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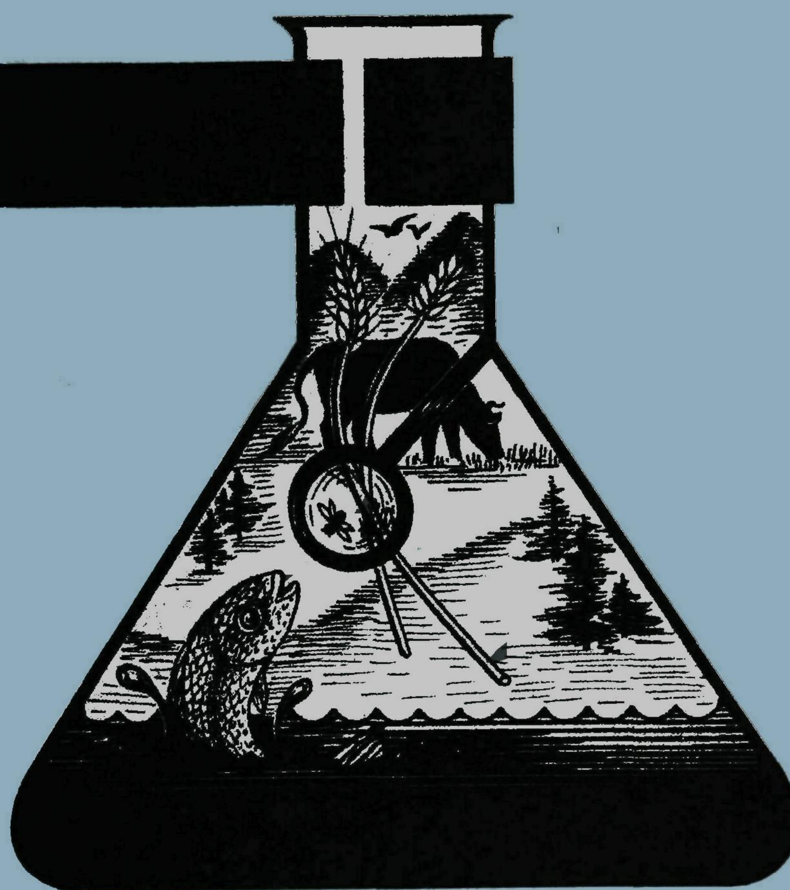
OIL DEVELOPMENT IN NORTHERN ALASKA

A GUIDE TO THE EFFECTS OF GRAVEL PLACEMENT ON WETLANDS AND WATERBIRDS



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A Guide to the Effects of Gravel Placement on Wetlands and Waterbirds

by

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ABSTRACT

This report provides guidance for resource managers involved with oil and gas development on Alaska's North Slope. The information is specific to the Arctic Coastal Plain, and much is drawn from the Prudhoe Bay area. Guidance on development impacts is most applicable in the Prudhoe Bay area and is generally applicable to other areas in the Arctic Coastal Plain. The review focuses on development impacts on tundra and the related changes in habitat value to waterbirds. Background information on development patterns and specific information on oilfield facilities are included.

General information is followed by an overview of impacts related to development and discussion of specific impacts.

The three appendices contain specific information on vegetation and birds. Appendix A is an annotated bibliography of major references on North Slope birds and on physical impacts related to oilfield development. Appendix B contains species accounts of the most common North Slope birds. Appendix C contains a list of common and scientific names for birds and plants commonly occurring on the Arctic Coastal Plain.

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1. INTRODUCTION

The purpose of this guidance manual is to:

Synthesize background information needed to evaluate environmental impacts of development on Alaska's Arctic Coastal Plain, and

Provide a scientifically sound basis for recommendations to mitigate the individual and cumulative impacts of wetland fills.

When oil and gas development projects are proposed, they are reviewed by various government agencies and public interest groups concerned with potential environmental effects. Agencies must evaluate proposed projects within set review periods and generally review several projects concurrently. Although each agency has a specific mandate or emphasis, individual reviews represent different aspects of the same issue -- the interaction between the proposed project and the environment -- and they are closely related. The guidelines presented in this manual will assist agency reviewers in providing timely and consistent reviews of development projects. The information and review criteria used by agencies are presented to assist developers in project planning and design. Incorporation of these criteria early in project planning and design should expedite permit review.

Rather than attempt to address all issues involved in North Slope development, this guidance manual initially emphasizes development activities in wetlands, specifically, impacts due to gravel fill. Because most development activities occur in wetlands, focusing on wetlands rather than single species provides a broader based evaluation of environmental impacts. The wetlands focus also was chosen because wetlands fill is the subject of major federal review mandated by the Clean Water Act, as amended in 1977.

This guidance manual is intended to aid both those familiar with the Arctic Coastal Plain and those who are not by providing a synthesis of existing information. The geobotanical classification developed by Walker et al. (1980) is the basis for much of the interpretation and analysis; information about impacts and habitat values are related to that classification. Wetlands impacts are measured in terms of physical disturbance and the subsequent loss or reduction in shorebird and waterfowl (collectively termed waterbirds) habitat value. Other species (e.g., caribou) and other sources of wetland impacts (e.g., contaminants) can be incorporated into the assessment once information becomes available. Waterbirds are addressed in detail as they are obligate and numerically dominant wetland users and, as migratory birds, are protected by international treaties.

Habitat for waterbirds is defined in terms of vegetation and surface forms. Two classification systems have been developed and tested in the Prudhoe Bay Region (between the Sagavanirktok and Kuparuk Rivers), Bergman et al. (1977) for waterfowl and Troy (1984, 1985) for shorebirds and common waterfowl. The habitat classification for waterfowl has been used in The National Petroleum Reserve-Alaska, but not east of Prudhoe Bay (Derksen et al. 1981). Troy (1985) provides a more detailed habitat classification derived from the geobotanical classification, but it has not been tested outside the Prudhoe Bay region.

General patterns of physical disturbance are described from studies of the Trans-Alaska Pipeline System (TAPS), International Tundra Biome Program (IBP) studies near Barrow, and miscellaneous studies of exploratory activities across the Arctic Coastal Plain of Alaska and Canada. These general observations apply across the Arctic Coastal Plain. Oilfield development patterns are drawn from small scale mapping analyses of the entire Prudhoe Bay Oilfield (PBO; 1:24,000) and more detailed analyses (1:6,000) of a portion of the oilfield (Walker et al. 1986). General patterns observed are valid for development in the flat thaw-lake plain and can be tentatively applied to the gently rolling thaw-lake plain, which is the dominant landscape in the Kuparuk Oilfield.

2. REGIONAL DESCRIPTION

PHYSIOGRAPHY

North of the Brooks Range, Alaska is divided into two physiographic provinces (Wahrhaftig 1965): the Arctic Foothills and the Arctic Coastal Plain (Figure 1). Only the Arctic Coastal Plan will be dealt with here.

The Arctic Coastal Plain is generally flat with numerous lakes and ponds connected by weakly integrated drainages (Wahrhaftig 1965, Walker et al. 1987). Water covers 30 to 90 precent of the surface. In the west the coastal plain forms a vast expanse of wetlands, 125 km-325 km wide, stretching south from the Chukchi Sea coast to the Foothills. East of the Colville River, this plain gradually narrows until it becomes a thin fringe, 10 km to 20 km wide, along the coast of the Arctic National Wildlife Refuge (ANWR). Wetlands vegetation covers most of the broad basins but drier communities are found on shores, banks, and small raised features such as pingos (ice-cored mounds) and relict beach ridges. To the south, the coastal plain grades into foothills, which are better drained and have fewer ponds and lakes. The entire region is underlain by permafrost and ground ice, which is common within 1 m of the surface.

Major landscape units described within the coastal plain (Figure 2) include flat thaw-lake plain, gently rolling thaw-lake plain, and floodplains (Walker et al. 1982, Walker and Acevedo 1984). Flat thaw-lake plains are associated with old floodplain surfaces and characterized by generally wet, flat terrain (surface relief seldom exceeding 2 m) covered by pond complexes, strangmoor (linear ridges) and low-centered polygons. They occur primarily along the coast and are most extensive in the Prudhoe Bay region. Only a few areas by deltas in the Arctic National Wildlife Refuge (ANWR) are considered flat thaw-lake plain. Between the Kuparuk and Colville Rivers, and between the

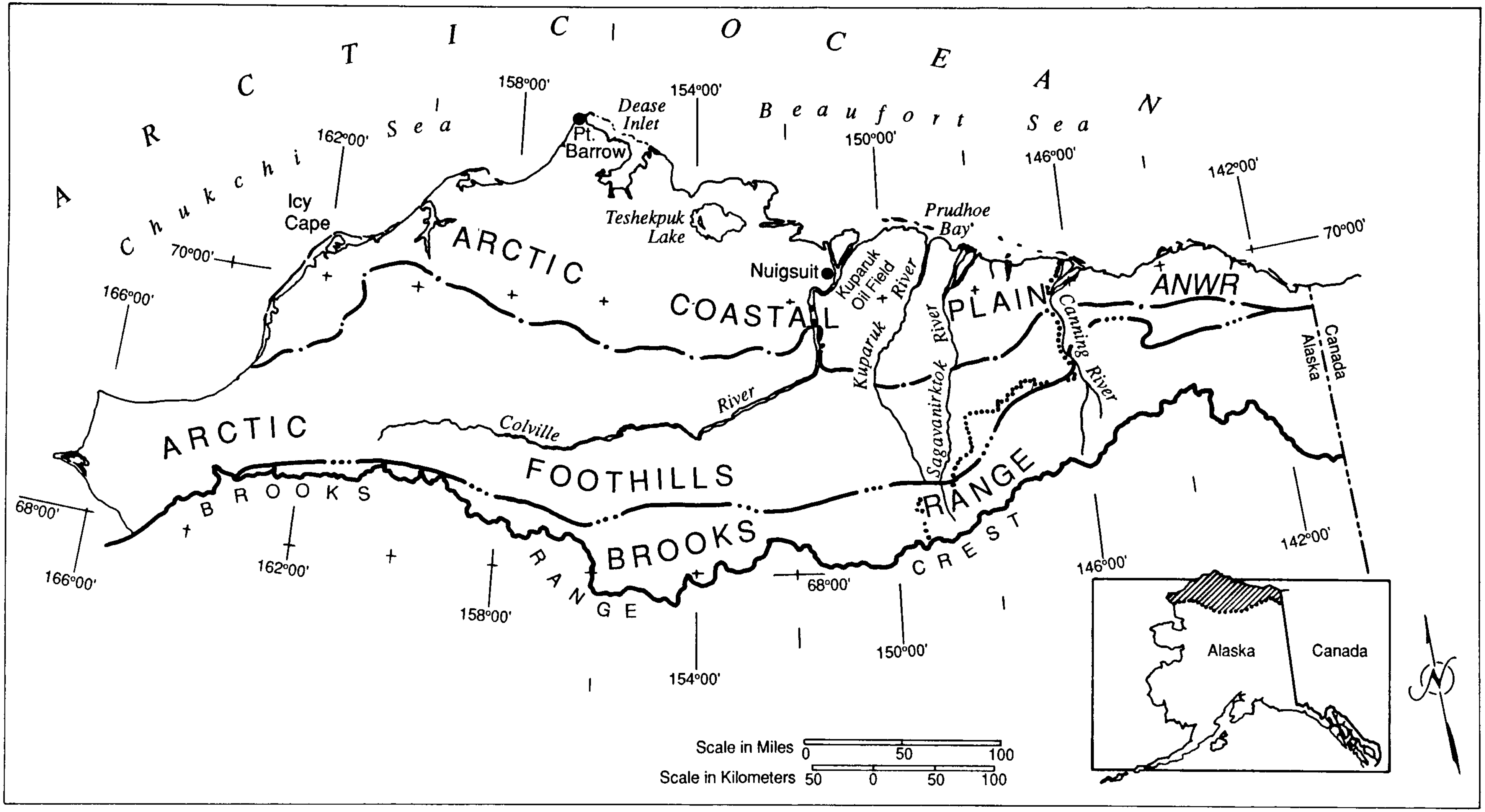

Figure 1. Physiographic provinces of the North Slope of Alaska.

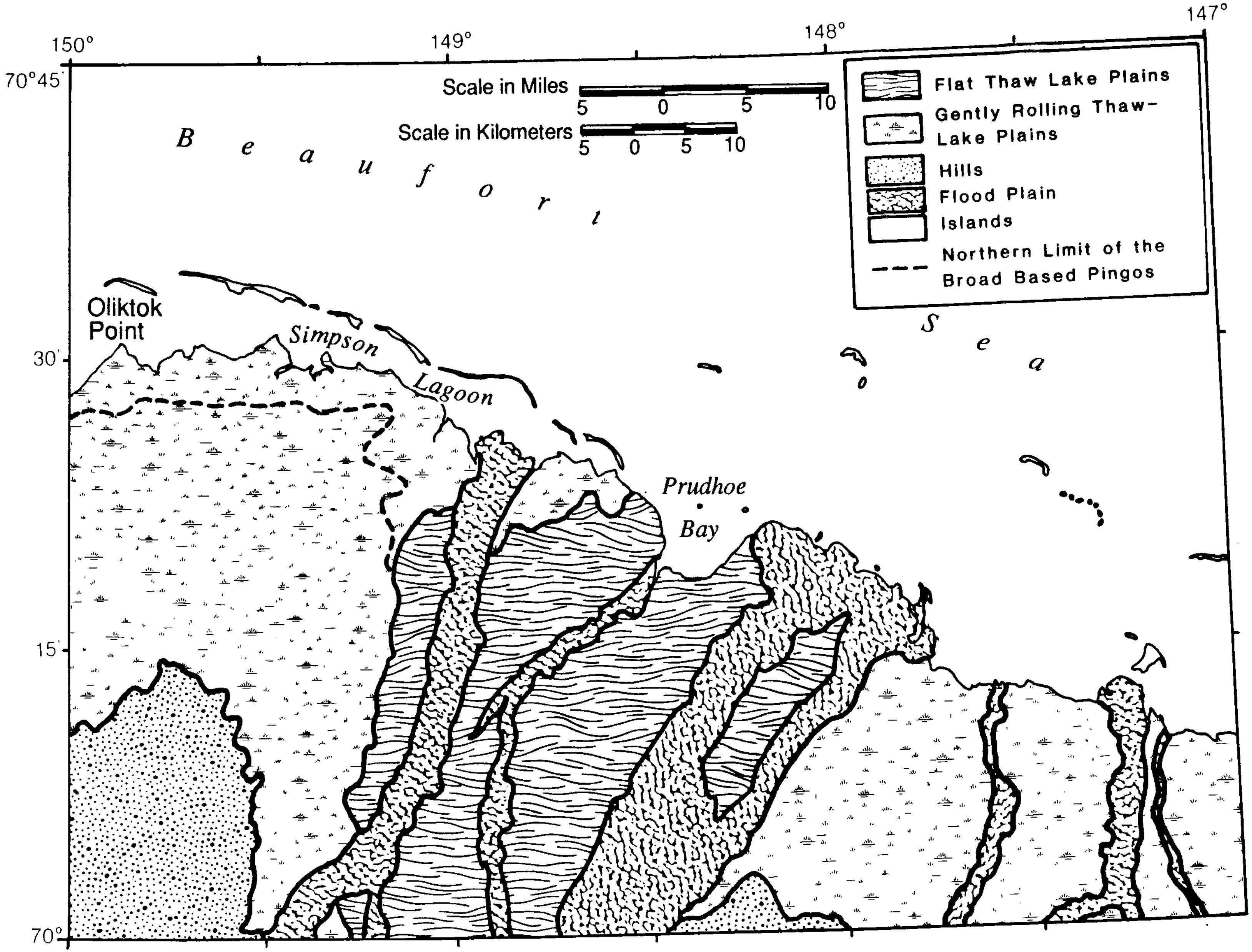

Figure 2. Landscape units of the Beechey Point quadrangle.

Sagavanirktok and Canning Rivers, gently rolling thaw-lake plain is the dominant landscape. Streams are better defined than in the flat thaw-lake plain and the terrain is better drained. Floodplains are found along the braided channels of major rivers and their deltas. Deltas of the Colville and Sagavanirktok Rivers have extensive mudflats, sand dunes and island complexes. The Colville River Delta is the largest delta on Alaska's North Slope.

Lakes are a prominent feature of the coastal plain and are estimated to occupy 25 to 35 percent of the landscape in the Prudhoe Bay region (Rawlinson 1983). Most lakes are part of the thaw-lake cycle, a dominant geomorphic process in the development of the regional landscape (Figure 3). The cycle begins when a depression in the landscape fills with water and becomes a shallow pool. A thaw-lake develops as the permafrost below and beside the pond melts, expanding the borders of the pond. Many of the lakes are oriented 15° west of north as a result of either differential erosion patterns due to the prevailing east-northeast winds (Carson and Hussey 1959, 1962, Rex 1961) or geologic fault patterns (Cannon and Rawlinson 1979). Lakes may be drained by stream capture or the breaching of low divides. The resultant drained basins are initially very wet, but over time a microtopography develops as the permafrost and ice wedges become reestablished. The actual successional sequence depends on the lake-bottom substrate and the drainage pattern. Slow drainage of lakes with peat bottoms often leads to a mosaic of ponds and strangmoor containing diverse vegetation. Rapid drainage of lakes with mineral bottoms creates a dry area that is slow to become vegetated. Pingos eventually develop in some drained basins (Britton 1957, Everett 1980, Rawlinson 1983, Walker et al. 1985).

The coastal plain between the Colville and Canning Rivers consists primarily of unconsolidated sediments deposited during the late Cenozoic Period (Rawlinson 1983). The gravel deposits mined in the Prudhoe Bay region are fluvial and glacio-fluvial material deposited by the Colville River during the late Pleistocene and early Holocene glacial and inter-glacial periods. Historically, the Colville River drainage extended further east and, for varying periods, followed in part the current drainages of the Sagavanirktok, Putuligayuk and the Kuparuk Rivers (Cannon and Rawlinson 1979). Current gravel replenishment along the Sagavanirktok is minimal and episodic, related to major storm events (Updike and Howland 1979).

CLIMATE

Climate on the Arctic Coastal Plain is characterized by short summers and severe winters (Brown 1975, Brown and Berg 1980). Average annual temperatures range from -10.6° C in the foothills to -12.8° C along the coast. The summer thaw season begins in mid- to late May and continues until mid- to late August. The coast is cooler than the foothills during the summer due to the presence of sea ice. Winter temperatures are similar from the coast to the foothills. Prevailing winds are from the northeast although storm winds are from the west. Precipitation is low (170-266 mm; 7-10 in) with a greater proportion occurring as snow.

The Prudhoe Bay region has a modified Arctic marine coastal climate (Brown 1975). Mean monthly temperatures range from 7°C in July to -30°C in February. During the summer months, soil temperatures are up to 10°C higher than air

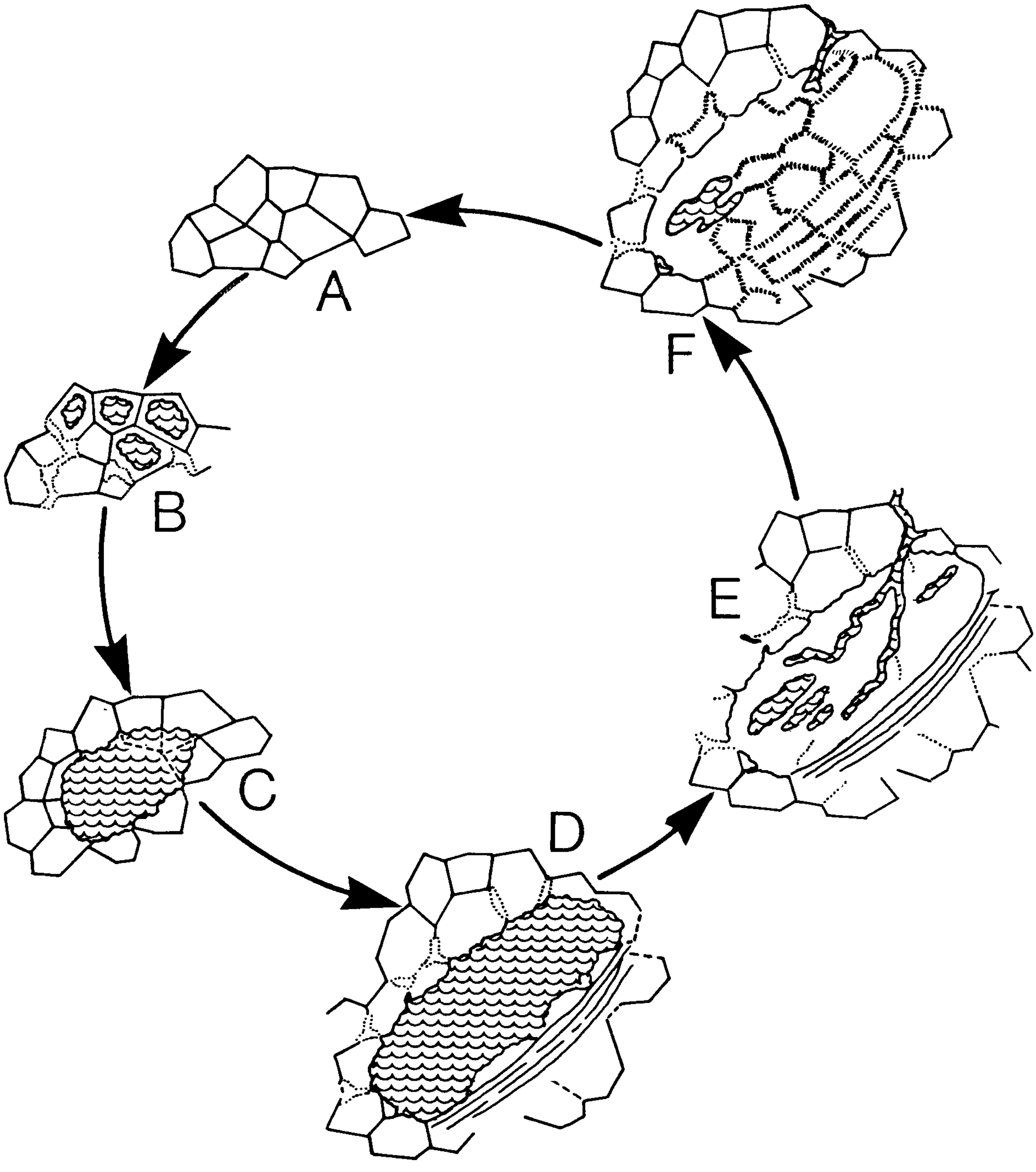

Figure 3. Thaw-lake cycle (from Everett 1980). In areas of polygonized tundra (A), standing water accumulates in the low-centered polygon basins and troughs (B). Ponds develop as thermal erosion melts the underlying permafrost (C). As ponds enlarge, differential erosion, caused by the increased velocity and temperatures of the water at the ends of the pond, results in a lake oriented perpendicular to the prevailing wind (D). The lake is eventually drained by stream capture or breaching of a low divide (E), and ice wedges and permafrost become reestablished in the drained lake basin (F).

temperatures 1 m above the ground surface (Walker 1980, Rawlinson 1983). Approximately 35 percent of the total precipitation recorded in 1977 and 1978 was rain and the remainder was snow. Average snowfall is about 13 cm of water equivalent, with a maximum April snowpack of 30 to 40 cm (normally wind packed). Total precipitation averaged over a two-year period was 20.3 cm (Walker et al. 1980). A steep summer temperature gradient is associated with the coastline, and fog is common within a few kilometers of the coast (Walker 1980, Rawlinson 1983).

Snow deposition and distribution are governed by east and west winds (Benson et al. 1975). Prevailing winds are from the northeast, although storm winds are often from the west. As a result, large drifts may be deposited on the east side as opposed to the west side of obstructions. Snowdrifts are also associated with natural features such as lake margins and stream channels (Klinger et al. 1983).

Most water flow on the tundra occurs in the spring during breakup. Much of the movement is by sheetflow as the ground is frozen and drainages are filled to capacity. The sheetflow often becomes channelized in the troughs alongside ice wedges and between polygons, leading to new drainage patterns (Rawlinson 1983). Wetlands are filled by the spring runoff and drain slowly as the summer progresses. Summer water movement is slow through ill-defined drainages.

VEGETATION

Vegetation cover is nearly complete in the interlake areas of the Arctic Coastal Plain (Britton 1967, Webber 1978, Walker and Webber 1980, Walker et al. 1987). The coastal plain is a mosaic of tundra grass communities which change dramatically along microtopographic moisture gradients (Wiggins 1951, Cantlon 1961). Low, poorly drained areas have wet grass and sedge tundra while drier sites have dwarf shrub communities. Drained lake basins are common features that contain a mosaic of wet communities surrounded by the historic lake shore, which is generally a dry ridge (Britton 1967, Billings and Peterson 1980). Dry areas also occur along river bluffs and on pingos, which are like dry islands in the midst of marshes. Localized vegetation patterns are caused by a variety of other periglacial features such as polygons and frost scars (Webber 1978, Walker 1985). Floodplains of the major rivers are dynamic and contain willow thickets, prostrate shrub communities, and barren gravel bars. Other local vegetation patterns are related to loess (alkaline wind-blown silt) deposits originating from rivers in the central portion of the coastal plain and to the presence of extensive subilited dunes west of the Colville River (Komarkova and Webber 1978, 1980). Tundra communities are affected by different soil types and by soil pH, and some plant distributions are related to patterns of loess distribution (Walker 1985).

Coastal wetlands or saltmarshes occur in low lying areas along the Beaufort Coast. The vegetation is salt-tolerant and the dominant species include Puccinellia phryganodes and Carex subspathacea (Jeffries 1977, Walker et al. 1980). These communities are classified as halophytic grass and sedge types of the saline sedge-grass class identified by Viereck and Dyrness (1980) and as emergent wetlands within the Estuarine System in the National Wetlands Inventory classification (Cowardin et al. 1979). Saltmarshes are not extensive, partly because the small mean tide range (10-30 cm; Aagaard 1978) and comparatively high relief shoreline -- less than 35% of the coast between Point Barrow and the Canning River is lower than 2 m in height (Hartwell 1972, 1973). In a survey of the coast between the Kuparuk and Colville Rivers, an estimated 16% of the coastline was considered coastal wetlands (Keiser and Meehan 1980). Typical wetlands were a mosaic of ponds, exposed mudflats, and salt tolerant vegetation that seldom extended further than 0.75 km inland and 1.0 km along the coast.

The productivity of Arctic tundra is low, because of the low air temperature (Bliss 1962), low soil temperature (McCown 1978), short growing season (Miller et al. 1976), and low nutrient availability (Chapin et al. 1975, Miller et al. 1976). Studies of the general pattern of vegetation recovery following disturbance suggest that soil water and nutrient movement may also limit productivity in natural environments (Chapin and Shaver 1981). More detailed studies of species compositions, production, and biomass turnover showed complex interactions between plant species and the environment. The results still indicate that tundra is generally nutrient limited, but also that species respond individually to various limiting factors (Chapin et al. 1982).

A hierarchical tundra vegetation classification has been developed for mapping in northern Alaska (Walker 1983, Walker 1985). The vegetation classification has three levels: Level A is for small scale mapping using Landsat multispectral satellite date; Level B is appropriate for aerial photo interpretation; and Level C is for detailed on-site mapping. Detailed historical mapping done in the Prudhoe region for this project used Level B of the classification. Level B units have three parts to their names; the first part is a site moisture modifier, followed by a dominant plant growth form, and a physiognomic descriptor. Moisture descriptors include aquatic, wet, moist, and dry, which are subjective terms based on the soil moisture at the end of the growing season. Dominant plant growth forms include tall shrub, low shrub, dwarf shrub, grass, rush, nontussock sedge, tussock sedge, forb, moss, crustose lichen, and fruticose lichen. Physiognomic descriptors describe the appearance of the general vegetation landscape and include tundra, marsh, and barren.

A geobotanical classification has been developed for mapping on the North Slope (Walker et al. 1980). The classification combines landscape information such as soil types and terrain features and the hierarchical vegetation classification. Surface forms and landforms are part of the geobotanical classification and are primarily patterned ground features related to the presence of permafrost. The classification applies specifically to the surface- and landforms and vegetation in the Prudhoe Bay region, but the units should be applicable to most areas of the wet Arctic Coastal Plain east of the Colville River (Walker 1985). Common vegetation types and surface forms of the Prudhoe Bay region are presented in Tables 1 and 2.

Table 1. Level B vegetation units common in the Prudhoe region.

Open water	Unvegetated water.
Aquatic grass marsh	Permanent water dominated by *Arctophila fulva*.
Aquatic sedge tundra	Permanent water with sedges, mainly *Carex aquatilis*, *Eriophorum angustifolium*, and *E. scheuchzeri*.
Wet sedge tundra	Wet tundra, flooded in early summer and remains saturated throughout the summer. Primary sedges are *C. aquatilis* and *E. angustifolium*, common forbs are *Pedicularis sudetica* and *Saxifraga hirculus*.
Wet sedge tundra (saline areas)	Coastal areas periodically inundated by salt water. Dominant taxa are *Puccinellia phryganodes* and *C. subspathacea*.
Moist nontussock-sedge, dwarf-shrub tundra	Moist, well drained sites. Common sedges are *C. bigelowii* and *E. angustifolium*, common shrubs are *Dryas integrifolia*, *Salix reticulata*, *S. arctica* and *S. lanata*.
Moist tussock-sedge, dwarf-shrub tundra	Moist tussock tundra on well drained sites. Dominant sedge is *E. vaginatum*.
Dry, dwarf-shrub, crustose-lichen tundra	Dry site with a mat of *D. integrifolia* and dwarf willows and a variety of forbs. Often with a high percentage of barren soil and crustose lichens.
Dry, dwarf-shrub, forb, lichen tundra	Dry river terraces with *D. integrifolia* and many forbs.
Moist or dry, dwarf-shrub, fruticose-lichen tundra	Snowbeds dominated by *Cassiope tetragona*, *D. integrifolia*, *S. rotundifolia* and lichens.
Dry grasslands	Partially stabilized sand dunes with *Elymus arenarius*.
Dry, Dwarf-shrub, forb, grass tundra	Partially vegetated river bars near the coast.

Table 2. Common surface forms in the Prudhoe region.

High-centered polygons	Polygons with a raised center and low trough.
Low-centered polygons	Polygons with low central basins bound by a raised rim, with troughs between polygons.
Frost scars	Roughly circular, slightly convex barren spots of fine, sandy loam caused by frost churning.
Strangmoor	Sinuous ridges up to 0.5 m in height, usually perpendicular to the local hydrological gradient.
Pingo	Small, ice-cored hill, usually circular or eliptical.
Non-patterned ground	Flat areas with minimal microtopography.
Sand dunes	Occur adjacent to river bars, and in river deltas.
Flood-plain alluvium	Common in braided channels of large rivers.
Thermokarst pits	Deep pits resulting from the decay of underground ice.

DEVELOPMENT HISTORY

The 1968 discovery of oil and gas adjacent to Prudhoe Bay marked the beginning of large scale oil development on Alaska's North Slope. Previous oil and gas related activity on the North Slope was limited to privately sponsored exploration of state-owned lands and begining in the early 1940s, to government sponsored exploration of the National Petroleum Reserve-Alaska (NPR-A). Early exploration found little oil and gas (Hanley et al. 1981). A minor exception is the Barrow gas field that was developed to provide an energy source for the village of Barrow. The discovery of a world class oilfield in Prudhoe Bay led to the construction of the Trans-Alaska Pipeline System (TAPS). Completed in 1977, it transports oil from Prudhoe Bay to a marine terminal in Valdez.

Exploration is continuing across the Arctic Coastal Plain. Lease sales have been held in NPR-A and, although prospects for oil and gas seem low for most areas, exploration is continuing. The state-owned lands between NPR-A and ANWR have been leased and exploration in this region is active. Seismic exploration was conducted in the coastal plain of the ANWR in 1984-1985 in preparation for a Congressional decision on authorization of a leasing program in the refuge (Alaska National Interest Lands Conservation Act, P.L. 96-487). Three lease sales have been held in the federally owned outer continental shelf of the Beaufort Sea and exploration and development activities are rapidly expanding into offshore areas (Figure 4).

Additional oilfields have been discovered and are being developed. The Kuparuk field, adjacent to the Prudhoe Bay field, extends over some 1,500 km^2. Smaller fields at Milne Point and in the West Eileen area are under development. The Lisburne formation, centered between Prudhoe Bay and the Sagavanirktok River Delta is being developed. An environmental impact statement for the first offshore development (Endicott), along the northern edge of the Sagavanirktok River Delta, was completed in 1984, causeway and facility construction began in 1985 and drilling was initiated in 1986. Additional areas are likely to be developed, expanding outward from the transportation network centered in the Prudhoe Bay region.

Oilfield development causes different impacts than those associated with exploration. Exploratory impacts are generally site-specific, isolated events. Impacts associated with development activities are greater in magnitude, intensity, and longevity. Exploratory operations typically last for only one or two seasons. Work is often done in the winter with access via ice road or airstrip. As a result, most surface disturbance tends to be restricted to the well site. Some construction techniques for temporary facilities, such as the thin pads used in NPR-A, limit the impact of exploratory activities. Winter operations have minimal contact with wildlife, arctic foxes and muskoxen being notable exceptions (Eberhardt 1977, Reynolds and LaPlant 1985). Development of a production oilfield is quite different since facilities are permanent and are used year-round. Activity levels are generally high and associated impacts such as dust deposition and traffic noise are continuous.

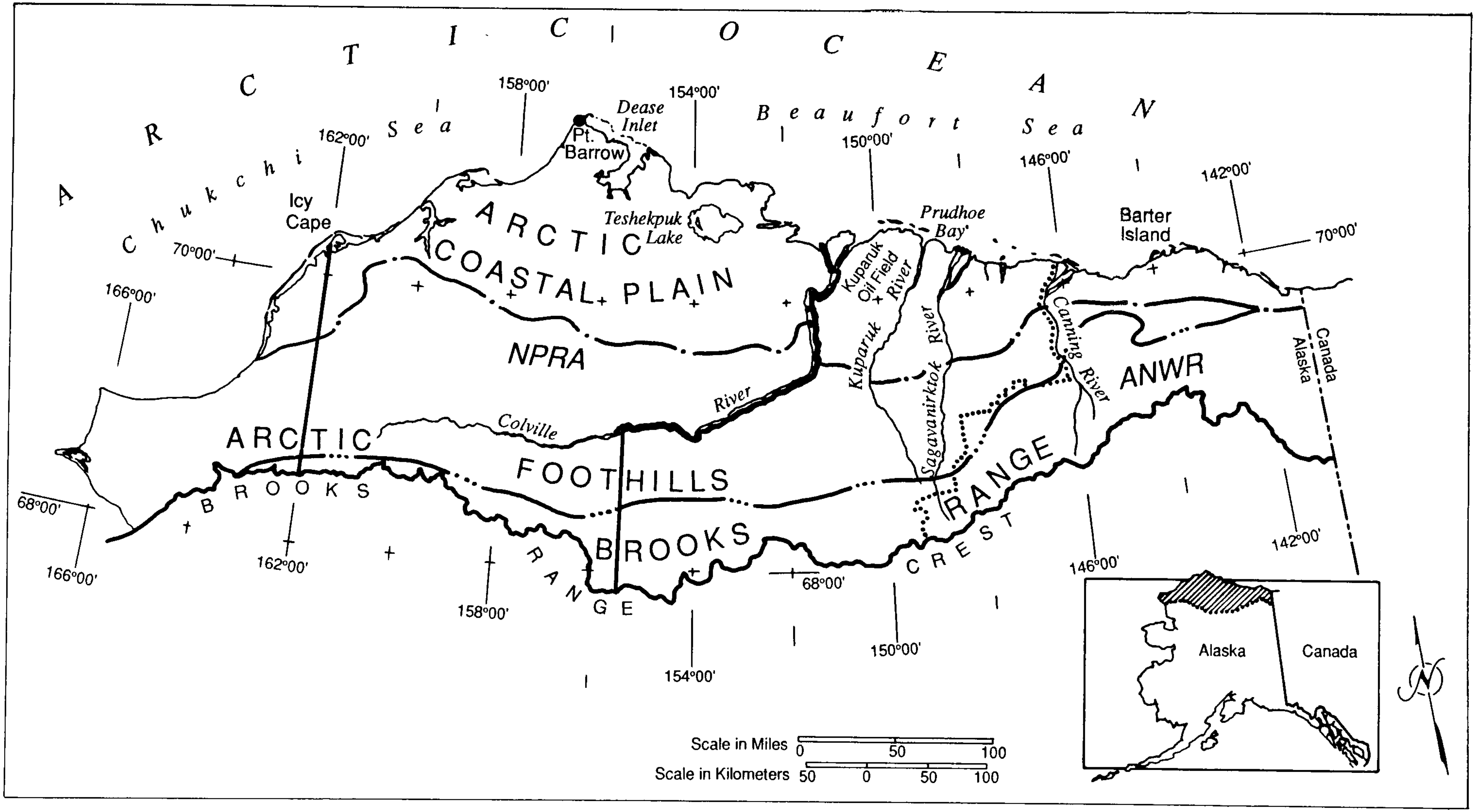

Figure 4. Areas of oil and gas interest on the North Slope of Alaska.

3. AVIFAUNA

OVERVIEW

Birds are a highly visible component of the tundra ecosystem during the summer season. The vast majority of the species that use the Arctic Coastal Plain are migratory and therefore protected by the Migratory Bird Treaty Act. Some birds that breed on the North Slope winter as far away as Antarctica (Arctic Tern) and southern South America (Pectoral Sandpiper). Others winter in the northern Bering Sea or southern Chukchi Sea (Oldsquaw, King Eider and Common Eider). Most are dependent upon wetlands for feeding, nesting cover and brood-rearing and may be affected (both directly and indirectly) by wetland development.

The Arctic Coastal Plain is the breeding ground for many species of waterbirds. Between late May and mid-September waterbirds are conspicuous occupants of the tundra and are often the dominant vertebrates in the wetlands. Birds generally arrive on the North Slope by the first week in June and begin nesting as soon as snow free tundra is available. The breeding season is short and activity on the tundra centers around the eggs and young. Due to the short season, only limited re-nesting in some species occurs when nests are lost early in the season. There is a progression of adults and then young moving to the coast for staging prior to migration, as evidenced by a gradual decline in bird numbers inland throughout the season with a concurrent increase near the coast.

Notable concentrations occur at various times and locations: during spring migration, during late summer, during fall staging, and during the goose molt in the Teshekpuk Lake Region. Spring waterfowl migrants rest and feed in open water and congregate around river deltas, which provide the first open water, prior to break-up of the tundra. Nearshore lagoons are a rich, sheltered habitat for molting ducks, primarily Oldsquaw. Prior to fall migration large numbers of waterfowl and shorebirds are found near the coast in salt marshes, river deltas, lagoons and on barrier islands.

SPRING MIGRATION

Spring migration along the Chukchi coast begins in late April or early May with birds moving into the Beaufort Coast in mid- to late May. Migration lasts until mid-June. Early migrants include King Eider and Common Eider and Glaucous Gulls. The majority of eiders pass Point Barrow the last week in May with King Eiders passing slightly earlier than Common Eiders and males in both species passing earlier than females (Johnson et al. 1975, Divoky 1983). Adult Glaucous Gulls move into the Beaufort in late May; subadults move into the area later in June. Shorebirds and passerines arrive in late May or early June. Most waterfowl arrive during the first week in June with loons arriving slightly later. Migration tends to follow the progression of break-up with birds moving north along the Chukchi and Beaufort Coasts as open water becomes available. Birds typically move onto the tundra as soon as snowfree areas are available.

Many spring migrants follow a coastal route around the west coast of Alaska to their North Slope breeding grounds. Although migrants tend to be concentrated within 10 km of the coast (Flock 1973, Johnson et al. 1975, Divoky

1983), some travel well offshore (Divoky 1983) while others, notably geese (Cade 1955), follow inland routes along major drainages. Both King and Common Eiders pass Point Barrow heading in an east-northeast direction. Large numbers of eiders are not observed along the Beaufort Coast past Barrow until Banks Island where they congregate in a large polynya (Salter et al. 1980). It has been suggested that eiders migrate far offshore, possibly at high altitudes, resting on leads in the pack-ice when necessary (Johnson et al. 1975, Divoky 1983, Johnson et al. 1983). During a severe ice year when few if any off-shore leads were available, a significant die-off (estimated at 10% of the population) of King Eiders was observed (Barry 1968). Inland routes along major drainages are followed by many geese; Brant migrate north through the Yukon Basin and along other major drainages (Cade 1955, Irving 1960, Johnson et al. 1975, Lehnhausen and Quinlan 1981). Great White-fronted Geese from the Pacific Flyway may also follow thse routes while those from the Midwest Flyway travel up the Mackenzie River (Johnson et al. 1975).

Waterfowl rest and feed in open water areas along their migratory paths. Most birds move north with the progression of break-up and concentrations occur as birds wait for open water and tundra to become available (Johnson et al. 1983). Waterfowl use shore leads extensively during May in the Chukchi Sea and during June in the Beaufort Sea (Divoky 1983). River deltas also provide open water early in the season and are important stopping places for migrants. Migrants rest and feed on deltas until tundra breeding areas become free of snow. Shorebirds use snow-free areas at river deltas, river bluffs, and stream headwaters during migration. The availability of open water varies annually. The type of habitat may be similar in any given locality but the timing of melt may vary considerably from year to year. In general, the least variable areas are large river deltas, such as the Colville River delta, where open water and tundra are predictably available early in the season.

BREEDING SEASON

The snow-free period on the North Slope is short and for many species provides barely enough time to successfully nest and rear young. Birds must arrive, initiate nesting, lay a clutch of eggs, incubate, and rear their young before the onset of freeze-up in late September. In years of late break-up or early freeze-up, many breeding efforts are not successful. Many waterfowl, therefore, only attempt one nest and do not renest if the first nest is lost. Brant and Greater White-fronted Geese are both determinate layers and do not have the ability to renest, except in rare cases where a nest is lost early in the egg-laying phase and only a few eggs have been lost (Johnson et al. 1975). Nests started too late do not allow sufficient time for young to fledge prior to freeze-up.

Waterfowl

Most waterfowl mate either on their wintering grounds or at staging areas prior to arrival on the breeding grounds. Breeding pairs start nesting upon arrival, as soon as snow-free areas for nest sites are available. Tundra Swans are among the earliest nesters with nest initiation noted in late May (Johnson et al. 1975) and the first week of June (Rothe and Hawkins 1982). By the third week of June, most waterfowl have begun nesting. Loons arrive slightly later than other waterbirds because they require more open water on lakes for landings and take-offs (Johnson et al. 1975, Bergman and Derksen 1977, Petersen 1979). Common Eiders nest primarily on offshore islands. Nesting densities are highest on islands surrounded by river runoff in late May and early June. Moats form around islands and isolate them from the mainland thereby providing protection from terrestrial predators, notably arctic foxes (Schamel 1978).

Waterfowl incubation periods range from 23 to 40 days, depending on the species. Hatching for most species peaks from mid-July to the first week of August and the young fledge by mid-September. Tundra Swans have one of the longest incubation periods, 35 to 40 days (Johnson et al. 1975, Rothe and Hawkins 1982); hatching generally occurs by the second week in July and the young fledge in mid-September. Loons nest later than most other waterfowl; egg-laying usually takes place by the third week in June and hatching by late July. Yellow-billed Loons incubate longer than Pacific and Red-throated Loons and their young fledge later, often near the end of September (Johnson et al. 1975, Sjolander and Agren 1976). Geese incubate an average of 24 days. Greater White-fronted Geese hatch by the first week in July and Brant by the second week. Adult geese stay with their young during the brood rearing period and molt just prior to fledging. Fledging takes place by the end of August. Oldsquaw and King Eiders incubate for 23 to 24 days and their young hatch the second or third week in July (Alison 1975, 1976, Johnson et al. 1975). Females do all of the incubation in both species and remain with the young until they fledge. Common Eiders nest mid- to late June and their young hatch by the end of July. Immediately after hatching the young are led from the nesting island to the lagoons, where they remain until fledging in September (Schamel 1978).

Waterfowl feed on vegetation, invertebrates, and fish during the breeding season. The importance of any particular food source varies by species, but most waterfowl feed on invertebrates and some vegetation (Bergman et al. 1977). Pacific Loons nest on large ponds and lakes and feed almost exclusively on invertebrates from the wetlands in which they nest. Red-throated Loons, in contrast, nest on smaller ponds and feed on fish caught in nearby lagoons and large lakes. Geese generally feed on vegetation, primarily sedges (Mickelson 1975, Bergman et al. 1977). Brant feed almost exclusively on *Carex subspathacea* and *Puccinellia phyrganodes* in saltmarshes during fall staging and migration (Kiera 1984).

Shorebirds/Passerines

Shorebirds arrive unmated on the North Slope and pair on the breeding grounds. Males of most species perform aerial displays to attract females. Male Lapland Longspurs establish territories as soon as small patches of bare ground are exposed (Seastedt and Maclean 1979). Nest initiation is a short, intense period with most species nesting within two weeks of their arrival on the North Slope, usually by the second week in June.

Four major patterns of shorebird mating systems are recognized (Pitelka et al. 1974), three of which occur on the North Slope. A majority of species have dispersed populations, strongly developed territorial systems, and strong monogamous pair bonds; their populations fluctuate little from year to year. Examples are Dunlin, Semipalmated Sandpiper, and Baird's Sandpiper. White-rumped Sandpipers are polygamous and the females can lay two clutches in rapid succession. White-rumped Sandpipers are rare to uncommon across the North Slope. The third pattern is promiscuity, shown by Pectoral and Buff-breasted Sandpipers. This pattern is characterized by clumped dispersions with strong year-to-year fluctuations in numbers. Males defend compressible, often small, territories. Local nesting densities can be high. Females do all of the incubation and rearing of the young and nest placement bears little relationship to male territory location. Phalarope mating systems are similar as both species are promiscuous and can be polyandrous; females lay one or more clutches for the male (or males) to incubate (Johnson et al. 1975, Schamel and Tracy 1977). The first strategy is conservative in that the over dispersion and maintenance of territories ensures sufficient food for the offspring. The latter strategies are more opportunistic as local abundances or favorable conditions can be exploited.

