site were low, the noises produced by the rig operation and helicopter support were clearly audible to humans 6.5 km away. In addition, odors associated with engine exhaust, steam from mud preparation, and kitchen and incinerator smoke were obvious.

(4) Every group entering the drilling area was approached by personnel intent on photographing or viewing them. One group of ca. 700 was frightened away from the drill site at 1,250 m distance when a worker from the rig approached them.

(5) On June 27, the Bell 212 disturbed one group of 97 cows and calves that were lying down when it flew over at 300 m AGL. The group rose and walked off. Two other groups of 17 and 9 each responded the same way.

(6) Although avoidance of the site was likely only during operation of the rig, impacts during exploration would be limited to one season and are probably not significant over the long term. The cumulative effects of numerous exploratory drill sites in one area should be considered, however.