Shorebirds overlap broadly in their diets during the breeding season (Holmes and Pitelka 1968, Baker and Baker 1973, Baker 1977). Two families within the order Diptera contain the most important prey species, Tipulidae and Chironomidae. Larvae from these two families are extensively exploited early and late in the season and the adults are preyed upon mid-season during their emergence. Differences in shorebird diets are related to habitat use. Species that occupy drier habitats, Buff-breasted Sandpiper and Lesser Golden Plover, take more spiders and beetles in their diets (Byrkjedal 1980, Connors et al. 1983). Chironomids are the most important prey for Semipalmated Sandpipers and Red Phalaropes while tipulids are most important for Dunlin and Pectoral Sandpiper (Holmes and Pitelka 1968). All species prey heavily on chironomid and tipulid adults during insect emergence, a period when the adult insects are extremely abundant and unable to fly well (Maclean and Pitelka 1971). The timing of shorebird hatch is thought to coincide with the peak of insect emergence (Holmes and Pitelka 1968), thus providing an easily accessible food source for the precocial young. Adult shorebirds show their young where to forage, but do not feed them directly. The young shorebirds' bills are too soft and short to probe effectively, so the insects are an important food source. Lapland Longspur diets are similar to shorebird diets except that they take more seeds throughout the season. Lapland Longspur young are altricial and are fed at the nest by the adults for seven to ten days. They hatch about a week earlier than the peak of shorebird hatch and their fledging may be timed such that the young are leaving the nest and beginning to forage on their own during the peak of food abundance (Custer and Pitelka 1977).

In July and August, shorebirds shift from tundra habitats to the littoral zone along the coast. Post-breeding adults are first to move to the coast, followed by juveniles. While nearly all species make this move, the extent of dependence on littoral habitats varies by species (Connors et al. 1979, Connors et al. 1983). Red Phalaropes and Ruddy Turnstones are the most dependent since post-fledging juveniles leave the tundra and use littoral areas almost exclusively (Connors et al. 1979, Connors et al. 1983). Semipalmated and Baird's Sandpipers use littoral habitats throughout the breeding season and have moderate to high dependence on the littoral zone. Baird's Sandpipers nest within the littoral zone and densities are comparable to tundra densities at Barrow during the breeding season (Connors et al. 1983). Semipalmated Sandpipers move to the coast in stages; first the females that leave the young two to six days after hatching, then the males, followed by juveniles (Ashkenazie and Safriel 1979). Dunlin and Long-billed Dowitcher juveniles are common in the littoral zone in the fall although both occur on the tundra as well. Lesser Golden Plovers and Pectoral Sandpipers use the littoral zone less than other shorebirds. Although Pectoral Sandpipers show a definite coastal movement, they remain on the tundra near the coast and only occasionally appear in the littoral zone (Connors et al. 1983). There is increased use of riparian areas, both coastally and inland by staging and migrating shorebirds (Moitoret et al. 1984).

WATERFOWL MOLTING AND STAGING

Large congregations of molting and staging waterfowl occur on the North Slope in late summer and fall. Brant, Greater White-fronted Geese and other waterfowl concentrate in the Teshekpuk region in July to molt prior to fall migration. Oldsquaw males molt in July in nearshore lagoons along the Beaufort coast. Snow Geese stage on the eastern portion of the Arctic Coastal Plain in the Arctic National Wildlife Refuge in late August and September. These areas are traditionally used and disturbances could affect large numbers of birds (Derksen et al. 1981, Johnson et al. 1983).

The Teshekpuk Lake region has long been recognized as unusual for the large numbers of waterfowl present in mid-summer, including an estimated 20 percent of the world's population of Brant molting in the region (King 1973, Derksen et al. 1979a, Derksen et al. 1982). The majority of these Brant are non-breeders or failed breeders. The region also contains one of the largest North Slope colonies of nesting Brant on the North Slope; over 100 pairs nest on Island Lake (Derksen et al. 1981). A significant portion of the NPR-A population of Greater White-fronted Geese molts in the region and large numbers of Canada Geese molt there as well. Geese spend the majority of their time feeding while in the region. Flocks move rapidly along shorelines as they feed, returning to the same places every three or four days (Derksen et al. 1979b, Derksen et al. 1982). Deschampsia spp. and Carex spp. are the primary food. Molting geese prefer deep, open lakes with low-relief shorelines rather than shallower lakes with emergent vegetation (Derksen et al. 1979b).

The attraction of the Teshekpuk Lake Region to molting geese is unknown. Physiographically similar lakes occur south of Barrow, yet are not used by large congregations of molting birds (Derksen et al. 1981, Derksen et al. 1982). Factors that may be important in selection of the Teshekpuk area include the many large lakes, the duration of the lake ice that provides resting areas, and the many lakes with gentle shorelines dominated by Carex spp. (Derksen et al. 1979b). Traditional use of the area may have resulted in nutrient enrichment along the shorelines. Whatever the underlying reasons for the congregations are, the area is unique for its high amount of bird use. Several authors have questioned the ability of molting birds to use other areas if they are displaced by development (Derksen et al. 1979a, Derksen et al. 1981, Derksen et al. 1982, Gilliam and Lent 1982).

Male Oldsquaw molt in nearshore lagoons and protected bays along the Beaufort coast. Molt begins when the lagoons become ice-free, generally by the third week in July. Lagoons along the eastern portion of the Alaskan Beaufort, from the Colville River Delta to Demarcation Bay, support more birds than the western portion (Johnson and Richardson 1981). An exception is in the vicinity of the Plover Islands, near Barrow, where many birds molt. Male Oldsquaw do not incubate or help at the nest and move to the lagoons to molt following mating and nest establisment. Lagoons provide safe resting areas on the barrier islands, and abundant food in the form of epibenthic invertebrates. Resting areas are critical as the birds lose many of their body feathers during molt and need to spend time out of water to dry. Barrier islands are generally free of predators. Oldsquaw stay inside the lagoons during molt but may move offshore into the pack ice following molt. Male Oldsquaw complete their molt by mid-August and begin leaving the lagoons. Females with young start moving into the lagoons by late August and early September as tundra wetlands begin to freeze and become unavailable.

Although Oldsquaw are the most numerous bird in the lagoons, other species use the lagoons as well. Species that commonly use lagoons include Yellow-billed Loon, Pacific Loon, Red-throated Loon, Common Eider, Oldsquaw, Glaucous Gull, Red Phalarope, Red-necked Phalarope, and scoters. Juvenile Red and Red-necked Phalaropes use lagoons extensively in August, feeding along the beaches of the barrier islands. Dunlin Sanderling and other shorebirds are also found along barrier islands in late August and early September. Lagoons along the Arctic National Wildlife Refuge were ranked by bird density, absolute number, and species diversity (Spindler 1981). In the individual rankings and a combined mean rank, Demarcation Bay, Simpson Cove, and Tamayariak Lagoon consistently ranked in the top five.

Snow Geese stage on the eastern portion of the Arctic Coastal Plain during the latter part of August and the first part of September. The birds come from the large nesting colonies on Banks Island and the Anderson River delta and, depending on the weather, spread out across the coastal plain (Johnson et al. 1975). Geese have been surveyed on the refuge since 1971 and most surveys were coordinated with Canadian investigators so the entire population could be censused. During that time, peak arrival usually occurred by August 30 and peak departure by September 20 (Oates et al. 1985). The number of geese on the refuge has ranged between approximately 10,000 and 325,000, although in 1975 no Snow Geese were recorded on the refuge. The geese spend their time feeding and resting, and leave just prior to freeze-up. Estimates of activity budgets showed adults spending 57 percent of the daylight hours feeding and juveniles spending 60 to 70 percent of their day feeding (Davis and Wisely 1974). Significant weight gains have been reported for Snow Geese between their entering and leaving the staging area. Use of the area is variable, both spatially and in overall numbers of birds. Weather is probably the major influence in the variability (Spindler 1983).

Snow Geese are particularly sensitive to aircraft and flush when approached by fixed-wing or rotary aircraft. Experimental disturbances by fixed-wing aircraft at two-hour intervals resulted in an 8.5 percent decrease in feeding time. The authors felt that similar disturbance by rotary aircraft could possibly reduce feeding time by 9.5 percent (Davis and Wisely 1974).

HABITAT

Two generally accepted habitat classifications have been developed in the Prudhoe region, a habitat classification for waterfowl related to characteristics of wetland basin development, and a classification for shorebirds and some waterfowl species derived from the geobotanical classification. The waterfowl classification was the result of several years study at Storkersen Point near Prudhoe Bay (Bergman et al. 1977) and has been used in studies of several sites on the North Slope (Derksen et al. 1981). The habitat system for shorebirds and common waterfowl species was derived from the geobotanical classification used in the Waterflood studies (Klinger et al. 1983, Troy 1984, 1985).

In the Bergman et al. (1977) study, eight wetland classes were defined based on dominant emergent vegetation and the general size of water bodies (Table 3). The classification refers mainly to waterbodies and lumps all other tundra wetlands into a single class, Flooded Tundra. Tundra Swans nested in a Class VI wetland and Class IV and V wetlands were thought to provide appropriate brood rearing habitat. Although the sample was small, all of the Brant observed strongly preferred Class VIII wetlands during pre-nesting and post-nesting, and nested in Class VI wetlands. White-fronted Geese preferred Class V lakes for post-nesting and molting; nests were generally located on polygon rims. Loons preferred Class IV and Class VI wetlands throughout the breeding season, with Arctic Loons also showing a preference for Class V lakes during post-nesting, brood rearing. Pacific Loons nested on the shores of larger lakes, while Red-throated Loons nested on smaller ponds (Bergman and Derksen 1977). Oldsquaw used Class II and Class IV wetlands during the pre-nesting and nesting periods, moving to Class V lakes for brood rearing, a pattern similar to that described by Alison (1975, 1976). King Eiders preferred Class IV wetlands throughout the nesting season but also showed a preference for Class II wetlands for brood rearing. A majority of waterfowl species preferred Class IV and Class VI wetlands during the entire nesting season. Brant showed a significant preference for Class VIII wetlands; all sightings during the post-nesting period occurred in that class. In evaluating total bird use, Classes I, II, VII, and VIII were the least preferred. Although there were differences in the available habitat types, similar habitat use patterns were found at study sites in NPR-A (Derksen et al. 1979a, Derksen et al. 1981).

Shorebird species differ in habitat use patterns and most species change habitat preference over the course of the breeding season (Myers and Pitelka 1980). Overall, most species use wetter habitats, particularly for feeding later in the summer. At the beginning of the breeding season, shorebirds are found where the snow has melted and the tundra is exposed. Some species prefer drier habitats, e.g., Lesser Golden Plover and Baird's Sandpiper, while other species prefer wetter areas, e.g., Pectoral Sandpiper and the phalaropes. Shorebirds leave their nests almost immediately following hatching and the family groups move into wet meadows where prey is more abundant.

Troy (1985) presents a habitat classification, at two levels of detail, based on bird sighting data that largely reflects foraging birds and so can be considered feeding habitat. The majority of regularly occurring breeding birds are included in a 10 habitat classification and all species tested showed significant habitat selection during the nesting period (Table 4). Nine of the classes are wetlands and the tenth is artificial impoundments due to road-blocked drainages. Patterns of habitat use differed between species both in the types of habitat used and in the degree of selection shown. Lapland Longspurs demonstrated the greatest degree of habitat selection, showing definite preference or avoidance for each habitat type. In contrast, Semipalmated Sandpipers demonstrated preference for only one and avoidance of only two of the natural

Table 3. Criteria used to delineate wetland classes (Bergman et al. 1977).

Wetland designation	Dominant emergents Shore zone	 Central zone	Size
Flooded Tundra (Class I)	*Eriophorum angustifolium* or *Carex aquatilis*	*E. angustifolium* or *C. aquatilis*	pond
Shallow-Carex (Class II)	*C. aquatilis*	Semi-open to open	pond
Shallow-Arctophila (Class III)	*C. aquatilis* or *Arctophila fulva*	*A. fulva*	pond
Deep Arctophila (Class IV)	*A. fulva*	open	pond or lake
Deep-open (Class V)	open	open	lake
Basin-complex (Class VI)	Basin interspersed with *C. aquatilis* *A. fulva* and open water		lake
Beaded Streams (Class VII)	*C. aquatilis* *A. fulva* or open	open or *A. fulva*	pond=bead
Coastal Wetlands (Class VIII)	*Puccinellia phryganodes*, *C. subspathacea*, or open	open	pond or lagoon

Table 4. Species preference for geobotanically based habitat classification -- 10 habitat classes (from Troy 1985).

Habitat Class	Species Preferring Class	Species Avoiding Class
Moist Tundra/Low Relief High Centered Polygons	Greater White-fronted Goose Lesser Golden Plover Buff-breasted Sandpiper Parasitic Jaeger Lapland Longspur	King Eider Pectoral Sandpiper
Moist Tundra/ Frostscar	Lesser Golden Plover White-rumped Sandpiper Dunlin Buff-Breasted Sandpiper Lapland Longspur	Northern Pintail King Eider Oldsquaw Pectoral Sandpiper Long-billed Dowitcher Red-necked Phalarope Red Phalarope
Moist, Wet Tundra/ Low Relief, Low-centered Polygons	Dunlin Buff-Breasted Sandpiper Lapland Longspur	Northern Pintail King Eider Oldsquaw White-rumped Sandpiper Pectoral Sandpiper Long-billed Dowitcher
Wet Tundra/Low Relief, Low-centered Polygons	Lapland Longspur	Oldsquaw Pectoral Sandpiper Long-billed Dowitcher Red Phalarope
Wet Tundra/ Strangmoor	Northern Pintail Semipalmated Sandpiper White-rumped Sandpiper Buff-breasted Sandpiper Lapland Longspur	Greater White-fronted Goose King Eider Oldsquaw Red-necked Phalarope Red Phalarope
Wet Tundra/Non-patterned ground	Pectoral Sandpiper Long-billed Dowitcher Red Phalarope	Oldsquaw Semipalmated Sandpiper Lapland Longspur
Aquatic Tundra/ Strangmoor	King Eider Pectoral Sandpiper Long-billed Dowitcher Red Phalarope	Northern Pintail Oldsquaw Lesser Golden Plover Red-necked Phalarope Buff-breasted Sandpiper Lapland Longspur

(continued)

Table 4 (continued)

Habitat Class	Species Preferring Class	Species Avoiding Class
Water/Ponds Without Emergent Vegetation	Oldsquaw Red Phalarope	Northern Pintail Semipalmated Sandpiper Pectoral Sandpiper Dunlin Buff-breasted Sandpiper Long-billed Dowitcher Red-necked Phalarope Lapland Longspur
Water/Ponds With Emergent Vegetation	Northern Pintail King Eider Oldsquaw Red-necked Phalarope Red Phalarope	Lesser Golden Plover Dunlin Buff-breasted Sandpiper Lapland Longspur
Impoundments	Northern Pintail Red-necked Phalarope Red Phalarope	White-fronted Goose King Eider Semipalmated Sandpiper Dunlin Buff-breasted Sandpiper Lapland Longspur

habitats, using all others in proportion to availability. This classification differs from Bergman's in subdividing Bergman's single Flooded Tundra class into seven classes of tundra wetlands. Habitat use patterns noted for waterfowl in this study were similar to patterns described in Bergman et al. (1977). A more detailed classification (20 classes) was developed to evaluate the importance of rare habitat types for the most common species. As in the 10 habitat classification, most species showed significant selection or avoidance for one or more habitat classes (Table 5) and the importance of Arctophila ponds for waterfowl, as shown by Bergman et al. (1977), was confirmed. Nest densities in the 10 habitat classification demonstrated a general preference by shorebirds for drier nest site habitats and avoidance of aquatic and pond habitat for nest sites (Table 6).

Three habitat types described for the littoral zone include gravel beaches, littoral flats, and slough edges (Connors et al. 1983). Groups of species show similar habitat preferences and use from year to year. Diets of shorebirds in the littoral zone are more related to habitat type than to the species; birds foraging in similar areas have broadly overlapping diets, e.g., species that forage along marine shores with gravel beaches (Ruddy Turnstone, Dunlin, Sanderling, Red Phalarope, and Red-necked Phalarope) all feed on marine zooplankton (Connors et al. 1983). Shorebirds concentrate in areas of gravel spits and barrier islands (Icy Cape, Peard Bay, Point Barrow, Plover Islands, Jones Islands) and in areas with extensive littoral flats, saltmarshes and slough edges (Icy Cape, Barrow, Fish Creek Delta, Colville Delta, Cape Halkett, Canning Delta).

DISTRIBUTION PATTERNS

Geographic

Zonal classification of the North Slope has relied mainly on physiographic criteria, primarily Wahrhaftig's (1965) classification of Brooks Range, Foothills, and Arctic Coastal Plain provinces (Figure 5). Kessel and Cade (1958), using information largely from the mid-Beaufort section, related general patterns of bird distribution to these major zones. They considered the coastal plain avifauna to contain 51 species, 15 of which were considered rare or sporadic in occurrence. Shorebirds and waterfowl dominated the coastal avifauna. Most species showed strong associations with surface water, either marine littoral or fresh and brackish lacustrine waters. Approximately 50 percent of the North Slope avifauna occurred primarily on the coastal plain.

The North Slope, though dominated by east-west features, can also be divided into north-south sections (Pitelka 1974). The eastern portion of the coastal plain is reduced to a narrow fringe because of the proximity of the Foothills and Brooks Range to the coast. The mid-Beaufort Section, between the Canning and Colville Rivers, has a defined coastal plain section with a broad foothills region and shallow lagoons along the coast. Between the Colville River and Wainwright, the coastal plain is extensive and characterized by numerous large lakes and meandering river systems and an extensive zone of low foothills. A fourth section in the west is characterized by the proximity of the foothills of the De Long Mountains to the coast.

Table 5. Species preferences for geobotanically based habitat classification -- 20 habitat classes (from Troy 1985).

Habitat	Species Preferring Class	Species Avoiding Class
Dry tundra/low-relief high-centered polygons	Lesser Golden-plover Semipalmated Sandpiper Red-necked Phalarope Lapland Longspur	Northern Pintail
Moist tundra/low-relief high-centered polygons	Lesser Golden-plover Lapland Longspur	Northern Pintail Oldsquaw Pectoral Sandpiper Red-necked Phalarope
Moist tundra/low-relief low-centered polygons	Oldsquaw	
Moist tundra/mixed high- and low-centered polygons	Northern Pintail	
Moist tundra/frostscar	Lesser Golden-plover Dunlin Lapland Longspur	Northern Pintail Oldsquaw Pectoral Sandpiper Red-necked Phalarope Red Phalarope
Moist tundra/strangmoor	Semipalmated Sandpiper Dunlin Lapland Longspur	Oldsquaw Pectoral Sandpiper Red-necked Phalarope
Moist tundra/non-patterned ground	Buff-breasted Sandpiper Red Phalarope Lapland Longspur	
Moist, wet tundra/low-relief low-centered polygons	Lapland Longspur	Northern Pintail Pectoral Sandpiper Red-necked Phalarope Red Phalarope
Wet tundra/low-relief low-centered polygon	Lapland Longspur	Pectoral Sandpiper Red Phalarope

(continued)

Table 5 (continued)

Habitat	Species Preferring Class	Species Avoiding Class
Wet tundra/ strangmoor	Northern Pintail Semipalmated Sandpiper Dunlin Buff-breasted Sandpiper Lapland Longspur	Oldsquaw Red-necked Phalarope Red Phalarope
Wet tundra/non-patterned ground	Pectoral Sandpiper	Oldsquaw Semipalmated Sandpiper Red Phalarope Lapland Longspur
Wet, moist tundra/ low-relief low-centered polygons	Dunlin Buff-breasted Sandpiper Lapland Longspur	Northern Pintail Oldsquaw Pectoral Sandpiper
Aquatic tundra/ strangmoor	Semipalmated Sandpiper Pectoral Sandpiper Red Phalarope	Northern Pintail Oldsquaw Lesser Golden-plover Buff-breasted Sandpiper

Table 6. Nest site preferences in the 10-habitat classification (from Troy 1985).

Habitat Class	Species Preferring Class	Species Avoiding Class
Moist Tundra/Low Relief High Centered Polygons	Semipalmated Sandpiper Lapland Longspur	
Moist Tundra/ Frostscar	Dunlin	
Moist, Wet Tundra/ Low Relief, Low-centered Polygons	Dunlin Red Phalarope Lapland Longspur	
Wet Tundra/Low Relief, Low-centered Polygons	Lapland Longspur	
Wet Tundra/ Strangmoor	Semipalmated Sandpiper	
Wet Tundra/Non-patterned ground	Red Phalarope	Semipalmated Sandpiper
Aquatic Tundra/ Strangmoor		
Water/Ponds Without Emergent Vegetation		Dunlin Red Phalarope Lapland Longspur
Water/Ponds with Emergent Vegetation		Semipalmated Sandpiper Dunlin Red Phalarope Lapland Longspur
Impoundments		Lapland Longspur

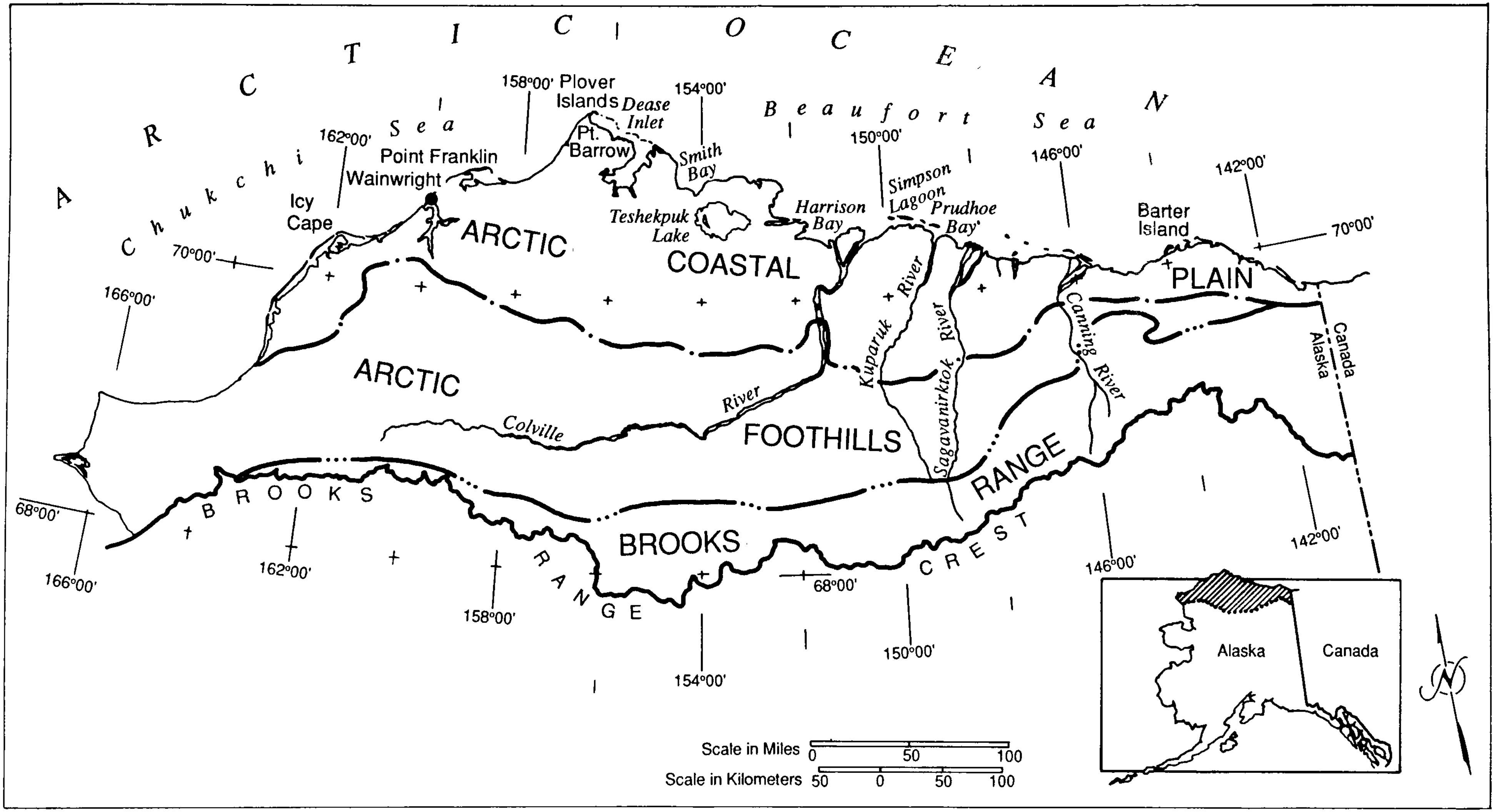

Figure 5. Locations referenced in the discussion of bird distribution.

Environmental features associated with these north-south zones probably influence bird distributions and modify the zonal association noted by Kessel and Cade (1958). The mid-Beaufort section, with its well-defined north to south zonation would be expected to show the strongest north to south bird distribution patterns. The same section also has the highest diversity of waterfowl, which may be related to the presence of extensive nearshore lagoons and river deltas that provide molting habitat for waterfowl. The waterfowl community to the west near the Meade River is less diverse (Pitelka 1974, Derksen et al. 1979a). Compared to the other regions, the eastern section, with its restricted zone of wetlands, has generally lower waterfowl densities and few loons, both on the tundra during the breeding season and in the coastal lagoons (Spindler et al. 1984, Miller et al. 1985, Moitoret et al. 1985).

Bird distribution on the North Slope has also been influenced by the former Bering Land Bridge and the proximity of Asia. Species diversity decreases from west to east. The greater diversity to the west represents, in part, the presence of species whose center of distribution is in Siberia (e.g., Arctic Warbler) and the occurrence of Aleutian avifauna whose center of distribution is in the Bering Sea (Kessel 1961). In general, the avifauna of the western North Slope is quite similar to that in eastern Siberia (Kessel 1961). Twelve of the 23 stragglers (birds appearing rarely) reported by Pitelka (1974) for the Barrow region are Asiatic species.

Distribution patterns of some species during the breeding season are tied to regional physiographic features or to specific ecologic requirements of the species. Distinctive distribution patterns are seen in Tundra Swans, Canada Geese, Snow Geese, Yellow-billed Loons, and Red-throated Loons. The first four are tied to specific physiographic features: Tundra Swans are concentrated on river deltas with the Colville River delta having the greatest numbers and highest concentrations (Johnson et al. 1975, Bartels et al. 1983, King 1979, Hawkins 1983); Canada Geese regularly breed only along the Colville River bluffs and in the Prudhoe Bay region (Kessel and Cade 1958, Gavin 1980); a single colony of breeding Snow Geese is at Howe Island in the Sagavanirktok River delta; and Yellow-billed Loons nest primarily in the Colville River delta (North et al. 1983) and at Alaktak (Sjolander and Agren 1976). Red-throated Loons eat fish and their distribution is likely related to feeding requirements; they are common along the coast and uncommon inland (Derksen et al. 1981, Spindler et al. 1983, Moitoret et al. 1985, Miller et al. 1985). Their breeding distribution is likely limited by access to fishing areas and may be largely limited to within 40 km of the coast or large lakes with sufficient freshwater fish stocks (Derksen et al. 1981).

Regional Concentrations

Birds are most vulnerable when they are concentrated during some portion of the annual cycle and when a population is dependent upon a specific area. Specific concentration areas are briefly outlined below as to location (Figure 5) and timing of concentrations. Regional descriptions are drawn primarily from Connors et al. (1983), Derksen et al. (1979a), Divoky (1983), and Johnson et al. (1983).

Seahorse Islands and Point Franklin Spit -- Densities of nests appear higher on the Seahorse Islands than on comparable islands in the Chukchi and Beaufort Seas. Breeders include Arctic Tern, Black Guillemot, Oldsquaw, and Common Eider. Horned Puffins may breed there as well. Large numbers of Red Phalaropes, Arctic Terns, Brant and Sabine's Gulls use the area during the post breeding season.

Elson Lagoon and the Plover Islands -- The gravel shorelines and adjacent waters consistently support high densities of shorebirds, gulls, terns and some waterfowl during the post breeding season. Densities of most species peak in August prior to fall migration. The most abundant species include Red and Red-necked Phalaropes, Dunlin, Ruddy Turnstone, Sanderling, Arctic Tern, Sabine's Gull, Glaucous Gull, Black-legged Kittiwake, Ross' Gull, Oldsquaw, King and Common Eiders, and Black Guillemot. Black Guillemot and Arctic Tern nest in colonies on the Plover Islands. High densities of surface feeding birds regularly occur on and adjacent to the Plover Islands. The birds feed on marine zooplankton concentrated in the Bering Sea intrusion, a mixing zone where the north-flowing Bering Sea water enters the Beaufort Sea.

Teshekpuk Lake Region -- Large numbers of waterfowl molt in the region, notably Brant, Greater White-fronted Geese, and Canada Geese. Most birds are non-breeders and their densities peak in late July. Coastal portions of this region, the west and southwest coasts of Harrison Bay. are used heavily in the late summer by shorebirds and waterfowl. The shorebirds and waterfowl use the extensive saltmarshes and mudflats along the coast.

Colville River and Fish Creek Deltas -- Densities of breeding waterfowl are the highest on the North Slope, notably Tundra Swans, Greater White-fronted Geese, Brant, and Yellow-billed Loons. This is also an important spring staging area for migrants as it is one of the first areas along the Beaufort coast to become ice-free.

Simpson Lagoon -- The highest densities of molting Oldsquaw occur in Simpson Lagoon. Other species use the lagoon as well; large numbers of juvenile Red and Red-necked Phalaropes feed along the shorelines in mid-August. The high density and large biomass of birds using the lagoon are supported by an abundant invertebrate fauna that consists mainly of epibenthic mysids, amphipods, and isopods.

Barrier Islands along Simpson Lagoon -- The barrier islands between the Colville and Canning Rivers provide the core nesting area for the Common Eider in the Alaskan Beaufort Sea. The highest numbers of nesting Common Eiders are found on Cross, Pole, Thetis, Egg, Stump, and Narwhal Islands, and Lion Point. The islands also support nesting Arctic Terns and Glaucous Gulls.

Sagavanirktok River Delta -- The only Snow Goose nesting colony in Alaska is on Howe Island, located at the outer fringe of the river delta. The geese rear their young in relatively discrete areas of the delta, with an apparent preference some years for wetlands south and southwest of the nesting island.

Canning River Delta -- The Canning Delta supports the highest breeding bird densities on the eastern coastal plain. The lagoon south of Flaxman Island supports high numbers of molting oldsquaw.

Barter Island to Demarcation Bay -- Bird use of the lagoons east of Barter Island is similar to that found in Simpson Lagoon. Overall numbers and densities of Oldsquaw are lower than in Simpson Lagoon, although high numbers regularly occur in Demarcation Bay. The extensive lagoon system still supports large numbers of Oldsquaw and may be of significant importance to a sizable proportion of the total Oldsquaw population that molts along the Beaufort coast of Alaska. Large numbers of Snow Geese stage in late summer on the inland portion of the coastal plain in this region.

4. OILFIELD DEVELOPMENT

GENERAL DESCRIPTION

Oilfield development on the Arctic Coastal Plain is expanding from Prudhoe Bay and the Trans-Alaska Pipeline System (TAPS); major developed oilfields include the Prudhoe Bay Oilfield (PBO) and the Kuparuk Oilfield (Figure 6). The PBO is operated by two companies: Atlantic Richfield Company (ARCO) on the east side and Standard Alaska Production Company (SAPCO) on the west side. New roads and facilities to improve oil recovery have been continually added, expanding the perimeter of the oilfield and creating a greater density of roads and pads in the developed areas.

The Kuparuk Oilfield is adjacent to the Prudhoe Bay development and operated by ARCO. It has developed at a nearly steady state since the completion in 1980 of the pipeline connecting the Kuparuk production centers with the TAPS. Design of the field has taken advantage of the Prudhoe Bay experience with greater consideration for natural drainage patterns and some consolidation of facilities. Facility development in Kuparuk is similar to that in Prudhoe Bay although the Kuparuk Oilfield extends over a much larger area and the wells may ultimately be spaced closer due to the nature of the oil reservoir.

The PBO is a network of roads and facilities. Many wells are drilled from single, large pads spaced about every 3.2 km (647,800 m^2 or 160-acre well spacing). Feeder pipelines connect the wells with central processing facilities known as Flow Stations (ARCO) or Gathering Centers (SAPCO). At the central facilities, the mixture of oil, gas, and water produced at the wells is separated. Oil is then piped to Pump Station Number 1 for shipment down the TAPS. Water is reinjected into an oilbearing formation as part of the waterflood operation and the gas is piped to the Central Compressor Plant where most of it is reinjected into the gas cap at the top of the oilbearing formation. About 10 percent of the gas is used by the power plant for Prudhoe Bay and as fuel for the first four pump stations.

All facilities are interconnected by roads. A main road (the Spine Road) traverses the field and is joined by access roads connecting it to the wellpads. Other major roads connect the center of the oilfield with the West Dock -- a causeway at the edge of Prudhoe Bay used for receiving equipment and materials shipped by ocean-going barges during the summer.

The majority of the oil service company camps are in the Deadhorse service area on state-owned land. Other principal service camps are the Frontier Camp, centrally located in the field, and the Service City complex adjacent to the Kuparuk River, which are on private land. These camps contain workshops and living facilities for employees. Each oil company has a Base Operations Center (BOC) that contains living quarters, office space, and workshops. Two major airfields serve the area: the State's Deadhorse Airport and the ARCO airfield adjacent to its BOC.

Oilfield facilities are placed on thick gravel pads that help maintain thermal insulation and provide a relatively stable work surface. Gravel fill insulates the permafrost and prevents major thermal erosion. Pads are connected by gravel roads of similar construction. Pad or road thickness depends

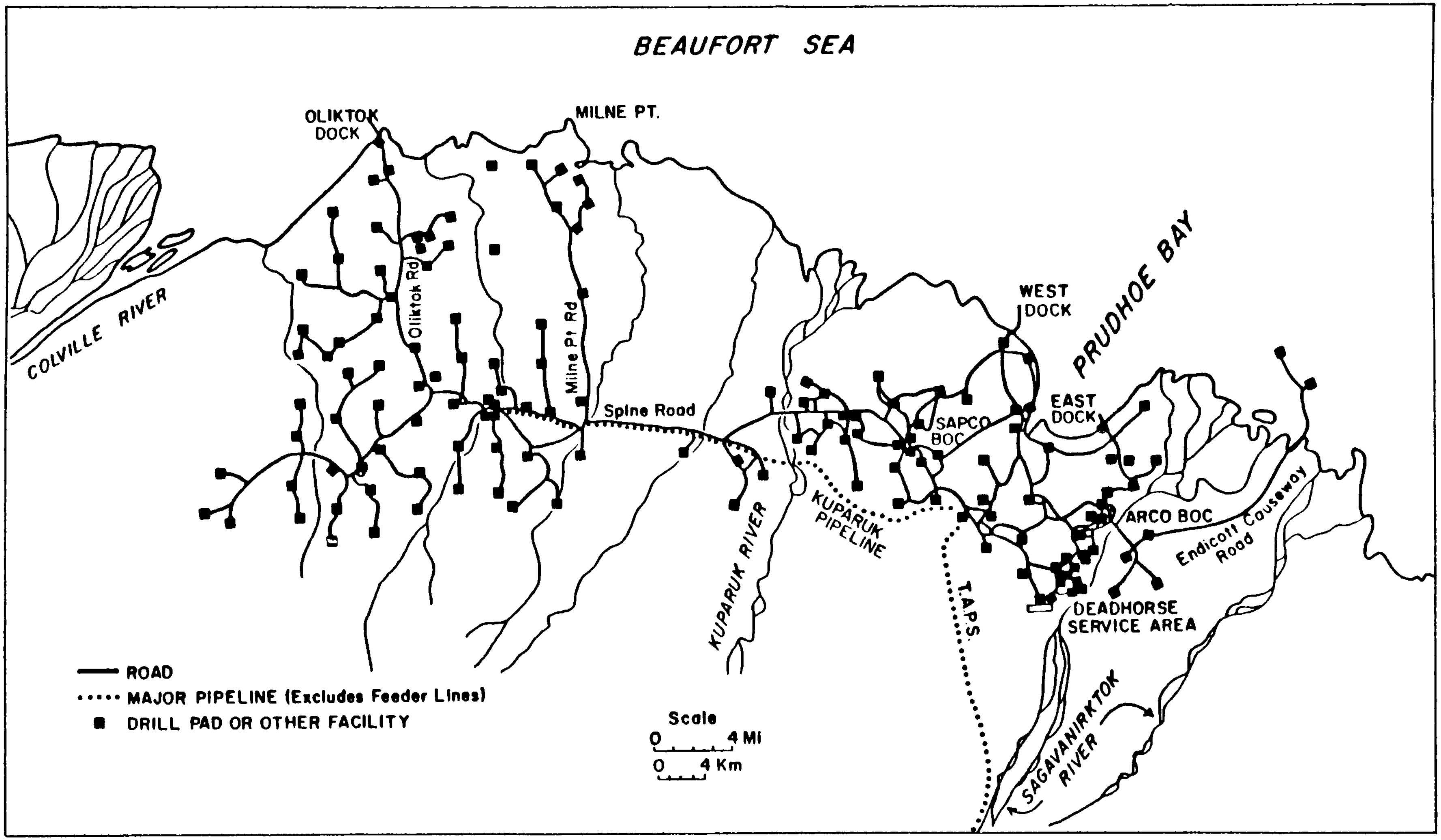

Figure 6. Oilfield development on the North Slope of Alaska.

on the weight-bearing capacity required and the duration of use (i.e., for one or more seasons). At Prudhoe Bay, most gravel pads and roads have a minimum thickness of 1.5 m (5 ft).

FACILITY DESCRIPTIONS

Gravel Mines and Overburden

Gravel in the Prudhoe Bay area comes from large open-pit mines located in the inactive floodplains and deltas of major drainages. Major mines are located along the Putuligayuk, Sagavanirktok and Kuparuk Rivers. The top organic layer of peat and fine mineral soil, termed overburden, is stripped off the mine sites and piled at the edge of the pits. Gravel deposits in the Kuparuk Oilfield are not as extensive as those in Prudhoe Bay, thus a larger number of smaller mines are required.

Drillsites/Wellpads

Multiple wells are drilled from each gravel pad, called a drillsite (ARCO) or wellpad (SAPCO). The pads in Prudhoe Bay range in size from 141,700 m^2 (35 acres; SAPCO's Pad Q) to 404,900 m^2 (100 acres; ARCO's Drillsite 1). Gravel volume ranges from 212,300 to 611,600 m^3 (276,000 to 800,000 yd^3, or about 8,000 yd^3/acre). The actual amount of gravel used depends upon site characteristics; the controlling factors are that the pad surface remains level and a minimum depth of 1.5 m be maintained. Eventually, most drillsites are expanded to accommodate new facilities and additional wells for enhanced oil recovery. Pads are usually constructed and allowed to settle and compact for a year prior to placing facilities on them.

The activity on a drillsite ranges from intense and nearly continuous during initial construction or expansion to minmal during normal operations. Construction involves nearly continuous gravel hauling and dumping at the site with heavy equipment constantly in use. Traffic is light to operating drill-sites, which are inspected periodically, and the only activity at the site is for minor maintenance. Intermediate levels of activity occur during drilling and well testing. Workers live at the drillsites in temporary camps when wells are drilled. Traffic and related noise levels are high during drilling operations compared to maintenance activities during production.

Several pits are constructed adjacent to drillsites. Drilling muds are discharged into large pits (reserve pits), enclosed by gravel berms contiguous to the pad. Flaring pits are small square pits, set out at an angle from the pad, used during drilling and well testing for flaring (burning) contaminated oil. Emergency relief pits are similar in size and shape to flare pits and are designed as potential disposal sites for oil and flaring sites for gas if pressure builds up in the manifold building or the feeder pipelines.

Flow Stations/Gathering Centers

Central processing facilities are collection and distribution centers located near the center of the oilfield (Figure 7). ARCO and SAPCO each operate three of these facilities. Central facility pads range in size from 161,943 to 385,615 m^2 (40 to 95 acres) and require a minimum of 15,000 m^3 of gravel/hectare

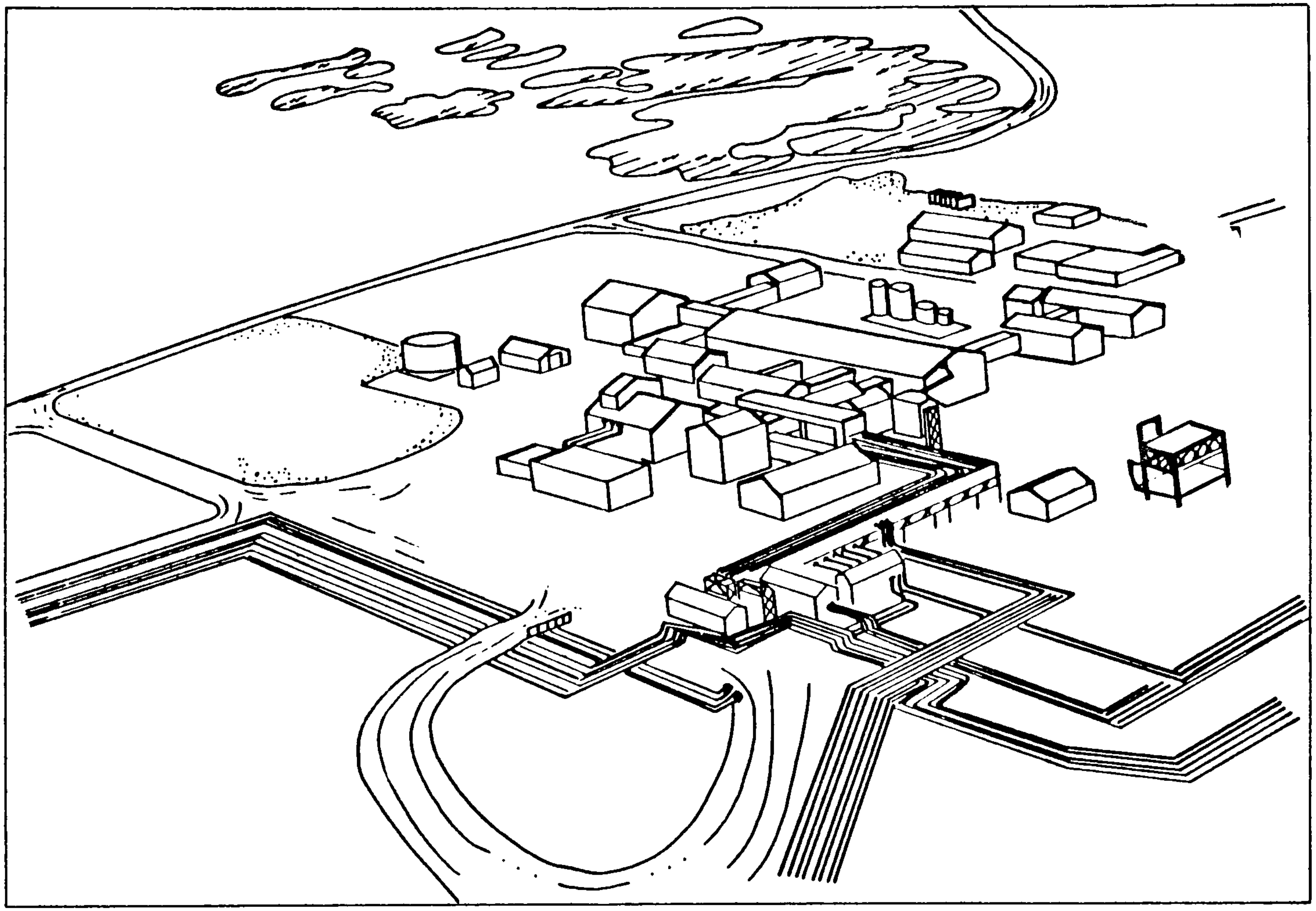

Figure 7. Schematic drawing of a central production facility showing pipeline congestion.

(8,000 yd^3/acre). The actual quantity of gravel used for a pad depends on the topography of the site. The pads are routinely expanded to accommodate additional facilities.

The central facilities handle the oil mixture from production wells and are distribution centers for secondary oil recovery systems. The oil mixture from production wells is piped to the facilities where it is separated into the oil, gas, and water fractions, by means of large separation chambers and by pumping large volumes between the chambers and other facilities. Seawater for waterflooding (a secondary oil recovery technique of injecting water into the producing reservoir to maintain pressure) is distributed to production wells from these facilities. The seawater is pressurized then transported via pipeline at high pressure to the drillsites. Safety systems adjacent to the pads include large flare pits for oil and gas that include burners for flaring. The gas burners are always lit, functioning as pilot lights. Several pipelines come together at the processing facilities and the areas immediately adjacent to the pads are congested.

Service Camp Pads

Most of the oilfield work is performed by companies under contract to the operators. Service companies maintain facilities in the Deadhorse area on state lands, and their gravel pads are nearly contiguous. Activity on service pads varies and is related to the type of work performed by the company. Some pads are used for storage and have little activity, some are used by companies that provide emergency or other services that have occasional bursts of activity, and some belong to gravel contractors who conduct nearly continuous activities. A variety of chemicals are stored on some pads, most notably by drilling mud contractors.

Gravel Roads

The Spine Road is the main transportation route through the oilfield and for most of the traffic between the Deadhorse airport and service area to the Kuparuk Oilfield. The Spine Road is wider than other roads in the oilfield, varying from 14 to 20 m (46 to 66 ft) at the base. The quantity of gravel used in the road ranges from 19,000 to 28,500 m^3/km (40,000 to 60,000 yd^3/mi). Other major roads in the oilfield connect the West Dock with the Deadhorse service area.

Major roads are heavily travelled by both light vehicles and heavy equipment, and are used as routes for the movement of modular building units (modules) that are transported to Prudhoe Bay by barge. The roads are continuously maintained, with snow clearing in the winter and dust control or grading during the summer. Dust is controlled by watering, most often with fluids pumped from reserve pits; fluids used must meet state water quality standards. There is limited road oiling.

Drillsites are connected to the Spine Road and other major roads by access roads. Access roads are generally not heavily travelled except during construction. Most access roads have a 9 m (30 ft) base width, with a minimum gravel requirement of 18,500 m^3/km (24,000 yd^3/mi). Roads that provide access to more than one drillsite are more heavily travelled and may be 12 m (36 ft) wide. Heavy traffic occurs during module movement and when drill rigs are moved to and from the pads.

Ice-roads and Pads

Ice-roads are used for winter transportation during oilfield exploration, and ice may be used for exploratory drilling pads. Ice-roads and pads are used in the developed oilfield as workpads for winter construction, primarily for pipelines and powerlines. The road or pad may be constructed by smoothing or compacting the snow surface and/or spraying water on the surface to build up an ice layer (Adam and Hernandez 1977, Johnson and Collins 1980).

Powerlines

Electrical power is supplied by a central power plant. Some powerlines are buried but most power distribution is by overhead lines. Powerlines are usually installed during the winter; maintenance is accomplished during the summer by using rolligons, an off-road vehicle with low pressure tires. Off-road vehicle trails commonly develop under powerlines and are most noticeable in wet tundra.

Pipelines and Construction Pads

Oil is transported to the central processing facilities and the TAPS via a network of small diameter pipelines. Most drillsites are connected by multiple pipelines. Major pipelines, such as the Kuparuk Pipeline connecting the Kuparuk Oilfield with the TAPS, and pipelines in areas where caribou movement is a particular concern, are constructed with a minimum of 1.5 m ground clearance. Many early pipelines in the center of the PBO have much less ground clearance.

Construction pads are built alongside pipeline corridors so that pipelines may be built and reached by vehicles during the summer. The pads are similar to roads but are travelled only during construction and for inspection and maintenance. The pads are usually only 1 m thick because they are not used for regular travel. The gravel requirement is approximately 5,700 m^3/km (12,000 yd^3/mi).

5. IMPACTS

OVERVIEW

Impacts are simply defined as changes from the original state (States et al. 1978, Westman 1985). In this manual, they are evaluated in terms of changes in habitat, and related changes in use by waterbirds. The original state is considered tundra which is physically undisturbed by man, and impacts are defined in terms of changes to the vegetation communities and microtopography. General patterns of impacts are presented below, followed by a section that relates impacts to specific types of oilfield facilities.

GENERAL PATTERNS

The dynamic nature of tundra vegetation is exemplified by the recovery of plant communities following disturbance. Mesic (moist) communities are initially more resistant to mechanical damage than wet communities, but once altered, are slower to recover (Komarkova 1983). The different response is largely due to the natural variation in moisture regimes that occurs within wet communities as compared to more stable moisture regimes in mesic communities; wet communities have broader environmental tolerances. In general, the recovery of vegetation following a one-time disturbance (e.g., single season disturbance associated with exploratory operations) is related to the intensity of the original disturbance and the resulting changes in moisture regimes (Lawson et al. 1978). Extreme disturbance occurs when the vegetation mat is removed or destroyed and the permafrost layer is exposed (Webber and Ives 1978). This results in subsurface melting due to alteration of the insulating layer of vegetation, known as thermal erosion. Disturbance patterns in the oilfield differ in that the activity causing the disturbance (e.g., dust deposition) is often continuous and the vegetation community is subject to a continual stress.

Recovery from disturbance can be considered complete or functional. Complete recovery, or a return to the original plant community, is possible only when the original microsite characteristics are maintained. When microsite characteristics (notably moisture and topography) are altered, the resulting species composition will differ from the original community. This type of recovery may be termed functional recovery, which is characterized by development of a relatively stable community that may be more or less productive than the original community (Walker et al. 1987). Recovery or development of a stable community may not occur in an oilfield until the facilities are abandoned and activities causing disturbances cease.

Many surface impacts in an oilfield can be related to gravel fill and usually extend beyond the direct loss of the area covered by the fill. Associated impacts include the source of the gravel, large open pit mines with adjacent overburden piles. Other typical impacts are related to the placement of the fill and include impoundments, late snowmelt, gravel spray from snow removal or small construction spills, dust and noise generation, and contaminants from dust and road oiling. Although not a cause of significant surface disturbance, powerlines may interfere with movements of migratory birds. In addition, support or construction activities not requiring gravel fill, such as winter ice roads or pads and occasional summer off-road traffic, may also have surface impacts.

Impacts may differ depending on the season in which construction takes place. Although no studies have compared the differences between summer and winter construction, some potential differences are related to the placement of drainage structures, the extent of gravel spills and debris, and the absence of most birds and caribou during the winter. Because drainage patterns and volumes can only be determined during the summer the accuracy of culvert placement may be higher in the summer. When culvert locations are marked for winter construction, exact placement is difficult because drainage patterns are not visible. Temporary culverts and breaks in the gravel pad have been tried during winter construction to allow placement of permanent culverts in the summer. These techniques, while potentially alleviating drainage problems, often result in small gravel spills adjacent to the drainage when high spring flows carry gravel from the toe of the gravel pad onto the tundra. The potential for small gravel spills and debris seem higher during winter construction due to the extreme weather conditions. In general, though, winter construction may have fewer impacts than summer because the vegetation is dormant, snow-covered ground is frozen, and most animals are not present.

Impacts do not always result in a complete habitat loss. Some species take advantage of change and show preference for the affected area when disturbance creates conditions analogous to preferred habitat types. For example, Northern Pintails and Red-necked Phalaropes preferentially use artificial impoundments (Troy 1984). Preference by some species does not mean the net change has been beneficial, however, as five other species were found to avoid impoundments.

SPECIFIC IMPACTS

Gravel Cover

The placement of gravel fill for roads or pads is a permanent, dramatic environmental change. The underlying vegetation is replaced with a feature whose closest natural analog is an unvegetated river bar. Abandoned pads in the Prudhoe Bay area have been sparsely colonized with some of the same taxa that are found on river bars. Colonization, however, is limited by the brief growing season (Billings 1973), limited nutrients and compacted gravel. Human activity on gravel pads and roads effectively prevents colonization and any significant wildlife use. In 1987, gravel covered over 8,650 acres of North Slope oilfields.

Gravel Mines and Overburden

Gravel mines represent a dramatic change from existing conditions and are not analogous to any natural feature. Unless the pits are deliberately altered, they will remain essentially unchanged, except where those adjacent to water courses are subject to flooding. Activity in and around a mine can be intense and dust deposition from the mines is heavy.

Gravel removal from upland sites is generally recommended over excavation in river floodplains, to avoid loss of riparian vegetation and potential impacts to fish. However, the Alaska Department of Fish and Game is currently investigating the feasibility of rehabilitating floodplain gravel pits of intentional flooding to provide overwintering habitat for fish. The relative value of this approach must be evaluated on a site-specific basis, as riparian areas provide important habitat for birds and mammals as well as fish.

Deposition of removed overburden material on surrounding tundra results in direct habitat loss as well as indirect effects from thermokarsting and blocked drainages, which may be as significant as the impact of the gravel pit itself. Revegetation of overburden piles is usually unsuccessful because of the inabilty of these raised piles to retain soil moisture. Sequential mining with replacement of overburden in previously excavated areas can minimize habitat loss and facilitate rehabilitation of the site.

Impoundments

Blockage or alteration of natural drainages creates artificial ponds and lakes. These impoundments can be extensive since gravel roads and pads act as dams, and the terrain is nearly level. Drained lake basin complexes are particularly susceptible to impoundments when crossed by roads, due to the weakly integrated drainages and sheetflow pattern of runoff in the spring. Aquatic sedge or wet sedge tundra, which naturally drains slowly, is generally susceptible to impoundment.

In 1983, a total of 13.81 km^2 (3,400 acres) of the PBO was classified as impounded (Walker et al. 1984). Impoundments were more common in the center of the oilfield where the same drainage was crossed numerous times and where drainages were often blocked by pads (which cannot be culverted). In a 20.9 km^2 area located near the center of the oilfield, 13.9 percent of the area was mapped as continuously flooded (>75 percent open water) and 5.8 percent of the area as discontinuously flooded (<75 percent open water). These measurements did not include the lakes and ponds within the flooded areas (Walker et al. 1984). Along a road in the northern part of the oilfield, impoundments were the most extensive type of impact (Klinger et al. 1983).

Culverts provide drainage across roads but are not always effective. Culverts can be damaged or blocked by gravel from maintenance activities (Brown and Berg 1980). The thermal properties of the road are altered by the presence of culverts which may, together with the weight of vehicle traffic, cause the culvert ends to bow upwards and prevent water flow (Brown et al. 1984). Culverts may also remain frozen or be blocked by late melting snowbanks (Klinger et al. 1983).

The effect of an impoundment depends on its duration and depth. Deep, permanent impoundments resulting from blocked or restricted drainage resemble deep, open lakes and may have aquatic vegetation around their edges. Plant growth or species composition may be affected. Arctophila fulva generally does not grow in water depths greater than 80 cm (Walker 1981) and may be eliminated from deep impoundments. Wet and aquatic sedge communities that are slightly flooded may show increased production where species are adapted to periodic flooding. These areas appear greener earlier in the spring and later in the summer (Klinger et al. 1983, Envirosphere 1984). Seasonal impoundments, due to inefficient or blocked culverts, may eliminate species not adpated to periodic flooding or deep water. Diverse communities, such as those within drained lake basins, may become monotypic sedge (Carex aquatilis) communities.

The effect of impoundments on birds has been studied along a lightly traveled road (Troy 1984, 1985). Most species avoided impoundments during the beeding season, particularly nesting birds. Major exceptions were Northern Pintails and phalaropes that foraged in the area. Post breeding season use of impoundments increased significantly, notably by White-fronted Geese. The only species that avoided impoundments late in the season was the Lapland Longspur. Differences in use between seasonal and permanent impoundments could not be statistically tested but it appeared that shorebirds that forage in flooded areas preferred seasonal impoundments (e.g., Pectoral Sandpipers, Long-billed Dowitcher, and Red Phalarope). Northern Pintails and Red-necked Phalaropes preferred permanent impoundments, while other species avoided both seasonal and permanent impoundments.

Dust

Road traffic and construction activities generate airborne dust that settles on adjacent tundra. Dust levels are directly related to the amount of traffic and construction activity. Dust deposition is greatest immediately adjacent to roads, and decreases logarithmically with distance (Everett 1980). In the Prudhoe Bay area, more dust is deposited by east winds than by west winds (Benson et al. 1975) because east winds prevail during the summer months when road dust is most easily generated. Dust along lightly traveled roads is generally deposited within 50 m (Klinger et al. 1983). In contrast, along the more heavily traveled Spine Road, a heavy dust shadow south of the road was obvious for 25 m and the effects of dust were noticeable up to 75 m from the road (Walker et al. 1987). A heavy dust shadow entirely due to the Spine Road was shown to cover over 0.2 percent (0.04 km^2; 10 acres) of a 20.9 km^2 (5,164 acres) area mapped in the center of the oilfield (Walker et al. 1984).

Dust has a significant effect on mosses and has been shown to reduce the productivity and growth of *Sphagnum* spp. (Spatt and Miller 1981). Some of the common moss species in the Prudhoe Bay area, such as *Drepanocladus* spp. and *Tomenthypnum nitens*, are not as sensitive to dust as is *Sphagnum* (Werbe and Walker 1981). Heavy dustfall along the Spine Road eliminated virtually all bryophytes within a few meters of the road, and both mosses and lichens were noticeably affected up to 75 m from the road. In addition, thaw depths were significantly deeper within 25 m of the road, corresponding to the area where the moss layer had been eliminated or severely affected. In some areas, low-centered polygons became high-centered polygons because of the loss of the moss carpet and the consequent thermal erosion (Walker et al. 1987).

Dust deposition in winter decreases the albedo of the snow, leading to earlier melting adjacent to roads (Benson et al. 1975). This zone extends some 30 to 100 m from heavily traveled roads (Walker et al. 1984). Areas adjacent to roads may be snow-free 10 to 14 days earlier than unaffected tundra areas. The early melt zone may increase annual productivity of the plants due to a slightly longer growing season (Envirosphere 1984). These areas are used extensively some years by waterfowl prior to break-up of the adjacent tundra (Norton et al. 1975, Hansen and Eberhardt 1981, Troy 1984). Waterfowl move to adjacent tundra areas as soon as they become snow-free, leaving the roadside areas. The roadside areas are functionally the same as river deltas in providing open tundra and open water early in the season. Major differences from the natural areas are the amount of human activity and potential contaminant problems in the oilfield.

Late-Melting Snowbanks

Persistent snowbanks form on the west side of lightly traveled roads and pads due to snow deposition by winter winds, which may shorten the growing season and reduce plant growth. In 1982, the snowbank along the West Field Road melted two weeks later than snow on adjacent tundra. The vegetation affected by the snowbank had a lower leaf-area index than did control areas, indicating reduced growth due to a shortened growing season (Klinger et al. 1983).

In 1981 and 1982 there were lower densities of birds within 100 m of the West Field Road than beyond the 100 m zone. Persistent snowbanks were suspected as a major factor contributing to this reduction (Troy and Johnson 1982, Troy et al. 1983). In 1984, dust deposition along a portion of the road enhanced snowmelt and there were more birds alongside the road (Troy 1985) than at distance from the road.

Snow clearing operations for construction and maintenance also creates late melting snowbanks. During winter construction, heavy equipment used to clear snow prior to gravel placement often causes damage to the tundra. Wet tundra is more resilient than moist or dry tundra where the vegetation mat may be damaged or removed (Envirosphere 1984). Snow that is routinely cleared from existing roads and pads contains gravel and other debris that remains on the tundra after snowmelt. Deposition of this material reduces plant growth, particularly in moist and dry tundra types. Along the West Field Road, disturbed study plots in moist tundra types had 15 to 20 percent less live vegetation than control plots, while dry plots had 80 percent less. Shrubs and lichens were most affected (Envirosphere 1984).

Late-melting snowbanks due to drifting or snow clearing along roads block culverts and prevent early season drainage (Klinger et al. 1983, Envirosphere 1984). The duration of the resulting impoundments depends upon the persistence of the snowbanks. Snowbanks also channel meltwater parallel to the road, which may increase heat flux along the channel and result in thermokarst.

Ice roads and ice pads may also reduce plant growth as they melt later than surrounding areas. Depending on the amount of travel and the snow cover, the vegetation mat may become compacted. Wet tundra types recover more quickly from compaction than dry types. Contaminants and debris incorporated into the road are deposited on the tundra.

Gravel Spray

Gravel and debris are deposited on the tundra adjacent to pads and roads during construction, snow removal, and other maintenance operations. Gravel may also be deposited along ice roads during winter gravel hauling. Deposition is usually limited in extent, occuring within 30 m of the road or pad (Envirosphere 1984, Walker et al. 1984). Gravel and debris were found in vegetation types adjacent to roads in the same proportions as the relative occurrence of these types along the roads (Walker et al. 1984). This deposition zone adjacent to roads and pads extends the area of direct physical change.

Culvert failure, wash-outs, and road breaching deposit gravel downstream on the tundra. Crossings that chronically wash-out can have extensive gravel deposits in the drainage. Road breaching (a winter construction technique of leaving a gap in the road in the approximate culvert location so that the culvert can be placed in the summer) results in scouring of the unstabilized edges and the gravel being carried downstream during breakup.

Thermokarst

Gravel placement, dust, or nearly any disturbance to the vegetation can disrupt the thermal equilibrium of the underlying permafrost, leading to thermokarst. The vegetation mat insulates the permafrost. When the vegetation is compressed (e.g., along a rolligon trail) or removed, heat flux increases and the active layer becomes thicker. As the permafrost melts, excess water in the soil layer drains, resulting in subsidence. In flat terrain, where drainage is slow, the depressions will fill with water. Standing water acts as a heat sink and accelerates the thaw process (Lawson et al. 1978). Thaw progression may also follow ice-wedge troughs between polygons (Rawlinson 1983), thus expanding the area of impact.

Thermokarst develops adjacent to roads and pads because the thermal properties of the surrounding area are changed by the gravel fill. When the fill provides less than the natural insulation (as it does near the edges of fill structures), the surrounding area thaws and subsides. Meltwater flows along the side of the pad, increasing heat flux and expanding the area of thermokarst. When gravel fill provides equal or greater insulation, the core of the fill generally remains frozen.

Thermokarst in Prudhoe Bay primarily occurs directly next to roads and pads with the most extensive and deepest thermokarst features next to heavily traveled roads, such as the Spine Road. Heavy dust along the Spine Road altered the thermal regime, as mentioned earlier. Most of the thermokarst mapped in a 20.9 km^2 area occurred in wet sedge tundra and in moist sedge, dwarf-shrub tundra (Walker et al. 1984).

The direct effect of thermal erosion on habitat value is not known; however, thermokarst formation may be a useful indicator of continuing secondary impacts. Thermokarst formation is the result of many processes (Lawson 1982) such as dust and flooding (Klinger et al. 1983). Continued thermokarst formation with time, as is occurring in the PBO (Walker et al. 1984, Walker et al. in press) indicates changes are still occurring long after placement of the gravel fill. By extension, habitat loss and change also continue long after initial gravel placement.

Off-road Travel

Off-road vehicles are used in the oilfield to service powerlines, explore and collect test cores for gravel, conduct seismic surveys, and construct powerlines and pipelines. Travel is regulated by the Department of Natural Resources to minimize surface disturbance. Winter travel by tracked vehicle is permitted when a minimum snow cover of 12.8 cm (6 in) is present. Summer travel is restricted to low pressure vehicles, such as rolligons and hovercraft. The impact of off-road travel depends on the type of vehicle used and the number of vehicle passes over the same area. Damage is related to the compression or destruction of the vegetation mat (Abele and Brown 1976, Abele et al. 1978, Felix and Jorgenson 1985). In general, grasses and sedges (except tussocks) are tolerant of vehicle disturbance and can be more abundant in vehicle tracks (Chapin and Chapin 1980, Chapin and Shaver 1981). Willow shrubs are generally sensitive to disturbance (Lawson et al. 1978, Chapin and Shaver 1981, Reynolds 1981). The skirt of air-cushion vehicles (hovercraft) abrades vegetation. Exposed bird nests are destroyed by a single pass of a hovercraft; well concealed nests are disturbed only by repeated passes (Abele and Brown 1976, Walker et al. 1977).

6. MITIGATION

DEFINITION

Individual or collective actions taken to offset adverse project impacts are termed mitigation. Mitigation of adverse impacts that affect the maintenance of functional aspects of the ecosystems (e.g., wildlife habitats, natural biological productivity, species diversity, and water quality maintenance) is important.

The definition of mitigation used by federal agencies is in the Council on Environmental Quality (CEQ) regulations for the National Environmental Policy Act (NEPA) (40 CFR 1508.20[a-e]). This definition lists five types of mitigation:

> "(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impact by limiting the degree of magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitation, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments."

POLICY

Several agencies in Alaska have mitigation policies. The Fish and Wildlife Service (FWS) has a national policy (Federal Register, Volume 46, No. 15, Friday, January 23, 1981, pp. 7644-7663); The Environmental Protection Agency (EPA) has a regional policy for the Pacific Northwest and Alaska that applies to dredge and fill activities (Region 10 Mitigation Policy); the Corps of Engineers has a formal policy (33 CFR 325.4, July 22, 1982, Federal Register); the National Marine Fisheries Service uses its Habitat Conservation Policy as a mitigation policy; and the Alaska Department of Fish and Game (ADFG) has internal mitigation guidance. Goals are similar in all mitigation policies. The goal of both EPA and FWS comes from NEPA and is to ensure that the natural environment receives proper or equal consideration in the review of development projects. The ADFG has the goal of allowing minimal change in the quality of the ecosystem. A goal of all three policies is to provide information in the planning and review process which is timely and will guide, not hinder, development.

The FWS Mitigation Policy recognizes mitigation as a management concept and sees the five elements in the CEQ definition as a desirable sequence of steps and not menu equivalents. The same approach is outlined in the ADFG guidance. The steps include: (1) avoid; (2) minimize; (3) rectify; (4) reduce or eliminate; and (5) compensate. Avoiding impacts is the highest attainable mitigation goal. Compensation may be required only after impacts have been determined to be unavoidable through the preceding four steps.

A key aspect of mitigation requires initial identification of resource values so losses resulting from project development and potential gains through mitigation can be evaluated and compared to determine the merits of recommended actions. The FWS Mitigation Policy uses four Resource Categories, based on the importance and relative abundance of habitats, to set values and goals for mitigation (Table 7). The purpose of Resource Categories is to ensure that the level of migitation recommended is consistent with the fish and wildlife resource values involved.

Values are determined for selected evaluation species and scarcity is based on relative abundance on a national or ecoregion scale. EPA adopts a "no loss of habitat value" determination for areas with unique aquatic resources, which is equated with Resource Category 1. Determination of value or damage assessment is recognized by the ADFG as being difficult to quantify, and the determination of value is left to the reviewer, based on specific site and project information.

MITIGATION STEPS

1. Avoid -- Modify the project to avoid predicted impacts. Specific impacts may be avoided by changes in structural design through engineering, relocation, or timing restrictions on construction or operation. In wilderness or previously undeveloped areas, the "no project" alternative or a non-structural alternative (e.g., use of existing facilties) are the only alternatives that truly avoid all impacts as construction disturbs natural processes and changes wil occur.

2. Minimize -- If development will cause unavoidable impacts to the natural environment, the second mitigation step is to minimize those impacts. Minimization occurs during planning, construction, and maintenance and includes actions taken to directly modify the project design by reducing the size, or by timing construction, operations, and maintenance to reduce disturbance to fish and wildlife. Some vegetation types are more sensitive to impacts than others and project impacts can often be minimized by avoiding specific areas.

3. Rectify -- Following completion or abandonment of the project, actions taken to rehabilitate or restore the site are termed rectification. These actions are particularly appropriate for exploratory activities where disturbance is less drastic and the life of the project is short. This would be a long-term goal for major development projects.

   Restoration of a site to its original state, or rehabilitation to a more productive condition, are often objectives of rectification. In many cases complete recovery of an area is not possible because the conditions under which the original community developed cannot be re-created (Webber and Ives 1978). Vegetation composition, determined primarily by micro-topogrpahy and microclimate, can be dramatically altered by construction activities. The resulting conditions may lead to a functional equilibrium (i.e. a different vegetation community) that is more or less productive than the original community (Walker et al. 1985). One way to predict the result is to relate the disturbed area (e.g. an abandoned gravel pad) to an analogous natural feature (a floodplain gravel bar). All other factors being equal, vegetation on the natural feature is likely to be similar to what will develop or could be developed on the disturbed area. For example, an abandoned gravel pad is similar to a floodplain gravel bar,

Table 7. Fish and Wildlife Service mitigation policy resource categories.

Category 1:	Unique and irreplaceable area of high value; the goal is no loss of existing habitat value.
Category 2:	Areas of high value that are relatively scarce; the goal is no net loss of in-kind habitat value.
Category 3:	Areas that are of high to medium value and are relatively abundant; the goal is no net loss of value while minimizing loss of in-kind habitat value.
Category 4:	Areas of medium to low value; the goal is to minimize loss.

thus the plant species characteristic of gravel bars are likely to be the most successful at colonizing abandoned pads (Kubanis 1982, Walker et al. 1987). Therefore, rather than complete restoration, a more realistic goal may be to physically rehabilitate the site to approximate the natural analog, thus encouraging establishment of a natural community. Where appropriate, natural recolonization may be further enhanced or supplemented through fertilization and seeding or planting of native species.

4. Reduce or Eliminate -- Mitigation measures must be monitored through the life of the project to ensure that they continue to be effective. Provisions for maintenance and repair or redesign (retrofitting) are necessary so that the level of mitigation initially required for project approval is achieved.

5. Compensate -- Compensation is necessary when actions taken to directly modifiy the project (steps 1 through 4) are insufficient to reasonably offset project impacts. Compensation involves determining the area permanently altered by the project, the resource value of the altered area, and replacing that value by increasing the value of other areas. This may involve rehabilitation of areas not affected by the project whose potential habitat value to affected species is similar to that being lost.

Mitigation banking is another approach, where land is acquired (title or easement) by a developer, agency or other private entity either in advance or concurrently with development, and the habitat is protected or improved to offset the effects of several development actions on a particular habitat type. A mitigation bank can be established to create new habitat, restore previously degraded habitat, improve the value of existing habitat or protect existing habitat scheduled for development. In either case, the amount and type of land purchased or enhanced is determined by the amount of area unavoidably affected by the project and the relative value of the affected land to wildlife.

RECOMMENDED MITIGATION OF SPECIFIC IMPACTS

The approaches outlined below address minimization, rectification and reduction of specific impacts associated with gravel placement. In all cases, complete avoidance is possible only through the "no project" or non-structural alternative because gravel placement does result in physical changes and consequently causes changes in habitat value. A discussion of compensation follows the guidance for specific impacts.

Gravel Cover

Gravel fill in wetlands permanently alters the area covered and the changes cannot be avoided. Impacts due to fill can be minimized in part by reducing the size of the fill and in part by following the recommendations discussed below to minimize associated impacts. Other possible ways to minimize associated impacts include winter construction and traffic restrictions (particularly during periods of high wildlife use). These latter two approaches may be appropriate in some cases and not in others depending on the characteristics of the project area. Pipelines can be constructed from existing gravel pads or from ice pads during the winter, thus reducing the need for gravel fill.

Rectification following abandonment is under investigation in the Prudhoe region but results from the studies are not yet available nor is there information on gravel pads of similar thickness in comparable areas. Consequently, little information on appropriate techniques is available. (Few pads in the Prudhoe region have been abandoned.) Restoration of any site to its original condition is highly unlikely, however, as the original site characteristics (e.g. microtopography and soil moisture) will have been dramatically altered. Even with complete removal of the gravel, the site characteristics will be dramatically different from the original condition. Rehabilitation to a stable community analagous to a riverbar may be possible. Appropriate measures need to be investigated and should be as comprehensive as possible, examining the potential outcomes of altering the gravel in place through partial or complete removal of the gravel.

Gravel Mines and Overburden

Large gravel mines, like the ones along the Putuligayuk River, permanently alter the area and should be considered a complete habitat loss. Rectification following abandonment of large mines has not been tried. The volume of material removed from the mines is tremendous and no feasible method of filling the mines with a solid fill is apparent. One mine adjacent to the Putulagayuk River has been converted to a landfill. Consolidated mines are preferable to gravel removal from active floodplains, but the loss associated with the large mines must still be considered. The Alaska Department of Fish and Game is currently investigating rehabilitation of large gravel mines in river floodplains so as to provide overwintering habitat for fish.

Filling of mines with water has been proposed with the idea that they would be similar to large lakes. Another mine in the Sagavanirktok River floodplain has been filled with water and converted to a water reservoir. Such techniques depend on the availability of a water supply, and the approach needs to be carefully reviewed on a site specific basis.

Impoundments

Large gravel pads cannot be culverted due to their size and weight bearing requirements; therefore they must be sited to minimize blocked drainages. Sites that should be avoided when constructing such facilities include drained basin complexes, aquatic and seasonally flooded wet sedge tundra, and minor or ephemeral water courses which may carry water during break-up. Preparation of surface hydrology maps prior to construction can aid in the identification of potential drainage problems.

Roads can be culverted or bridged to allow drainage where it is clearly defined, but current engineering practices have not been entirely effective. Consistent drainage problems occur where roads traverse drained lake basins and aquatic or wet sedge tundra. Therefore, to minimize impoundments, roads should not be sited across these types. Design and construction of drainage structures should be improved to prevent slumping, bowing, or blockage. Ideally, some combination of bridging and filling, rather than culverting, should be employed in these situations or where drainage is not clearly defined or where problems have persisted.

Infrequently traveled pads, such as those utilized for pipeline construction, should include low water crossings instead of culverts, as along the Trans-Alaska Pipeline workpad. The pads should be breached across larger drainages or where wash-outs have occurred in previous years. Further reduction of impoundments can be accomplished by consolidating facilities (e.g. siting pipelines adjacent to roads instead of constructing separate workpads).

Culverts blocked with snow and ice delay drainage. Large, early season impoundments can be minimized by using steam pipes to thaw culverts. Culverts that are susceptible to drifting snow or that become filled with snow due to road clearing should be identified for regular thawing in the spring. The ends of culverts may be intentionally blocked following freezeup to prevent filling with snow and the blocks removed during breakup. To prevent blocking or damaging culverts, their locations need to be marked clearly and maintenance operations modified. Impoundments due to inadequate or damaged culverts may require retrofitting. Upgrading of drainage structures must be done before there is an effect on vegetation (i.e., prior to the next growing season). When winter construction is planned, culvert locations along new road alignments should be determined and marked during early summer. A drainage and culverting plan should be prepared for review prior to construction. Winter construction of roads and culvert placement is preferred when drainages have been identified.

To rectify impoundments, culverts should be removed from pads when they are abandoned, and the pad breached at culvert or drainage structure locations. Introduction of aquatic vegetation, such as Arctophila fulva should be considered. The feasibility of re-vegetation with A. fulva is currently being studied jointly by FWS and SAPCO.

To reduce impoundments, culverts should be inspected every spring immediately prior to breakup to ensure that they are open. The inspection should occur during late May and any necessary maintenance should be performed immediately. It is important that drainage be unhindered throughout breakup, since even temporary spring impoundments affect vegetation and bird use.

Dust

Airborne dust generated by road traffic and construction settles on and affects adjacent vegetation. As with impoundments, total avoidance of dust is impractical. During the summer, dust can be controlled but not eliminated, along heavily traveled roads by watering (oiling roads can introduce contaminants into adjacent wetlands). However, the effects of using water from reserve pits on roads or of dewatering lakes for the water source must be considered. North-south roads generally have the greatest dust shadow due to prevailing summer winds, and should be watered on a regular basis. In situations requiring regular and heavy traffic, regular and frequent road watering should occur. In general, traffic patterns should be monitored and regular watering initiated when dust plumes become apparent.

Where dust deposition has been extensive, such as along the southern side of the Spine Road, revegetation may be necessary following abandonment of the road. A heavy dust shadow is similar to a fill, although it takes a long time to develop.

Snowbanks

Snowbanks cannot be entirely avoided because elevated structures alter wind patterns and enhance snow deposition, and it is not feasible to haul cleared snow to a disposal site.

Structures should be oriented so that their long axis is oriented parallel to the prevailing wind (i.e., east-west). Since late-melting snowbanks are also the result of winter snow clearing, designated dumping sites adjacent to pads should be established and used exclusively (i.e. formal snow removal plans should be prepared and approved). Clearing should be done to the west side of a facility where snowbanks form naturally, thus impacts will be consolidated. This will also reduce deposition of the debris and gravel that are incorporated into the cleared snow. Snow removal operations along roads should avoid culvert openings.

Rehabilitation, including revegetation, may be necessary following abandonment where the vegetation has been severely disturbed.

Gravel Spray

Gravel spray generally occurs during both construction and snow removal and cannot be completely avoided. Therefore, a buffer of at least 50 m should be maintained between construction and maintenance activities and sensitive habitats (e.g. habitats that support the most birds and/or habitats that are unique to a project area).

Proper handling of heavy equipment during construction and during snow removal can minimize gravel spray. Designated snow disposal areas identified in an approved snow removal plan will also minimize this problem. Excessive amounts of gravel deposited during snow removal should be removed early in the spring, prior to surface thawing and preferably while some snow cover remains. Removal should be discontinued if it damages the tundra. Rehabilitation may be required for some sites, involving removal or revegetation as appropriate. Extensive gravel spray may be considered an unauthorized fill.

Thermokarst

Complete avoidance of thermal erosion is not possible since it is the indirect result of other factors (e.g. dust and impoundments) which are also not completely avoidable. Thermokarst develops adjacent to structures either as a result of the structure altering the thermal stability of the adjacent area or due to the presence of dust, impoundments or other disturbances. The extent of thermal erosion depends in part on the extent of other disturbances; it will be more extensive adjacent to major facilities and heavily traveled roads. Vegetation types most susceptible to thermal erosion are wet, sedge tundra and moist sedge, dwarf-shrub tundra. Care should be taken during construction not to disturb adjacent vegetation and to maintain thermal stability of the pad.

COMPENSATION

Successful compensation requires the identification of lost resource values (analagous to loss of habitat units), proven techniques to enhance resource values of previously impacted areas, and a means to equate the lost resource values with the enhanced resource values. The assessment method presented above can be used to help determine the lost resource values (e.g. number of birds potentially supported by the impacted habitat). Different methods of enhancing resource values need to be tried and the results studied to provide a suite of potential actions appropriate for different situations. A caution in conducting such studies is that the desired outcome is not just that the impacted area is changed but that the change results in habitats that are more productive. Studies must be designed to follow changes through to the resulting effect on wildlife use of the area.

7. RECOMMENDATIONS

The following recommendations identify data gaps in the information presented and provide guidance on how the additional information could be incorporated. Additional issues that should be added to the manual are listed, and new issues will no doubt be identified as development expands into new regions.

INFORMATION NEEDS

1. Bird-habitat relationships in landscape units other than the flat thaw-lake plain.

   The general pattern of habitat relationships has been described from several locations and detailed studies have been conducted in the Prudhoe Bay region, within the flat thaw-lake plain landscape unit (Bergman et al. 1977 and Troy 1985). Bird-habitat relationships may vary between landscape units as the abundance and composition of vegetation types varies between units. Habitat use in the gently rolling thaw-lake plain is being studied as part of a Fish and Wildlife Service project in which field work began in summer 1986.

   Detailed habitat use patterns are needed for other areas outside the Prudhoe region and out of the flat thaw-lake plain.

2. Local bird concentration areas need to be identified.

   Bird distribution is not entirely explained by fine-grained habitat use. Local concentrations occur, particularly for colonially nesting species (e.g. Brant) and in productive areas like river deltas. Concentrations also occur during both spring and fall migration and during molting. Identification of local concentrations should take place prior to detailed project planning and information on these areas included in the species accounts and in the discussion of distribution patterns.

3. Baseline information on the coastal region between Teshekpuk Lake and Barrow needs to be collected.

   Little is known about bird use in the coastal region between Teshekpuk Lake and Barrow. Areas of particular interest in terms of potentially productive habitat are Smith Bay with its extensive salt-marshes and Dease Inlet due to its estuarine character. Information on bird use in these areas should be incorporated into species accounts and into the discussion of distribution patterns as appropriate.

4. Test relationships between human-induced disturbances and covertype measured in the Prudhoe Bay Oilfield and in the Kuparuk Oilfield.

The results of the detailed (1:6,000) mapping analysis of gravel cover and associated impacts in the Prudhoe Bay Oilfield (Walker et al. 1984) need to be tested in the other major landscape units; the gently rolling thaw-lake plain, and the large floodplains. The relationships may differ between the units due to differences in topography and covertype composition. These units describe the majority of the landscape between the Colville and Canning Rivers and mapping information from both units would make quantitative predictions of potential impacts throughout this region possible.

5. Study habitat use by birds adjacent to roads and pads in the center of a developed oilfield.

Information from the Waterflood studies (Troy et al. 1984, Troy 1985) have provided extensive information on habitat use by birds adjacent to a seldom traveled road. The results of the study showed some roadside effects on birds, primarily due to impoundments, but the effect was largely restricted to a narrow zone adjacent to the road. This same type of analysis is needed adjacent to heavily traveled roads and adjacent to facility pads because the extent of physical disturbance is greater in these areas. The potential for behavioral disturbance/avoidance is greater where activity is greater. (A recent report by Troy 1988 addresses this issue.)

6. Develop and test additional mitigation methods.

Much remains to be learned about effective mitigation, largely because information on the extent and persistence of impacts is just becoming available. By way of example, impoundments are the most extensive impact due to inadequate drainage structures. Development and testing of various structures needs to be conducted and guidelines developed identifying appropriate structures for different types of tundra drainages. Effective means of minimizing other types of impacts need to be developed and tested as well.

ADDITIONAL ISSUES

1. Caribou

Issues relating to impacts of development on caribou have been recently analyzed by the Alaska Department of Fish and Game (Shideler 1986). Their report is thorough and should be incorporated as a separate chapter in the manual and the specific impact information incorporated as appropriate.

2. Other impacts of development

Available information on noise, water quality, and contaminants should be summarized and presented in a chapter. Impact and mitigation information, to the extent available, should be incorporated into the appropriate chapters.

3. Other vertebrates

Information on other wildlife that occurs on the North Slope and may be affected by development needs to be summarized and included as a chapter in the manual. Notably, Arctic Foxes, which are common scavengers in developed areas, and Polar Bears that may be attracted to development along the coast or may be affected by development near denning areas, need to be addressed.

4. Riverine systems

Effects on major rivers and their ecosystems need to be addressed, particularly as development expands into the Savavanirktok and Colville River deltas. Information on resources, such as fisheries, and potential impacts, such as gravel mining, needs to be summarized and data gaps identified.

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APPENDIX A.

WATERBIRD AND SURFACE IMPACT ANNOTATED BIBLIOGRAPHIES

APPENDIX A. WATERBIRD AND SURFACE IMPACT ANNOTATED BIBLIOGRAPHIES

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PREFACE

Evaluation of the impacts due to oil and gas development on the North Slope is hampered by a lack of a consolidated information base. Information relevant to the assessment of impacts is contained in a variety of published and unpublished sources. The purpose of this bibliography is to provide a comprehensive information source of annotated, relevant studies. The annotations are detailed and contain the site of the study, the emphasis, major results, and conclusions. Sufficient information is included in the annotations so that the user, in most cases, will not need to consult the original reference. The bibliography addresses two topics in depth, waterbirds and surface impacts, other topics may be added at a later date.

The annotated bibliographies are included as an appendix to the impact assessment manual to provide detailed references for the material presented in the manual. The manual will address the impacts due to development, not exploration, and the references in the surface impact section of the bibliography are focused on development impacts, although many studies of exploratory operations are included. Exploratory impacts have been addressed in detail in a Cold Regions Research and Engineering Laboratory (CRREL) report entitled "Disturbance and recovery of Alaskan tundra terrain: a summary of recent CRREL research" (Walker et al. 1987). The two topics, exploration and development, are distinct because development impacts are more severe than exploratory impacts due to the intensity and longevity of the development activity.

Surface impacts are addressed in depth because surface disturbance due to gravel placement is one of the major sources of impacts. Nearly all development facilities in the Prudhoe Bay region are placed on extensive gravel pads due to the engineering constraints of construction on permafrost. Gravel placement in wetlands causes significant, long-term changes to the wetlands. Facilities are also interconnected by a spiderweb of roads and pipelines, so surface impacts are ubiquitous in a development. Contaminants are addressed only in a superficial manner because major gaps remain in our understanding of how contaminants act in North Slope wetlands, specifically their longevity and dispersal in the natural environment. The effect and behavior of contaminants need to be understood before the effects of a contaminant spill, other than those impacts caused by direct contact, can be related to impacts on wildlife. This is an important topic and basic research of the fates and effects of contaminants in the oilfield is needed.

The amount of information available on North Slope wildlife resources is extensive and project timing and funding did not allow an exhaustive coverage of this information base. Waterbirds are addressed in depth because of their legal importance as migratory birds, the amount of ecological information available, and their direct dependence on wetlands. Waterbirds are of international significance and they are a readily visible, major component of the North Slope ecosystem. Waterbirds are directly dependent on wetlands for breeding habitat and numerous studies have addressed their specific habitat use patterns. Changes in landcover due to development can be interpreted in terms of local and cumulative impacts on migratory bird habitat. This information can be used as a basis for developing a practical planning guide that outlines relative values of specific habitats, the susceptibility of those habitats to development, and recommended mitigation measures.

The selection of references for inclusion in the bibliography involved several steps. An initial list of references was compiled through a title search of appropriate publications and government holdings. The specific sources are listed in the introductions to each section in the bibliography. The list of titles that seemed related to development impacts and to waterbirds was distributed for review. The references were acquired, read and those that actually addressed the topic were annotated. The specific criteria for selection are detailed in the introductions to each section. Not all titles originally listed were ultimately selected for inclusion.

1. WATERBIRD BIBLIOGRAPHY

INTRODUCTION

The waterbird bibliography includes information on the breeding biology and ecology of birds that regularly breed on the North Slope of Alaska (Table 1). The birds included are either those of special emphasis identified by the Fish and Wildlife Service or are common tundra breeders. Inclusion of other species was limited by the availability of ecological and life-history information. Species that do not breed in significant numbers on the North Slope, but use the North Slope for a significant portion of their life cycle were included. Examples of significant non-breeding use are the molting concentrations of Brant in the Teshekpuk Region and the staging of Snow Geese on the Arctic National Wildlife Refuge. Information on subsistence harvest patterns were included when the article contained life-history information for a species. Studies conducted in the sub-Arctic and in Canada were included to supplement life-history information for some species.

The annotations include the site of the study, its duration, and the study's emphasis. Major results of the study and the conclusions are summarized. The annotations are intended to contain sufficient information such that the user, in most cases, would not need to consult the original reference. Exceptions are publications of species accounts, which are impractical to summarize. Many studies were published as a series of progress reports with a final report. In most cases, only the final report was annotated, with the exception of progress reports that contained information not included in the final report. Dissertations were not annotated if the information had been subsequently published in a journal or other type of report. Dissertations not published in any other format were included.

The citations were taken in part from An Annotated Bibliography of Literature on Alaskan Waterbirds (Handel et al. 1981). References for this bibliography published before 1976 were taken from the electronic data services of the Fish and Wildlife Service Reference System (Denver Public Library), BIOSIS, NTIS, Ocean Abstracts, and Dissertation Abstracts; these were supplemented by visual searches of key references and periodicals. References published after 1976 were obtained by visual searches of common journals and bibliographic sources, primarily Arctic, Auk, Canadian Field Naturalist, Condor, Ecology, Ecological Monographs, Ibis, Journal of Field Ornithology, Journal of Wildlife Management, Murrelet, Pacific Seabird Group Bulletin, Wader Study Group Bulletin, Western Birds, Wildlife Review, and Wilson Bulletin. Material published after this bibliography were obtained by visual searches of the same journals. Searches were made of federal and state government holdings for unpublished technical reports. Interim reports were not included when a final report was available.

KEY WORD INDEX

Key words accompany each annotation. The key words include the geographic location of the study, the bird species studied, and the major topics of the study (e.g., habitat, behavior). "Migration" as a key word includes staging and migration. "Behavior" includes territoriality and behavior associated with mating. Studies located along the Beaufort Sea Coast had "coastal" as a key

Table 1

Red-throated Loon	Gavia stellata
Pacific Loon	Gavia arctica
Tundra Swan	Cygnus columbianus
Greater White-fronted Goose	Anser albifrons
Snow Goose	Chen caerulescens
Brant	Branta bernicla
Canada Goose	Branta canadensis
Northern pintail	Anas acuta
King Eider	Somateria spectabilis
Spectacled Eider	Somateria fischeri
Oldsquaw	Clangula hyemalis
Lesser Golden Plover	Pluvialis squatarola
Semipalmated Sandpiper	Calidris pusilla
Baird's Sandpiper	Calidris bairdii
Pectoral Sandpiper	Calidris melanota
Dunlin	Calidris alpina
Buff-breasted Sandpiper	Trygnites subruficollis
Red-necked Phalarope	Phalaropus lobatus
Red Phalarope	Phalaropus fulicaria
Lapland Longspur	Calcarius lapponicus

word. "Impacts" was used as a key word for studies that discussed direct impacts due to habitat modification and impacts due to noise disturbance. If the study contained recommendations pertinent to evaluating impacts due to development, "recommendations" was included as a key word. Figure 1 shows geographic locations used as key words.

Geographic Location

ANWR:

Bartels et al. 1984; Bartels and Doyle 1984a; 1984b; Bartels and Zellhoefer 1983; Brackney et al. 1985a; 1985b; 1985c; 1985d; Garner and Reynolds 1983; 1984; Martin and Moitoret 1982; Moitoret et al. 1985; Miller et al. 1985; Oates et al. 1985; Spindler 1978; 1983; 1984; Spindler and Miller 1983; Spindler et al. 1984a; 1984b; U.S. Fish and Wildlife Service 1982

Alaska:

Gabrielson and Lincoln 1959; Handel et al. 1981; Kessel 1979; Kessel and Gibson 1978

Atkasook:

Myers and Pitelka 1980

Barrow:

Ashkenazie and Safriel 1979a; 1979b; Barry 1968; Connors et al. 1979; Custer and Pitelka 1977; Dodson and Egger 1980; Holmes 1966; 1970; Holmes and Pitelka 1968; Maclean 1980; Maclean and Pitelka 1971; Myers 1979; Myers and Pitelka 1980; Norton 1972; Pitelka 1959; Schamel and Tracy 1977; Seastedt and Maclean 1979

Canada:

Alison 1975; 1976; Baker 1977; 1979; Baker and Baker 1973; Mayfield 1978; Salter et al. 1980

Canning River Delta:

Martin and Moitoret 1982

Colville Delta:

Hall 1975; Hawkins 1983; 1986; Kiera 1979; North et al. 1983

Colville River:

Kessel and Cade 1958

Icy Cape:

Lenhausen and Quinlan 1981

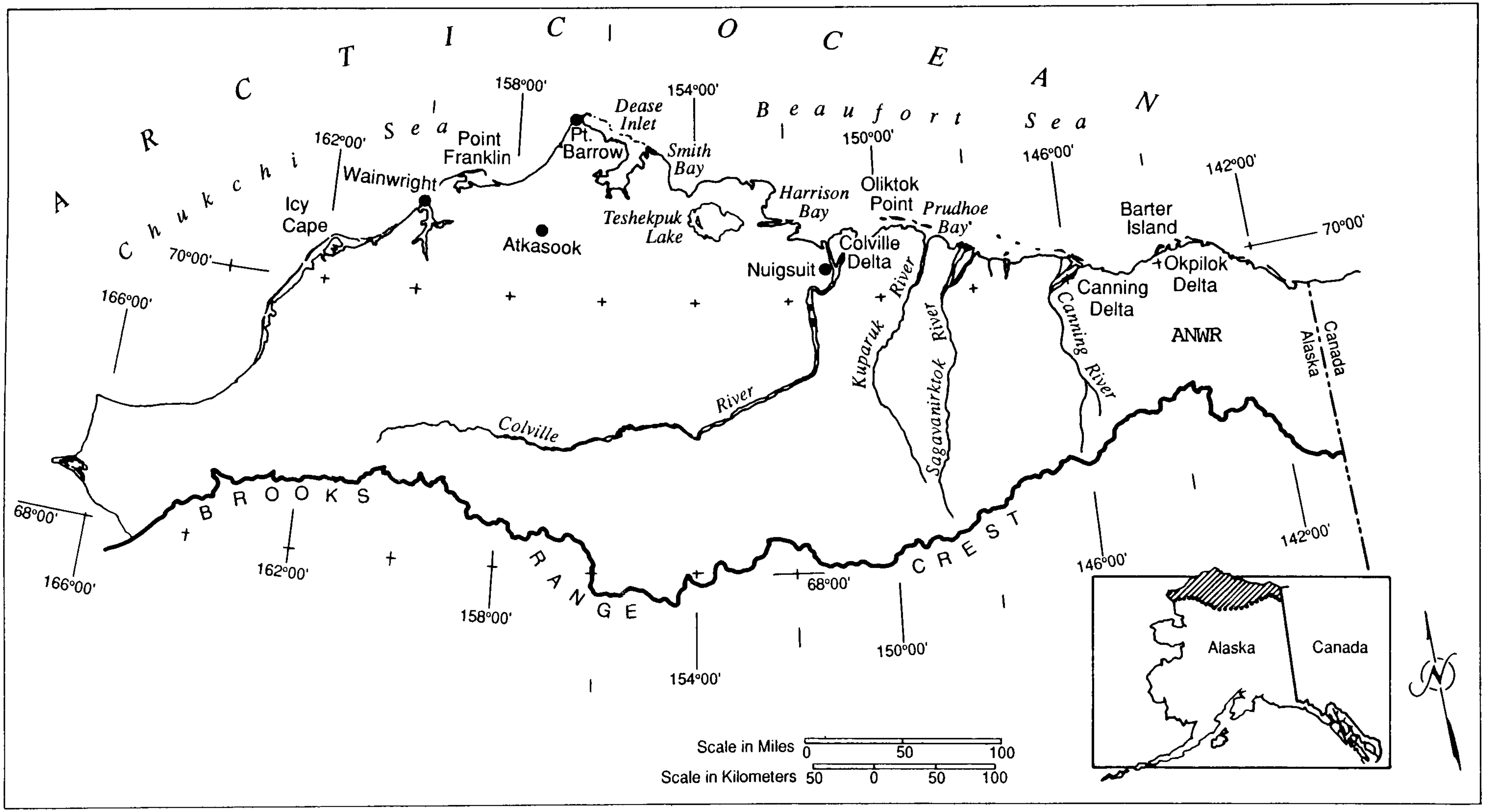

Figure 1. Geographic locations used as key words.

Kuparuk:

Truett et al. 1982; Woodward-Clyde Consultants 1982a

Manitoba:

Alison 1975; 1976; Baker 1977; 1979; Baker and Baker 1973

North Slope:

Barry and Spencer 1976; Connors et al. 1983; Davis and Wisely 1974; Derksen and Eldridge 1980; Derksen et al. 1979a; 1979b; 1981; 1982; Divoky 1983; Flock 1973; Gabrielson and Lincoln 1959; Garner and Reynolds 1983; 1984; Gilliam and Lent 1982; Gollop and Richardson 1974; Handel et al. 1981; Johnson and Richardson 1981; Johnson et al. 1975; 1983; Kessel 1961; 1979; Kessel and Gibson 1978; King 1973; 1979; Koski 1975; Myers and Pitelka 1980; Pitelka 1974; Pitelka et al. 1974; Schamel 1977; Seamen et al. 1981; Sjolander and Agren 1976; Sladen 1973; U.S. Fish and Wildlife Service 1982

Okpilak Delta:

Spindler 1978; Spindler and Miller 1983; Spindler et al. 1984a; 1984b

Oliktok Point:

Hall 1975; Woodward-Clyde Consultants 1982b

Prudhoe Bay:

Bergman and Derksen 1977; Bergman et al. 1977; Gavin 1979; 1980; Hansen and Eberhardt 1981; Kiera 1979; Murphy et al. 1986; Norton et al. 1975; Troy 1985a; 1985b; Troy and Johnson 1982; Troy et al. 1983; Woodward-Clyde Consultants 1983

Major Topic

Behavior:

Alison 1976; Ashkenazie and Safriel 1979b; Baker and Baker 1973; Brackney et al. 1985d; Connors et al. 1982; Davis and Wisely 1974; Derksen et al. 1982; Hawkins 1986; Holmes 1970; Murphy et al. 1986; Myers 1979; Pitelka et al. 1974; Schamel 1977; Schamel and Tracy 1977; Seastedt and Maclean 1979; Sjolander and Agren 1967; Spindler 1984a

Breeding Biology:

Alison 1975; Ashkenazie and Safriel 1979a; Bartels and Doyle 1984b; Bartels et al. 1983; Bergman and Derksen 1977; Brackney et al. 1985b; Hansen and Eberhardt 1981; Hawkins 1983; 1986; Johnson et al. 1975; Mayfield 1978; Mickelson 1975; Moitoret et al. 1985; Myers and Pitelka 1980; North et al. 1983; Norton 1972; Petersen 1979; Pitelka 1959; Pitelka et al. 1974; Schamel 1977; Schamel and Tracy 1977; Sjolander and Agren 1967; Soikkeli 1967; Troy 1985b

Coastal:

Barry 1968; Bergman and Derksen 1977; Bergman et al. 1977; Connors et al. 1979; 1983; Divoky 1983; Flock 1973; Gollop and Richardson 1974; Hall 1975; Holmes 1966; Johnson et al. 1975; Miller et al. 1985; Moitoret et al. 1985; Meyers and Pitelka 1980; Spindler and Miller 1983; Spindler et al. 1984a; 1984b

Distribution:

Bartels et al. 1983; 1984a; 1984b; Bartels and Zellhoefer 1983; Brackney et al. 1985b; 1985c; Connors et al. 1983; Divoky 1983; Gabrielson and Lincoln 1959; Hall 1975; Irving 1960; Johnson et al. 1975; 1983; Kessel 1961; Kessel and Cade 1958; Kessel and Gibson 1978; King 1973; 1979; Maclean and Holmes 1971; Martin and Moitoret 1982; Miller et al. 1985; Moitoret et al. 1985; Pitelka 1974; 1979; Sage 1974; Salter et al. 1980; Sladen 1973; Spindler et al. 1984a; 1984b

Habitat:

Alison 1976; Ashkenazie and Safriel 1979a; Baker 1977; 1979; Baker and Baker 1973; Bergman and Derksen 1977; Bergman et al. 1977; Connors et al. 1979; 1983; Custer and Pitelka 1977; Derksen and Eldridge 1980; Derksen et al. 1979a; 1979b; 1981; 1982; Garner and Reynolds 1983; 1984; Gollop and Richardson 1974; Holmes 1966; Holmes and Pitelka 1968; Johnson and Richardson 1981; Johnson et al. 1983; Kiera 1979; Lenhausen and Quinlan 1981; Martin and Moitoret 1982; Mickelson 1975; Myers and Pitelka 1980; North et al. 1983; Norton et al. 1975; Seamen et al. 1981; Seastedt and Maclean 1979; Spindler 1978; Spindler et al. 1984a; Troy 1985a; Troy and Johnson 1982; Troy et al. 1983; van der Zande et al. 1980

Habitat Classification:

Bergman et al. 1977; Connors et al. 1983; Derksen et al. 1979; Kessel 1979; Troy et al. 1983

Impacts:

Barry and Spencer 1976; Bartels et al. 1983; Brackney et al. 1985a; Connors et al. 1983; Davis and Wisely 1974; Divoky 1983; Gilliam and Lent 1982; Hansen and Eberhardt 1981; Johnson and Richardson 1981; King and Sanger 1979; Murphy et al. 1986; Spindler 1984a; Troy 1985a; Troy and Johnson 1982; Troy et al. 1983; van der Zande et al. 1980

Inland:

Derksen et al. 1981; Kessel and Cade 1958; Myers and Pitelka 1980

Lagoon:

Bartels et al. 1984; Bartels and Doyle 1984; Bartels and Zellhoefer 1983; Brackney et al. 1985c; 1985d; Johnson and Richardson 1981; Spindler and Miller 1983

Migration:

Barry 1968; Brackney et al. 1985a; Cade 1955; Connors et al. 1983; Davis and Wisely 1974; Derksen et al. 1974b; 1981; Divoky 1983; Flock 1973; Garner and Reynolds 1983; 1984; Gollop and Richardson 1974; Johnson et al. 1975; 1983; Koski 1975; Lenhausen and Quinlan 1981; Martin and Moitoret 1982; Miller et al. 1975; Moitoret et al. 1975; Oates et al. 1985; Pitelka 1979; Salter et al. 1980; Spindler 1978; 1983; 1984b

Population:

Connors et al. 1983; Derksen and Eldridge 1980; Derksen et al. 1979b; 1981; Maclean and Holmes 1971

Prey:

Ashkenazie and Safriel 1979b; Baker 1977; Baker and Baker 1973; Bergman and Derksen 1977; Bergman et al. 1977; Byrkjedal 1980; Connors et al. 1982; Custer and Pitelka 1977; Divoky 1983; Dodson and Egger 1980; Holmes 1966; 1970; Holmes and Pitelka 1968; Johnson and Richardson 1981; Kiera 1979; Maclean 1980; Maclean and Pitelka 1971; Mayfield 1978; Myers and Pitelka 1980

Recommendations:

Alison 1976; Bergman et al. 1977; Connors et al. 1983; Derksen et al. 1979a; 1979b; 1981; 1982; Gollop and Richardson 1974; King 1973; Lenhausen and Quinlan 1981; Seamen et al. 1981; Troy and Johnson 1982; Troy et al. 1983; Truett et al. 1982; van der Zande et al. 1980

Shorebirds:

Baker 1977; 1979; Baker and Baker 1973; Connors et al. 1979; 1983; Garner and Reynolds 1983; 1984; Hansen and Eberhardt 1981; Holmes and Pitelka 1968; Johnson et al. 1975; 1983; Maclean 1980; Maclean and Pitelka 1971; Martin and Moitoret 1982; Miller et al. 1985; Moitoret et al. 1985; Myers and Pitelka 1980; Norton et al. 1975; Pitelka 1974; 1979; Pitelka et al. 1974; Salter et al. 1980; Seamen et al. 1981; Spindler 1978; Troy 1985a; 1985b; Troy and Johnson 1982; Troy et al. 1983; Truett et al. 1982; U.S. Fish and Wildlife Service 1982; Woodward-Clyde Consultants 1982a; 1982b

Species Accounts:

Derksen et al. 1979a; Divoky 1983; Garner and Reynolds 1983; 1984; Hall 1975; Johnson et al. 1975; Kessel and Cade 1958; Lenhausen and Quinlan 1981; Martin and Moitoret 1982; Miller et al. 1985; Salter et al. 1980; Spindler and Miller 1983; Spindler et al. 1984b; U.S. Fish and Wildlife Service 1982

Waterfowl:

Barry and Spencer 1976; Bergman et al. 1977; Derksen et al. 1979a; 1981; Divoky 1983; Flock 1973; Garner and Reynolds 1983; 1984; Gavin 1979; 1980; Gilliam and Lent 1982; Gollop and Richardson 1974; Hall 1975; Irving 1960; Johnson et al. 1975; 1983; King 1973; 1979; Lenhausen and Quinlan 1981; Martin and Moitoret 1982; Miller et al. 1985; Moitoret et al. 1985; Pitelka 1974; Salter et al. 1980; Seamen et al. 1981; Spindler 1978; Troy 1985a; Truett et al. 1982; U.S. Fish and Wildlife Service 1982; Woodward-Clyde Consultants 1982a; 1982b; 1983

Species

Pacific Loon:

Bergman and Derksen 1977; Petersen 1979

Baird's Sandpiper:

Holmes and Pitelka 1968; Norton 1972; Pitelka et al. 1974

Brant:

Berry and Spencer 1976; Cade 1955; Derksen et al. 1979b; 1982; Kiera 1979; King 1973; Koski 1975; Mickelson 1975; Murphy et al. 1986; Woodward-Clyde Consultants 1982b

Buff-breasted Sandpiper:

Myers 1979; Pitelka et al. 1974; Troy 1985a

Canada Goose:

Barry and Spencer 1976; Derksen et al. 1979a; 1979b; 1982; Mickelson 1975; Murphy et al. 1986

Common Eider:

Gotmark and Ahlund 1984; Schamel 1977

Dunlin:

Baker 1977; 1979; Baker and Baker 1973; Holmes 1966; 1970; Holmes and Pitelka 1968; Maclean and Holmes 1971; Norton 1972; Pitelka et al. 1974; Soikkeli 1967; Troy 1985; Troy et al. 1983

Golden Plover:

Baker 1977; Byrkjedal 1980; Troy 1985a

King Eider:

Barry 1968; Divoky 1983; Troy 1985a

Lapland Longspur:

Custer and Pitelka 1977; Maclean 1980; Seastedt and Maclean 1979; Troy 1985a; Troy et al. 1983

Oldsquaw:

Alison 1975; 1976; Bartels and Doyle 1984; Bartels and Zellhoefer 1983; Bartels et al. 1984; Brackney et al. 1984c; 1984d; Divoky 1983; Garner and Reynolds 1983; 1984; Johnson and Richardson 1981

Pectoral Sandpiper:

Holmes and Pitelka 1968; Norton 1972; Pitelka 1959; Pitelka et al. 1974; Troy 1985a; Troy et al. 1983

Pintail:

Derksen and Eldridge 1980; Derrickson 1978; Troy 1985a

Red-necked Phalarope:

Baker 1977; Divoky 1983; Johnson and Richardson 1981; Troy 1985a

Red Phalarope:

Divoky 1983; Dodson and Egger 1980; Johnson and Richardson 1981; Mayfield 1978; Schamel and Tracy 1977; Troy 1985a; Troy et al. 1983

Red-throated Loon:

Bergman and Derksen 1977; Divoky 1983

Semipalmated Sandpiper:

Ashkenazie and Safriel 1979a; 1979b; Baker 1977; 1979; Baker and Baker 1973; Holmes and Pitelka 1968; Norton 1972; Pitelka et al. 1974; Troy 1985a; Troy et al. 1983

Snow Goose:

Barry and Spencer 1976; Brackney et al. 1985a; Davis and Wisely 1974; Derksen et al. 1979b; Garner and Reynolds 1983; 1984; Gavin 1979; 1980; Koski 1975; Murphy et al. 1986; Oates et al. 1985; Spindler 1983; 1984

Tundra Swan:

Barry and Spencer 1976; Bartels and Doyle 1984b; Bartels et al. 1983; Brackney et al. 1985b; Garner and Reynolds 1983; 1984; Hawkins 1983; 1986; King 1973; Koski 1975; Murphy et al. 1986; Sladen 1973

White-fronted Goose:

Barry and Spencer 1976; Derksen et al. 1979b; 1982; King 1973; Koski 1975; Mickelson 1975; Murphy et al. 1986; Troy 1975a

Yellow-billed Loon:

Divoky 1983; Sjolander and Agren 1976; North 1986; North et al. 1983

ANNOTATED REFERENCES

Alison, R. M. 1975. Breeding biology and behavior of the Oldsquaw (Clangula hyemalis). AOU Ornithological Monographs 18. 52 pp.

Canada, Manitoba, Oldsquaw, breeding biology

The breeding biology and behavior of Oldsquaw were studied at Churchill, Manitoba, from 1968 through 1971. Oldsquaw mated on their wintering grounds and arrived at the breeding grounds in pairs. The males defended territories. The females did not participate in territorial defense. The author suggests that territoriality limits local breeding-population density.

Nests were located on islands and on the mainland, usually near lakes or ponds. The females chose the nest sites. About half of the nests were in clusters on the islands and the rest were isolated. Traditional nest sites were used and the re-use of a site was not affected by the success or failure of the previous year. Predation was the major cause of nest failure.

Egg laying commenced in the second week of June. Severe May temperatures could significantly delay nest initiation by delaying breakup on the tundra. Males departed the breeding grounds by the end of July. Hens with broods remained until the end of August.

Alison, R. M. 1976. Oldsquaw brood behavior. Bird-Banding 47:210-213.

Canada, Manitoba, Oldsquaw, behavior, habitat, recommendations

Oldsquaw brood behavior was observed near Churchill, Manitoba, in July and August of 1974 and 1975. Adult females and immatures were captured and marked and their movements and behavior observed. Communal broods were common as was brood adoption. Older females were more successful in rearing young and they often formed the nucleus of a communal brood. The composition of the communal broods changed frequently as the females with their young moved to different ponds.

The young avoided predators by diving and swimming along the bottom, which disturbed the sediments and clouded the water. In small ponds, they surfaced in dense vegetation near the shore. In large ponds, they remained in the center within the turbid water. The females either performed distraction displays or helped stir up the bottom sediments.

Broods typically remained on small ponds for the first week following hatching. Communal broods began forming on larger lakes during the second week. Individual broods moved between lakes at night, perhaps in response to food depletion of the current lake or pond. Broods began congregating on large lakes prior to departing the area. The lakes used were traditional sites and routes walked between some lakes were traditional as well. As large lakes used prior to departure are traditional sites, the author recommended that these sites be identified and retained in their natural state.

Ashkenazie, S., and U. N. Safriel. 1979a. Breeding cycle and behavior of the Semipalmated Sandpiper at Barrow, Alaska. Auk 96:56-67.

Barrow, breeding biology, habitat, Semipalmated Sandpiper

The breeding biology of the Semipalmated Sandpiper was studied at Barrow, Alaska, in the summer of 1973. The birds arrived on the breeding grounds by the end of May or beginning of June. The males established territories and the females seemed to select territories of the established males. Egg laying began four to six days after pair formation and partial incubation began prior to completion of the clutch. Both sexes incubated, during which time the incubating bird was constantly alert. Incubation lasted 20 days. The female left between two and six days after hatching and the male remained with the family group until the young fledged.

Nests were located in high-centered polygons. During incubation, the free adult fed up to 3 km away from the nest. Following hatching, the family group remained and fed within the nesting territory until the female left. The male then moved the family group to areas of low relief, sedge meadows and stream edges, up to 3 km away from the nesting territory.

Ashkenazie, S., and U. N. Safriel. 1979b. Time-energy budget of the Semipalmated Sandpiper, Calidris pusilla, at Barrow, Alaska. Ecology 60:783-799.

Barrow, prey, behavior, Semipalmated Sandpiper

The time-energy budget of the Semipalmated Sandpiper was studied in Barrow, Alaska, in the summer of 1973. Feeding, incubating and young-attending were the most time consuming activities. Females spent approximately 80 percent of their time feeding during the egg-laying period and both sexes fed about 80 percent of time prior to migration.

Energy requirements were estimated from the time activity budget. Energy uptake was estimated by using available data on diet composition and observed feeding rates. Females had a 15 percent higher energy requirement than males, but ultimately required less energy from the local area as they left shortly after hatching. The energy budget calculated for the season was generally negative. The authors concluded that either the energy uptake was under estimated or that the birds rely on energy reserves obtained at wintering grounds or during migration.

Baker, M. C. 1977. Shorebird food habits in the eastern Canadian arctic. Condor 79:56-62.

Canada, Manitoba, shorebirds, Semipalmated Sandpiper, Dunlin, Golden Plover, Red-necked Phalarope, prey, habitat

Food habits of ten shorebird species breeding at Churchill, Manitoba, were studied by stomach analyses. The species included: Least Sandpiper, Semipalmated Sandpiper, Red-necked Phalarope (referred to as Northern Phalarope), Semipalmated Plover, Hudsonian Godwit, Stilt Sandpiper, Dunlin, Golden Plover, Lesser Yellowlegs, and Short-billed Dowitcher. Shorebird body size was positively correlated with prey size, i.e., larger birds ate larger prey. Comparisons of the food available to the food eaten showed larger birds to be more selective foragers. However, the ten species overlapped broadly in the prey consumed. The authors suggest competition may be relaxed due to abundant food resources.

Larval chironomids, tipulids, and dolichopodids were common in the diets of Stilt Sandpiper, Dunlin, Semipalmated Plover, Lesser Yellowlegs, Least Sandpiper, and Semipalmated Sandpiper although the frequency of occurrence varied between the species. Short-billed Dowitchers and Golden Plovers ate substantial numbers of seeds. Diptera larvae of the Cyclorrapha group predominated in Hudsonian Godwit stomachs. Red-necked Phalarope ate primarily adult chironomids.

Baker, M. C. 1979. Morphological correlates of habitat selection in a community of shorebirds (charadriiformes). Oikos 33:121-126.

Canada, Manitoba, habitat, Semipalmated Sandpiper, Dunlin, shorebirds

Feeding habitat for six species of shorebirds (Least Sandpiper, Semipalmated Sandpiper, Dunlin, Short-billed Dowitcher, Lesser Yellowlegs, and Semipalmated Plover) was compared with the surrounding environment on both the summer and winter ranges. The summer range was near Fort Churchill, Manitoba, and the winter range was in Florida. Habitat was defined by the height of the vegetation and depth of water. These variables were measured along foraging paths and were compared with the surrounding areas. In general, the shorebirds tended to forage along the edge of deeper water and the edge of taller vegetation. The degree to which the foraging area differed from the surrounding area varied among species. Semipalmated Sandpipers and Semipalmated Plovers were the most selective and Dunlin were the least selective.

Baker, M. C., and A. E. M. Baker. 1973. Niche relationships among six species of shorebirds on their wintering and breeding ranges. Ecological Monographs 43:193-212.

Canada, Manitoba, Semipalmated Sandpiper, Dunlin, habitat, behavior, prey, shorebirds

Foraging behavior and habitat utilization of six species of shorebirds (Least Sandpiper, Semipalmated Sandpiper, Dunlin, Short-billed Dowitcher, Lesser Yellowlegs, and Semipalmated Plover) were studied on the breeding grounds in the eastern Canadian arctic and the wintering grounds in southern Florida. Foraging behavior, defined by the pattern of locomotion and by how the bill was used, changed seasonally. The change was independent of air temperature, number of conspecifics present and total number of shorebirds present.

Microhabitat was defined by the presence of vegetation and the depth of water. There was greater microhabitat diversity on the breeding grounds than on the wintering grounds. Foraging behavior and microhabitat use was analyzed in combination to determine the amount of resource overlap between the six species on a seasonal basis. Overlap was generally higher during the breeding season than on the wintering grounds. Based on this overlap, the authors hypothesized that food is abundant on the breeding grounds and may be limiting on the wintering grounds. The need to analyze the entire annual cycle to determine parameters that regulate populations was emphasized.

Barry, T. W. 1968. Observations on natural mortality and native use of eider ducks along the Beaufort Sea coast. Canadian Field Naturalist 832(2):140-144.

coastal, Barrow, King Eider, migration

An extensive die-off of King Eiders was recorded in 1964. The die-off was due to an extreme ice year when few if any leads were open. The numbers in the natural die-off were estimated to represent 10 percent of the population. In contrast, the native take of King Eiders was estimated to be less than one percent of the population. At the time of this paper, traditional hunting techniques were still being employed, e.g., snares and slings.

Barry, T. W., and R. Spencer. 1976. Wildlife response to oil well drilling. Canadian Wildlife Service Progress Notes No. 67. Canadian Wildife Service, Edmonton, Alberta. 15 pp.

Snow Goose, Brant, Tundra Swans, White-fronted Goose, Canada Goose, waterfowl, impact, North Slope

Effects of an oil well drilling operation on wildlife in the Mackenzie River delta were studied for one season in 1971. Both the effects of the drilling itself and the transportation activities to and from the drilling were monitored.

Waterfowl were less abundant in plots within 2.5 km of the drilling operation than in the control plots 8 km from the drilling. Waterfowl that showed this response included Tundra Swans, White-fronted Geese, Canada Geese, Pintails, Green-winged Teal, and Scaup. Molting flocks and family groups of swans, White-fronted geese, Canada Geese, and Snow Geese generally stayed more than 2.5 km from the drilling.

Air traffic caused varying amounts of disturbance, depending on the species and their stage in the breeding cycle. Swans and geese flushed from helicopters at distances ranging from 10 m to 2.4 km. Nesting Snow Geese flushed 0.8 to 2.4 km ahead of helicopters and did not return to their nests until the aircraft was at least 0.8 km away. Resettling on the nests took up to 45 minutes. Predation by gulls and jaegers increased while the geese were off their nests.

Bartels, R. F., T. J. Doyle, and T. J. Wilmers. 1984. Movement of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1983. pp. 157-168. In: Garner, G. W., and P. E. Reynolds (eds.). 1984. 1983 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 641 pp.

Oldsquaw, lagoon, ANWR

Sixteen molting Oldsquaw were captured in Tapkaurak Lagoon and fitted with radio transmitters. Observers relocated the birds, weather permitting, until the birds departed the refuge. Over 75 percent of the relocation points were within lagoons or within 400 m of the barrier islands. The oldsquaw were fairly sedentary with 47 percent of the sitings in the lagoon system where they were originally captured and the majority of all sitings (90 percent) were in water less than 5 m deep. Migration coincided with the beginning of freeze-up in the lagoons. Distribution patterns noted in this study agree with patterns observed in aerial surveys.

Bartels, R. F., and T. J. Doyle. 1984a. Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1983. pp. 170-200. In: Garner, G. W., and P. E. Reynolds (eds.). 1984. 1983 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 641 pp.

Oldsquaw, lagoon, distribution, ANWR

Aerial surveys of 10 lagoons revealed Oldsquaw as the primary species using the lagoon (over 80 percent of all birds sited). Temporal distribution of Oldsquaw was similar to the previous three years although a westerly shift in lagoon use occurred as well as a gradual increase in use of offshore areas.

Comparisons of a single strip transect and a three strip survey with a complete lagoon survey showed the latter techniaue as the best estimate of bird numbers.

Bartels, R. F., and T. J. Doyle. 1984b. Distribution, abundance and productivity of Tundra Swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1983. pp. 201-209. In: Garner, G. W., and P. E. Reynolds (eds.). 1984. 1983 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 641 pp.

Tundra Swan, breeding biology, distribution, ANWR

Coastal wetlands of ANWR were surveyed twice during 1983 to determine distribution, abundance and productivity of Tundra Swans. An estimated 105 pairs nested in ANWR, which was greater than that observed in 1981 and 1982. Productivity in 1983 was higher than in either 1981 or 1982. Nesting success was between 60 and 81 percent, the lower figure represent-

ing the number of nests plus pairs present, and the higher figure representing actual nests observed and the number of broods observed. A total of 377 adults and 175 cygnet tundra swans were observed.

Bartels, R. F., and W. J. Zellhoefer. 1983. Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska. 1981 and 1982. pp. 62-86. In: Garner, G. W., and P. E. Reynolds (eds.). 1983. 1982 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 379 pp.

Oldsquaw, ANWR, lagoon, distribution

Aerial sursveys of 10 coastal lagoons in the ANWR showed similar temporal use patterns for oldsquaw as described in previous years. Spatial distribution varied with large numbers of birds observed outside of the lagoons. Oldsquaw were the dominant lagoon user, over 80 percent of all birds were Oldsquaw.

Attempts to use two new survey techniques showed problems with both. A strip transect in lagoons was not comparable to entire lagoon surveys because the birds were not evenly distributed in the lagoons. Attempts to capture Oldsquaw for marking with nasal saddles were not successful. Oldsquaw were adept at avoiding capture, either by swimming under (or over) capture nets and under boats used for driving.

Bartels, R. F., W. J. Zellhoefer, and P. Miller. 1983. Distribution, abundance, and productivity of Whistling Swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska. In: Garner, G. W., and P. E. Reynolds (eds.). 1983. 1982 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 379 pp.

Tundra Swan, distribution, breeding biology, impact, ANWR

Wetlands along the ANWR coast were surveyed for Tundra Swans on 12 August 1982 and the results compared with a simliar survey in 1981. Swan concentrations were noted on the Canning-Tamayariak Delta (0.38 and 0.15/km^2 in 1981 and 1982, respectively), Hulahula-Okpilak Delta (0.48 and 0.23/km^2 in 1981 and 1982, respectively), and the Aichilik Delta (0.66/km^2 both years). The density estimates include adults and young, breeders and non-breeders. The apparent decrease between 1981 and 1982 was undetermined due to insufficient data, but human disturbance was suggested as a possible cause and previous incidents of nest desertions due to disturbance were summarized.

Bergman, R. D., and D. V. Derksen. 1977. Observations on Arctic and Red-throated Loons at Storkersen Point, Alaska. Arctic 30:41-51.

Prudhoe Bay, coastal, Arctic Loon, Red-throated Loon, habitat, prey, breeding biology

Habitat requirements of Arctic Loons and Red-throated Loons were studied at Storkersen Point on the Arctic Coastal Plain of Alaska from 1971 to 1975. The two species were ecologically isolated by their feeding habits and use of wetlands. Arctic Loons fed invertebrates caught in their nesting pond to their young and Red-throated Loons fed fish caught in the Beaufort Sea. Both species preferred islands as nest substrates, but Arctic Loons utilized large ponds with stands of Arctophila fulva for nesting, and Red-throated Loons used smaller, partially drained basins or ponds. Arctic Loons and their young would move between lakes, perhaps in response to diminishing food resources. Red-throated Loons do not rely on their nesting ponds for food and their young remained on the same pond throughout the nesting period.

Bergman, R. D., R. L. Howard, K. F. Abraham, and M. W. Weller. 1977. Waterbirds and their wetland resources in relation to oil development at Storkersen Point, Alaska. U.S. Fish and Wildlife Service, Resource Publication 129. 39 pp.

Prudhoe Bay, coastal, waterfowl, habitat classification, prey, habitat, recommendations

Waterbirds were studied for five years at Storkersen Point, Alaska. Nesting density, success, and breeding phenology of the waterbirds were recorded. Twenty-five species nested in the area. Wetlands were classified on the basis of size, depth, vegetation, and water chemistry and the resulting classes related to bird use. These wetland categories are readily identified on aerial photography.

Invertebrate populations were examined to provide a basis for understanding the food relationships and potential pollution problems. A strong relationship was found between Arctophila fulva and Carex spp. and high invertebrate populations. The peak of emergence for adult invertebrates coincided with peak hatching of shorebirds and ducks. Limited sampling of bird food habits indicated that invertebrates are the major food source.

Eight wetland classes were identified and characterized by their dominant emergents. Not all areas of tundra fit in this classification, just those areas with standing water during at least a portion of the growing season. The eight classes and their dominant emergents are: Class I (Flooded Tundra) -- Eriophorum augustifolium or Carex aquatilis; Class II (Shallow-Carex) -- C. aquatilis; Class III (Shallow-Arctophila) -- A. fulva; Class IV (Deep-Arctophila) -- A. fulva; Class V (Deep-open) -- Open; Class VI (Basin-complex) -- Basin interspersed with C. aquatilus, A. fulva, and open water; Class VII (Beaded Streams) -- C. aquatilus, A. fulva, or open; and Class VIII (Coastal Wetlands) -- Puccinellia phyrganodes, C. subspathacea, or open. Classes III, IV, and VI were identified as the most productive for breeding birds. Class VIII is important for migrating geese.

Potential conflicts between breeding birds and oil development were discussed. Major potential problems identified were pollution by oil and wetland modification by impoundment or drainage due to the road and pipeline system. Preservation of wetlands was recommended to maintain the populations of breeding birds. Specific recommendations were: (1) preserve large tracts in their natural state; (2) small and well-distributed units of about 42 sq km should be left undisturbed; and (3) key production units should be protected from oil pollution, even in areas of intense development.

Brackney, A. W., M. A. Masteller, and J. M. Morton. 1985a. Ecology of Lesser Snow Geese staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, fall 1984. pp. 246-267. In: Garner, G. W., and P. E. Reynolds (eds.). 1985. 1984 update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 777 pp.

Snow Goose, migration, impacts, ANWR

Feeding ecology and energetics of fall staging Lesser Snow Geese were studied along the ANWR coastal plain. The study gathered information to address the potential effects of disturbance by aircraft and ground activities on the energy budget of staging geese.

Thirty-six geese were collected during the staging period; 14 during the arrival phase, two during the middle of the period, and 20 during departure. Mean weight gain was 23.4, 17.6, and 14.5 g/day for adult males, adult females, and juvenile males, respectively. Food items, based on esophageal and proventricular contents, were primarily cottongrass (over 90 percent Eriophorum augustifolium).

Time budgets were examined by recording the behavior of individual birds at 15 second intervals while they were on the ground, and by instantaneous counts of the number of flying and total geese in flocks. Adults spent 60.6 percent of the day feeding and juveniles spent 78.7 percent of the day feeding. Alert behavior by adults occupied 12.2 percent of the day compared to 1.5 percent by juveniles. Sleeping by juveniles was insignificant, while adults spent 6 percent of the day sleeping. The estimated time spent flying by the geese was 5.8 percent of the day.

Brackney, A. W., J. M. Morton, J. M. Noll, and M. A. Masteller. 1985b. Distribution, abundance, and productivitry of tundra swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1984. pp. 298-308. In: Garner, G. W., and P. E. Reynolds (eds.). 1985. 1984 update report, Baseline study of the fish, wildlife, and their hbaitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 777 pp.

Tundra Swan, breeding biology, distribution, ANWR

Two aerial surveys to estimate the number of Tundra Swans along the ANWR coast were flown in 1984. The first survey was for pair/nesting birds and 149 pairs and 100 nests were counted, an increase of 42 percent and 23 percent over 1983. The second survey was for productivity and the average brood size was 2.7 cygnets/pair. Nesting increased the most on the Canning-Tamayariak delta.

Brackney, A. W., J. M. Morton, and J. M. Noll. 1985c. Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1984. pp. 310-350. In: Garner, G. W., and P. E. Reynolds (eds.). 1985. 1984 update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 777 pp.

Oldsquaw, lagoon, distribution, ANWR

Fourteen lagoons were surveyed three times during Oldsquaw molt, on 22 July, 5 August, and 18 August. The peak of molt was estimated to occur between 7 and 13 August. No set pattern of spatial distribution within the lagoon system could be detected, although Oldsquaw seemed to move offshore as the season progressed.

Brackney, A. W., J. M. Morton, J. M. Noll, and M. A. Masteller. 1985d. Movements of molting Oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1984. pp. 351-361. In: Garner, G. W., and P. E. Reynolds (eds.). 1985. 1984 update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 777 pp.

Oldsquaw, lagoon, behavior, ANWR

Forty-four Oldsquaw were captured during molt (August 7-11) and 28 fitted with radio transmitters. Of the 28, 21 Oldsquaw died prior to migration, 10 of which died within before August 12. High mortality may have been due to behavioral changes or physical irritation of the back-pack attachment. Habitat selection inferred from 23 relocations indicated an avoidance of open water in the center of the lagoon and offshore of barrier islands.

Cade, T. J. 1955. Records of the Black Brant in the Yukon basin and the question of a spring migration route. Journal of Wildlife Management 19(2):321-323.

Brant, migration

The author hypothesizes an important movement of Brant through interior Alaska based on specimens collected along the Yukon River and observations of Brant by locals throughout the Yukon River basin. Brant are primarily a coastal species and an interior migration route had not been considered prior to these findings. The note includes observers names and short accounts of their observations.

Connors, P. G., J. P. Myers, and F. A. Pitelka. 1979. Seasonal habitat use by Arctic Alaskan shorebirds. Studies in Avian Biology 2:101-111.

Barrow, coastal, shorebirds, habitat

Shorebirds display a wide range in seasonal patterns of habitat use along the arctic coast near Point Barrow. Differences between species reflect habitat preferences, the timing of movements with respect to

seasonal habitat availability, and whether the use is breeding, post-breeding, or migrational. During the breeding season, most activity is centered on the tundra, but by early August a marked coastal movement occurs, resulting in high densities of particular species in shoreline and adjacent habitats. In August and September, widespread use of littoral habitats develops, especially by such species as Red Phalarope, Ruddy Turnstone, and Sanderling. In contrast, Golden Plovers and Pectoral Sandpipers restrict most of their activities to the tundra. Other species exhibit intermediate patterns of habitat use. These patterns determine the dependence of each species on arctic coastal habitats and the susceptibility of each species to disturbances related to offshore oil development. The detailed results of this are presented in Connors et al. (1982).

Connors, P. G., C. S. Connors, and K. G. Smith. 1983. Shorebird littoral zone ecology of the Alaskan Beaufort Coast. In: Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska. 101 pp.

shorebirds, coastal, habitat, habitat classification, behavior, population, migration, prey, recommendations, North Slope, distribution

Shorebird distribution, habitat relationships, trophic dependencies and behavior were studied at several Beaufort sea coast sites from 1975 to 1982. The objective was to assess the degree and nature of dependence of shorebird species on arctic habitats that are potentially susceptible to perturbation from oil development activities. Common shorebird species were categorized in terms of relative sensitivity to habitat disturbances associated with oil development, and seasonal habitat use patterns of all species have been defined to determine sensitive periods within the year. Types of coastal habitats were ranked on the basis of bird use and possible effects of oil development. With other researchers, several sensitive sites along the Beaufort coast were identified.

During June and early July, shorebird activity centered on the tundra where shorebirds nest. In July and August a major shift in habitat use occurred, beginning with post-breeding adults followed by fledged juveniles, from the tundra to littoral habitats to forage prior to southward migration. Species varied in timing and magnitude of this habitat shift, but the phenomenon is widespread across species. Bird use of the littoral zone in Barrow represents more than local breeding populations. Shorebird populations are most sensitive to perturbations when they are concentrated in the littoral habitat. Three important habitats were identified in the littoral zone: gravel beaches, littoral flats and slough edges. Groups of species occurred in the same types of habitats within each year, and some showed similar microhabitat preferences. Groups of species with similar preferences will likely be affected in the same way by environmental disturbances. Diets of shorebirds in the littoral zone related to the habitat rather than preferences by the species. Birds that foraged along slough edges and in littoral flats fed

mainly on chironomid fly larvae, and birds that fed along gravel beaches (marine shorelines) took a mix of marine zooplankton and under-ice amphipods.

The common shorebird species were classified with respect to their sensitivity to disturbances. Oil spills were considered to be the most likely type of disturbance along the coast. The ranking was based on the relative use of littoral versus tundra habitats modified by the type of littoral habitat use, choice of microhabitats, foraging methods and behavior of each species. Red Phalarope, Northern Phalarope, Sanderling, and Ruddy Turnstone were considered highly sensitive. A moderate rating was assigned to Semipalmated Sandpipers, Western Sandpipers, Baird's Sandpipers, Dunlin, and Long-billed Dowitchers. Lesser Golden Plovers, and Pectoral Sandpipers had a low sensitivity rating.

Sensitive areas along the Beaufort Sea coast in terms of large concentrations of shorebirds are: Peard Bay, Pt. Barrow, Plover Islands, Jones Islands, Fish Creek Delta and the Colville Delta. Sensitivity of littoral habitats, based on use and availability, was determined and the following ranking produced: (1) littoral flats and saltmarsh; (2) sloughs and small lagoons; (3) spits and barrier islands; (4) mainland shorelines with broad beaches; and (5) mainland shorelines with narrow beaches.

At Prudhoe Bay, the dust shadow produced on tundra beside gravel roads reduced densities of nesting shorebirds and passerines. A tundra area where natural drainage was altered by construction showed a reduction in shorebird breeding densities but an increase in densities of late summer migrants. An artificial gravel pier at Prudhoe Bay was used less than adjacent mainland shores by passerines and several species of shorebirds, but densities of Red-necked Phalaropes were extremely high.

Custer, T. W., and F. A. Pitelka. 1977. Seasonal trends in summer diet of the Lapland Longspur near Barrow, Alaska. Condor 80:295-301.

Barrow, Lapland Longspur, prey, habitat

Contents of Lapland Longspur stomachs and esophagi were sampled near Barrow, Alaska, during four breeding seasons. Data from stomach contents were corrected for differential digestion of prey items. Longspurs shifted seasonally from larval to adult arthropods and back to larvae in response to their changes in abundance. Seeds were a vital supplementary food in late May and August when arthropods were scarce or inaccessible. Longspur diets were similar to those of the four common shorebird species. The most overlap occurs when feeding sites were restricted because of snow and surface water and when prey was abundant in early and mid-July. Competition may have occurred early in the season but was unlikely in July when surface insects were abundant.

Davis, R. A., and A. N. Wisely. 1974. Normal behavior of Snow Geese on the Yukon-Alaska North Slope and the effects of aircraft-induced disturbance on this behaviour, September 1973. Arctic Gas Biological Report Series 27:1-85.

North Slope, Snow Goose, impacts, migration, behavior

Observations of staging Snow Geese were made at five locations on the North Slope during the fall of 1973. The geese normally spent 57 percent of the daylight hours feeding. Juveniles spent 65-70 percent of their time feeding. The geese flushed at the approach of both fixed-wing and rotary aircraft. Non-experimental aircraft disturbances averaged 0.25 per daylight hour. These resulted in a potential decrease of 2.6 percent in time spent feeding. Experimental overflights at two hour intervals by fixed-wing aircraft produced more severe reactions. These caused an 8.5 percent decrease in feeding time, and could cause a reduction of 20.4 percent in the energy reserves that juvenile geese can acquire on the North Slope in preparation for migration. The corresponding figure for overflights by small helicopters is a possible reduction of 9.5 percent. These potential decreases are dependent upon the extent of accommodation by the geese to increase overall feeding efforts.

Derksen, D. V., and W. D. Eldridge. 1980. Drought-displacement of Pintails to the Arctic Coastal Plain, Alaska. Journal of Wildlife Management 44:224-229.

North Slope, Pintail, habitat, population

Pintail migration, breeding densities and production at selected sites along the Arctic Coastal Plain of Alaska were compared to the 1977 wetland conditions in the Prairie Potholes region. Spring migration was monitored in a major migration corridor near southcentral Alaska and breeding information was gathered at three sites along the Beaufort Coast (Storkersen Point, Teshekpuk Lake, and the Meade River Delta) and one site near the foothills of the Brooks Range (Singiluk).

1977 was a severe drought year and pond counts in the Prairie Pothole region ranged from 20 percent to 50 percent below the 10-year average. Pintail densities at the coastal site were nearly double that of previous years. An estimated 6 percent of the continental population of Pintails occurred on the North Slope in 1977 compared with an estimated 0.7 percent in 1978 (post-drought). Production was low, which may be related to the birds arriving on the Coastal Plain in poor breeding condition. The northern area is important to the population in providing a refuge from the drought conditions and therefore a reservoir of Pintails for the pothole region when the conditions there improve. The northern habitat may be essential habitat for these ducks that normally breed in an area where drought can be severe.

Derksen, D. V., W. D. Eldridge, and T. C. Rothe. 1979a. Waterbird and wetland habitat studies. pp. 229-312. In: P. C. Lent (ed.). Studies of Selcted Wildlife and Fish and Their Use of Habitats on and Adjacent to NPR-A, 1977-1978. Field Study 3, Volume 2. U.S. Department of the Interior, National Petroleum Reserve-Alaska, Anchorage.

North Slope, waterfowl, habitat, habitat classification, species accounts, recommendations

Distribution, abundance, and use of wetlands by migratory birds was studied at several locations in the National Petroleum Reserve-Alaska for two years. Wetlands were classified using the system developed by Bergman et al. (1977) and bird use related to these classes. Use patterns followed those observed by Bergman and this report presents detailed accounts for the common species. Information from this study is presented in Derksen et al. (1981).

Based on waterbird abundance, distribution, and sensitivity to disturbance, the following recommendations were made:

1. Modification of water levels of wetlands used by waterbirds should be avoided.

2. Construction activities, including roadways, drillpads, and airstrips should be restricted to dry, upland sites. When this is not possible, use of flooded tundra wetlands will least impact waterbirds. Construction activities should not be allowed within 1,500 ft of Shallow and Deep-Arctophila wetlands, Deep-open wetlands, and Coastal wetlands. No construction activities that alter the flow of Beaded Streams should be permitted.

3. If waterbird species diversity and maximum productivity are to be ensured, large blocks of wetland habitat will need to be protected from disturbance and development.

4. The Teshekpuk Lake goose molting area should have complete protection from all exploration and development activities. Such protection must include coastal wetlands, bays, lagoons, and stream deltas since geese shift use from inland lakes to these areas following completion of the wing molt. Any winter rolligon trails across this area should be no less than 1,500 ft from shoreslines of deep-open lakes, especially where contiguous wet meadows are present.

5. Overlights by small aircraft at altitudes of less than 4,600 ft during the month of July in the Teshekpuk Lake goose molting area can be expected to have particularly disturbing and deleterious effects on geese.

Derksen, D. V., W. D. Eldridge, and M. W. Weller. 1982. Habitat ecology of Pacific Black Brant and other geese molting near Teshekpuk Lake, Alaska. Wildlfie 33:39-57.

North Slope, Canada Goose, Brant, White-fronted Goose, behavior, habitat, recommendations

Behavior, habitat selection, and foods of molting Brant, Canada Geese, and White-fronted Geese were studied in the Teshekpuk Lake area in

1977 and 1978. The geese gathered in large flocks and spent the majority of their time feeding. Flocks moved rapidly along shorelines and returned to the same sites every three to four days. All three species were highly social. Flocks responded to aircraft by moving from feeding or nesting sites to the safety of open water or ice flows.

Deschampsia sp. and Carex spp. were the most important grass and sedge, respectively, found in Brant and Canada Goose droppings. Mosses were also found in droppings from both species at both sites, but percentages were considered abnormally high probably due to their tendency to fragment more readily than vascular plants. Grasses were higher in nitrogen and non-structural carbohydrates than were sedges. Percentage of nitrogen, as well as phosphorus and potassium, in above-ground biomass declined from early July through early August and peaked as geese were in their second week of wing molt.

Protection of the Cape Halkett peninsula from petroleum development is recommended because of the unique combination of large, isolated lakes that afford protection to molting geese and nutrient-rich food supplies that occur in abundant drained basins.

Derksen, D. V., T. C. Rothe, and W. D. Eldridge. 1981. Use of wetland habitats by birds in the National Petroleum Reserve-Alaska. U.S. Fish and Wildlife Service, Resource Publication 141. 27 pp.

North Slope, inland, waterfowl, habitat, recommendations

Distribution, abundance,and use of wetland habitats by migratory birds were studied at two interior and three other Arctic Coastal Plain sites in the National Petroleum Reserve in Alaska (NPR-A) in 1977 and 1978. Comparative data were collected in the same years from a Beaufort Sea coastal site near Prudhoe Bay.

Species composition and densities varied between the sites, although the variation was greatest between the coastal and the foothills sites. Species richness was greatest at Storkersen Point, which may be due to the effects of the Beaufort Sea coast in channeling movements of birds. Variation seen between the sites is at least partially explained by differences in habitat composition and availability.

Wetlands were classified using the Bergman (1977) system and the composition for each site determined. Class III and Class IV wetlands, both with Arctophila fulva, were the principal breeding habitats for the most common waterfowl. A. fulva is considered a key component of the habitat as it provides food for grazing waterfowl, protective cover for young, nest material for loons, and substrate for aquatic invertebrates that are important prey. Deep open lakes near Cape Halkett and Teshekpuk Lake were important for large concentrations of molting geese.

Management recommendations to minimize the impacts of oil and gas development follow those of Bergman et al. (1977). Preservation of large blocks of habitat is encouraged to avoid the cumulative impacts of piecemeal development. In addition, high-density or unique breeding, molting, and staging areas should be preserved. The molting area near Teshekpuk Lake is specifically identified for protection.

Derksen, D. V., M. W. Weller, and W. D. Eldridge. 1979b. Distributional ecology of geese molting near Teshekpuk Lake, National Petroleum Reserve-Alaska. pp. 189-207. In: R. L. Jarvis and J. C. Bartonek (eds.). Management and Biology of Pacific Flyway Geese: A Symposium. OSU Book Stores, Inc., Corvallis, Oregon.

North Slope, Brant, Canada Goose, White-fronted Goose, Snow Goose, migration, habitat, population, recommendation

Aerial and ground surveys of lakes used by molting Canada Geese, Black Brant, White-fronted Geese, and Snow Geese were conducted in 1976, 1977, and 1978. These surveys showed a significant increases in Brant, a slight increase in Canada Geese, and a decline in White-fronted Geese and Snow Geese in the 2000 km^2 Teshekpuk Lake molting area.

Canada Geese and Brant used inland lakes during the molt. Both species exhibited a shift to coastal wetlands and stream deltas along the Beaufort Sea following molt. White-fronted Geese were more concentrated in the western portion of the area and did not move to the coast after completion of the wing molt.

Habitat requirements of molting geese were evaluated in order to develop management recommendations. Geese showed a definite preference for deep, open lakes as opposed to those having emergent vegetation. Low-relief shorelines that supported grasses and sedges were used more frequently by geese than precipitous shorelines with dry adjacent uplands.

It is recommended that the Teshekpuk Lake molting area receive special protection from petroleum development in the National Petroleum Reserve-Alaska and the Beaufort Sea.

Derrickson, S. R. 1978. The mobility of breeding Pintails. Auk 95(1):104-114.

Pintail

The mobility of breeding Pintails was studied for three years in the pothole region of central North Dakota. Home range estimates were made based on the movements of 5 unpaired males, 8 paired males, and 15 females. The mean home range size for unpaired males, paired males, and paired females were 579 ha, 896 ha, and 480 ha, respectively. Mobility varied with reproductive chronology and males were more mobile than females. Female mobility was greatest prior to egg-laying. Four pair ranges that included only the nesting period averaged 167 ha.

Divoky, G. J. 1983. The Pelagic and nearshore birds of the Alaskan Beaufort Sea: Final Report. In: Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska. 114 pp.

North Slope, distribution, coastal, impact, migration, prey, waterfowl, species accounts, Arctic Loon, Oldsquaw, King Eider, Red-necked Phalarope, Red Phalarope, Red-throated Loon, Yellow-billed Loon

Large scale distribution and abundance patterns of birds using the nearshore and pelagic Beaufort Sea were determined by shipboard surveys. The surveys were conducted during the period of maximum bird abundance (early August through mid-September). Over 1400 km^2 were surveyed during six pelagic and three nearshore cruises. Pelagic refers to waters deeper than 20 m and nearshore to waters shallower than 20 m but not within 300 m of land. The pelagic and nearshore regimes were divided into longitudinal sections (five for the pelagic and six for the nearshore) in order to demonstrate geographic differences in bird use. The activities of birds were examined by analyzing migration rates and the number of birds sitting on the water to better interpret bird density data.

The pelagic regime consisted primarily of surface feeding species (gulls, terns, phalaropes, and jaegers) with almost no use by diving species, except as a migratory area. The extreme western Beaufort had high bird densities, which is likely due to increased productivity caused by the Bering Sea Intrusion. Nearshore waters contained large numbers of Oldsquaw, loons, and migrant eiders with low densities of surface feeders. The density of surface feeders approximated that of the pelagic zone. Densities in most nearshore regions were similar with the exceptions of Harrison Bay, which had consistently lower densities, and the extreme western Beaufort, which had abundant surface feeding species. Calculations of biomass densities in each region showed a marked east-west trend with highest biomass reported in the west. The eastern region had low biomasses for many surface feeders.

Species accounts are presented that include information on distribution, breeding, post-breeding dispersal, and migration. Information for some species are lumped into species groups, e.g., loons. The accounts primarily present information from the cruises, with information from other studies presented as necessary to place dispersal and migratory information in perspective. Average densities and frequency of occurrence for the numerically important species by region are presented in tables for the nearshore and pelagic zones.

Several birds were collected for stomach content analysis. In general, arctic cod were the primary prey for birds feeding in the pelagic zone and zooplankton was most important for birds in the nearshore. The common diving species are largely restricted to the nearshore and fed on epibenthic crustaceans.

The vulnerability of species to development-related impacts, primarily oil spills, is discussed. In general, diving species are considered more vulnerable than surface feeders to oil spills because the former can become oiled by diving through and surfacing in spills. Surface feeders can more easily avoid spills. The Jones Island group and associated lagoon, Simpson Lagoon, and the Plover Island vicinity are considered especially sensitive due to the large concentrations of birds that regularly occur in those areas.

Dodson, S. E., and D. L. Egger. 1980. Selective feeding of Red Phalaropes on zooplankton of Arctic ponds. Ecology 61:755-763.

Red Phalarope, prey, Barrow

Food preferences and feeding rates were estimated for five Red Phalaropes eating zooplankton. Birds were captured in the Barrow, Alaska, area and put into enclosures containing a known amount of zooplankton. Predation preference and feeding intensity were calculated from the rate of disappearance of zooplankton from the cages. Results indicate phalaropes are size-selective predators on zooplankton. Preferred food included Daphnia middendorffiana, D. pulex, Eurycercus lamellatus, and Diaptomus bacillifer.

Flock, W. L. 1973. Radar observations of bird movements along the Arctic Coast of Alaska. Wilson Bulletin 85:259-275.

migration, coastal, waterfowl, North Slope

DEW line radar records of bird movements along the northern arctic coast of Alaska appear to document the westward summer migration of eiders past Pt. Barrow, Wainwright, and Lonely. In addition the records show a sometimes heavy fall westward migration that persists into November at Pt. Barrow. An extensive spring east-west migration and a high-altitude eastward summer migration have also been observed by radar at Oliktok, near Prudhoe Bay east of Pt. Barrow. At the time of the summer westward eider migration, identification of radar echoes as due to eiders was based on correlation with visual observations and on the fact that no major westward migration of other species is known to take place then. In the other cases, positive identification by visual or other means was not accomplished. The spring migration at Oliktok was complex in nature, presumably involved at least several species, and took place at a time of heavy overcast when the ocean and tundra were frozen and covered with snow. The summer eastward migration recorded at Oliktok took place at a sufficiently high altitude that it could not be seen by naked eye or binoculars in clear weather.

Gabrielson, I. N., and F. C. Lincoln. 1959. The Birds of Alaska. Wildlife Management Institute, Washington, D.C. 922 pp.

Alaska, North Slope, distribution

This is the classic reference on bird status and distribution in Alaska. It has been partially updated by Kessel and Gibson (1978). It is out of print.

Garner, G. W., and P. E. Reynolds (eds.) 1983. 1982 Update report: Baseline study of the fish, wildlife and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 379 pp.

North Slope, Snow Goose, Tundra Swan, Oldsquaw, lagoon, habitat, migration, shorebirds, waterfowl, species accounts, ANWR

This report is an update to the 1982 Baseline report. Appendices of this report include studies conducted on fall staging Snow Geese, breeding Tundra Swans, migratory bird use of the lagoon systems, and terrestrial bird populations and habitat use on coastal tundra. The studies and their major conclusions are summarized below.

Snow Geese from three major colonies in Canada stage on the North Slope between Parry Peninsula, Northwest Territories, and the Canning River, Alaska. Distribution within this area varies annually. The geese departed the area between 16 and 18 September in 1981 as the tundra lakes were freezing over. Major departure in previous years has ranged from 7 to 27 September.

An aerial survey was conducted to determine the distribution, abundance, and productivity of Tundra Swans utilizing coastal wetlands. The results were compared with a survey conducted in 1981. Total numbers declined in 1982 as did productivity. Swan numbers on one concentration area remained the same both years, but declined on three other concentration areas. Possible reasons for the decline include inclement spring weather, increased air traffic, or increased human disturbance.

Aerial surveys were conducted on 10 selected lagoons. Oldsquaw were identified as the major species using the lagoons. The temporal distribution observed was similar to previous years but the spatial distribution varied. Comparison of Oldsquaw numbers and density observed in a 400 m strip transect within the lagoon to the whole lagoon area showed that the birds were not randomly distributed and the strip transect cannot be used as an index of numbers or densities. Terrestrial bird populations and habitat use on coastal plain tundra in 1982 were measured at the Okpilak River Delta and inland along the Katakturuk River. Four large (25-50 ha) plots previously censused in 1978 at the Okpilak Delta were censused as were four 10 ha plots. Six 10 ha plots were established and censused at the inland site. The 10 ha plots were censused to test the efficiency of smaller replicate plots versus censusing single larger plots.

Break-up was late and migration was delayed compared to previous years. Twenty species bred on the Okpilak Delta and fourteen species bred at the Katakturuk site. Breeding densities were highest in riparian willow

and mosaic tundra plots, while lowest densities were recorded in flooded and sedge meadow tundra plots. Overall breeding densities on the Okpilak Delta plots were relatively constant between years except for a 200 percent increase in Pectoral Sandpiper density. The total summer population was higher than the breeding population, with 48 species observed at Okpilak and 35 at Katakturuk. Highest total populations were observed in riparian willow and flooded plots. Numerous birds used but did not breed in the flooded plot. In August, shorebirds using Okpilak coastal habitats increased while shorebird use at the inland Katakturuk area declined. Fall staging populations of shorebirds in the flooded plot reached a peak in excess of 500 birds/km^2.

Comparisons of replicate 10 ha plots and the corresponding 25 or 50 ha plot indicated that the replicate plots and the singular large plot provided comparable estimates of mean summer total population in the wet sedge and sedge-tussock plots, but estimates were not comparable on the more populous and diverse flooded and wet sedge plots.

Garner, G. W., and P. E. Reynolds (eds.). 1984. 1983 Update report baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 614 pp.

North Slope, Oldsquaw, Snow Goose, Tundra Swan, shorebirds, waterfowl, habitat, ANWR, lagoon, migration, species accounts

This is the second annual report for the Arctic National Wildlife Refuge's assessment of fish and wildlife on the Arctic coastal plain. It summarizes work completed or ongoing in 1983 with emphasis on studies being conducted by the Fish and Wildlife Service. Progress reports for these studies are included as appendices of this report. Many of the results reported are part of continuing studies whose findings should be viewed as preliminary.

Aerial surveys of Lesser Snow Geese were conducted in August and September to determine their distribution, abundance, and productivity. The surveys were coordinated with the Canadian Wildlife Service so that the entire staging area was surveyed. Fall staging was later than previous years, beginning two days later than the long-term average. A total of 393,000 geese were estimated to be present; 12,828 were estimated on the Arctic National Wildlife Refuge. Age ratios varied spatially with the highest proportion of young occurring on the Yukon North Slope. The geese occupied generally the same areas of the Wildlife Refuge as in previous years, although the "core" area was located slightly closer to the coast, perhaps due to snow cover. The majority of geese observed on the ground were feeding. The Snow Geese were as sensitive to aerial disturbance as noted in previous studies. Flushing distances averaged 3 km and altitudes up to 3000 ft. Low altitude (less than 30 m) flights caused less disturbance, perhaps due to lessened lateral dispersion of sound.

Two aerial surveys of Tundra Swans utilizing coastal wetlands were conducted, one in early June and one in late August. The nesting population was estimated to be a minimum of 105 pairs. Total swan numbers increased over the previous two years, with a big increase in cygnet production.

Terrestrial bird populations and habitat use on the coastal plain were measured at three sites. Forty-one 10 ha plots representing seven habitat types at the three sites were censused. Variability in bird populations due to location was primarily attributed to differences in habitat type available at coastal versus inland sites. Habitat type was found to be one of the most significant factors controlling densities of birds as well as the mean total populations and number of species. Seasonal variation was noted in most habitat types and the numbers of birds at the inland sites decreased through the season and increased at the coastal site. An attempt was made to characterize the bird communities associated with the Landsat level mapping done for the Wildlife Refuge, but it was not successful. Features that are important in determining bird habitat are not represented in the Landsat classes. The Landsat classes were therefore subdivided to take these variables into account.

Species accounts for the birds present at each of the study sites are presented. Separate accounts were presented for each of the study sites. Each account includes the status, breeding chronology, migration, and habitat use for each bird at each study site. Field work was carried out between 1 June and 18 August so the first and last dates of observation may not reflect the actual status of the bird.

Gavin, A. 1979. Wildlife of the North Slope: The islands offshore Prudhoe Bay, the Snow Geese of Howe Island, the seventh year of study. Atlantic Richfield Co., Anchorage, Alaska.

Prudhoe Bay, waterfowl, Snow Geese

Qualitative obervations of wildlife made over a 7-year period are presented. Arrival dates for some species are presented. Estimates of breeding densities of waterfowl were made based on aerial helicopter surveys of the area. An overall breeding density of 2.8 pairs per square mile was recorded with pockets of higher density, 5.8 pairs per square mile. A small colony of Snow Geese was oberved on Howe Island that successfully nested in 1971 and 1972.

Gavin, A. 1980. Wildlife of the North Slope: A ten-year study, 1969-1978. Atlantic Richfield Co., Anchorage, Alaska.

Prudhoe Bay, waterfowl, Snow Goose

Observations made over a ten-year period in the Prudhoe Bay region are presented. Qualitative observations of numbers within the area are summarized. The breeding history of the Snow Geese is presented and possible reasons for breeding failures in some years discussed; poor weather one year and extensive helicopter overflights another.

Gilliam, J. K., and P. C. Lent. 1982. Proceedings of the National Petroleum Reserve in Alaska (NPR-A), Caribou/Waterbird impact analysis workshop. U.S. Department of the Interior, Bureau of Land Management, Alaska State Office, 701 C Street, Box 13, Anchorage, Alaska. 29 pp.

North Slope, waterfowl, impact

A group of experts on waterbirds and the potential effects of development was convened by the Bureau of Land Management, National Petroleum Reserve-Alaska Office to discuss the implications of the proposed leasing program in the NPR-A. The panel discussed species and species groups and identified sensitive locations along the Beaufort coast.

Impacts associated with various development activities were briefly outlined. Aircraft traffic has the potential to cause severe impacts depending on a number of factors, e.g., flight altitude, number of flights, frequency of flights, activity of the birds. Powerlines and towers can kill flying birds. Contamination by oil and drilling muds can alter habitats and should be completely contained. Summer use of rolligons and hovercraft may disturb birds and should not be allowed in high use areas. Roads and facilities should be sited to cause least surface impacts. Waterfowl were noted as being sensitive to noise disturbance. Avian scavengers may be attracted to developments and their presence may lead to increased mortality of the local breeding birds. Impacts of ports and material sites would be related to the exact location in relation to concentration areas, the season of the activity, and the project size.

Gollop, M. A., and W. J. Richardson. 1974. Inventory and habitat evaluation of bird breeding and molting areas along the Beaufort Sea Coast from Prudhoe Bay, Alaska to Shingle Point, Yukon Territory, July 1973. Arctic Gas Biological Report Series 26:1-61.

migration, coastal, waterfowl, North Slope, habitat, recommendations

Aerial surveys were flown along the arctic coast between July 17 and 21, 1973, from Prudhoe Bay, Alaska, to Shingle Point, Yukon Territory. The purpose of the surveys was to identify correlations between specific habitat features and areas in which breeding and molting birds are present. Univariate and multivariate statistical procedures were applied in examining the relationships between the degree to which islands were used by waterbirds and various characteristics of these islands. The characteristics that were considered were soil composition, elevation, area, distance from shore, extent and size of driftwood present, extent and type of vegetation, signs of human activity, accessibility to predators, presence of standing water, and presence of ice.

Ninety-five coastal spits and islands and seven river deltas were surveyed. Evidence of breeding was found on 15 coastal islands and one spit, and on five river deltas. The principal breeding species observed was the Glaucous Gull. However, nesting Brant, Common Eider, Oldsquaw, and Arctic Terns were also noted. A total of 31,778 molting Oldsquaw was counted on the survey, and 16 locations accounted for 67 percent of this total. More birds were found on vegetated than on unvegetated islands. Islands with relatively long shorelines were found to have more ducks than islands with shorter shorelines.

This study demonstrated the critical importance of a few areas to breeding and molting birds and the importance of not altering the characteristics of these areas. Islands that supported nesting Brant and/or Common Eiders included Arey Island, Flaxman Island, Foggy Island, Tigvariak Island, Cross Island, Jago Delta, and Shaviovik Delta.

Gotmark, F., and M. Ahlund. 1984. Do field observers attract nest predators and influence nesting success of Common Eiders? Journal of Wildlife Management 48(2):381-387.

Common Eider, impact

The effect of observers on nesting Common Eiders was studied for one season in an eider colony in southern Sweden. Egg predation by gulls increased for birds flushed from their nests because the nests were left uncovered. Under natural conditions, birds leaving a nest pull the nesting material (down) over the eggs, which camouflages the nest. The authors recommend observers cover nests of flushed birds in a similar fashion to reduce aerial predation.

Hall, B. E. 1975. A summary of observations of birds at Oliktok Point Summer 1971. pp. 245-274. In: P. J. Kinney et al. (eds.). Baseline data study of the Alaskan Arctic aquatic environment. Institute of Marine Sciences, University of Alaska, Fairbanks, Report R723.

coastal, distribution, species accounts, waterfowl, Colville Delta, Oliktok Point

Birds were observed in the vicinity of the Oliktok DEW-line station for seven weeks in the summer of 1971. The observation period was from 12 June until 23 August. Bird observations were made from the tower at Oliktok, walks in the surrounding areas and boat trips in Simpson Lagoon and the Colville Delta. The qualitative observations are presented in an annotated list of species seen. Observations are presented in detail and the list provides important distributional information for the area.

Handel, C. M., M. R. Petersen, R. E. Gill, Jr., and C. J. Lensink. 1981. An annotated bibliography of literature on Alaska waterbirds. U.S. Department of Interior, Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-81/12. 515 pp.

Alaska, North Slope

This bibliography includes both published and unpublished references on Alaskan waterbirds. The listing is extensive and is divided into four sections, seabirds, waterfowl, shorebirds and avifauna. Each section is a separate bibliography. Each reference includes the citation, a brief

summary or evaluation of content, and key words that identify the region and locality of the study, family or species of concern and subject of discussion.

Hansen, H. A., and L. E. Eberhardt. 1981. Ecological investigations of Alaskan resource development. In: Pacific Northwest Laboratory annual report for 1980 to the C.O.E. Assistant Secretary for the Environment, Part 2. Ecological Sciences.

Prudhoe Bay, shorebirds, breeding biology, impact

Nesting densities of tundra birds were measured in 1979 and 1980 at two sites, one in Prudhoe Bay and one at Mile 12 along the Dalton Highway (North Slope Haul Road). Nesting densities were affected adversely by the snow fence effect of the elevated pipeline; persistent snow drifts precluded nesting. Banded bird returns have demonstrated breeding site fidelity and pair fidelity in Semipalmated Sandpipers.

Hawkins, L. 1983. Tundra Swan study, 1983 Progress report. unpublished field report, USFWS, Special Studies, 1011 E Tudor Road, Anchorage, Alaska. 6 pp.

Tundra Swan, breeding biology, Colville delta

Breeding biology of Tundra Swans was studied on the Colville River Delta in 1982 and 1983. Objectives of the study were to measure productivity, describe behavior, and continue a neck banding program.

Swans arrived on the delta at the end of May with movement onto the delta in 1983 peaking on 30 May. Territorial defense began by 24 May. Nests were found through ground searches and aerial surveys, only half of the nests found during ground searches were noted during the aerial survey. Nest density in the ground-searched area (central and western delta) was 0.18/km^2, for the rest of the delta it was 0.10/km^2, and for Fish Creek delta it was 0.15/km^2.

Clutch size averaged 3.59 eggs in 1983 and 3.42 in 1982. Clutches hatched from 7-15 July, after an estimated 30-31 days incubation. Arctic fox predation seemed to be the source of all nest failures. Productivity increased overall in 1983, due in part to slightly larger clutches and in part to higher nest success.

Large numbers of non-breeding swans move into the delta during the latter part of June.

Hawkins, L. L. 1986. Tundra Swan (Cygnus columbianus colubianus) Breeding Behavior. unpublished MS thesis, University of Minnesota. 145 pp.

Tundra Swan, breeding biology, behavior, Colville delta

Tundra Swan breeding behavior was studied from 1981 through 1983 on the Colville delta. The purpose of the study was to quantify male and female nesting, compare male and female nest care, and determine the effect of nest attendance on the daily activity budgets of males and females. Behavior of wild birds was compared with captive birds.

In the wild, males sat on the nest during incubation while the females were absent. In captivity, males stood near, but did not generally sit on the nest.

Females incubated between 60 and 80 percent of the time, with individuals showing high variability in the amount of incubation time. Females increased their incubation time when wind chill and absolute temperature decreased. Females increased their foraging time mid-to-late incubation, then increased incubation sharply when hatching began. Male incubation behavior was related to territorial defense and associated aggression.

Holmes, R. T. 1966. Feeding ecology of the Redbacked Sandpiper (Calidris alpina) in Arctic Alaska. Ecology 47:32-45.

Dunlin, Barrow, coastal, prey, habitat

The Red-backed Sandpiper, or Dunlin (Calidris alpina), was studied near Barrow, Alaska, for five summers. The Dunlin fed largely on larvae and adults of the families Tipulidae and Chironomidae (Diptera). Sampling for availability and abundance of insect populations shows that the food source readily available and heavily used in early summer and again in late summer consists of tipulid larvae. As summer predation proceeds, important changes in numbers and availability of different food species result from progression of their life-cycle stages and from changes in environmental conditions. Food supply and diet are most varied in July.

Although feeding behavior and diet of Dunlin change with prey availability, preferences are shown by adult sandpipers for tipulid larvae in early and late summer and to a lesser extent for chironomid larvae in midseason. Recently hatched young feed entirely on small-sized adult insects, mostly chironomid flies, which are obtained easily on the tundra surface. Differences between adult and young Dunlin in habitat and food selection during late summer represent an intrapopulational means of apportioning food supply in a critical part of the season.

With arctic insect faunas depauperate in variety of taxa, there is a limited diversity of food species for sandpipers. Adverse weather conditions characteristic of high-latitude climates can cause local food shortages. The widest variation in food conditions occurs in July when young sandpipers are hatching and growing.

Holmes, R. T. 1970. Differences in population density, territoriality, and food supply of Dunlin on arctic and subarctic tundra. Symposium of the British Ecological Society 10:303-319.

Barrow, Dunlin, prey, behavior

The densities, territorial activities, and food supplies of Dunlin breeding in the Barrow area were compared with those breeding in the Yukon Delta region. The population in the Yukon Delta region nested at densities approximately five times higher than that in the Barrow area. The food supply was more abundant in the Yukon Delta study area. Weather in the Barrow region is much harsher and less predictable and this may affect the food supply. The presence of congeneric species in Barrow and lack of congeners in the Yukon area does not seem to affect the densities. Removal experiments conducted at Barrow showed that males were replaced immediately if removed prior to June 20. After that date, the territories remained empty, probably because there would not be sufficient time to mate, nest and raise a brood prior to the onset of adverse weather. It was concluded that the density of breeding Dunlin is related to the abundance and availability of their food supply and that the main function of territorial behavior is to disperse the populations in relation to food.

Holmes, R. T., and F. A. Pitelka. 1968. Food overlap among coexisting sandpipers on northern Alaska tundra. Systematic Zoology 17:305-318.

Barrow, Dunlin, Pectoral Sandpiper, Semipalmated Sandpiper, Baird's Sandpiper, shorebirds, prey, habitat

Diets of the four commonly breeding sandpipers in the Barrow area were studied over a 5-year period. The diets of the four species, Dunlin, Pectoral Sandpiper, Semipalmated Sandpiper, and Baird's Sandpiper, overlapped broadly. Among adults, the period of strongest species separation is late June, when insect diversity is maximal and when a rapid rise in insect numbers toward a mid-July peak is just beginning; among young, the period of strongest species separation is early August, when the insect supply is declining rapidly. The early migratory departure of the adults of three of the species may act to reduce competition among the four species. Partial habitat separation of the two smaller species, Baird's and Semipalmated Sandpipers, may also reduce the competition. There is also an important difference between the two larger species; Dunlin populations are relatively stable between years and they nest in relatively low densities while Pectoral Sandpiper populations fluctuate widely between years and between areas to take advantage of locally abundant food resources.

Irving, L. 1960. Birds of Anaktuvuk Pass, Kobuk, and Old Crow. U.S. National Museum Bulletin 217. 409 pp.

distribution, waterfowl

Distribution information for birds in the central Brooks Range and Old Crow is given based on personal observations and those of the local inhabitants. Although an old publication, this has useful information on distribution patterns and migration timing.

Johnson, S. R., and W. J. Richardson. 1981. Beaufort Sea Barrier Island-Lagoon Ecological Process Studies: Final Report, Simpson Lagoon. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, Volumes 7 and 8. National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska.

North Slope, Oldsquaw, Red Phalarope, Red-necked Phalarope, hābitat, prey, impact

An integrated ecological study of the Simpson Lagoon-Jones Islands area and vicinity was conducted over a 4-year period. The study focused on geological, oceanographic, and ecological processes that supported vertebrate species of primary interest to people.

Numerically important bird species in the coastal environment include Oldsquaws and Red and Red-necked Phalaropes. These feed mainly on crustaceans; Oldsquaws eat mostly mysids, and phalaropes eat large amounts of copepods. The activities of these birds are largely restricted to the shallow bays, lagoons, and beaches from mid-summer to early fall (Oldsquaw) and in August (Phalaropes). These birds use the nearshore environment mostly for resting, feeding, and (for Oldsquaws) molting, but not for nesting. Their main vulnerability to human activities would probably be to oil on the water and beaches in late summer and early fall. Additionally vulnerable to human activities would be island-nesting species (eiders, Brant, and Snow Geese), that occur area-wide in small numbers. Island nesting species are particularly vulnerable to fox predation; productivity is generally high when no foxes are present on the islands and may be zero when a fox is present.

Migration patterns were observed for the two years of the study. Spring migration occurred over a broad front and the major species groups passing through the lagoons included loons, Brant, Pintails, Oldsquaws, eiders, gulls and jaegers. Two peaks were noted during the male seaducks' westward molt migration, the first in late June and early July and the second during the latter half of July. Fall migration extended over a long period with some species leaving the study area by the end of August and others not until the end of September.

Johnson, S. R., W. J. Adams, and M. R. Morrell. 1975. Birds of the Beaufort Sea: I. Literature Review. II. Spring migration observed during 1975. Unpublished report, Canadian Wildlife Service, Prairie and Northern Region, Edmonton. 310 pp.

North Slope, coastal, waterfowl, shorebirds, breeding biology, migration, distribution, species accounts

This publication is a comprehensive review of the information on the majority of species that migrate and/or nest along the Beaufort Sea coast. The first part of the paper reviews the studies of all waterbird species in the Beaufort Sea area and presents the information in detailed species accounts. A list of the papers cited in the accounts and other references that may be useful follow each account. The accounts cover the distributions and statuses of birds in the area and the patterns of movement that accompany these distributions. Major events within the breeding cycle of each avian species that breeds or occurs commonly in the area are discussed; these include such phenologically-determined phenomena as first spring occurrences at various locations within the Beaufort Sea area, breeding chronology and biology, and the timing and routing of fall and spring movements to and from wintering areas. Part II covers information gathered during spring and fall migration watches. The information is organized into species accounts that cover the status and distribution information known about the species as well as the information gathered on migration. The accounts include passerines as well as waterbirds.

Johnson, S. R., G. J. Divoky, P. G. Connors, D. W. Norton, R. Meehan, J. Hubbard, and T. Warren. 1983. Avifauna. In: Sale 87, Harrison Bay synthesis. National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska.

North Slope, distribution, habitat, migration, coastal, shorebirds, waterfowl

An overview of avifaunal use of coastal and marine systems is presented that updates previous OCS syntheses. The coast and marine areas are subdivided into regions and general use patterns, relative productivity or importance and data gaps are described. Bird use of specific areas along the Chukchi and Beaufort coasts is outlined and the primary sources of the information identified, summaries are presented below.

Seahorse Islands and Point Franklin Spit have vegetated dunes that are unusual for the area north of Cape Lisburne. Approximately 40 pairs of Arctic Terns and a few Black Guillemots, Oldsquaw, and Common Eiders nest near or in the dunes. The Point Franklin Spit is used extensively by feeding and roosting birds during the post-breeding staging and migration period. A shoreline transect in early August recorded about 12,000 Red Phalaropes, 6,000 Arctic Terns and 800 Sabine's Gulls. Brant stage in this area later in the fall.

Point Barrow-Elson Lagoon and the Plover Islands have been extensively studied and consistently support high densities of shorebirds, gulls, terns, and some waterfowl in the late summer. Densities of most species peak in August as birds are staging for or stopping during migration. The Plover Islands are an important feeding and roosting area. Two primary food sources are the abundant under-ice zooplankton and the high productivity associated with the Vering Sea Intrusion. Arctic Terns and Black Guillemots nest in the Plover Islands. The high densities of birds in this area compared to other portions of the Beaufort make it one of the most sensitive areas.

Little is known about the coastal area from Admiralty Bay to Smith Bay. Smith Bay to Cape Halkett has been studied some and apears to include several areas of productive saltmarsh. (The inland area in the vicinity of Teshekpuk Lake has been studied extensively by USFWS in connection with the molting geese; see Derksen et al. 1980, 1981, 1982.) The southwestern coast of Harrison Bay is used extensively during the later part of the summer by shorebirds and waterfowl. The most extensive saltmarshes and mudflats along the Beaufort coast are along this part of the coast, including the Colville River delta. The Colville River delta is a unique and important area for breeding waterfowl.

Simpson Lagoon has the highest average density and biomass of Oldsquaw of any lagoon along the Alaskan Beaufort coast. Thousands of juvenile Red and Red-necked Phalaropes also concentrate in the lagoon during August. The birds feed on epibenthic invertebrates in the lagoon. Nearby Prudhoe Bay is not nearly as productive as the lagoon. The Sagavanirktok River delta has the only colony of breeding Snow Geese in Alaska nesting on Howe Island in the outer delta.

Bird use of the coast and lagoons between the Sagavanirktok River and Barter Island is relatively low compared to other parts of the Beaufort Coast with the exception of river deltas. The Canning River and Okpilak River deltas are used extensively by waterfowl during spring migration. Nesting densities of shorebirds and waterfowl were higher than at any other North Slope study sites.

Lagoons east of Barter Island are used by molting Oldsquaw although the densities are not as high as in Simpson Lagoon. In general, the pattern of lagoon use by Oldsquaw and other species is similar to that described for Simpson Lagoon. Snow Geese stage inland of the coast in the fall but do use coastal areas and lagoons for resting on occasion.

Kessel, B. K. 1961. West-East relationships of birds of Northern Alaska. pp. 79-84. In: J. C. Grisset (ed.). Pacific Basin Biogeography: A Symposium. Bishop Museum Press, Honolulu, Hawaii.

distribution, North Slope

Distribution patterns of North Slope birds were analyzed in terms of their faunal affinities. In general, the avifauna of the North Slope is similar to the avifauna of Siberia. This pattern is most pronounced in the Barrow area, including the Chukchi coast, while the eastern portion of the coastal plain includes fewer of the Siberian species and more North American species.

Kessel, B. 1979. Avian habitat classification for Alaska. Murrelet 60:86-94.

Alaska, North Slope, habitat classification

A basic overall classification system for Alaskan birds was developed. The two morphologic features with the greatest impact on the avian community relate to the occurrence and characteristics of water and of woody plant growth. These features provide the basis for the classification. The classification includes seven major categories, each of which can be defined in more detail to fit a particular situation. Each of the classes is defined and common birds listed.

Kessel, B., and T. J. Cade. 1958. Habitat preferences of the birds of the Colville River, northern Alaska. Biological Papers of the University of Alaska 2. 83 pp.

species accounts, inland, Colville River, distribution

A survey of the Colville River was conducted to learn more about the occurrence, distribution, and habitats of the birds of the North Slope. The findings of a full summer of observation and parts of two others are presented as species accounts. The accounts are supplemented by information from published literature. This is a dated, but for that time, complete listing of birds that occur in the region and contain important information on distribution.

Kessel, B., and D. D. Gibson. 1978. Status and distribution of Alaskan birds. Studies in Avian Biology 1. Cooper Ornithological Society. 100 pp.

Alaska, North Slope, distribution

This publication updates Gabrielson and Lincoln (1959), Birds of Alaska. Complete accounts of 202 species, their status and distribution, are presented. The differences noted between the distribution of these species today and that presented in Birds of Alaska may be due to actual changes in distribution, or, more likely, be the result of improved information. This publication is intended to be used as a companion to Gabrielson and Lincoln.

Kiera, E. F. W. 1984. Feeding Ecology of Black Brant on the North Slope of Alaska. pp. 40-48. In: Marine birds: their feeding ecology and commercial fisheries relationships. D. N. Nettleship, G. A. Sanger, and P. F. Springer (eds.). Proceedings of the Pacific Seabird Group Symposium, Seattle, Washington, 6-8 January 1982. Canadian Wildlife Special Publication.

Colville Delta, Prudhoe Bay, Brant, prey, Habitat

A population of nesting Brant on the island in the Colville Delta and the late summer use of a salt marsh near Prudhoe Bay were observed for one season. Food preferences and food intake were estimated for Brant feeding on salt marshes.

Migrating Brant began arriving in salt marshes in mid-August just after salt-marsh vegetation reached peak production. They fed primarily on Carex subspathacea and Puccinellia phyrganodes. Food intake during this time was estimated at 283 g dry weight of vegetation per day. Seventy-seven percent of the daylight hours was spent feeding. Chemical analysis of graminoid samples showed no relationship between goose preference and the nutritional characteristics of the vegetation they ate. Grazing pressure on arctic salt marshes where Brant fed was calculated at 373 goose-days/ha. This is believed to be near the carrying capacity of the marshes without resulting in overgrazing.

King, J. G. 1973. The swans and geese of Alaska's arctic slope. Wildfowl 21:11-17.

North Slope, distribution, waterfowl, recommendations, Brant, Tundra Swan, White-fronted Goose

Aerial surveys of the North Slope were conducted in 1966. The purpose of the surveys was to assess the overall use of the North Slope by waterfowl and determine if their habitat may be affected by man's activities. In general, the area is characterized by low production. The production may be important, though, in years when failures occur in areas. Large numbers of molting Brant and White-fronted Geese were observed in the area between Teshekpuk Lake and Cape Halkett. This area was identified as unusual and the author recommended further studies of the area and development of management recommendations.

King, J. G., and G. A. Sanger. 1979. Oil vulnerability index for marine oriented birds. pp. 227-240. In: J. C. Bartonek and D. N. Nettleship (eds.). Conservation of marine birds of Northern North America, USFWS, Wildlife Research Report 11, Washington, D.C. 315 pp.

impact

A system to determine relative susceptibility of species to oil development is presented. The system is based on subjective determination of a species' sensitivity in 20 aspects of its biology, including considerations of range, population, habits, mortality, and annual esposure. Scores for the 20 factors are summed for a total oil vulnerability index. The intent of the system is to compare potential vulnerability of the avifauna of different areas by summing the scores of the species that occur in each of the areas and comparing the combined sums.

King, R. 1979. Results of aerial surveys of migratory birds on NPR-A in 1977 and 1978. pp. 187-226. In: P. C. Lent (ed.). Studies of Selected Wildlife and Fish and Their Use of Habitats on and Adjacent to NPR-A 1977-1978, Volume 1. U.S. Department of the Interior, National Petroleum Reserve in Alaska, 105(c) Land Use Study, Anchorage, Alaska.

waterfowl, North Slope, distribution

Aerial surveys of the National Petroleum Reserve-Alaska (NPR-A) were conducted three times each summer for two summers. The purpose of the study was to estimate populations of birds that use NPR-A. Categories of birds were counted as not all species are identifiable from aircraft. When possible, birds were identified to species. Ground surveys were conducted to provide a ratio of birds seen from the air to total birds present. Conversion factors were developed to interpret the aerial data using the ground information, general knowledge of the species and information from previous studies. The estimated number of birds decreased from 1977 to 1978 by 16 percent. The decrease is apparently related to drought conditions in the Prairie Pothole region in 1977, which led to increased numbers of ducks -- primarily Pintails -- on the North Slope, and the improved wetland conditions in the Pothole region in 1978, which kept the ducks from immigrating north. Raptors increased between 1977 and 1978, probably in relation to increased numbers of lemmings.

High densities of loons, more than three per square mile, occurred 20 miles west of the Colville River delta, within a 20 mile radius of Barrow, and immediately adjacent to and within 20 miles of Icy Cape. The highest densities of swans, more than 1 per square mile, were found west and southwest of Teshekpuk Lake and adjacent to the Colville River delta. High densities of geese, more than 7 per square mile, were found adjacent to and west of the Colville River delta, in the Teshekpuk Lake area, and southwest of Barrow 30 miles. High densities of dabbling ducks were found near most of the coastline in 1977; in 1978 moderate densities of dabblers were found over most of NPR-A. High densities of diving ducks were found within 30 miles of the coast between Icy Cape and Wainwright and from Smith Bay to Peard Bay. High densities of Snowy Owls were recorded near the coast from Icy Cape to Barrow in 1978.

Highest densities of shorebirds were found within 40 miles of the Arctic coast from Harrison Bay west to Point Barrow and within 15 miles of the arctic coast east of Icy Cape to Wainwright. The aerial survey did not sample the coastline itself and thus omitted large concentrations of shorebirds staging prior to and during migration.

Koski, W. R. 1975. Study of the distribution and movement of Snow Geese, other geese and Whistling Swans on the Mackenzie Delta, Yukon North Slope and Alaskan North Slope in August and September with similar data from 1973. Arctic Gas Biological Report Series 30:1-58.

North Slope, Snow Goose, White-fronted Goose, Brant, Tundra Swan, migration

Aerial surveys of the Mackenzie Delta and the Yukon and Alaskan North Slope were conducted in the end of August to determine the usage by geese in this area and compare the usage with that of the previous year. Snow Geese used the study area between August 21 and September 30; a peak number of 160,000 geese used the area between August 29 and September 15. The major concentration sites in Alaska were the Upper and Lower Aichilik River sites. The peak numbers of White-fronted Geese occurred between September 4 and 6 at 22,000 birds. In both years, Brant used the entire coastline extensively.

Lehnhausen, W. A., and S. E. Quinlan. 1981. Bird migration and habitat use at Icy Cape, Alaska. unpublished manuscript, U.S. Fish and Wildlife Service, Office of Special Studies, 1011 E. Tudor Road, Anchorage, Alaska. 298 pp.

Icy Cape, migration, habitat, waterfowl, species accounts, recommendations

An intensive one year study was conducted at Icy Cape, on the northwestern coast of Alaska. The purpose of the study was to document wildlife use of the Icy Cape area and determine which areas were most important. A major part of the study focused on bird migration. Bird censuses were conducted on mainland tundra, barrier islands, salt marsh, mudflat, beach, and staging areas. Major spring migration occurred during two periods, 26 May to 12 June and 16 June to 14 July. The first movement was primarily birds migrating to breeding grounds and the second was waterfowl moving north to molting areas. Waterfowl made up 84 percent of the net movement northward, jaegers 6.1 percent and shorebirds 4.8 percent. Fall migration was more diffuse with noticeable southward movement beginning in mid-July. Fall migration was most intense in September. The majority of migrating birds flew along the barrier islands or over the sea.

Average bird density on the tundra plots was 182.8 birds/sq km. Shorebirds and passerines occurred in the highest densities. Average bird density in the salt marsh was 479 birds/sq km with the species composition dominated by Dunlin, Pintail, Brant, and Western Sandpiper.

Species accounts of all birds seen at Icy Cape are presented. The accounts include observations of the birds during the season and compares their observations with those of others on the North Slope.

Recommendations for protecting parts of the Icy Cape area from development were made based on their observations of bird and wildlife use. The recommendations include: protection of a zone of nearshore water, protection of the barrier island, all development related activity should avoid the lagoon and associated salt marshes, and large blocks of upland tundra should be preserved.

Maclean, S. F., Jr. 1980. The detritus-based trophic system. pp. 411-457. In: J. Brown, P. C. Miller, L. L. Tieszen, and F. L. Bunnell (eds.). An Arctic Ecosystem: The Coastal Tundra at Barrow, Alaska. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania.

shorebirds, Barrow, Lapland Longspur, prey

The structure of the detritus-based trophic system is outlined and discussed in detail. The system is made up of organisms that use energy only after it has passed from living components through the pool of dead organic matter. Shorebirds and Lapland Longspurs are at the top of this community, feeding primarily on soil invertebrates.

Bird breeding is timed so that the young can feed on the adult Diptera that emerge in early and mid-July. In June and August dipteran larvae, especially those of craneflies, are the most important prey. Energy requirements are determined by body size and duration of residence on the tundra. When breeding density is also considered, longspurs are the most important consumers of tundra arthropods. Birds may consume 35 percent of the annual production of the cranefly, Tipula carinifrons, and 50 percent of the peak emergence of adult craneflies.

Maclean, S. F., Jr., and R. T. Holmes. 1971. Bill lengths, wintering areas, and taxonomy of North American Dunlins, Calidris alpina. Auk 88:893-901.

Dunlin, population, distribution

Bill lengths of Dunlins collected on their breeding grounds in northern Alaska, western Alaska, and their wintering grounds along the Atlantic and Pacific coasts of North America and the Pacific coast of Asia identify two separate breeding populations. The birds breeding in western Alaska, on the Seward Peninsula, have larger bills than the birds breeding on the North Slope. The west coast birds winter along the Pacific coast of North America. The North Slope birds are close in bill length to birds that breed in Siberia and are thought to migrate across the Bering Strait and winter along the coast of the Sea of Japan with the Siberian population.

Maclean, S. F., Jr., and F. A. Pitelka. 1971. Seasonal patterns of abundance of tundra arthropods near Barrow. Arctic 24:19-40.

prey, shorebirds, Barrow

Arthropods active on the surface of the tundra near Barrow, Alaska, were trapped for four seasons using "sticky board" traps. More than 95 percent of the arthropods (excluding Acarina and Collembola) captured were of the order Diptera. Adults of most species of Diptera emerged in the middle two weeks of July; the abundance of arthropods on the tundra surface was maximal at that time. Peak emergence is accompanied by the peak in hatching for shorebirds. Young shorebirds rely on the surface-active adult Diptera for food as the shorebirds' bills are still soft and they are unable to probe for food. Year-to-year variation in abundance of various arthropod taxa is related to prevailing weather conditions and to the cycle of tundra disturbance and recovery associated with the abundance of brown lemmings.

Martin, P. D., and C. S. Moiteret. 1982. Bird populations and habitat use, Canning River Delta, Alaska. Report to the Arctic National Wildlife Refuge, U.S. Fish and Wildlife Service, Fairbanks, Alaska.

Canning delta, habitat, shorebirds, waterfowl, migration, distribution, species accounts, ANWR

Bird populations and use of habitat at the Canning River Delta, Arctic National Wildlife Refuge, was studied during the summers of 1979 and 1980. Bird use of tundra habitats, shoreline habitats, and the progression of migration was studied. Species accounts for all 84 species recorded at the Canning Delta were prepared. The accounts include a review of the status and distribution in the region as well as details of chronology of migration and breeding activities for each species.

Four intensive study plots were established: in a lowland (wet, polygonal), an upland (well-drained, indistinctly polygonized), a mosaic (intermixed wet and dry), and a saline tundra area. The upland and mosaic had high populations of Longspurs and shorebirds early in the season, probably as a result of relatively early melt-off at these sites. The mosaic had the highest nesting density of longspurs and shorebirds, while the lowland was most used by late summer migrants. The saline meadow was used extensively by shorebirds including staging phalaropes, but also by

breeding and migrant waterfowl, loons, and larids; this habitat attracted the highest concentrations and diversity of birds. Complex wetlands with Arctophila had high concentrations of breeding loons and waterfowl.

An intensive study of bird use of coastal shoreline habitats was conducted in 1980. The river mouth provided the first open water in the spring and was heavily used by migrant waterfowl. Early snow-melt on the sand dunes provided the first open tundra habitat for migrating shorebirds. Shoreline use was heaviest in the late summer by molting Oldsquaw and staging shorebirds. Saline meadows received the highest use of any type of shoreline habitat.

Migration watches were conducted in the spring and fall. Oldsquaw and jaegers were the most common spring migrants, other species may have been following offshore leads. A gradual westward molt migration of Oldsquaw was observed from mid-June to late July. A major westward movement of male Common Eiders peaked on 28 July. Westward fall migration of Brant, Oldsquaw, and loons built up gradually from mid-August to a peak on 31 August. During spring migration, the open water of the Canning River was heavily used as a resting place for migrating waterfowl. During fall migration, the saline meadow provided important resting and feeding areas for Brant and shorebirds.

Mayfield, H. F. 1978. Undependable breeding conditions in the Red Phalarope. Auk 95:590-592.

Red Phalarope, prey, breeding biology, Canada

Red Phalaropes were studied on Bathurst Island for seven years. A one sq km plot was censused each year. Phalarope nesting was affected by weather and predation by Arctic foxes. The primary food taken was chironomids: larvae early in the season and adults during their emergence in early July. Hatching rate measured over a three year period was 25 percent. Polyandry was suspected based on the behavior of individual females and post-ovulatory scars on one female. The pair bond is terminated shortly after the clutch is completed and females are able to mate again. Males incubate and care for the young. The females leave the breeding areas prior to the males and the males leave prior to the young. The sequence of departures may reflect an adaptation to an uncertain food supply by leaving a minimum of consumers at each stage.

Mickelson, P. G. 1975. Breeding biology of Cackling Geese and associated species on the Yukon-Kuskokwim Delta, Alaska. Wildlife Monographs 45:1-35.

Canada Goose, Brant, White-fronted Goose, breeding biology, habitat

The breeding biology of Cackling Geese, Brant, White-fronted Geese and Spectacled Eiders was conducted during the breeding seasons of 1969 through 1972. The study took place on the Clarence Rhode National Wildlife Range on the Yukon-Kuskokwim Delta. Brant nested on islands in lakes and sloughs in colonies. White-fronted Geese generally nested on the shorelines of ponds or along sloughs. Brant, being smaller birds, were unable to successfully defend their nests against foxes, but the White-fronts were able to defend successfully. The geese showed no preferences for vegetation types in their selection of nest sites.

During the brood season, Cackling Geese preferred sedge meadows for feeding and resting areas. Brant reared their young along tidal sloughs and rivers. White-fronted Geese utilized the heads of smaller sloughs for feeding and resting.

Predation was the cause of 65.8 percent of all goose and eider egg losses. Most losses were due to predation by Glaucous Gulls. The other predators, e.g., foxes and jaegers, did not cause significant losses. About half of all losses of goose and eider eggs and young were the result of human-induced predation. Adults, when disturbed, abandoned the nest or young, which exposed the nest or young to aerial predators. It was recommended that human activity on the nesting and brood rearing grounds be minimized.

Miller, P. A., C. S. Moitoret, and M. A. Masteller. 1985. Species accounts of migratory birds at three study areas on the coastal Plain of the Arctic National Wildlife Refuge, Alaska, 1984. pp. 447-485. In: Garner, G. W., and P. E. Reynolds (eds.). 1985. 1984 update report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 614 pp.

coastal, distribution, migration, species accounts, shorebirds, waterfowl, ANWR

Species accounts are presented based on intensive investigations of three sites during June-August 1984. The accounts are drawn from the investigator's field notes and from notes taken during brief site visits in 1983. The accounts describe status, breeding chronology, migration and habitat use.

Moitoret, C. S., P. A. Miller, R. Oates, and M. Masteller. 1985. Terrestrial bird populations and habitat use on coastal plain tundra. In: Garner, G. W., and P. E. Reynolds (eds.). 1984 update report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 777 pp.

coastal, distribution, migration, shorebirds, waterfowl, breeding biology, ANWR

Breeding birds were censused at three sites in ANWR as a continuation of previous terrestrial bird studies. As in past years, plots were arranged within landsat classes within each of the study areas and the densities of birds within each class compared between areas and between plots within a single study area.

Analysis of variance indicated significant differences due to location within each of the three habitats found at all three study sites. The most variable habitats were mosaic, wet sedge, moist sedge-shrub, and tussock tundra. Based on the diversity within these habitats and the

associated diversity in levels of bird use, the authors suggest defining tundra bird habitats by factors such as micro-relief, interspersion of ponds, and shrub cover rather than broad vegetation-type classes.

Murphy, S. M., B. A. Anderson, and C. L. Cranor. 1986. Lisburne terrestrial monitoring program -- 1985, The effects of the Lisburne Development Project on geese and swans. Prepared for Arco Alaska, Inc., P.O. Box 100360, Anchorage, Alaska. 151 pp.

Prudhoe Bay, Brant, Snow Goose, White-fronted Goose, Tundra Swan, Canada Goose, impact, behavior

Potential effects of the Lisburne development on geese and swans were evaluated through behavioral observation throughout the breeding season and surveys conducted largely from the road system. The entire area was searched on foot for nests.

Peak abundance of geese and swans during the pre-nesting period occurred during late May. The most abundant species were Canada and Greater White-fronted Geese, which concentrated in the vicinity of the West Dock Road.

Nest distribution, except for Tundra Swans, did not suggest any avoidance of development or disturbance. A total of 75 nests (46 Canada Goose, 24 Brant, # Greater White-fronted Goose, and 2 Tundra Swan) were found. Overall nest success was 16 percent. Canada Geese and Brant had near total breeding failures. Nests were lost to predation by gulls and foxes, flooding, clean-up crews, and road construction activities. Predation and human activity appeared to be related and more detailed observations were suggested to clarify this relationship.

There was a net movement of geese into the study area during the brood rearing period. Snow Geese and Brant primarily used salt-marsh areas, while the other geese remained inland. Distribution during the brood-rearing period was similar to distribution patterns recorded in previous years. Numbers of birds peaked during fall staging. Distribution patterns for Brant and Snow Geese were similar to brood-rearing but patterns for the other geese were less defined.

Vehicular traffic was the most frequent source of potential disturbance with a range of 0 to 67 vehicles/hour recorded along the roads. Noise levels exceeded 70 dB throughout most of the area; ambient levels outside the field were about 36 dB. Activity budgets of Canada and White-fronted Geese were affected by road traffic with the geese showing more alert and feeding behavior near the roads and less resting behavior. No effects were seen for Tundra Swans, Brant, or Snow Geese.

Myers, J. P. 1979. Leks, sex, and Buff-breasted Sandpipers. American Birds 33:823-825.

Barrow, Buff-breasted Sandpipers, behavior

Mating between Buff-breasted Sandpipers occurs on leks, small display grounds that are used exclusively for mating. Females choose their mates, copulate and then nest and raise the young alone. The males leave the tundra long before the eggs hatch. Behavior on the leks consists of a variety of raised wing displays and short flights.

Myers, J. P., and F. A. Pitelka. 1980. Effect of habitat conditions on spatial parameters of shorebird populations. Report to the Department of Energy. 82 pp.

shorebirds, habitat, breeding biology, prey, inland, coastal, Barrow, Atkasook, North Slope

Habitat ecology of shorebirds was studied intensively for five years on the North Slope of Alaska. Data were gathered at two study sites; a coastal site near Barrow and an inland site near Atkasook, along the Meade River. Permanent transects were censused every five days throughout the field season at each site. A total of 100 ha at Barrow and 140 ha at Atkasook was censused. Fourteen variables reflecting the physical and vegetative characteristics of the tundra were measured in each transect unit. The measurements wer combined in a factor analysis to identify major gradients explaining the variation in tundra. Habitat preferences were determined by analyzing the distribution along the habitat gradient corrected for the abundance of units defined along the gradients.

Four gradients describe the range of conditions seen in different tundra habitats: polygonization, pondiness, vegetation density, and shrubbiness. Shorebirds showed a seasonal shift in habitat use, moving to lower and wetter sites as the season progressed. Habitat selectivity varied inversely with density during the breeding season for territorial species. Following the breeding season, no correlation was seen between selectivity and density. Early in the season, shorebirds were distributed more evenly across habitat types, but toward the end of the summer, almost all were in low and wet ponded areas.

At Barrow, peaks in abundance were noted in the beginning of June (arriving birds), beginning of July (non-breeding transients), and late August (staging and migrating birds). The only peak of abundance at Atkasook occurred at the beginning of the summer. Numbers of birds inland gradually decreased following the end of breeding in early July. Inland habitats are used for breeding and coastal habitats are used by breeding birds for staging and resting during migration.

The annual variability of the bird communities was compared with that of other regions. The magnitude of variability was comparable to that of North American grasslands, and was not as variable as that in deserts. The coastal site was more variable than the inland site.

North, M. R., R. B. Renken, and M. R. Ryan. 1983. Habitat use by breeding Yellow-billed Loons on the Colville River Delta: 1983 Progress Report. U.S. Fish and Wildlife Service, Special Studies, 1011 East Tudor Road, Anchorage, Alaska. 13 pp.

Colville delta, breeding biology, habitat, Yellow-billed Loon

Habitat use of the Colville Delta by Yellow-billed Loons was studied in 1983. The loons were common breeders, with nesting beginning in mid-June. Incubation took about 27 days and productivity for 17 nests was 1.3 chicks/nest. The loons preferred deep _Arctophila fulva_ (Class IV) and deep-open (Class V) wetlands throughout the nesting season.

Intensive observations of seven pairs in July were made to determine home ranges, core use areas, and response to disturbances. Home ranges changed with the progression of ice-melt on the lakes. Males seldom left their territories and a single incident of a female leaving the territory was recorded. Adults seldom used river channels and foraging seemed confined to territories. Both parents fed the young. The young were brooded on or near the shore by one of the adults.

Norton, D. W. 1972. Incubation schedules of four species of calidridine sandpipers at Barrow, Alaska. Condor 74:164-176.

Barrow, Pectoral Sandpiper, Dunln, Baird's Sandpiper, Semipalmated Sandpiper, breeding biology

Incubation by four species of sandpipers at Barrow was observed for three seasons. Incubation was monitored by telemetric nest temperature recordings and by direct observation. For all species, nearly continuous incubation began during the latter part of egg-laying. The amount of time spent incubating began decreasing with the onset of hatching. Pectoral Sandpipers had the lowest nest attentiveness, 85 percent of the time, because all of the incubation is done by the female. For this species, the time spent incubating decreased during inclement weather due to the increased amount of time the female would have to spend foraging. Nest attentiveness in Baird's Sandpipers and Dunlins was greater than 95 percent of the time because both sexes shared incubation duties and did not have to compromise incubation time with foraging requirements.

Norton, D. C., I. W. Ailes, and J. A. Curatolo. 1975. Ecological relationships of the inland tundra avifauna near Prudhoe Bay, Alaska. pp. 125-133. In: J. Brown (ed.). Ecological Investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska. Biological Papers of the University of Alaska, Special Report 2. 215 pp.

Prudhoe Bay, shorebirds, habitat

Breeding shorebirds were studied at Prudhoe Bay for two years. Birds were censused on study plots totaling 45 ha. Plots were censused on a regular basis throughout the breeding season.

Habitat use by shorebirds in Prudhoe Bay was similar to that observed in Barrow. Nesting densities and species composition differed between the two areas and is likely due to differences in habitat composition. The study site in Prudhoe Bay lacked the extreme variation in microhabitat composition that is characteristic of Barrow. Nesting densities were lower in Prudhoe Bay for all species except for Semipalmated Sandpipers and Red Phalaropes.

Oates, R. M., A. W. Brackney, and M. A. Masteller. 1985. Distribution, abundance, and productivity of fall staging Lesser Snow Geese on Coastal habitats of northeast Alaska and northwest Canada, 1984. pp. 226-224. In: G. W. Garner and P. E. Reynolds (eds.). 1985. 1984 update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 777 pp.

Snow Geese, migration, ANWR

Staging Snow Geese were surveyed twice in September to determine their distribution, estimate population size, and estimate reproductive success. The main influx of geese occurred between 30 August and 7 September. Peak numbers counted gave an estimate of 94,528 geese. Photographs of the flocks for reproductive estimates were of insufficient quality to determine age ratios.

Petersen, M. R. 1979. Nesting ecology of Arctic Loons. Wilson Bulletin 91:608-617.

Arctic Loon, breeding biology

Arctic Loons were studied on the Yukon-Kuskokwim Delta from the time of their arrival in May to their departure in September, in 1974 and 1975. Nests were found in a 26.3 km^2 study area and the chronology of all nests followed. Pairs arrived on breeding ponds as soon as sufficient meltwater was available to allow their take-off and landing. Nesting did not begin immediately and was not related to the availability of nest sites. Loons may not begin yolk formation until their arrival on the breeding grounds and the delay in nest initiation may be due to the period required for the yolk formation. Predation was the major cause of nest failure. Gulls and jaegers primarily took island nests, while foxes took nests along lake shorelines.

Pitelka, F. A. 1959. Numbers, breeding schedule, and territoriality in Pectoral Sandpipers of Northern Alaska. Condor 61:233-264.

Pectoral Sandpiper, breeding biology, Barrow

Breeding bird censuses were conducted at Barrow for five seasons. Three study plots totaling 146 acres were censused each year. Information from these censuses and other incidental observations of Pectoral Sandpipers provided the data for this paper.

Breeding densities ranged from three to fifteen male territories per 100 acres and the number of females was similar. The pair bond is brief and nests are placed independently of the males' territory. Eggs may be laid over a long period from the beginning of June to the beginning of July. Males leave their territories in late June and early July. Females depart in late July and early August and the juveniles depart in August.

Flocking is most conspicuous in July when the numbers of both breeders and non-breeders moving about in early stages of migratory departure are greatest.

Pitelka, F. A. 1974. An avifaunal review for the Barrow region and North Slope of Arctic Alaska. Arctic and Alpine Research 6:161-184.

shorebirds, waterfowl, North Slope, distribution

This is a complete review of the status and distribution of birds that occur on the North Slope up to the time of publication. The main features of species composition and seasonality of the Barrow region avifauna are summarized and discussed. The avifauna of the region is strongly influence by the proximity of Siberia and many species have old world affinities.

Distributional zonation of birds on the North Slope is examined briefly with regard to physiographic and biological criteria for the delimitation of zones. The mid-Beaufort section is noteworthy in having relatively high densities of breeding waterfowl, which may be related to the presence of large river deltas and extensive nearshore lagoons.

Pitelka, F. A. 1979. Introduction: The Pacific Coast shorebird scene. Studies in Avian Biology 2:1-11.

migration, shorebirds, distribution

The distribution of shorebirds along the entire Pacific Coast, from Barrow to the southern tip of South America is discussed. The greatest diversity of breeding shorebirds occurs between 65 and 70 degrees north latitude. In the winter, the numbers of species in South America are roughly quadrupled by the influx of North American species. The geographic distributions are presented to exemplify the importance of various segments of the coast and the need to look at migratory requirements on a very broad eco-geographic scale.

Pitelka, F. A., R. T. Holmes, and S. F. Maclean, Jr. 1974. Ecology and evolution of social organization in Arctic sandpipers. American Zoologist 14:185-204.

shorebirds, breeding biology, North Slope, behavior, Semipalmated Sandpiper, Baird's Sandpiper, Dunlin, Pectoral Sandpiper, Buff-breasted Sandpiper

A comparative analysis of sandpiper social systems on arctic and subarctic breeding grounds (24 species in the family Scolopacidae, subfamily Calidridinae) shows four major patterns. In a majority of the species (15), populations are dispersed through a strongly developed territorial system, with strong monogamous pair bonds and only minor yearly fluctuations in numbers, e.g., Semipalmated Sandpiper, Baird's Sandpiper, and Dunlin. The second pattern is seen in three species in which the female of a pair may lay two sets of eggs in quick succession, one for each member of the pair to incubate, e.g., Sanderling. The third

and fourth patterns are of polygyny, e.g., White-rumped Sandpiper, and promiscuity, e.g., Pectoral Sandpiper and Buff-breasted Sandpiper. These last two groups show clumped dispersions; their year-to-year fluctuations tend to be strong; the males defend compressible, often small, territories; and high densities can occur locally. It is suggested that the pattern of overdispersion and monogamy represents a conservative mode of adapting to high latitude environments, while the pattern of clumped dispersion with polygyny or promiscuity represents an opportunistic mode in that the birds are concentrated into breeding areas where and when weather, food, and/or some other environmental factors are particularly favorable.

Sage, B. L. 1974. Ecological distribution of birds in the Atigun and Sagavanirktok River Valleys, Arctic Alaska. Canadian Field-Naturalist 88(3):281-291.

distribution

Bird observations made in the Brooks Range during the construction of the TAPS are compiled and listed as species accounts. This contains distributional information for a portion of the North Slope that has received relatively little attention.

Salter, R. E., M. A. Gollop, S. R. Johnson, W. R. Koski, and C. E. Tull. 1980. Distribution and abundance of birds on the Arctic Coastal Plain of northern Yukon and adjacent Northwest Territories, 1971-1976. Canadian Field-Naturalist 94(3):219-238.

Canada, shorebirds, waterfowl, migration, distribution, species accounts

Observation on avian distribution, abundance, habitat relationships, and seasonal movements in extreme northwestern Canada are summarized. A total of 122 species was recorded; at least 46 (and possibly an additional 14) nest in the area. The known breeding ranges of 15 species are extended. Species accounts in this paper present information on distribution, status, breeding and migration that was gathered during 30 studies conducted in the area. The coast is a major migration route for various waterfowl and shorebirds. The avifaunas of the Canadian and Alaskan portions of the Coastal Plain are similar, with the primary exception that Asiatic, Beringian, and maritime stragglers are confined largely to the Alaskan portion.

Schamel, D. 1977. Breeding of the Common Eider (Somateria mollissima) on the Beaufort Sea coast of Alaska. Condor 79:478-485.

North Slope, Common Eider, breeding biology, behavior

Common Eiders were studied for two breeding seasons on Egg Island, a barrier island near Prudhoe Bay. Behavioral observations were made from a blind using a 20 power spotting scope.

Eiders arrived as soon as open water was available. They were already paired and began nesting as soon as the island was surrounded by open water, which is assumed to be a defense against predators, notably Arctic foxes. Nests were camouflaged with vegetation and/or driftwood that also provided some wind protection. Males departed prior to incubation, which was done exclusively by the females. Nests tended to be clumped within Glaucous Gull territories, which may serve to reduce predation by the gulls.

Schamel, D., and D. Tracy. 1977. Polyandry, replacement clutches, and site tenacity in the Red Phalarope (Phalaropus fulicarius) at Barrow, Alaska. Bird-Banding 48:314-324.

Barrow, Red Phalarope, behavior, breeding biology

Red Phalarope behavior was observed at Barrow for two seasons. The Red Phalaropes showed less site tenacity than other Calidris sandpipers. Only four instances of serial polyandry were observed and it does not seem to be a common occurrence in the population. For polyandry to occur, there has to be an excess of males. This does not always occur and in one year there was an excess of females. Females are able to lay replacement clutches for clutches lost early in the incubation period.

Seaman, G. A., G. F. Tande, D. L. Clausen, and L. L. Trasky. 1981. Mid-Beaufort Coastal evaluation study: Colville River to Kuparuk River. MCHM, Alaska Department of Fish and Game, Anchorage, Alaska. Prepared for: The North Slope Borough. 180 pp.

North Slope, shorebirds, waterfowl, habitat, recommendations

This report was prepared for the North Slope Borough to provide information needed for their Coastal Management Plan. The report summarizes existing information on the area between the Colville and Kuparuk Rivers, called the Mid-Beaufort Area. Coastal habitats were identified and their use by fish and wildlife described. Critical habitat areas were described. Major activities that might affect the area were identified and mitigation measures recommended. Major information gaps and needed studies of fish and wildlife were identified.

Important areas identified for waterfowl included: Simpson Lagoon for molting Oldsquaw, the Colville River delta for breeding waterfowl, shorelines for migrating shorebirds, and saltmarshes for migrating shorebirds and waterfowl, particularly Brant. Management recommendations include timing and distance restrictions for activity in the vicinity of the high bird use areas and reiterate the recommendations made in Bergman et al. (1977) regarding wetlands.

Seastedt, T. R., and S. F. Maclean, Jr. 1979. Territory size and composition in relation to resource abundance in Lapland Longspurs breeding in Arctic Alaska. Auk 96:131-142.

Barrow, Lapland Longspurs, habitat, behavior

The relationship of size and composition of breeding territories to productivity of arthropod prey in the component habitats was studied in a population of Lapland Longspurs nesting near Barrow. Territories are established quite synchronously around the time of snow melt in early June, before their resource value can be assessed directly. Twenty territories averaged 1.76 ha in area. Large territories contained nearly equal amounts of wet, mesic, and dry habitat. Small territories contained less wet and dry habitat, but a much larger proportion of mesic habitat. Territory size was positively correlated with prey density in the year of measurement, due to an unusual abundance of prey in the relatively unpreferred wet habitat. Territory size was inversely correlated with indices of resource density based upon 3 and 7 years of data on prey productivity in the various habitats. These indices show average or expected prey density. The inverse correlation is increased when prey biomass data are weighted for prey selectivity by longspurs. No relationship between territory size and reproductive success was seen.

Sjolander, S., and G. Agren. 1976. Reproductive behavior of the Yellow-billed Loon, Gavia adamsii. Condor 78:454-463.

North Slope, Yellow-billed Loon, breeding biology, behavior

Breeding behavior of the Yellow-billed Loon was studied at Alaktak, approximately 80 km southeast of Barrow. Pairs were highly territorial, using both displays and calls in territorial encounters. Copulations, preceded by very little courtship, took place on land. The nest site was chosen by the male. Both sexes engaged in limited nest-building, mostly at nest relief, throughout incubation. Both parents incubated the eggs. The young left the nest at hatching but were brooded on the nest or on shore during the first days. Both parents fed the young, mostly with fish but also with plants. All pairs had two eggs, but only in one case were two young reared.

Sladen, W. F. L. 1973. A continental study of Whistling Swans using neck collars. Wildfowl 24:8-14.

Tundra Swan, distribution

The use of coded colored neck collars increased the resighting rate of individual Tundra Swans to as much as 90 percent compared with a resighting rate of only 5 percent for leg-banded birds. Individual birds were observed on both their breeding grounds on the North Slope and their wintering grounds in Maryland. Details of the continental marking protocol are given for four swan species. The information gained by the use of color neck collars far outweighed the small negative impact on the birds.

Soikkeli, M. 1967. Breeding cycle and population dynamics in the Dunlin (Calidris alpina). Annals Zoologica Fennica 4:153-198.

Dunlin, breeding biology

A color banded population of Dunlin was studied in Finland for 5-years. Dunlin arrived on the study site in mid-April. No difference in arrival dates was seen between males and females. Egg laying occurred over the course of a month and with few exceptions, the female laid a clutch of four eggs. Destroyed clutches were replaced during the early part of the incubation. Both adults incubate; incubation lasts 22 days. The female remains with the brood approximately 6 days past hatching; the male remains for approximately 19 days. The young are able to fly after 20 days.

Males showed strong site tenacity as did females. Males were often faithful, with the change of mate often due to the late arrival of one of the pair from the wintering grounds. In general, the young returned to the place of birth to nest. Of 222 Dunlin marked as young, 15 percent were later recovered on the study area and 11 percent were found nesting.

Spindler, M. A. 1978. Bird populations and habitat use in the Okpilak River delta area, Arctic National Wildlife Range, Alaska. U.S. Fish and Wildlife Service, Fairbanks, Alaska. 86 pp.

Okpilak delta, shorebirds, waterfowl, habitat, migration, ANWR

Bird census plots totaling 1.75 sq km in area on the Okpilak River delta were sampled to determine nesting bird density and total breeding and non-breeding population during the summer of 1978. A total of 57 bird species was observed on the study area, while 23 species were recorded as breeding. The most abundant species were: Lapland Longspur, Pectoral Sandpiper, Red Phalarope, Northern Phalarope, and Semipalmated Sandpiper. Bird populations varied about two-fold between the most productive and least productive habitat types censused. Ranked in descending order of total bird population, the four habitat types censused were Flooded Tundra, Mosaic Wet Sedge/Dry Sedge Tunrda, Upland Sedge-Tussock Tundra, and Wet Sedge Tundra. Total population ranged from 111.9 to 245.2 birds/square kilometer. Nesting density ranged from 45 to 87 nests/square kilometer. Features such as wetland characteristics and interspersion of microhabitat and micro-relief, to a large extent, best characterize coastal plain habitats, and combined with a knowledge of snow melt-off pattern, are likely the best predictors of avian density and productivity. On the Okpilak area, flooded polygonal tundra and mosaic wet/dry-high/low polygonal tundra will generally support more birds than drier tundra with less relief, a pattern which has been observed in other areas of the Alaska and Yukon North Slope.

Large bird populations were censused in a much larger (50 sq km) area. The most abundant species were Oldsquaw, Brant, Glaucous Gull, Red-throated and Arctic Loon, and Tundra Swan. Total density of large birds was 21.7/sq km but nesting density was low, at 3.5 nests/square kilometer. On two wetland areas regularly censused, total bird populations were lower but stable early in the summer; later, numbers were occasionally high, but sporadic. Patterns of large bird use were quite similar to those observed at Storkersen Point, with the areas receiving highest use including diverse wetland complexes (drained basins) and large, deep Carex, shallow

Arctophila and deep Arctophila wetlands. All are quite recognizable and separable during aerial surveys or from aerial photography taken in August.

Chronology of bird use includes an intense migratory period during the first week of June, high populations during courtship in mid-to-late June, and generally declining populations through July as nesting is completed and adults depart from mainland areas. A shift of bird use from generally dispersed in June to locally concentrated in July and August was noted, especially with respect to shorebirds moving to wetland areas, and waterfowl moving to larger wetlands and coastal lagoons during mid-July and early-August.

Spindler, M. A. 1983. Distribution, abundance, and productivity of fall staging Lesser Snow Geese in coastal habitats of northeast Alaska and northwest Canada, 1980 and 1981. pp. 88-106. In: Garner, G. W. and P. E. Reynolds (eds.). 1982 update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 379 pp.

Snow Goose, migration, ANWR

Fall staging of Snow Geese on the ANWR and adjacent Yukon Territory and Mackenzie River delta was observed from 7 August to 22 September. Observers censused the geese and estimated productivity through the use of aerial surveys and aerial photography of the flocking geese. The onset of staging in 1982 was earlier than in previous years, but major arrivals were normal, occurring 24-36 August. The duration of the staging period (20 days) was the second longest observed since 1971. A gradual buildup in numbers occurred through late August and early September with 30-40,000 birds estimated using the ANWR coastal plain at that time. Peak Snow Goose numbers were estimated on 14-15 September at 107,072 ± 13,866 in Alaska; 117,892 ± 15,279 in Yukon, and 6,155 in the Mackenzie delta, for a total western arctic population esimate of 231,119 ± 29,242. Estimated productivity was low, at 4.6 percent young. Spatial variation in productivity was observed, with concentrations of higher productivity occurring in Alaska as compared to farther east, a pattern opposite to that observed in 1981.

Medium telephoto lenses with a large-format 60 x 70 mm camera and ASA 400 film on cloudy days and a 35 mm camera and ASA 50 fine-grain film on sunny days produced the best photos for counting geese.

Spindler, M. A. 1984. Distribution, abundance, and productivity of fall staging Lesser Snow Geese in coastal habitat of northeast Alaska and northwest Canada, 1983. pp. 75-101. In: Garner, G. W., and P. E. Reynolds (eds.). 1984. 1983 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 614 pp.

Snow Goose, migration, behavior, impact, ANWR

USFWS and the Canadian Wildlife Service cooperated on the 1983 studies of staging Snow Geese in northeast Alaska and northwest Canada. Aerial surveys emphasized the temporal and spatial distribution patterns. Ground crews studied habitat use, feeding, and behavioral responses to aircraft overflights.

Fall staging was later than the previous 11 years, with major arrival occurring within the Canadian sections on 1 September and on ANWR sections on 8 September, which was 13 days later than 1982 and 2 days later than the long term average. Peak numbers were counted on 12 September for a total of 393,000 geese: 12,828 on ANWR, 300,651 on the Yukon North Slope, 54,523 on the Mackenzie delta and 25,000 south of the delta. The estimated numbers of geese on the Mackenzie delta and in ANWR were much lower than the long term average for those areas, while the estimate for the Yukon North Slope was much higher than average.

The entire staging ground was photographed and the age ratio determined on September 12. An overall ratio of 26.8 percent $\pm$ 11.0 young was observed, although the age ratios varied spatially. The highest percentage of young was observed on the Mackenzie River delta and the lowest on the Yukon North Slope. Productivity levels were higher than in 5 of the previous 9 years. The majority of the birds departed the staging areas between 21 and 26 September.

Snow Goose distribution on ANWR occupied generally the same area between the Hulahula and Egaksrak Rivers as in previous years, although the most frequently used concentration area centered more coastally and eastward in the Aichilik, Egaksrak, and Kongakut River deltas. Snow cover may have been a factor in this distribution. The majority of geese observed from the ground were feeding. The geese appeared to be feeding extensively on sedge rootstocks in wet sedge tundra and on grass leaf blades in riparian areas.

The sensitivity of Snow Geese staging in ANWR ws simliar to that noted in other studies in the Yukon. Geese were flushed by aircraft at an average of 3 km lateral distance and 3000 m altitude. An evening aircraft overflight on the lower Aichilik River caused all geese within a 4 km radius to take flight, 70 percent of which left the area, but total numbers the following morning were comparable to the previous morning's numbers. Low altitude flights (less than 30 m) caused less disturbance than those at higher altitudes.

Spindler, M. A., and P. Miller. 1983. Terrestial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge. pp. 108-200. In: Garner, G. W., and P. E. Reynolds (eds.). 1983. 1982 Update report, Baseline study of the fish, wildlife, and their habitas. U.S. Fish and Wildlife Service, Anchorage, Alaska. 379 pp.

coastal, inland, species accounts, ANWR, Okpilak delta

Birds were censused throughout the summer on plots near the Okpilak River delta and inland along the Katakturuk River to determine breeding, summer total, and fall bird populations. Census plots were placed within uniform habitat types and ranged in size from 25 to 50 ha. Smaller 10 ha plots were also censused to test the efficiency and reliability of using smaller plots. Habitats censused included: flooded, mosaic, wet-sedge, sedge-tussock, riparian willow, tussock, and sedge meadow. Detailed descriptions of all habitat types are included in the report. The riparian willow plots were all inland along the Katakturuk River. Species accounts for all birds observed during the study follow the report and include arrival and departure dates, habitat use, and breeding information.

A late break-up was followed by warm weather in late June and nesting dates were comparable to 1978. Twenty species bred on the Okpilak delta and 14 along the Katakturuk River. Breeding densities were highest in Riparian Willow and Mosaic plots and were lowest in Flooded and Sedge Meadow plots. Breeding densities on the Okpilak delta were generally comparable to 1978 densities, an exception being a 200 percent increase in Pectoral Sandpiper breeding densities.

Total summer population was higher than the breeding population, with 48 species observed at Okpilak and 35 along the Katakturuk. The largest numbers of birds occurred on Riparian Willow and Flooded plots. The lowest summer population was in the Sedge Meadow plot. Within year changes in the summer total were similar to those observed for breeding populations, and ranged from a 7 percent increase in the Mosaic plot to a 59 percent increase in the Wet Sedge plot.

In August, shorebirds increased at the coastal Okpilak site and decreased at the inland sites along the Katakturuk River. Fall staging densities were highest in the Flooded plot, exceeding 500 birds/km^2.

The replicate 10 ha plots gave larger estimates of breeding density and total summer density than did the large plot, except in the Wet Sedge habitat. Comparisons of replicate 10 ha plots and the corresponding 25 or 50 ha plot indicated that the replicate plots and the singular large plot provided comparable estimates of mean summer total population in the Wet Sedge and Sedge-Tussock plots, but estimates were not comparable on the more populous and diverse Flooded and Wet Sedge plots. Census of plots every 7-10 days during the breeding season and once in August gave comparable estimates to those from weekly censuses of the same plots.

Spindler, M. A., P. A. Miller, and C. S. Moitoret. 1984a. Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge. pp. 211-291. In: G. W. Garner and P. E. Reynolds (eds.). 1983 Update report, Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Ak. 614 pp.

coastal, distribution, habitat, ANWR, Okpilak delta

Birds were censused at three sites in the ANWR, at the Okpilak River delta, the Katakturuk River and at the Jago River-Bitty area. The study addressed the following objectives; (1) determine and compare habitat occupancy levels of breeding, resident, and transient birds using the major habitat classes defined by Landsat mapping; (2) determine breeding,

resident and transient population density estimates for population extrapolations based on Landsat classes; and (3) determine baseline levels of annual and seasonal variation for the most abundant and most conspicuous species.

The Landsat classification was found unsuitable for describing bird habitat and therefore also unsuitable as a basis for area-wide population extrapolations. Problems with Landsat included small scale patchiness in covertypes that was too small for Landsat to characterize, wide variation within Landsat Classes, and the absence of some important habitat parameters (notably shrub height). Riparian habitat showed the greatest variation, largely due to shrub height.

Landsat classes were modified by additional descriptors for habitat analysis. With the modified classification, habitat was generally more important in explaining variability than study site location. Exceptions were Pectoral Sandpipers and shorebirds as a group. Location is more important for these birds because they move to the coast upon completion of breeding. The shift to the coast is most pronounced in the later surveys.

Ranking of habitats by mean total bird density for three years of surveys on the Okpilak River delta produced the same ranking all three years. Some habitats had high annual varibility, but this variation did not affect the overall ranking.

Spindler, M. A., P. A. Miller, and C. S. Moitoret. 1984b. Species accounts of migratory birds at three study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984. pp. 421-463. In: G. W. Garner and P. E. Reynolds (eds.). 1983 update report of baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 614 pp.

coastal, distribution, migration, species accounts, ANWR, Okpilak delta

Species accounts describe the status, breeding chronology, migration and habitat use of birds at three study sites, Okpilak river Delta, Jago-Bitty River, and Katakturuk River. Each study are is presented separately. The information was drawn from the daily field notes of the investigators during June to August. The accounts include status information from previous years at the Katakturuk and Okpilak study areas. Information for 45 species observed at Okpilak River Delta, 51 species at Katakturuk, and 56 species at Jago-Bitty River is presented.

Troy, D. M. 1985a. Tundra Bird Monitoring Program. Annual Report of the Prudhoe Bay Waterflood Environmental Monitoring Program, U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska. 163 pp.

Prudhoe Bay, shorebirds, impact, waterfowl, habitat, Semipalmated Sandpiper, Pectoral Sandpiper, Dunlin, Buff-breasted Sandpiper, Golden Plover, White-fronted Goose, King Eider, Lapland Longspur, Pintail, Red Phalarope, Red-necked Phalarope

Impacts of a lightly traveled road on birds was studied for three years (over a four year period). Effects were measured on sighting density, nesting density and productivity. The study was part of the Prudhoe Bay Waterflood Monitoring Program and the road studied was the west field road, which connects the SOHIO side of the field with the West Dock.

Impoundments due to insufficient drainage across the road were the most extensive type of impact. They reduced or eliminated nesting habitat for Greater White-fronted Geese, King Eiders, Semipalmated Sandpipers, Dunlin, Buff-breasted Sandpipers and Lapland Longspurs. In contrast, Northern Pintail and Red and Red-necked Phalaropes used impoundments extensively during the breeding season and several species used impoundments during the post-breeding season.

Densities of early nesting species, e.g., Semipalmated Sandpiper, Dunlin, and Lapland Longspurs, are reduced close to the road due to the presence of persistent snowbanks and impoundments. This impact was less in 1984 than in 1981 and 1982.

Dust-induced early melt zones are used by early migrants and may support higher densities of nesting birds, at least under the low traffic conditions that occur along the West Road.

Pipelines and debris along the road provide nesting habitat for Snow Buntings and have resulted in much higher use of the road corridor than prior to the pipeline.

Troy, D. M. 1985b. Birds of Prudhoe Bay and Vicinity, A synopsis of the natural history of birds of the Central Arctic Coastal Plain of Alaska. Prepared by D. M. Troy, LGL Alaska Research Associates, Inc., Anchorage, Alaska. For Sohio Alaska Petroleum Company, Anchorage, Alaska. 36 pp.

Prudhoe Bay, shorebirds, waterfowl, breeding biology

Information about birds in the Prudhoe Bay vicinity is presented in two parts, first a general overview of the pattern of bird use followed by species accounts for some of the more common species. It is written to present detailed information about birds to the lay person and contains numerous excellent photographs. Species accounts include Snow Goose, Canada Goose, Oldsquaw, Common Eider, Lesser Golden-Plover, Semipalmated Sandpiper, Rednecked and Red Phalaropes, and Lapland Longspur.

Troy, D. M., and S. R. Johnson. 1982. Bird monitoring program. Annual Report of the Prudhoe Bay Waterflood Environmental Monitoring Program, U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska. 62 pp.

Prudhoe Bay, shorebirds, recommendations, habitat

This was the first year's report of a study conducted to determine the effects of a road on bird distribution, abundance, and nest success. The road was not open for through traffic and many of the effects were considered minimal, e.g., dust and noise disturbance. Two study areas

were established, an experimental area around the road and a control area away from the road. More birds were found in the experimental area, although nesting densities were similar for the two areas. The only exception was for Red Phalaropes, which nested in the experimental area at almost twice the density observed in the control area. Proximity to the coast was not a major factor in determining bird nest densities.

The road created extensive impoundments along the east side. Nesting density was only half as great on the east as on the west side. Immediately adjacent to the road (within 100 m) bird use was also reduced in the impounded area; however, over a broader area phalaropes decreased in abundance at increasing distances from the road. Semipalmated Sandpipers increased in abundance with increasing distance from the road.

Troy, D. M., D. R. Herter, and R. M. Burgess. 1983. Tundra Bird Monitoring Program. Annual Report of the Prudhoe Bay Waterflood Environmental Monitoring Program, U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska. 86 pp.

Prudhoe Bay, shorebirds, habitat, recommendations, habitat classification, Semipalmated Sandpiper, Pectoral Sandpiper, Dunlin, Red Phalarope, Lapland Longspur

This is the second year's report of a study conducted to determine the effects of a road on bird distribution, abundance, and nest success. The same experimental and control areas were used both years. Comparisons were made between areas and among years using ANOVA and paired-sample statistical methods to determine if changes in bird distribution, nest density, and nest success had occurred between years and if these changes might be attributable to the presence of the West Road. Because traffic levels were low during the two years of study, it is assumed that disturbance and dust effects were minimal. The only impact specifically addressed in this report is the effect of road-created impoundments on birds.

The 10 most common species were analyzed for changes in distribution and abundance. Five of these species: Semipalmated Sandpiper, Pectoral Sandpiper, Dunlin, Red Phalarope, and Lapland Longspur, were monitored for changes in nest density and success. The results showed that Semipalmated, Pectoral, and Buff-breasted Sandpipers, Dunlin, and Lapland Longspurs avoided impoundments. Repetition of the analyses using only birds observed foraging resulted in the addition of Red Phalaropes to the list of birds avoiding impoundments. Some of these species preferred natural aquatic habitats to other tundra habitat types available in the area. Nest density within 100 m of the road of all 5 species examined was approximately 50 percent lower on the southeast (impoundment) side. When the two sides of the road were compared, a reduction in nest density of all areas out to 1 km from the road could only be demonstrated for Dunlin. Nest success of Semipalmated Sandpipers and Red Phalaropes appeared to be reduced by approximately 20 percent near the road. Northern Pintails and Red-necked Phalaropes preferentially used the impoundments over other habitats.

Habitat analysis was based on the vegetation and surface form geobotanical units of the Walker and Webber classification. Similar units were combined to form 11 habitat classes. Preferred habitats varied among species to the extent that each habitat was preferred by at least one species.

Truett, J. C., R. Howard, and S. R. Johnson. 1982. The Kuparuk Oilfield Ecosystem -- A literature summary and synthesis and an analysis of impact research. L.G.L. Ecological Research Associates, Inc. Prepared for: ARCO Alaska, Inc., Anchorage, Alaska. 168 pp.

Kuparuk, shorebirds, waterfowl, recommendations

Available information on shorebirds and waterfowl as it applied to the Kuparuk Oilfield area was summarized, potential sensitivity to impacts discussed, information needs identified and reseach recommendations made. Sensitivity to impact was evaluated in terms of potential population level effects. For the birds that nest in the area, little is known about population regulation mechanisms and so potential levels of impact are not possible to predict. It was postulated that adult survival of some shorebird species may be controlled on the wintering grounds, but that the evidence was not clear and further study was needed. A major question regarding the impact of development on birds is the potential for birds displaced by development (birds have been shown to avoid roads) to successfully nest away from the disturbance, i.e., is there available habitat that can be used by displaced breeders.

U.S. Fish and Wildlife Service. 1982. Arctic National Wildlife Refuge coastal-plain resource assessment -- initial report. Baseline study of the fish, wildlife and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 507 pp.

North Slope, shorebirds, waterfowl, species accounts, ANWR

This is the first in a series of reports on the fish and wildlife on the coastal plain of the Arctic National Wildlife Refuge. The reports are mandated by congress to provide information prior to a final decision on oil and gas leasing in the refuge. The report contains a section on avifauna. Bird use is described for Landsat classes at two coastal study sites, for shorelines, and for lagoons. An annotated species list is presented that summarizes available records for each bird species known to occur on the refuge, as well as other pertinent ecological information currently available.

Nesting densities reported for the ANWR sites (Canning River and Okpilak River Deltas) were lower than other areas of the Arctic Coastal Plain. Differences may be related to census techniques, habitat composition, and/or geographic distribution of individual species. High annual variability was noted for plots with two years of data, largely due to decreased Red Phalaropes and Pectoral Sandpipers during the second year of the study. Seasonal habitat use was summarized from Martin and Moitoret (1981).

Four major periods of littoral or shoreline use were defined. Pre-breeding adults foraged along shorelines and saline pools during early June. Non-breeding birds used littoral areas in late June and July. Adults and junveniles staged in littoral areas prior to migration, with the heaviest use in August.

Three years of lagoon surveys demonstrated periods of peak use by species. The 11 lagoons surveyed were ranked based on density, absolute numbers, and diversity. Demarcation Bay, Tamayariak Lagoon, and Simpson Cove had the highest overall mean ranks.

The annotated species list summarizes all previous information on the status, population, habitat use and distribution of the species present on the Arctic Coastal Plain of ANWR. Most work had been done along the coastal portion of the region and data from the inner coastal plain were scarce. Much of the information was drawn from unpublished refuge reports.

van der Zande, A. N., W. J. ter Keurs, and W. J. van der Weijden. 1980. The impact of roads on the densities of four bird species in an open field habitat -- evidence of a long-distance effect. Biological Conservation 18:299-321.

impacts, habitat, recommendations

The effect of roads on the use of adjacent areas by birds were measured in open grassland areas in Norway. Bird use and nesting density was measured on strip plots placed perpendicular to the roads. Habitat distribution and other potential sources of disturbance, e.g., farm buildings, were included in the analyses. A long-distance effect was found for two of the four common species, the Lapwing and the Black-tailed Godwit, no effect was observed on the Oystercatcher and insufficient data were available for the Ruff. Depressed use of the area by affected species was measured up to 1.5 km from the road. The authors recommended that this type of effect be considered in evaluating the impact of planned roads.

Woodward-Clyde Consultants. 1982a. Oliktok Point and Vicinity: 1981 Environmental Studies. Prepared for: ARCO Alaska, Inc., Anchorage, Alaska.

Kuparuk, shorebirds, waterfowl

Qualitative surveys in the vicinity of Oliktok Point were conducted to determine bird use of the area. Brief surveys were conducted three times during the season, coinciding with major breeding events. Bird use was related to a general habitat classification: coastal spits and beaches, coastal lagoons, coastal brackish marshes, freshwater marshes, lakes and streams, and moist upland tundra. The study area was considered to be similar to the surrounding area and since no unusual components were present, many potential impacts in the area would be insignificant.

Woodward-Clyde Consultants. 1982b. Kuparuk Waterflood Project -- Final Report, Chapter 6 -- Avifauna. Prepared for: ARCO Alaska, Inc., Anchorage, Alaska.

Oliktok Point, Brant, shorebirds, waterfowl

Qualitative observations of bird use of coastal marshes were made during the latter part of 1982. Aerial surveys of the coast between Oliktok Point and Kavearak Point were conducted on three occasions and waterfowl and gull use recorded. Brant use appeared to be heavier in the vicinity of the Ugnuravik River. Bird abundance appeared higher in the nearshore zone than in the coastal marshes. Use of the coastal marshes declined in September.

Woodward-Clyde Consultants. 1983. Lisburne Development Area: 1983 Environmental Studies. Prepared for: ARCO Alaska, Inc., Anchorage, Alaska.

Prudhoe Bay, waterfowl

The Lisburne Development Area, located directly south of Prudhoe Bay, was surveyed in 1983 for waterfowl use. Goose, duck and swan nests were located and mapped. Nest densities for Brant, White-fronted Geese and Tundra Swans were considered typical for the Arctic Coastal Plain. Nesting Canada Geese were noted as unusual. Brood rearing areas were identified and mapped and substantial movements between nesting areas and brood rearing areas were observed.

2. SURFACE IMPACT BIBLIOGRAPHY

INTRODUCTION

The bibliography is focused on terrestrial impacts resulting from petroleum related development, primarily due to the placement of gravel. Gravel placement is a key activity as all facilities are placed on gravel pads which are interconnected by gravel roads. Many impacts are associated with gravel placement, such as direct loss of habitat, impoundments due to altered drainage patterns and thermokarst due to altered permafrost regimes. Contaminants and their associated impacts in wetlands are a separate major topic that is not addressed by this bibliography.

The geographic region of concern is the Arctic Coastal Plain and only studies relevant to this region are included. Studies conducted in the high Canadian Arctic and in the low Arctic taiga regions are generally not applicable as the ecosystems are different. Impacts to the terrestrial system are the focus of the bibliography and the aquatic system is not included.

Information on the actual impacts due to development is limited. The majority of impact-related research has addressed the effects of exploratory activities and much of this information is not relevant in addressing development impacts. The impacts due to exploration are different from development impacts in magnitude, intensity and type of activity. Exploratory operations typically last for only one or two seasons and usually are conducted during the winter. As a result, surface impacts are minimized and the only direct interactions with vertebrates are with scavengers, notably arctic foxes. Development activities occur year-round with continuous impacts to the surface such as dust deposition and impoundments. Vertebrates that breed and use the area for summer range, such as waterbirds and caribou, are directly affected by the activity. Many construction techniques used in exploration are for temporary facilities and are not used in development. The thin pads used in the National Petroleum Reserve and ice roads and runways are examples of temporary facilities used in exploration. Studies along the Dalton Highway have shown the qualitative difference between the two types of activity (e.g., Brown and Berg 1980) on surface impacts, noting that the impacts from ice roads were minor in comparison to those of gravel roads.

The lack of information on the types and severity of development impacts should be addressed. Information from studies on exploration has been used to partially address the lack of specific information and the bibliography includes those studies in which the author discussed the resistance and resilience of the vegetation or landforms to impacts. Resistance is the susceptibility or sensitivity of species and communities to disturbance in general. Resilience is the ability of species or communities to recover after disturbance and is often described for plants as pre-adaptation to colonize disturbed areas. These two concepts are important in developing the impact assessment methodology and this type of information will be used in developing the impact analysis portion of the manual.

Principles of revegetation are included in the bibliography, but not an exhaustive listing of all of the revegetation work that has been done. Revegetation will not be a major mitigation technique in an operating oilfield as few, if any, facilities are abandoned. The most current studies and older studies that present basic principles or discuss the resistance and resilience of vegetation to impacts are included. The knowledge about revegetation and the techniques are developing rapidly and much of the earlier work is now out of date.

The citations for the bibliography were obtained from searches of the following publications: Arctic, Arctic and Alpine Research, American Naturalist, Biological Conservation, Canadian Field Naturalist, Ecology, Ecological Monographs, Holarctic Ecology, Journal of Applied Ecology and Oecologia. Searches were made of federal, state, and local government holdings for unpublished technical reports.

KEY WORD INDEX

Each citation is followed by a list of key words. The key words include the geographic location and the major topics addressed by the study. Key studies of the natural condition of the North Slope are included. These and studies that discuss baseline conditions prior to disturbance have "baseline conditions" as a key word. Studies or review articles that make specific recommendations for future development have "recommendations" as a key word. "Resistance" is used as a key word for studies that discuss the susceptibility of species and communities to disturbance. "Resilience" is used for studies that discuss the ability of species or communities to recover after disturbance; the majority of these studies are about plants and refer to the pre-adaptation of particular species to colonize disturbed areas. "Recovery" is used for studies that determined the actual rate or period of recovery following specific disturbances. "Off-road travel" is used for any type of vehicle used to travel across the tundra and includes rolligons, air-cushion vehicles, and tracked vehicles.

Key words are listed below with the author and year of the citations that include that key word. The key words are listed first by geographic location, then by major type of impact (development or exploratory) and then by specific type of impact or information (e.g., dust, recovery, baseline conditions).

Geographic Location

Banks Island:

Kerfoot 1972; Lambert 1972

Barrow:

Abele 1976; Abele and Brown 1976; Abele et al. 1984; Webber 1978

Canada:

Adam and Hernandez 1977; Bliss and Wein 1972; Kerfoot 1972; Lambert 1972; Radforth 1972

Mackenzie Delta:

Kerfoot 1972; Lambert 1972; Radforth 1972

North Slope:

Abele et al. 1978; 1984; Alexander and Van Cleve 1983; Billings 1973; Brown and Berg 1980; Brown and Hemming 1980; Chapin and Chapin 1980; Chapin and Shaver 1981; Chapin et al. 1982; Ebersole and Webber 1983; Gartner 1983; Hanley et al. 1981; Hobbie 1984; Hok 1969; Komarkova 1983; Kubanis 1980; 1982; Lawson 1986; Lawson et al. 1978; Nelson and Outcalt 1982; Pamplin 1979; Reynolds 1981; Technan Engineering Limited 1982; Walker et al. in press; Webber 1978; Webber and Ives 1978; USDI-BLM 1978

Prudhoe Bay:

Benson et al. 1975; Brown 1975; Brown et al. 1984; Envirosphere 1984; Howe 1982; Klinger et al. 1983; Rawlinson 1983; Simmons et al. 1983; Walker et al. 1980

Trans-Alaska Pipeline:

Alexander and Van Cleve 1983; Brown and Berg 1980; Pamplin 1979; Spatt and Miller 1981

Major Type of Impact

Development Impacts:

Benson et al. 1975; Brown 1975; Brown and Hemming 1980; Brown et al. 1984; Eller 1977; Envirosphere 1984; Howe 1982; Klinger et al. 1983; Pamplin 1979; Rawlinson 1983; Simmons et al. 1983; Spatt and Miller 1981; Walker et al. 1980

Exploratory Impacts:

Abele 1976; Abele and Brown 1976; Abele et al. 1978; 1984; Adams and Hernandez 1977; Chapin and Shaver 1981; Ebersole and Webber 1983; Hanley et al. 1981; Kerfoot 1972; Komarkova 1983; Lambert 1972; Lawson 1986; Lawson et al. 1978; Nelson and Outcalt 1982; Radforth 1972; Reynolds 1981; Walker et al. in press; Webber and Ives 1978; USDI-BLM 1978

Specific Impact or Information

Impact Prediction:

Alexander and Van Cleve 1983; Bliss and Wein 1972

Baseline Conditions:

Brown 1975; Brown and Berg 1980; Hobbie 1984; Komarkova 1983; Rawlinson 1983; Walker et al. 1980; Walker et al. in press; Webber 1978

Impoundments:

Brown and Berg 1980; Brown et al. 1984; Envirosphere 1984; Howe 1982; Klinger et al. 1983

Contaminants:

Hobbie 1983; Simmons et al. 1983; Walker et al. in press; West and Snyder-Conn 1984

Dust:

Benson et al. 1977; Brown and Berg 1980; Dyck and Stockel 1976; Eller 1977; Envirosphere 1984; Techman Engineering Limited 1982

Gravel Spray:

Envirosphere 1984

Ice Roads:

Adam and Hernandez 1977

Off-road Travel:

Abele 1976; Abele and Brown 1976; Abele et al. 1978; 1984; Chapin and Shaver 1981; Hok 1969; Radforth 1972

Pipelines:

Brown and Berg 1980

Recommendations:

Brown and Hemming 1980; Chapin et al. 1982; Hanley et al. 1981; Klinger et al. 1983; Kubanis 1982; Lawson et al. 1978; Pamplin 1979; Webber and Ives 1978; USDI-BLM 1978

Recovery:

Abele 1976; Chapin and Shaver 1981; Ebersole and Webber 1983; Komarkova 1983; Lawson et al. 1978; Reynolds 1981; Walker et al. in press

Resilience:

Abele et al. 1984; Chapin et al. 1982; Ebersole and Webber 1983; Klinger et al. 1983; Komarkova 1983; Reynolds 1981; Walker et al. in press

Resistance:

Abele 1976; Abele et al. 1978; Billings 1973; Bliss and Wein 1972; Brown and Berg 1980; Lambert 1972; Spatt and Miller 1981; Webber and Ives 1978; USDI-BLM 1978; Walker et al. in press

Revegetation:

Bliss and Wein 1972; Brown and Berg 1980; Chapin and Chapin 1980; Chapin et al. 1982; Gartner 1983; Kubanis 1980; 1982; Lawson et al. 1978

Review:

Alexander and Van Cleve 1983; Brown 1975; Hanley et al. 1981; USDI-BLM 1978; Walker et al. in press

Roads:

Benson et al. 1977; Brown and Berg 1980; Brown et al. 1984; Howe 1982; Klinger et al. 1983; Spatt and Miller 1981

Snowbanks:

Benson et al. 1975; Envirosphere 1984

ANNOTATED REFERENCES

Abele, G. 1976. Effects of hovercraft, wheeled and tracked vehicle traffic on tundra. Proceedings of the Sixteenth Muskeg Research Conference, National Research Council of Canada. Associate Committee on Geotechnical Research Technical Memorandum No. 116. pp. 186-215.

Barrow, off-road travel, exploratory impacts, resistance, recovery

The effect of an air cushion vehicle (Bell SK-5), a small tracked vehicle ("Weasel"), and a rolligon on tundra was tested at Barrow. The test consisted of 1, 5, 25, and 50 passes of the first two vehicles in four separate areas over varying terrain. Effects were measured for the initial year and the four following years. Only 1, 5, and 15 passes were made with the rolligon due to deterioration of the vegetation mat after 15 passes. The rolligon was available only during the fourth year and so only the initial effects were recorded.

The visual appearance of the area was worst in the initial year but showed improvement the following year. After 4 years, the air cushion vehicle tracks were not visible for the 1- and 5-pass tracks and barely perceptible for the 25- and 50-pass tracks. The tracks for the Weasel were barely perceptible for the 1- and 5-pass tracks and visible for the 25- and 50-pass tracks. All of the rolligon tracks were visible the initial year.

The major impact of the air cushion vehicle was due to abrasion of the surface by the skirt of the vehicle. Microrelief affected the level of impact; areas of greater microrelief, such as high-centered polygons, were the most affected. These effects were enhanced with repeated passes. Well-concealed bird nests were not affected except by repeated passes. Exposed nests did not survive even one pass.

The visibility of tracks was due initially to the compression of the active layer. Visibility in subsequent years was due to the regrowth of some vascular plants that caused a "greening" effect. In all cases, except for the rolligon's 15 passes, any depression of the active layer began to rebound the following year. The visual impact appears largely aesthetic and no significant ecologic effects were noted.

Abele, G., and J. Brown. 1976. Arctic transportation: operational and environmental evluation of an air cushion vehicle in northern Alaska. American Society of Mechanical Engineers, ASME Paper No. 76-Pet-41. Journal of Pressure Vessel Technology, pp. 1-7.

Barrow, off-road travel, exploratory impacts

This is another report of the tests conducted with the air-cushion vehicle in Barrow (see Abele 1976). The same results and conclusions are presented. This report does include a detailed description of air cushion vehicles that is not contained in the other report.

Abele, G., J. Brown, and M. C. Brewer. 1984. Long-term effects of off-road vehicle traffic on tundra terrain. Journal of Terramechanics 21(3):283-294.

North Slope, Barrow, off-road travel, exploratory impacts, resilience

The effect of off-road vehicles on vegetation and thaw depth were studied at two sites on the North Slope, Barrow and Lonely. -Impacts of air cushion vehicles, light track vehicles, and rolligons were tested. Recovery of the active layer and qualitative observations of the vegetation were made 2, 3, and 10 years after the tests.

After 10 years, recovery had occurred in all test lanes. Rebound of the depressed tundra surface reached its original level. Rate of rebound for the rolligon test area is approximately 0.25 cm/year. Soil thermal regime (decrease in thaw depth) begins 2 or 3 years after the initial traffic impact. Standing water in vehicle tracks inhibits the recovery of the thermal regime.

Significant regrowth of some vascular plant species results in a "greenbelt" effect, which makes the traffic signature quite visible. This effect is longer lasting than surface depression or thermal changes and is considered largely an aesthetic impact. A general conclusion is that the tundra vegetative mat will usually recover to nearly its original state within several years, as long as the disturbance from vehicular traffic is limited to depression of the surface, even though it may have involved serious damage to the growing vegetation, as long as it did not damage the root system. If the disturbance due to traffic has resulted in shearing or separation of the organic mat due to excessive wheel or track depression, which is ordinarily accompanied by complete destruction of the mat, the result is a water-filled trough, and any recovery is very slow.

Abele, G., D. A. Walker, J. Brown, M. C. Brewer, and D. M. Atwood. 1978. Effects of low ground-pressure vehicle traffic on tundra at Lonely, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory. Hanover, NH. CRREL Special Report 78-16. 63 pp.

North Slope, off-road travel, exploratory impacts, resistance

Tests were conducted near Lonely to determine the effects of three different types of all-terrain vehicles on tundra. Two sizes of rolligons and a smaller tracked vehicle (Nodwell) were tested in similar terrain. The effects of 1, 5, and 10 passes along a straight path and around a curve were evaluated immediately after the test and one year later.

Vegetation impact was caused primarily by compression of the vegetation and the organic mat, and some displacement of vegetation and plant breakage. The large rolligon caused slightly more total impact than the smaller one; the Nodwell caused the least. The impacts were higher on curves than on the straight path.

The major impact seemed to be visual, that is the tracks were visible both on the ground and from the air immediately after the test and 1 year later.

Thawing of the active layer was not significantly increased in any of the test areas. None of the tests sheared or broke the vegetation mat and therefore the trails were expected to recover, based on the tests conducted at Barrow.

Adam, K. M., and H. Hernandez. 1977. Snow and ice roads: ability to support traffic and effects on vegetation. Arctic 30(1):13-27.

Canada, exploratory impacts, ice roads

A test of winter snow and ice roads was conducted in March 1973 near Norman Wells, N.W.T. Vegetation on the test site was boreal forest, characterized by black spruce, Laborador tea and other heaths, shrub birch, and several willows with a ground cover of bearberry and mosses. A test loop of road was built by first clearing the area, part with a bulldozer and part by hand for comparison purposes. Three road types were tested, a compacted snow road, an ice-capped snow road, and an ice road.

The snow road failed to support light traffic due to insufficient moisture in the snow, which resulted in the snow road not being hard enough. Capping the snow road with water, making an ice-capped snow road, strengthened the road so that it could support heavy traffic. The ice road supported heavy traffic. Both the ice-capped snow road and the ice road were tested with wheeled and with track vehicles. Both performed equally with wheeled vehicles but the ice-capped snow road was more durable when tested with track vehicles.

Vegetation recovery following the tests was similar in pattern to that reported for seismic lines. Average plant cover the season immediately following the tests was 12 percent. Plant cover increased to between 30 and 40 percent and consisted of shrubs and herbs. Plant cover on hand-cleared areas and bulldozed areas adjacent to the snow and ice roads was compared. In general, the hand-cleared areas showed less disturbance with slightly greater live-plant cover, taller shrubs, and less litter. These differences were slight and would be insignificant if the area was subject to additional disturbance.

In conclusion, the authors felt winter roads could be successfully used if sufficient moisture was present for snow roads or a water source for either ice-capped snow roads or ice roads.

Alexander, V., and K. Van Cleve. 1983. The Alaska pipeline: a success story. Annual Review of Ecology and Systematics 14:443-463.

North Slope, impact prediction, review, Trans-Alaska Pipeline

This article reviews the scientific successes and failures associated with the Trans-Alaska Pipeline. Extensive study programs were conducted to gather information about potential impacts from construction of the pipeline and to provide guidelines to minimize potential impacts. The authors consider the pipeline a success story because of the quantity and quality of the studies conducted that provided information on a previously little known region. They also noted the increased access provided by the pipeline and its infrastructure as a benefit in that it would allow continued study of the region, which had previously been difficult and costly to study.

Terrestrial and aquatic topics were briefly reviewed in this paper. Terrestrial topics include: vegetation and soils, oil spills, revegetation, mammals, and birds. The aquatic topics include: lakes, fish, disturbance to aquatic systems, and oil in streams and rivers. The reviews provide a good starting point for finding information on a particular topic. The conclusions presented for some of the topics, notably revegetation, birds and mammals are now outdated.

Benson, C., R. Timmer, B. Holmgren, G. Weller, and S. Parrish. 1975. Observations on the seasonal snow cover and radiation climate at Prudhoe Bay, Alaska during 1972. pp. 13-52. In: Brown, J. (ed.). Ecological Investigations of the Tudra Biome in the Prudhoe Bay Region, Alaska. Biological Papers of the University of Alaska, Special Report Number 2. 215 pp.

Prudhoe Bay, dust, roads, development impacts

Seasonal snow cover and snow distribution patterns were studied during the winter of 1971 and 1972 in the Prudhoe Bay area with some additional observations made in 1973. Transects for measuring snow depth, water content and other variables were established perpendicular to roads.

Prevailing winds are almost exclusively from two directions, either east or west, during the winter. Winter storms were generally from the west and new snow deposition was largely associated with west winds. East winds tended to redistribute the new snow. Large drifts formed along roads that were perpendicular to the prevailing winds (north-south roads).

Windblown dust is deposited on the snow in the spring. Dust comes from the dunes adjacent to the Sagavanirktok River delta and from heavily trafficked roads in the oilfield. Dust decreases the albedo of the snow resulting in earlier melt than other areas. Most dust deposition is associated with east winds and the west side of roads tends to melt first.

Billings, W. E. 1973. Arctic and alpine vegetations: similarities, differences, and susceptibility to disturbance. BioScience 23:697-704.

North Slope, resistance

The author reviews the characteristics of alpine and arctic areas over a vast geographic region, from the Andean mountains in Ecuador to Peary Land in Greenland. Fragility of arctic and alpine systems and their susceptibility to disturbance is discussed in general. Differences in susceptibility are noted and related to the type of vegetation, soil, permafrost and animal life present.

In general, recovery is slow because of the short growing season and harsh climate. The extent of potential disturbance varies, largely related to the amount of ground ice. Permafrost areas are most susceptible due to thermokarst processes that can occur when the vegetation mat is disrupted. The resulting loss of soil leads to an indefinite recovery period. (Once the soil is removed, an unknown time is required to replace it, which could easily be thousands of years.) Areas with rocky or dry soils are less susceptible to damage.

Bliss, L. C., and R. W. Wein. 1972. Ecological problems associated with Arctic oil and gas development. In: Proceedings, Canadian Northern Pipeline Research Conference, 2-4 February 1972. National Research Council of Canada, Associate Committee on Geotechnical Research, Technical Memorandum 104 (NRCC 12498).

impact prediction, Canada, revegetation, resistance

Different regions in the Canadian Arctic were described and the biota, climate, and topography contrasted. Major regions included the Mackenzie Delta, the eastern Arctic Islands, and the mainland. The differences were emphasized to illustrate the need for different management strategies in each of the regions.

Vegetation response to disturbance was discussed in general terms. Moss and lichen communities were noted as the most susceptible to disturbance and the slowest to recolonize disturbed areas. Some of the difficulties with revegetation include the need to use plants that will be sufficiently hardy to survive in the high Arctic and the variation in the various regions that will require different plants. Revegetation will not lead to "natural communities" at least in the short term due to changes in the microtopography and microclimate.

Vertebrates were predicted to be affected by losses of habitat, when the development was extensive, and by behavioral avoidance of development structures. The exact magnitude of the effect could not be predicted due to the lack of detailed ecologic knowledge. Two major recommendations were to continue integrated baseline studies and to set aside nature preserves, such as the Arctic National Wildlife Range (now the Arctic National Wildlife Refuge).

Brown, J. (ed.). 1975. Ecological investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska. Biological Papers of the University of Alaska, Special Report No. 2. 215 pp.

Prudhoe Bay, baseline conditions, development impacts, review

During the period 1970-1974, the U.S. Tundra Biome Program, which was stationed in Barrow, performed a series of environmental and terrestrial ecological studies at Prudhoe Bay. The purpose of many of the studies was to compare the Prudhoe area with the more intensely studied Barrow area. The studies were grouped into three major subdivisions: abiotic and soil investigations, plant investigations, and animal investigations. The abiotic section contains papers on the air and soil temperature regimes;

the snow cover, particularly its properties adjacent to the roadnet; major soil and landform associations; and the chemical composition of soils, runoff, lakes, and rivers. The plant section contains reports on a general vegetation survey; a follow-up vegetation mapping project, and a study of the growth of arctic, boreal, and alpine biotypes in an experimental transplant garden. The animal section contains reports on the tundra invertebrates; the bird, lemming, and fox populations, and the behavioral and physiological investigations of caribou and several experimental reindeer. Appendices contain a checklist of the vascular, bryophyte, and lichen flora of the Prudhoe Bay area and selected data on vegetation.

Brown, J., and R. Berg (eds.). 1980. Environmental engineering investigations along the Yukon River to Prudhoe Bay Haul Road, Alaska, U.S. Army Cold Regions Research and Environmental Laboratory, Hanover, NH. CRREL Special Report 80-19. 187 pp.

North Slope, Trans-Alaska Pipeline, baseline conditions, dust, impoundments, revegetation, resistance, roads, pipelines

The Federal Highway Administration sponsored a series of environmental engineering investigations along the Yukon River to Prudhoe Bay Haul Road from 1975 to 1978. The Department of Energy joined these investigations in 1976 with ecological studies that continued through 1980. This volume is a collection of the major studies conducted by these two agencies. The research had five main objectives: (1) evaluate the performance of the road; (2) assess the changes in the environment associated with the road; (3) document the flora and vegetation along the road; (4) develop methods for revegetation and restoration; and (5) assess biologic parameters as indicators of environmental integrity. Specific studies were made of climate, thaw and subsidence, drainage and side slope performance, distribution and properties of road dust, vegetation distribution, vegetation disturbance and recovery, occurrence of weeds and weedy species, erosion and control, and revegetation. Studies that pertain to the North Slope are outlined below. Names of the authors follow the summaries.

Climate on the Arctic Coastal Plain is characterized by cold winters, cool summers and short thaw seasons. The mean annual temperature is -10.6 to -12.8 degrees centigrade. Wind is a significant environmental factor due to wind-chill effects and the blowing and drifting of snow. Precipitation amounts are relatively low (170 to 266 mm) with a greater proportion occurring as snow (95-165 mm frozen vs 56-101 mm unfrozen). (J. Brown)

The roadbed investigation focused on the magnitude of thaw under and adjacent to representative portions of the road and the associated settlement of the road. Drainage problems were surveyed. Seasonal thaw probably does not penetrate the 1.7 m or 1.8 m thick embankment along the northernmost portion of the road. Ice-rich side slopes tend to stabilize from erosion after a few years by thaw degradation and resulting subsidence that continues beneath the ditches and roadway embankment. The most frequent problem related to cross drainage was observed to be clogging of culverts by gravel pushed down during maintenance. Lateral drainage problems were caused by the interception of waterflow by access roads that did not have culverts. (R. Berg)

Road dust loads decreased logarithmically away from the road at all sites and was closely related to prevailing wind direction. Silt and finer material constituted between 8 and 15% of the material available for transport. Significant peaks in the concentration of available soil cations occurred with respect to distance from the road, most commonly at 312 m from the road. Other peaks occurred at 30 and 125 m and were probably related to particle size. The dust loads contained insufficient soluble calcium and magnesium to directly affect either the pH or nutrient status of the soil but the direct effects were observed on some plant species. Early snow melt (2 to 3 weeks) brought about by dust accumulation in the winter may extend between 30 and 100 m on either side of the road. (K. Everett)

Revegetation and restoration approaches were observed and their short-term success was evaluated. The majority of revegetation involved mulching, fertilizing, and seeding with non-native grasses. Attempts to use native grass species were limited due to a lack of availability. Native species had been slowly reinvading revegetated areas. Willow cuttings using unrooted cuttings seemed to be successful. Impacts from a snow and ice pad used during the construction of the fuel gas line were varied. Microtopography was generally reduced due to debris filling the depressions and abrasion of tussock or hummock tops. Depth of thaw was initially greater where the snowpad was located, but decreased with time. Plant species varied in susceptibility to damage; willow and birch shrubs were frequently sheared off and mosses were more susceptible to damage from debris. Overall, the disturbance due to the snowpad was minor when the construction was conducted in a careful manner and gravel and fill material were not stored on the snowpad. (L. Johnson)

Brown, J., B. E. Brockett, and K. E. Howe. 1984. Interaction of gravel fills, surface drainage, and culverts with permafrost terrain. Final report prepared for State of Alaska Department of Transportation and Public Facilities, Division of Planning and Programming, Research Section; 2301 Peger Road, Fairbanks, AK. 35 pp.

Prudhoe Bay, roads, impoundments, development impacts

Culvert performance in terms of drainage across roads in the Prudhoe Bay and Kuparuk Oilfields was studied for three years. Thermal probes were placed around culverts to assess the causes of failure or inefficiency in operating.

A major cause of culvert failure or insufficient drainage is due to alteration of the thermal regime beneath the culvert. Frozen ground below the culverts thaws, resulting in subsidence of the center of the culvert. Sinking of the center causes the ends of the culverts to bow upwards, which reduces the drainage efficiency.

Brown, J., and J. Hemming. 1980. Report on the Workshop on Environmental Protection of Permafrost Terrain. The Northern Engineer 12(2):30-36.

North Slope, development impacts, recommendations

A workshop on Environmental Protection of Permafrost Terrain was held in May of 1980 in Fairbanks. The purpose of the meeting was to discuss the effects of large engineering projects on permafrost terrain. Recent experiences with the Trans Alaska Pipeline were the focus of much of the discussion. The intent of the meeting was to provide a forum for information exchange between engineers and scientists from the government, universities and the private sector.

Conclusions and recommendations from the workshop included:

1. Interdisciplinary teams should be utilized in all phases of large projects.

2. Effective communications along all disciplines involved should be established early and maintained. Surprises should be avoided.

3. Monitoring prior to, during, and after construction should be an integral part of the project design. Analysis of data to assess impacts should be a continuing part of the process.

4. Case histories should be documented, published, and available.

5. Engineering designs based on recent innovative practices should be incorporated into revised doctrine, manuals, or specifications.

6. Data acquired on a project should be readily available to all interested parties and only patentable or otherwise competitive data treated as proprietary.

Chapin, F. W., III, and M. C. Chapin. 1980. Revegetation of an arctic disturbed site by native tundra species. Journal of Applied Ecology 17:449-456.

North Slope, revegetation

Succession on an organic tundra soil in interior Alaska was monitored for ten growing seasons following removal of vegetation. The study was conducted at Eagle Creek in an upland tundra community underlain by permafrost and dominated by <u>Eriophorum vaginatum</u>. The site is similar to other <u>E. vaginatum</u> dominated communities in northern Alaska and other circumpolar tundra. A 20 x 50 m plot was bulldozed free of vegetation and the organic layer exposed. Seeds of six exotic grass species commonly used in revegetation were sown in a random design, both with and without fertilizer.

Exotic grasses established on the plots in the first season but decreased in density after three years and were virtually eliminated after five years. Fertilization did not affect initial density or long-term survival of the exotic species but did increase shoot density of native species three years after the disturbance.

Native sedges established on the disturbed site in 5-10 years, producing an above-ground biomass equal to that in undisturbed tundra. The sowing of exotic species neither promoted nor retarded long-term natural revegetation and the utility of sowing exotics is questioned except in cases where severe erosion may occur.

Chapin, F. Stuart, III, and G. Shaver. 1981. Changes in soil properties and vegetation following disturbance of Alaskan Arctic tundra. Journal of Applied Ecology 18:605-617.

North Slope, off-road travel, exploratory impacts, recovery

Soil characteristics and vegetation were studied in and adjacent to four vehicle tracks over a broad geographic range. The study was conducted at sites adjacent to the Haul Road and along a moisture gradient. The wet sites were at Franklin Bluffs and Slope Mountain, mesic sites at Sagwon, Slope Mountain, and Fish Creek, and dry sites at Franklin Bluffs, Slope Mountain, and Fish Creek. The organic mat at Franklin Bluffs had been only lightly compacted; it was partially removed at Sagwon, Slope Mountain, and Fish Creek. A track where the organic mat had been removed entirely was examined at Sagwon. The following soil parameters were measured: thaw depth, soil temperature, bulk density, moisture content, pH, organic content, available phosphorus, and presence of ferrous iron. The following vegetation parameters were measured: above-ground biomass, tiller density, shoot weight, nitrogen and phosphorus concentration, leaf production rate, depth distribution of live root biomass in selected stands, and cover (visually estimated).

Vehicle tracks generally had slightly higher soil temperatures, deeper thaw, and higher concentrations of available soil phosphate than adjacent undisturbed tundra, but did not differ consistently from controls in soil bulk density, volumetric moisture content, pH, or soil organic content. Vegetation in the tracks had fewer species than controls, reflecting decreased abundance of shrubs, particularly evergreens, and increased dominance by a few species of graminoids. Wet and mesic tracks exhibited a 2- to 15-fold increase in above-ground standing crop of nitrogen and phosphorus as a result of increased leaf nutrient concentrations and increased leaf biomass of graminoids, a consequence of increases in both shoot density and shoot weight.

The results do not support the original hypothesis that the known temperature effects upon root growth, nutrient absorption, and organic matter mineralization account for the increased standing crop of biomass and nutrients in vehicle trails. The authors conclude that other factors, perhaps related to soil water and nutrient movement, are in large part responsible for the increased nutrient status and production of vehicle tracks and exert an important control over growth in undisturbed tundra.

Chapin, F. S., G. R. Shaver, and A. E. Linkins. 1982. Revegetation of Alaskan disturbed sites by native tundra species. U.S. Army Research Office, Grant #DAA G 29-79-C-0112. 16 pp.

resilience, revegetation, North Slope, recommendations

This is a summary report of 6 years of studies conducted by the authors and their associates. The purpose of the research was to develop methods by which the recovery of native plant populations might be promoted on development-related disturbances in northern Alaska. Much of the revegetation to date had been done with non-native species, which is undesirable because they may eliminate native plants or reduce their recovery.

The research focused on two major topics. The first was a series of descriptive and experimental studies of relationships between species composition, primary production, biomass turnover, and nutrient cycling in tundra ecosystems. The assumption underlying these studies was that vegetation response to tundra disturbance is largely mediated by changes in nutrient cycling caused by the disturbance. The second line of research addressed plant population dynamics, in particular, the establishment and growth of species in natural and man-caused disturbances. The latter comparison looks at how well native plants might be "pre-adapted" to unnatural disturbances, and how the disturbances might be manipulated to promote native plant recovery. The research was conducted at Toolik Lake, sites along the Haul Road, and in alpine tundra at Eagle Summit. As the studies addressed basic ecologic processes, the results are widely applicable.

Species composition, production, and biomass turnover studies showed complex interactions between factors that limit growth. Species respond differently to yearly variation in weather conditions, each species is individually distributed, there are patterns of specialization of resource use, and no single limit to growth and productivity. As a result, it is difficult to generalize about specific nutrient limitations although tundra in general is nutrient limited.

Studies of plant population dynamics demonstrated the importance of seeds present in the soil. This buried "seed bank" contributes to the reproduction of some tundra species. Eriophorum vaginatum was the most abundant species due in part to establishment from seeds in the seed bank and in part to its ability to alter its life history strategy in response to disturbance.

The primary recommendation was to stockpile and reuse organic soil to cover disturbed areas. The original recommendation to fertilize the adjacent area to stimulate seed production was determined to be less successful because most native plant populations are established from the buried seed bank. In cases of severe erosional potential, the organic cover could be fertilized or sown with non-native species.

Dyck, R. I., and J. J. Stokel. 1976. Fugitive dust emissions from trucks on unpaved roads. Environmental Science and Technology 10(10):1046-1048.

dust

A mathematical expression for estimating the fugitive dust emissions from trucks operating on unpaved roads was developed. The expression suggests a linear relationship between vehicle speed, vehicle weight, and silt content of the road.

Ebersole, J. J., and P. J. Webber. 1983. Biological decomposition and plant succession following disturbance on the Arctic Coastal Plain, Alaska. pp. 266-271. In: Proceedings of the Fourth International Conference on Permafrost, University of Alaska, Fairbanks, Alaska; 18-22 July 1983. Washington, D.C.: National Academy Press.

North Slope, exploratory impacts, recovery, resilience

Vegetation at a 30-year-old well site was investigated and the recovery measured. Vegetation plots were established and species abundance and distribution monitored through four seasons. Growth of willows was measured for 2 years.

Vigorous stands of grasses and erect willows dominate the mesic disturbed areas. The presence of these communities was hypothesized to be the result of greater decomposition rates in the warm, well-drained sites and greater nutrient availability. The increase in willows and grasses, which are pre-adapted to colonizing natural disturbances, was at the expense of other plants usually present in tundra communities. The conditions on the disturbance are predicted to continue for an extended time.

Eller, B. M. 1977. Road dust induced increase of leaf temperature. Environmental Pollution 13:99-107.

dust, development impacts

Only a part of the solar radiation absorbed by plant leaves is used for photosynthesis, the rest is converted to heat and influences energy balance. Dust cover on leaves increases their absorptivity and increases leaf temperatures, which leads to overheating. Respiration may increase much faster with rising temperature than does photosynthesis, consequently reducing the net photosynthesis. The primary factor causing overheating is absorbed energy in the wavelengths over 700 nm.

Envirosphere. 1984. Synthesis, Prudhoe Bay Waterflood Project Environmental Monitoring Program 1983. Prepared for Department of the Army, Alaska District, Corps of Engineers, Anchorage, Alaska. 46 pp.

Prudhoe Bay, development impacts, dust, impoundments, gravel spray. snowbanks

An aspect of the Waterflood Monitoring Program was to measure the effects of the West Field Road on the surrounding vegetation and birds. Bird and vegetation studies were not conducted in 1983, but measurements of some of the physical attributes were continued. The road was used during the winter for construction of the adjacent pipeline and during the summer for construction of Pad K. Both activities resulted in major physical changes along the road, the most notable being an increase in gravel cover, which destroyed several vegetation plots and parts of established bird transects.

Snowbanks along the road were not generally persistent with the exception of a north-south section of the road that had a large drift, which may have been partially responsible for the extensive impoundment in the area. Snow removal for pipeline construction and road traffic resulted in scraping of vegetation and soil underneath the pipeline and deposition of gravel and debris adjacent to the road. Construction disturbed vegetation plots had less vegetation cover (mesic 15-20 percent less and dry 80 percent less).

Impoundments were more extensive than in the previous two years. Impoundments were greener than the non-impounded side of the road. A pilot study showed that the greening was due to increased growth of Carex aquatilis, less standing dead, and water cover. Thaw depth in the impoundments was the same as the opposite side of the road but impoundments did not appear to be in a steady state and conditions may change. In some impoundments, the active layer had detached and it seems likely that the thaw conditions would change, perhaps leading to a deeper impoundment with no vegetation.

Gartner, B. L. 1983. Germination characteristics of Arctic plants. pp. 334-338. In: Proceedings of the Fourth International Conference on Permafrost, University of Alaska, Fairbanks, Alaska; 18-22 July 1983. Washington, D.C.: National Academy Press.

North Slope, revegetation

The seeds of _Eriophorum vaginatum_ and many other arctic plants were found to have germination traits similar to colonizers in the temperate zone. In general, they have the following traits: the seeds are wind dispersed, intrinsic dormancy is non-existant or weakly developed, the optimal temperature for germination varies between populations within the range of 20 to 30 degrees centigrade, and some viable seeds are stored in the buried seed bank in organic soil (no seeds were found in the mineral soil).

Hanley, P. T., J. E. Hemming, J. W. Morsell, T. A. Morehouse, L. E. Leask, and G. S. Harrison. 1981. Natural resource protection and petroleum development in Alaska. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-80/22.

review, North Slope, recommendations, exploratory impacts

This study reviews a variety of issues associated with oil and gas development. The purpose of the study was to provide a review of oil and gas leasing and development procedures and activities because leasing of federal lands for oil and gas was expected with the final resolution of Section d2 of the Alaska Native Claims Settlement Act. It was believed that some federal lands contained high oil and gas potential and that the federal government would be involved in leasing programs and be responsible for environmental protection of the lands.

The then-existing permitting system and the associated legislative mandates are covered in detail. Much of this information is now out of date. The history of oil and gas development in Alaska is reviewed. Petroleum industry practices are listéd with brief descriptions. The descriptions present the general case and, as stated in the summary, are lacking in details. Potential impacts on wildlife are listed and subjectively related to the various types of development activities. The impact information is not well referenced and again is presented for the general case. Two case studies of petroleum activities are presented, exploration in the National Petroleum Reserve-Alaska and the Kenai Peninsula. The information on NPR-A covers only exploratory activities.

Information needs for evaluating impacts are discussed in some detail. The need for information is critical, particularly in the Arctic where relatively little is known about the natural system. Decisions regarding studies designed to gather information for resource managers are important and guidelines are presented for making these decisions. Much of these guidelines were drawn from the Trans-Alaska Pipeline experience and the planning effort for the Natural Gas Pipeline. The major recommendations include: an interdisciplinary approach, an open planning system that involves resource managers and scientists, incorporation of a method for information synthesis, and follow-up studies to determine the value of mitigation and the accuracy of predicted impacts. These recommendations need to be formalized into a written agreement prior to the initiation of any large projects.

Hobbie, J. E. 1984. The ecology of tundra ponds of the Arctic Coastal Plain: A community profile. U.S. Fish and Wildlife Service, FWS/OBS-83/25. 52 pp.

North Slope, baseline conditions, contaminants

This community profile synthesizes much of the information on the ecology of tundra ponds and wetlands. Information on pond ecology is drawn largely from the IBP studies at Barrow and information of birds comes largely from Fish and Wildlife studies in NPRA and at Point Storkerson. Wetlands are classified using the system developed by Bergman et al. (1977).

Nutrient dynamics in the ponds are complex and interactions are controlled by the sediments. Iron comes from the iron-rich peat soils and is present in a thin oxygenated zone on the surface of the pond sediments. Phosphorus binds to the iron, which results in low concentrations of phosphorus in the water column. Relatively more nitrogen is present but most is inorganic and therefore not available. Nitrogen fixation occurs at a low rate in the sediments and the available organic nitrogen is rapidly used by the plants. As a result of these processes, production in the ponds and lakes is limited by both phosphorus and nitrogen.

Ponds contain many organisms similar to temperate ponds although some groups are not present and those that are have fewer species represented. Phytoplankton, zooplankton, and benthic organisms are all prestent but amphibians, dragonflies, mayflies and true bugs are missing. Fish are present only in waters deeper than 1.7 m.

The majority of carbon fixed in a pond is by Carex. As there are no herbivores that eat the sedge, the carbon is deposited in the pond and enters the detrital system. Carex achieves the same productivity as temperate plants.

Two ways development can adversely affect wetlands are through oil spills and through road construction. Zooplankton are the most dramatically affected by oil and in an experimental spill in a pond near Barrow, it was six years before the zooplankton community was re-established. Roads block drainages and create artificial impoundments, which resemble natural lakes but may be less productive for birds than the original wetlands.

Hok, J. R. 1969. A reconnaissance of tractor trails and related phenomena on the North Slope of Alaska. U.S. Department of Interior, Bureau of Land Management Publication. 66 pp.

North Slope, off-road travel

A broad reconnaissance of off-road vehicle trails was conducted for one summer to obtain preliminary observations of vegetation recovery on trails of known history, to compile a bibliography of studies on the effects of off-road vehicles, and to develop hypotheses about the effects of vehicles on tundra vegetation. Trails of known history were visited and the effects of past disturbance were described in relationship to the topography of the region. For each trail, the season of use, mode of construction, and vehicle that caused the major disturbance were recorded. Numerous photos of each site were taken and are included in the report.

The report presents a broad overview of the types of disturbance that can occur. The importance and interrelationship of season, the degree of disturbance, the moisture content and topography and their effects on erosion are well illustrated.

Howe, K. 1982. Observations of impoundments and culvert performance along the West Dock to Pad E Road, Prudhoe Bay, Alaska. Draft interim report to Alaska Department of Transportation and Public Facilities. 44 pp.

Prudhoe Bay, impoundments, road, development impacts

Culvert performance and impoundments were observed along a road in Prudhoe Bay that was built according to typical design criteria. Measurements of thaw depth, water movement and culvert status were conducted for one summer.

In late July, approximately 15 cm of frozen gravel was encountered at the base of the road, however, by early September the thaw had penetrated through the gravel fill. The road, with a frozen base, acts like a dike and does not pass surface water. As a result, extensive impoundments were formed along the east side of the road. Maps from earlier years showed that the extent of ponding varies from year to year depending on climatic conditions.

Culverts placed in the road were not effective due to deformation and subsidence. The culverts may alter the surrounding thermal regime enough to thaw frozen gravel and allow permafrost degradation beneath them. They subside in the middle and the ends bow up until they are above the level of adjacent standing water.

Kerfoot, C. E. 1972. Tundra disturbance studies in the western Canadian Arctic. ALUR 1971-1972. Department of Indian Affairs and Northern Development, Canada. 115 p.

Mackenzie Delta, Banks Island, exploratory impacts

Impacts of summer and winter seismic operations on the Mackenzie Delta region and a winter exploratory operation on Banks Island were measured in the summer of 1971. The short-term impacts were quantified by evaluating relative changes in surface microrelief features and the thickness and thermal regime of the active layer. Qualitative assessments were made of the degree of disturbances of the tundra vegetation cover. The sample size of disturbed sites was limited and the specifics of the operations were not known so the obesrvations were tentative.

Winter road routes used for more than one season showed increased depth of thaw and thermokarsting. Snow-packed roads seemed to cause more damage than ice roads. The authors recommended that routes not be used for more than 2 years in succession.

Summer seismic lines, in some terrains, showed negligible disruption of the surface. Most of the surface disturbance was due to compaction of the vegetation layer, which is able to deform slightly in the summer. The abrasive action on frozen surfaces can cause more surface disruption. The surface could not hold up under repeated passes in the summer and the surface degraded after two passes of even lightly loaded vehicles.

The surface disturbance associated with the winter operation on Banks Island seemed negligible. The careful selection of routes and the presence of a local resident throughout the operation was thought to have contributed to the minimal disturbance.

Klinger, L. F., D. A. Walker, M. D. Walker, and P. J. Webber. 1983. The effects of a gravel road on adjacent tundra vegetation. Prudhoe Bay Waterflood Project Environmental Monitoring Program. Prepared for the Alaska District, Corps of Engineers, Anchorage, Alaska 99510.

Prudhoe Bay, road, development impacts, impoundments, resilience, recommendations

A gravel road in the Prudhoe Bay oilfield was studied for 2 years to determine the effect of the road on the surrounding vegetation. The vegetation was sampled along transects perpendicular to the road. The sampling was done in a non-destructive manner by systematically measuring the leaf-area index.

The area adjacent to the road was mapped using the classification of Walker and Webber. The area was mapped four times throughout the growing season to present the serial progression of snow-melt and impoundments. Flooding, or impounding, was the most extensive impact of the road, covering nearly twice the area covered by late melting snowbanks. The snowbanks and main dust cover occurred within 50 m of the road. The snowbanks did not completely melt until June 28. The main effect of the snowbank was to channel melt water and block culverts.

Impacts after 2 years and general changes expected after 5 years are summarized in a table. The effects of the late snowbanks are expected to be overridden by those due to dust and flooding. Flooding will affect moist and wet areas the most and lichens and mosses will likely be eliminated. Deeply flooded areas will resemble lakes. Dust will eliminate some of the less tolerant species adjacent to the road, notably mosses.

Komarkova, V. 1983. Recovery of plant communities and summer thaw at the 1949 Fish Creek Test Well 1, Arctic Alaska. pp. 645-650. In: Proceedings of the Fourth International Conference on Permafrost, University of Alaska, Fairbanks, Alaska, 18-22 July 1983. Washington, D.C.: National Academy Press.

North Slope, baseline conditions, exploratory impacts, resilience, recovery

Plant communities at a test-well site abandoned in 1949 were studied to determine the amount of natural recovery that had occurred on the disturbed areas. The similarity between disturbed and undisturbed communities was compared with the similarity between undisturbed communities. The average similarity between the disturbed and undisturbed communities was slightly less than between undisturbed communities. The differences were found primarily in the mesic communities; wet marshes had almost completely recovered.

The common marsh species, _Carex aquatilis_ and _Eriophorum augustifolium_, spread by rhizomes and this allowed their rapid colonization of the disturbed areas. The grass species that colonize the drier areas, _Poa_ and _Arctagrostis_ species, spread by seeds and due to a high seedling mortality are not able to colonize as quickly. The difference in recovery between wet communities and mesic communities reflects the average conditions under which they occur. Mesic areas show less fluctuation in environmental factors such as depth of thaw. Environmental factors in wet areas show a much wider range and therefore the plants are adapted to a wider range of conditions. While recovery does occur following disturbance, the rate is slow due to the slow dynamics of the system.

Kubanis, S. A. 1980. Recolonization by native and introduced plant species along the Yukon River-Prudhoe Bay Haul Road, Alaska. Unpublished Master's thesis, San Diego State University.

revegetation, North Slope

Recolonization, plant migration and persistence, phenological development, and reproductive success of native and introduced species in subarctic and arctic environments were examined along the Prudhoe Bay Haul Road from 1977 to 1979. Forty-nine native species and 20 weeds were observed. Both increases and decreases in ranges occurred. More invasion of disturbed areas occurred south of the Brooks Range than north of the range. Older disturbances were occupied primarily by native species. The number of sites in which weeds or native plants appeared over time was nearly offset by the number from which plants disappeared. Mean percent cover values for most native species and all weeds represented less than 20 percent cover. Mean percent cover of bare ground represented the 80-99 percent cover class. Nine weed species were observed dispersing seed north of the Brooks Range and the collected seeds proved viable. Native plants did invade disturbed areas but their persistence was limited. Recolonization is a slow, erratic process. Introduced species have the capability of establishing in the arctic and native and introduced species have not shown a dramatic difference in persistence or rate of invasion.

Kubanis, S. A. 1982. Revegetation techniques in arctic and subarctic environments. Office of the Federal Inspector, Alaska Natural Gas Transportation System, Office of Environment, Biological Programs. 40 pp.

North Slope, revegetation, recommendations

In preparation for possible construction of the natural gas pipeline, a review and analysis of revegetation techniques was conducted. Based on past experiences with the Trans-Alaska Pipeline and other revegetation research, recommendations were made. The results and recommendations are summarized below.

Severe environmental conditions limit the rate of vegetative recovery following disturbances in arctic and subarctic areas and must be considered in revegetation efforts. Changes associated with construction-related superficial disturbances also limit both natural and induced vegetative recovery. Revegetation success is increased with greater percentages of organic matter and silts. Adequate site preparation including reapplication of stripped surface materials and scarification is essential in maximizing the rate and success of induced revegetation and natural reestablishment of vegetation. Non-native, agronomic grasses show limited success in revegetating subarctic and, particularly, arctic disturbed areas. Cover of these agronomics decreases over time and maintenance treatments of seeding and fertilization may be needed. In addition, agronomics slow or prevent the reinvasion and reestablishment of native species which might otherwise provide long-term vegetative cover. Use of native grasses where moderate cover for erosion control is needed would be advantageous. Three native grasses identified as suitable for this purpose are Arctagrostis latifolia, Poa glauca, and Calamagrostic canadensis. Areas which do not have potential for erosion problems necessitating vegetative cover should be left to revegetate naturally after receiving site preparation to facilitate the reestablishment of cover. Only areas with the need for rapid, dense vegetative cover should be seeded with an agronomic grass because it provides only temporary cover. Several species of shrubs and trees would also be beneficial to this revegation program for specialized uses including ameliorating visual impacts and revegetating streambanks. Fertilization with standard N-P-K fertilizers rather than specialized fertilizers with micronutrients is adequate for both areas to be seeded and those to be left to revegetate naturally. Use of mulches can be disadvantageous and should be limited.

Lambert, J. D. H. 1972. ALUR 1971-72. Department of Indian Affairs and Northern Development, Canada.

Canada, Mackenzie Delta, Banks Island, exploratory impacts, resistance

Botanical studies of the impacts due to two types of winter road, and a winter and a summer seismic operation were conducted during the summer of 1971. Numbers and species of plants within quadrats were measured to quantitatively assess the impacts of the operations.

Two-year winter use of a road using standard snow pack methods eliminated the lichen cover and reduced coverage of vascular plants to 8 percent and mosses to 6 percent. The effects were not as severe on a road only used for one season. Hummocks had been levelled and microdrainage patterns altered on both the single season and the 2-year road. The effect of an ice road had a similar effect on the vegetation but only a minimal effect on the microtopography and was therefore expected to recover more rapidly.

Initial observations of the effects of summer seismic operations were that damage was extensive. The observations were considered very preliminary and no conclusions were drawn.

Lawson, D. E. 1986. Response of permafrost terrain to disturbance: a synthesis of observations from northern Alaska, USA. Arctic and Alpine Research 18:1-17.

North Slope, exploratory impacts

Long-term physical modifications resulting from disturbance of perennially frozen terrain was examined at former exploratory drilling sites in the NPR-A. Camp construction and drilling activites in the late 1940s and early 1950s resulted in disturbances to the vegetation; trampling, killing, and removal. Removal of the vegetation led to the most extensive modifications at all sites, but the subsequent response to disturbance varied with four primary factors; ground ice volume, distribution and size of massive ground ice, material properties during thaw, and relief. Variations in response time resulted from the influence of these factors on the type and activity of degradation. Physical stability is required for growth of vegetation and thermal equilibration has taken over 30 years to attain in ice-rich, thaw-unstable areas. Ice-poor, thaw-stable materials in undrained or low relief areas required an estimated 5 to 10 years for stability.

Lawson, D. E., J. Brown, K. R. Everett, A. W. Johnson, V. Komarkova, B. M. Murray, D. F. Murray, and P. J. Webber. 1978. Tundra disturbances and recovery following the 1949 exploratory drilling, Fish Creek, northern Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Report 78-28. 81 pp.

North Slope, exploratory impacts, recovery, revegetation, recommendations

A 1949 test well site was investigated in 1977 to measure the amount of visible disturbance and the amount of recovery. The well was drilled during the summer of 1949 at Fish Creek, 28 km south of Atigun Point on the Arctic Coastal Plain. Terrain characteristics, soils and permafrost, and vegetation characteristics, floristics and geobotany, were measured. Disturbances at the site included bladed trails, excavations, pilings, solid waste, and hydrocarbon spills.

Thaw depth on the disturbed sites was generally higher than surrounding areas and in some cases dramatically deeper. Thermokarst processes led to the development of hummocky terrain with a relief of up to 2 m. Thermokarst was still occurring in some of the heavily disturbed areas. Soil horizons were still compressed under some of the deeper vehicle trails and soil morphology was completely destroyed in some areas. Diesel fuel was still detectable in the soils and the thaw depth of spill areas was twice that of the surrounding area and the vegetation still had not recovered.

Vegetation recovery was related to the intensity of the original disturbance and the resulting moisture regime. Vegetation cover was complete in wet and mesic sites while xeric sites and fuel spill sites remained barren. The communities on the mesic sites differed from natural mesic sites in that many species were absent or present only in low numbers, such as shrubby species. The disturbed mesic sites were dominated by grasses.

The authors recommended that prior to abandonment of future sites, the slope of the pad should be graded to form an even slope to the tundra. This would allow the establishment of moisture gradients. Non-native or domestic species should not be used for revegetation as natural revegetation can occur on some sites. Areas that need rapid revegetation due to potential erosion problems should be revegetated with willow cuttings and grasses as clones. Suggested species are: *Salix alaxensis*, *S. niphoclada*, *S. glauca*, and *Poa arctica*, *Festuca rubra*, *Leymus mollis* (= *Elymus arenarius*), *Bromopsis pumpelliana* (= *Bromus pumpellianus*), *Carex obtusata*.

Nelson, F., and S. I. Outcalt. 1982. Anthropogenic geomorphology in northern Alaska. Physical Geography 3(1):17-48.

North Slope, exploratory impacts

Natural geomorphic processes that occur after the abandonment of a bladed road were measured in 1980. The road studied is an abandoned road in the Deadhorse area constructed in 1968 by blading the organic surface layer.

Drainage patterns were severely disrupted by subsidence and the road's influence extends laterally many meters. Thaw season flow has caused extensive thermal subsidence. In general, thaw progression plotted as a linear form against the square root of time in undisturbed areas and some disturbed areas. Some areas of the road did not show a linear relationship, indicating that the road had still not stabilized 12 years after the disturbance.

Pamplin, W. L. 1979. Construction-related impacts of the Trans-Alaska Pipeline System on terrestrial wildlife habitats. Special Report Number 24, Joint State/Federal Fish and Wildlife Advisory Team. 132 pp.

Trans-Alaska Pipeline, development impacts, recommendations, North Slope

Wildlife habitats along the entire length of the Trans-Alaska Pipeline System (TAPS) were evaluated using aerial photography. The study area was cover typed on pre-construction aerial imagery using a classification system consisting of 12 habitat types. A broad habitat classification was developed that corresponded in part with the Viereck and Little vegetation classification. Post construction imagery of the same scale was used to determine the surface area impacts. Approximately 31,403 acres of terrestrial wildlife habitat were altered or destroyed by construction activities as of July 1976. The greatest overall impact occurred on the North Slope (10,900 acres). Material sites caused the most habitat alteration.

Recommendations for future large-scale projects include:

1. An inter-agency/inter-disciplinary approach must be used to evaluate the potential adverse impacts of all project features on wildlife habitats.

2. Comprehensive terrestrial and aquatic habitat evaluations of proposed project areas must be conducted to identify wildlife habitats in terms of quantity and quality.

3. These evaluations must be emphasized during the preliminary planning and design stages prior to the construction phase.

4. Results of inter-disciplinary evaluations must be incorporated in project designs to ensure the protection of wildlife habitats.

5. Regardless of the habitat type, unnecessary and avoidable impacts must be eliminated.

6. When adverse impacts are unavoidable, the least environmentally damaging alternative must be selected.

7. Mitigative measures must be applied consistently throughout project development.

8. The project sponsor should be required to adequately compensate for all significant unmitigated losses of public wildlife resources as determined by government resource agencies.

Radforth, J. R. 1972. Analysis of disturbance effects of operations of off-road vehicles on tundra. ALUR 1971-72. Department of Indian Affairs and Northern Development, Canada. 77 pp.

Canada, Mackenzie Delta, off-road travel, exploratory impacts

During the summers of 1970 and 1971, observations were made of off-road vehicle tracks in the Mackenzie Delta region. Temperatures in and out of the vehicle tracks and the frost depths were made. The tracks were photographed at ground level and from the air to determine if aerial photography could be a useful technique in evaluating disturbance levels.

The photographic analysis was useful in analyzing vegetation damage and recovery and the exposure of mineral soil. Vegetative recovery was related to the season in which the activity occurred, the weight of the vehicle, and the number of passes by the vehicles. Thermokarsting was most likely to occur on slopes where melt water could be channelized in the vehicle ruts. Any level of traffic caused some recession of the permafrost table.

Rawlinson, S. E. 1983. Guidebook to permafrost and related features, Prudhoe Bay, Alaska. Prepared for: Fourth International Conference on Permafrost, July 18-22, University of Alaska, Fairbanks, Alaska. 202 pp. (available from: DGGS, 794 University Avenue, Fairbanks, Alaska 99701, cost $6).

baseline conditions, development impacts, Prudhoe Bay

This guidebook was prepared for participants of the field trip to Prudhoe Bay, Alaska, associated with the Fourth International Conference on Permafrost held in Fairbanks, Alaska, July 18-22, 1983. Common permafrost mechanisms and features in the Prudhoe region are identified and described. Some of the impacts due to development, such as thermokarst pits, are identified and their history described. The guidebook begins with a general discussion of the climate, biota and landforms of the region. This is a good introductory guide to the area and the landform features associated with permafrost terrain.

Reynolds, P. C. 1981. Some effects of oil and gas exploration activities on tundra vegetation in northern Alaska. Presented at: Society of Petroleum Industry Biologists, Annual Meeting, Denver, 1981. 15 pp.

resilience, recovery, exploratory impacts, North Slope

Winter cross-country travel associated with oil and gas exploration in the National Petroleum Reserve-Alaska was monitored between 1978 and 1981. Different effects on four vegetation types were documented. Tractors pulling sled-mounted trailers did more damage than did low ground-pressure seismic vehicles. A dry upland meadow was moderately affected by tractor trains, but recovered within 16 months. Sedge tussocks and riparian willows recovered in 16 months from the effects of low ground-pressure seismic vehicles, but significant effects were still present along a tractor trail after 28 months. Trails created by tractor trains will be visible through riparian willows for several years. A major effect of winter cross-country travel was to mar aerial scenic values of a wilderness area. Impacts had no apparent effects on wildlife as the amount of plants killed or altered were small compared to the total habitat available.

Simmons, C. L., K. R. Everrett, D. A. Walker, A. E. Linkins, and P. J. Webber. 1983. Sensitivity of plant communities and soil flora to seawater spills, Prudhoe Bay, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Report 83-24. 35 pp.

Prudhoe Bay, development impacts, contaminants

To determine the effects of a potential leak in the seawater pipeline used for waterflooding the oilfield, test saltwater spills were done in the summer of 1980. Eight sites representing the range of vegetation types along the pipeline route were treated with single, saturating applications of seawater.

Within a month of the treatment, 30 of 37 taxa of shrubs and forbs in the experimental plots developed clear symptoms of stress, while none of the 14 graminoid taxa showed apparent adverse effects. Live vascular plant cover was thus reduced by 89 and 91 percent in the two dry sites and by 54, 74, and 83 percent in the three moist sites.

Live bryophyte cover was markedly reduced in the moist experimental sites in 1981. Bryophytes in all but one of the wet site experimental plots were apparently unaffected by the seawater treatment. Two species of foliose lichens treated with seawater showed marked deterioration in 1981. All other lichen taxa were apparently unaffected by the seawater treatment.

The absorption and retention of salts by the soil is inversely related to the soil moisture regime. In the wet sites, conductivities approached prespill levels within about 30 days. In such sites, spills at the experimental volumes are quickly diluted and the salts flushed from the soil. In the dry sites, on the other hand, salts are retained in the soil, apparently concentrating at or near the seasonal thaw line.

On spill sites, microbial-related soil respiration and hydrolysis of cellulose and organic phosphorus were significantly reduced, as were soil enzymes and viable microbial biomass, for up to one year after treatment. Ectomycorrhizal roots of Salix on the treated plots showed a significant reduction in viable biomass, number of mycorrhizal roots, and respiration rates of the viable roots.

Spatt, P. D., and M. C. Miller. 1981. Growth conditions and vitality of Sphagnum in a tundra community along the Alaskan Pipeline Haul Road. Arctic 34(1):48-54.

Trans-Alaska Pipeline, road, development impacts, resistance

The effect of road dust and road-related construction on Sphagnum lenense were measured along the Alaska Pipeline Haul Road, the Dalton Highway. Plots were established at various distances from the road and the dust deposition and chemistry of the area monitored for one season.

Dust from traffic settled in greatest quantities near the road with the amount rapidly decreasing away from the road. Water content of S. lenense in quadrats close to the road and to a buried gasline was generally low when compared with those in more distant quadrats. Total conductivity, pH, and calcium content of water extracted from the Sphagnum was greatest in heavily dust-impacted quadrats. Chlorophyll content was greatest in the Sphagnum little exposed to dust and lowest in Sphagnum heavily exposed. Carbon uptakes in Sphagnum was greatest in the quadrats furthest from the road. A long-term effect of heavy road dust accumulation upon Sphagnum may be decreased productivity and growth.

Techman Engineering Limited. 1982. Road dust suppression in Northern and Western Canada, Review of alternatives and existing practices. Environment Canada, Water Pollution and Contaminants Control, Environmental Protection Service, Edmonton, Alberta. 102 pp.

North Slope, dust

Mechanisms of road dust generation and suppression techniques were reviewed for the Canadian Federal Environmental Protection Service. Road dust is generated by passing vehicles in three ways; vortex entrainment, slippage entrainment, and saltation and creep of larger vehicles. The rate and amount of dust generated depend upon vehicle speed, number of wheels/vehicle, particle size distribution, surface moisture, vehicle weight, vehicle cross-section, tire width, tire design, length of unpaved road, and design of roadway. Dust impacts include safety, aesthetics, health, vegetation, soils, and aquatic resources.

Road dust may be reduced by traffic controls, paving, and applications of road stabilizers or dust suppressants. Paving is the most effective method of dust control but is expensive and the impact of the paving operation may be great. Dust suppressants include water and wetting agents, deliquescent and hygroscopic chemicals, organic non-bituminous binders, and petroleum based suppressants. Water and wetting agents have no environmental impacts, except for salt water. Calcium chloride is the most widely used deliquescent chemical and it may adversely affect water supplies, plants, and aquatic species. Petroleum-based products have adverse effects on plants and aquatic species.

Walker, D. A., D. Cate, and J. Brown (eds.). In press. Disturbance and recovery of arctic Alaskan tundra terrain: a summary of recent CRREL research. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. 177 p.

North Slope, exploratory impacts, baseline conditions, recovery, resilience, resistance, review, contaminants

The response and recovery of permafrost terrain following disturbance has been a major topic of research in northern Alaska for the past 25 years. Much of the work has been funded through the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). This report presents a summary of the work that has been done by CRREL and its affiliated university personnel. The goals of their research were to document natural and man-caused disturbances on Alaskan tundra and to investigate responses of tundra ecosystems to disturbance.

The report is organized in two major sections. The first section is a review of disturbance studies. Natural disturbances addressed include thaw lakes and thermokarst, streambank erosion and slope failures, coastal storm surges, frost action, animal disturbance, fire, and other natural disturbances. Man-caused or "anthropogenic" disturbance is divided into off-road transportation, permanent structures, and contaminants. The second section discusses the ecological relationships between disturbance and recovery. Natural and man-caused disturbances are compared and related. Recommendations are made for future arctic disturbance research.

Walker, D. A. P. J. Webber, K. R. Everett, and J. Brown. 1980. Geobotanical Atlas of the Prudhoe Bay region, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Report 80-14. 73 pp.

baseline conditions, development impacts, Prudhoe Bay

The interrelationships among the landforms, soils, and vegetation of the Arctic Coastal Plain of Alaska are illustrated. Vegetation communities, landforms, and soil types are described. The vegetation is related to three important gradients: temperature, soil pH and moisture. Aspects of the Prudhoe Bay region are discussed: the climate, geology and permafrost. Historical descriptions of the development of the oilfield are included.

This is the initial classification scheme developed by Drs. Walker and Webber. The classification system has undergone several revisions since this publication; however, important historical information is contained in this atlas.

Webber, P. J. 1978. Spatial and temporal variation of the vegetation and its production, Barrow, Alaska. In: Vegetation and Production Ecology of an Alaska Arctic Tundra, Ecological Studies 29 (L. Tieszen, ed.). Springer-Verlag, New York.

Barrow, North Slope, baseline conditions

The tundra at Barrow is characteristic of the seaward areas of the Arctic Coastal Plain. It has a cool, moist climate and it is flat, poorly drained, and underlain by permafrost. The vegetation changes character every few meters in concert with the microrelief of ice-wedge polygon complexes. Species, growth forms, standing crop and production were related to moisture, aeration, and phosphate. Other environmental controls included were wind, snow cover, temperature, depth of active layer, substrate stability, and the effects of lemming grazing. The interrelations are complex but they are all initially controlled by the microrelief. The vegetation is dominated by bryophytes and monocotyledons. The dominant species are wide ranging along the principal environmental gradients. Production increases along the moisture gradient. The majority of production occurs in 60 days and seeds can be produced within 75 days.

Webber, P. J., and J. D. Ives. 1978. Recommendations concerning the damage and recovery of tundra vegetation. Environmental Conservation 3(5):171-182.

North Slope, exploratory impacts, recommendations, resistance

The notion of fragility is discussed with respect to tundra. In general, the term has been misused, referring to the slow recovery time associated with disturbance rather than the actual susceptibility to disturbance. Some types of tundra are more susceptible than others, notably the wet tundras of northern Alaska that have ice-rich soil. In these areas, recovery is related to the extent of thermokarsting that occurs when the thermal regime has been disrupted.

The use of non-native species in revegetation is discussed. Based on the history of agriculture in Greenland and the introduction of non-native species around settlements, the spread and competition of introduced species with the native flora was not seen as a major problem. The longevity of non-native species in revegetated sites was questioned and the authors suggest that these species may be useful to establish an initial ground cover but that they would not persist. Presumably, with time, the area would be recolonized by native species.

Principal to successful design of revegetation programs is an understanding of natural plant succession. This knowledge is not available in the arctic and the authors stress the need to conduct regular inventories of permanent plots to address this. Mapping of the soils, landforms and vegetation on composite maps was also suggested as a useful technique for planners. Once the effects of activities are known on the various components of the ecosystem, predictive or sensitivity maps can be made. Detailed mapping was noted as time-consuming and labor intensive.

West, R. L., and E. Snyder-Conn. 1985. The effects of Prudhoe Bay reserve pits on the water quality and macroinvertebrates of tundra ponds. Unpublished report, U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, Alaska. 50 pp.

Prudhoe Bay, contaminants, development impacts

Water quality and macroinvertebrates were sampled in tundra ponds adjacent to reserve pits. Water was being removed from reserve pits and deposited directly on the tundra or pumped onto roadways.

Grab samples of water and composite sweep net samples of invertebrates from three remote control ponds were compared with those from six reserve pits; six adjacent ponds that had received direct pit fluid discharges in 1983; and six far ponds that may have been contaminated as a result of connections with the adjacent ponds. All six reserve pits examined were devoid of any invertebrate taxa and most displayed poor water quality as well as elevated levels of metals and hydrocarbons. Simple linear regressions on treatment (control ponds, far ponds, adjacent ponds and reserve pits) demonstrate significant (P=0.05) gradients of increase in pH, salinity, alkalinity, turbidity and sediment loads proceeding toward reserve pits. Also, significant trends of increase in aluminum, barium, chromium, zinc, arsenic, aliphatic hydrocarbons and aromatic hydrocarbons occur proceeding from control ponds to pits. Most of the above water quality and contaminant parameters are statistically correlated with significant (P=0.05) decreases in total taxa, species diversity and invertebrate abundance of tundra ponds, even when pit data are excluded from regression analyses. Multiple linear regressions are used to suggest the best water quality and contaminant parameters to monitor in the future. Water quality parameters that best predict deteriorating biological conditions include alkalinity, hardness, pH, and turbidity. The metals most indicative of biological change include aluminum, nickel, copper and arsenic. The abundance of crustaceans is, in addition, forecast by aromatic hydrocarbon concentrations.

USDI-BLM. 1978. Proceedings of the symposium on surface protection through prevention of damage. Focus: the Arctic Slope. May 1977. BLM-Alaska State Office. 302 pp. NTIS # PB 284 966.

exploratory impacts, North Slope, resistance, recommendations, review

A symposium was held by the Bureau of Land Management to discuss surface management on the Arctic Slope. One purpose of the symposium was to update information presented at the previous year's symposium. Another purpose was to provide a forum for all people involved in surface management to interact, which would lead to continued cooperation between the agencies involved. Although the focus was on the entire Arctic Slope, most of the discussion and information came from experiences in the National Petroleum Reserve-Alaska (NPRA) and the Trans-Alaska Pipeline (TAPS). The symposium was followed by a two-day workshop to discuss and recommend guidelines for surface activities.

The majority of the symposium concerned the legislative mandates for surface protection. The actual legislation and the procedures for implementation were presented by both federal and state representatives. Protection requirements currently in effect were also presented. The status of the North Slope Borough's planning effort was also presented.

The experiences on the TAPS line were presented by an engineer and a former member of the Joint State-Federal Fish and Wildlife (JFWAT) team. The engineer stressed the need for clear, specific guidelines that could be used in planning. Problems incurred with changing guidelines were illustrated. The experience from the JFWAT team was that the greatest impacts occurred in the aquatic system -- largely due to siltation of important fishery areas and blockage of fish movement -- and to caribou in restricting their movements. The need for resource information was stressed as was the need to re-establish tight coordination between the various government agencies.

Some information on revegetation was presented. Of the grasses used in revegetation, those strains developed from Arctic stock were the best. The use of hardwood cuttings, primarily willows, was presented as a potentially useful technique and the factors that must be considered for this evaluated. The information presented has been updated since this symposium.

The working groups made extremely general guidelines. The only specific guidelines presented were for air and water quality and these were based on existing state and federal standards.

APPENDIX B.

SPECIES ACCOUNTS

APPENDIX B. SPECIES ACCOUNTS

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1. INTRODUCTION

The following species accounts briefly describe distribution and status on the North Slope, breeding biology, migration, and vulnerability to impacts due to development for selected bird species. Distribution and status information describe where the species occur, when and where they concentrate, and include all available density estimates. Breeding biology is summarized and known requirements or resource limitations during the breeding season are identified. Migration timing and routes are summarized. Susceptibility to impacts includes information from specific studies of impacts and hypothesized sensitivity to development activities based on the life history of the species. Known sensitivity to development based on previous studies is clearly referenced to ensure hypothesized and known impacts are not confused. The purpose of the species accounts is to summarize life history information for the selected species, provide key references for all aspects of their life history, and summarize distribution information so that areas with high concentrations or high diversities can be identified.

References are contained in the annotated bibliography. The species accounts are drawn from studies in the Arctic. Distribution and status information comes primarily from species accounts written for specific studies, notably for the Arctic National Wildlife Refuge (ANWR) (Martin and Moitoret 1981, Miller et al. 1985, Spindler et al. 1984), the Canadian Wildlife Service (Johnson et al. 1975, Salter et al. 1980), the Outer Continental Shelf environmental studies (Connors et al. 1983, Divoky 1983), and the Fish and Wildlife Service (Derksen et al. 1981, Lenhausen and Quinlan 1981).

Accounts are arranged in taxonomic order (after Gibson 1982) and follow the conventions of the American Ornithologists Union (Thirty-fourth Supplement to the AOU Check-List of North American birds [Auk 99(3):1CC-16CC, 1982]). Two commonly used habitat classifications are referenced for most species; Bergman et al. 1977 and Troy 1984. Status and abundance terminology follows Kessel and Gibson (1978) and their definitions are listed below.

Abundant -- Species occurs repeatedly in proper habitats, with available habitat heavily utilized, or the region regularly hosts great numbers of the species.

Common -- Species occurs in all or nearly all proper habitats, but some areas of presumed suitable habitat are occupied sparsely or not at all, or the region regularly hosts substantial numbers of the species.

Fairly common -- Species occurs in only some of the proper habitat, and large areas of presumed suitable habitat are occupied sparsely or not at all, or the region regularly hosts substantial numbers of the species.

Uncommon -- Species occurs regularly, but utilizes little of the suitable habitat, or the region regularly hosts relatively small numbers of the species; not observed regularly even in proper habitats.

Rare -- Species within its normal range, occurring regularly but in very small numbers. "Very" rare is used for a species which occurs more or less regularly, but not every year, and usually in very small numbers.

Casual -- A species beyond its normal range, but not so far but what irregular observations are likely over a period of years; usually occurs in very small numbers.

Accidental - A species so far from its normal range that further observations are unlikely; usually occurs singly.

Resident -- A species present throughout the year.

Migrant -- A seasonal transient between wintering and breeding ranges; in spring, includes species that have overshot their normal breeding range.

Breeder -- A species known to breed; prefixed by "possible" or "probable" if concrete breeding evidence is unavailable.

Visitant -- A nonbreeding species; also, in fall, a species not directly enroute between breeding and wintering ranges.

Red-throated Loon (Gavia stellata)

Distribution and Status

Red-throated Loons are abundant and common breeders along the Beaufort coast and at Icy Cape (Pitelka 1974, Johnson et al. 1975, Lenhausen and Quinlan 1981, Martin and Moitoret 1981). They become less common inland (Sage 1974), much less common in interior Arctic Coastal Plain sites in NPR-A than coastal sites (Derksen et al. 1981). Red-throated Loon distribution may be limited by access to fishing areas due to their reliance on fish during the breeding season (Davis 1972, Bergman and Derksen 1977, Derksen et al. 1981) and may be restricted to areas near the coast or where sufficient quantities of freshwater fish are available.

Breeding densities were 0.5 and 0.6 nests/km^2 at the Canning River Delta (Martin and Moitoret 1981). Tundra densities of 1.3/km^2, 0.53/km^2, and 0.1/km^2 were reported for the Teshekpuk area, 0.2 for the Meade River, and none at Square Lake or Singiluk, which were adjacent to the Foothills region (Derksen et al. 1981). A similar pattern of high densities along the coast and low densities inland was observed in the Arctic National Wildlife Refuge at the Okpilak, Sadlerochit and Jago Deltas and inland sites along the Jago and Aichilik Rivers (Spindler et al. 1984, Miller et al. 1985).

Breeding Biology

Red-throated loons nest on small ponds and wetlands. Class III wetlands were used throughout the breeding season in the Teshekpuk region and at Storkersen Point, where Class IV wetlands were also used during the latter part of the breeding season (Bergman and Derksen 1977, Derksen et al. 1981). Nests are on marshy islands or along the shore if no islands are present. The clutch usually consists of two eggs, laid during the last week of June (Davis 1972). Both adults incubate and the first egg laid has a better chance of survival than the second egg. The four loon nests found at Icy Cape in 1980 were all single egg clutches (Lenhausen and Quinlan 1981). Hatching generally begins during the third week in July and the young fledge about a month later. Late hatching young may not fledge by freeze-up. The young and adults leave the breeding areas for coastal waters following fledging.

Adult loons fed in the lagoons and estuaries of the Beaufort adjacent to the Canning River Delta (Martin and Moitoret 1981), and by Storkersen Point (Bergman and Derksen 1977). In the Teshekpuk region, loons fished for white-fish in large lakes and in pools of beaded streams. In general, Red-throated Loons are associated with lagoons, estuaries and large lakes in the coastal region (Salter et al. 1980).

Migration

Red-throated Loons migrate along the coast in the spring, arriving at their breeding grounds by the second week in June (Johnson et al. 1975). They were first sited during the first week of June at Icy Cape (Lenhausen and Quinlan 1981). Peak spring movement at the Canning River Delta occurred during the first week in June (Martin and Moitoret 1981). Birds rest in overflow areas adjacent to river deltas until tundra ponds are thawed (Martin and Moitoret 1981).

Fall migration begins by the end of August and continues through September (Divoky 1983). They migrated singly or in loosely associated flocks of up to 20 birds and within 0.5 km of the barrier islands past Icy Cape (Lenhausen and Quinlan 1981).

Susceptibility

Red-throated Loons feed in either large fresh water lakes or nearshore lagoons and would be adversely affected by actions that affect their prey resources. Loons would be most sensitive to contaminant spills in the marine environment from mid-August to freeze-up as this is the period of greatest congregation in nearshore waters (Divoky 1983).

Pacific Loon (*Gavia arctica*)

Distribution and Status

Pacific Loons are common breeders on the Arctic Coastal Plain (King 1979, Derksen et al. 1981, Divoky 1983). They are more abundant than Red-throated Loons in most areas, such as, Demarcation Bay (Dixon 1943), Okpilak River Delta (Spindler 1978), Canning River Delta (Martin and Moitoret 1981), Storkersen Point (Bergman et al. 1977), at inland locations in the National Petroleum Reserve-Alaska (King 1979, Derksen et al. 1981), and at Icy Cape (Lenhausen and Quinlan 1981). Reported nesting densities are: 0.55/km^2 in 1979 and 0.75/km^2 in 1980 for the Canning River Delta (Martin and Moitoret 1981).

Breeding Biology

Pacific Loons generally nest on islands surrounded by deep water or Arctophila fulva in lakes with fish (Derksen and Bergman 1977, Lenhausen and Quinlan 1981, Martin and Moitoret 1981). The birds move from the nearshore to tundra lakes as soon as sufficient melt water is available in the lakes for take-off and landings (Petersen 1979). Nests are mounds made from the surrounding vegetation and are not concealed. A clutch is usually two eggs. Hatching success is strongly influenced by predation; on the Yukon-Kuskokwim River Delta, 95 percent of the nests in 1974 and 68 percent of the nests in 1975 were destroyed by predators. The adults and young feed on small fish and invertebrates in their lake and will move between lakes, presumably when the food becomes depleted. Some adults will forage in the lagoons and bring fish back to the young. Use of lagoons sharply increases in August as failed breeders then family groups move to the lagoons prior to migration (Derksen and Bergman 1977, Petersen 1979).

Migration

Spring migration of Pacific Loons occurs from early to mid-June. They arrive in the Beaufort prior to breakup on the tundra and rely on the meltwater off river deltas for resting and feeding (Martin and Moitoret 1981). Pacific Loons are not as dependent on the flaw-leads in the Chukchi and Beaufort as are Yellow-billed Loons, which may reflect a later spring migration (Divoky 1983). Fall migration peaks in mid-September (Lenhausen and Quinlan 1981, Divoky 1983). Migration in the Beaufort is scattered across a large front, with many birds travelling over the pelagic zone (Divoky 1983). The loons migrated as individuals or in small flocks of up to 10 birds flying low over the water and near the barrier islands (Lenhausen and Quinlan 1981).

Susceptibility

Pacific Loons are most susceptible to spills in the nearshore waters of the Beaufort Sea in late August and early September when they are concentrated prior to migration (Divoky 1983). On the tundra, movement between lakes is important for family groups to ensure access to a sufficient food supply; loons may therefore be adversely affected by structures or activities that restrict these movements. The sensitivity of Pacific Loons to noise and disturbance is unknown; however, activities that flush adults from their nests exposes the eggs to predation. Adults may remain off their nests for long periods after being disturbed (Petersen 1979).

Yellow-billed Loon (Gavia adamsii)

Distribution and Status

The Yellow-billed Loon is an uncommon breeding species across most of the North Slope. Exceptions are the Colville River Delta, where it is a common breeder (North et al. 1983) and the Alaktak area (80 km south of Barrow) where it is a fairly common breeder. Breeding has been reported in several interior coastal plain and foothills region sites; in the National Petroleum Reserve-Alaska (Derksen et al. 1979), near Franklin Bluffs (Sage 1971), in the Lake Schrader area, and in the Killik River valley (Irving 1960).

Non-breeding birds use coastal lagoons beginning in mid-July (Schmidt 1973, Martin and Moitoret 1981, Johnson et al. 1983). Isolated birds have been reported in the Brooks Range region as well (summarized in Martin and Moitoret 1981).

Breeding Biology

Two studies of breeding Yellow-billed Loons have been conducted on the Arctic Coastal Plain, on the Colville River Delta (North et al. 1983) and at Alaktak (Sjolander and Agren 1976). Loons nest on deep-open lakes (Classes IV and V in the Bergman system [Bergman et al. 1977]). Pairs that nest in small Class IV wetlands moved to larger Class V lakes for brood rearing as soon as the young hatch. Nesting lakes at Alaktak ranged from 20 ha to 150 ha. The adults are territorial and seldom leave the nesting areas. Nests are small mounds built of surrounding vegetation. Incubation takes 27 to 29 days and is performed by both adults. The clutch consists of two eggs; generally only one survives to fledging. The young swim within a day of hatching. They are initially brooded at the nest, then occasionally along the shore for the first 9 or 10 days. The parents feed the young small fish caught in the lake. The young are unable to fly until 10 or 11 weeks of age.

Migration

Yellow-billed Loons migrate east along the Beaufort Coast in late May and June (Johnson et al. 1975, Salter et al. 1980) and spring migration has been observed through Anaktuvuk Pass as well (Irving 1960). Migrants are found in leads off the major river deltas by the first week in June, where they remain until the rivers and lakes break up (Johnson et al. 1975). Little is known of the fall migration pattern but the main fall movement is thought to occur during the latter part of September and early part of October (Lenhausen and Quinlan 1981, Divoky 1983). Yellow-billed Loons arrive in their wintering areas in Southeast Alaska in late October (Gabrielson and Lincoln 1959).

Susceptibility

Yellow-billed Loons use flaw leads in the Chukchi and Beaufort Seas during spring migration (Divoky 1983). They would be most susceptible to an oil spill in a lead during this time as the amount of open water is restricted. They also dive for their prey, which increases their susceptibility as they may dive through or surface in a spill.

Two geographic areas where Yellow-billed Loons are susceptible to impacts are the Colville River Delta and Alaktak, where they are common and fairly common breeders, respectively. The degree of sensitivity to noise and disturbance is unknown. They are likely to be sensitive to contaminants as family groups depend entirely on their large lake during the nesting and brood rearing period.

Tundra Swan (Cygnus columbianus)

Distribution and Status

Tundra Swans breed across the Arctic Coastal Plain into the Northwest Territories, Canada. Within this broad region, maximum densities occur between the Anderson River and Mackenzie River Deltas and the lowest densities along the Alaskan North Slope and east of the Anderson River Delta (Johnson et al. 1975). Tundra Swans are considered an uncommon breeder in the Arctic National Wildlife Refuge (Spindler et al. 1984, Miller et al. 1985), although concentration areas have been noted on the Canning-Tamayariak River Delta and the Aichilik River Delta (Brackney et al. 1985b). Nesting densities in ANWR ranged from 0.02 pairs/km^2 to 0.14 pairs/km^2 in 1983 and 0.03 to 0.18 pairs/km^2 in 1984, with the highest densities on the Aichilik River Delta, and a total of 78 and 100 nests in 1983 and 1984, respectively. Aerial surveys of the NPR-A in 1977 and 1978 found the highest densities (0.4/km^2) adjacent to the Colville River Delta and south of Dease Inlet (King 1979). High nesting densities of swans occur on the Colville River Delta, 0.22 pairs/km^2 and 0.18 pairs/km^2 in 1982 and 1983, respectivley; 59 nests were found in 1983 (Hawkins 1983). The Colville Delta is the largest swan concentration area on the Alaskan North Slope.

Breeding Biology

Tundra Swans do not begin breeding until five or six years of age. Groups of nonbreeding swans have been observed along the coast of the Yukon Territory, notably along river deltas (Johnson et al. 1975). Nonbreeding flocks also occurred near the Meade River Delta (Derksen et al. 1981). Nonbreeding swans began arriving on the Colville River Delta by the end of June and may have been competing with nesting swans for habitat as aggressive encounters were frequently observed (Hawkins 1983). Swans may traditionally use nesting territories and may use previous nests; 20.6 percent of the nests found on the Colville Delta in 1983 were in nests used in 1982 (Hawkins 1983). Swans arrive on the nesting grounds prior to breakup and were defending territories on the Colville River Delta by May 24, 1983. Nests are built of moss and peat clumps, grass, weed stalks, feathers and down, and are large. Nests on the Colville Delta are usually on raised areas in moist graminoid meadows at the junction of polygon rims. The number of Tundra Swans in the Yukon Kuskokwim River Delta was related to the linear miles of lake shoreline, number of lakes, and number of small islands (King and Hodges 1981). Clutches are usually three to five eggs (3.59 mean clutch size on the Colville Delta in 1983). Incubation takes about 30 to 40 days (Johnson et al. 1975) and the peak of hatching occurs in late June and early July. Broods are raised in large wetlands or lake complexes with stands of Arctophila fulva, which provides food and cover for the young (Derksen et al. 1981). The young fledge by mid-September, just prior to fall migration.

Migration

Tundra Swans move to the North Slope in the spring following overland routes. Sladen (1973) suggests that at least some of the population winters along the Atlantic coast and migrates directly across the continent to the Mackenzie River Valley. Birds may also travel along other major drainages, e.g., the Porcupine, Yukon, and Koyukuk Rivers (Irving 1960). The majority of swans observed during spring migration by Johnson et al. (1975), at the Canning Delta (Margin and Moitoret 1981), and the Colville Delta (Hawkins 1983) were traveling west. Only a few individuals were observed at Icy Cape (Lenhausen and Quinlan 1981). Swans arrive at the breeding grounds by the end of May and appear to arrive in the vicinity of the Mackenzie River Delta before arriving at areas to the east or west (Johnson et al. 1975). Fall migration is the reverse of spring migration beginning in mid to late September, depending on the weather (Johnson et al. 1975). Fall migration past Komakuk peaked between 25 and 27 September in 1973.

Susceptibility

Incidental reports of nest desertions indicate Tundra Swans may be adversely affected by human activity (summarized in Bartels et al. 1983). Desertions were related to helicopter traffic near nests. Concentration areas, such as river deltas where nesting concentrations are highest, are most susceptible to disturbance. Areas that should be avoided by extensive air traffic and other types of disturbance are the Colville, Canning-Tamayariak, and the Aichilik River Deltas. Of these, the Colville is the largest and has the greatest number of regularly breeding birds.

A Tundra Swan habitat model is being developed by FWS for the Prudhoe Bay region. The model is limited in that it is based on information gathered primarily on the Colville River Delta, which is physically and biologically different from the Prudhoe region. Major model assumptions are: (1) reproductive habitat suitability is a function of nest site, feeding, and brood habitat suitability and that all three factors are equally important; (2) all non-wetland cover types have some value as potential nest sites if they are within a reasonable distance of suitable feeding and brood rearing wetlands; and (3) disturbance zones are subjective estimates.

Greater White-fronted Goose (*Anser albifrons*)

Distribution and Status

Greater White-fronted Geese have a circumpolar distribution and occur commonly along the North Slope, although they nest in low numbers (Johnson et al. 1975, Salter et al. 1980). High nesting densities have been recorded only at the Colville River Delta where the overall nesting density was 0.29/km^2; densities at four colony sites were 6.6/km^2, 3.4/km^2, 2.8/km^2, and 2.5/km^2 (Simpson 1983). Bergman et al. (1977) considered them common in the Prudhoe Bay area although they occurred in low numbers and over 90 percent of the birds present in June were non-breeders. Nesting densities in the Prudhoe Bay area are low, only three nests were found in a 63 km^2 study area in 1985 (Murphy et al. 1986). White-fronts are a common spring and fall migrant across the ANWR although little nesting has been observed (Salter et al. 1980, Martin and Moitoret 1981, U.S. Fish and Wildlife Service 1982). Groups of molting geese occur all over the North Slope but high concentrations occur only in the Teshekpuk Lake area (King 1970, 1979; Derksen et al. 1981).

Breeding Biology

Greater White-fronted Geese nest either singly or in loose colonies. The birds arrive on the breeding grounds already paired and are often accompanied by offspring from the previous year. Nesting begins in late May or the first half of June depending on snow melt. These geese are determinate layers (they can not replace a clutch if it is lost) and clutch size is usually from 5 to 7. Sub-adults help guard the nest during early incubation but leave during the latter part. Incubation takes from 23 to 28 days. Upon hatching, young are led directly to water, usually beaded streams or lakes (Derksen et al. 1981). Both adults remain with the brood and molt during the brood rearing period. Family groups often join in large groups around lakes. Fledging occurs during mid-August. The geese do not make a pronounced shift to the coast prior to migration (Johnson et al. 1975, Bellrose 1976, Derksen et al. 1981, Troy 1985a).

On the Colville River Delta, most nests were on polygon rims, particularly in areas of high nest density. Family groups often joined to form larger groups for brood rearing. Hatching success over three years ranged from 50.0 percent to 59.4 percent. Arctic foxes were the primary predator (Markon et al. 1982, Simpson 1983).

Migration

Spring migration seems to be primarily overland with birds following major drainages through interior Alaska. Major routes seem to be along the Yukon, Koyukuk, Kobuk, and Noatak Rivers (Johnson et al. 1975, Salter et al. 1980). Low numbers were seen during spring migration watches at Icy Cape (Lenhausen and Quinlan 1981) and at Peard Bay (Gill et al. 1985), which supports the interior migration routes. White-fronts are an uncommon spring migrant along the ANWR coast (Martin and Moitoret 1981, U.S. Fish and Wildlife Service 1982). Fall migration follows a broad front to the east across the Arctic Coastal

Plain (Johnson et al. 1975, Salter et al. 1980, Derksen et al. 1981). They are a common fall migrant in the ANWR (Martin and Moitoret 1981, U.S. Fish and Wildlife Service 1982).

Susceptibility

Greater White-fronted Geese may be most affected by disturbance in areas where they concentrate, the nesting concentrations on the Colville River Delta and the molting concentrations in the Teshekpuk Lake area. Management recommendations for the Teshekpuk Lake area have repeatedly stressed complete protection of the area from development due to its importance to all the species of geese (Derksen et al. 1979a, Derksen et al. 1979b, Derksen et al. 1981, Gilliam and Lent 1982).

In a study of disturbance effects on geese in the Prudhoe Bay area, Murphy et al. (1986) found that Greater White-fronted Geese displayed more alert behavior near roads and more resting behavior at distances greater than 300 m from roads. The observations are based on a small sample and the authors suggest that the difference in behavior patterns may be related to the distribution of feeding and resting habitat with relation to the road.

Snow Goose (*Chen caerulescens*)

Distribution and Status

Snow Geese historically may have been common nesters along the arctic coast and it has been suggested that introduced reindeer and their herders may have destroyed the nesting areas (Bailey 1948, Gabrielson and Lincoln 1959). Records of the geese are not substantive and it is possible that early sitings were of Glaucous Gulls (Johnson et al. 1985). Currently, the only breeding colony of Snow Geese along the Alaskan coast is on Howe Island, in the outer portion of the Sagavanirktok River delta, which has between 50 and 100 breeding pairs (Gavin 1979, 1980, Johnson et al. 1985). Incidental nesting has been reported for the Colville River delta and the Smith Bay-Teshekpuk Lake area (King 1979).

Immigration into the Howe Island colony is low and it appears to be relatively discreet from other, larger colonies in Canada and Siberia (Johnson et al. 1985). Geese from the Canadian colonies that nest on Kendall Island, Anderson River Delta and Banks Island stage on the ANWR in fall (Koski 1975, Garner and Reynolds 1983, Spindler 1983, 1984, Brackney et al. 1985a). Snow Geese from all nesting colonies have on occasion been recorded molting in the Teshekpuk Lake area (Derksen et al. 1979b).

Breeding Biology

Snow Geese arrive mated in the spring and can lay eggs upon arrival, weather permitting. Eggs are usually laid within one to two weeks of arrival. Clutches range from 3 to 5. Snow Geese are determinate layers and lack the ability to replace lost clutches. Nests are placed on high sites near saltwater. Extreme temperatures, either high or low, during incubation and hatching reduce productivity (Cooke et al. 1981). Incubation takes 20 to 22 days. Brood rearing takes place in nearby wetlands, usually in traditional areas, and family groups join to form large flocks. Salt marshes and marsh/pond complexes are preferred feeding areas. Adults molt during the brood rearing period. (Johnson et al. 1975, Bellrose 1976, Cooke et al. 1981, Troy 1985b).

Birds on Howe Island move off the island to the Sagavanirktok River delta immediately following hatching. The delta, within 6 km south of the island, receives most use during brood rearing. Densities in brood rearing areas are lower for the Howe Island birds than at other colonies and the Howe Island birds seem to have low fidelity to specific brood rearing areas (Johnson et al. 1985).

Productivity of the western arctic population (the Canadian colonies) has been estimated during aerial surveys of the fall staging birds. Production peaked in 1973 with productivity estimated at 119 percent. Low years recorded were 1979 and 1980 with an estimated 3.1 percent productivity. 1982 was a low year for Howe Island, less than 25 percent of the total population were young of the year compared with greater than 50 percent recorded for 1980 through 1984 (excluding 1982) (Johnson et al. 1985, Troy 1985b).

Migration

Spring migration is slow and follows the progress of snow-melt on the Canadian Prairies and up the Mackenzie River. Birds arrive on their breeding grounds in mid- to late May (Johnson et al. 1975, Salter et al. 1980). Fall migration of the Howe Island birds, as evidenced from band recoveries and resightings of neck-collared birds, proceeds south through the Canadian prairies. They winter in both the Sacramento and Rio Grande valleys (Johnson et al. 1985).

Fall staging on the ANWR takes place in late August and early September. Birds from Banks Island, Anderson River delta and Kendall Island spread out across the coastal plain, primarily to feed prior to migration. In years of bad weather, the geese may not move past the Mackenzie River delta. Use of the ANWR has ranged from 0 (1975) to over 300,000 (1978) (U.S. Fish and Wildlife Service 1982, Spindler 1984).

Susceptibility

Breeding Snow geese flushed 0.8 to 2.4 km ahead of helicopters and took up to 45 minutes to return to their nests (Barry and Spencer 1976). Predation by gulls and jaegers increased while the birds were off their nests. Staging birds flushed up to 3000 m from aircraft and flushed at greater distances when the craft was below 300 m (Salter and Davis 1974). Davis and Wisely (1974) found staging birds flushed at greater distances from helicopters but remained disturbed longer following fixed-wing craft. Howe Island was abandoned in 1977, probably due heavy helicopter traffic (Gavin 1980, Johnson et al. 1985).

Howe Island is adjacent to an offshore development, the Endicott Project, and may be subject to increased levels of disturbance. Productivity of the colony has been adversely affected by weather (1982) as well as helicopter traffic (Johnson et al. 1985). During the brood rearing period, flocks have moved across roads and through the edge of the developed oilfield (in the Lisburne area) (Johnson et al. 1985, Murphy et al. 1986). Densities in the brood rearing areas are low in comparison to other colonies, brood rearing site fidelity is low, and energetic requirement estimates indicate that sufficient delta wetlands will be available for brood rearing even if the Endicott Road and causeway prevent the geese from reaching the eastern delta (Johnson et al. 1985). With the information available, it appears that the Howe Island colony is susceptible to disturbance during the nesting period and less susceptible during the brood rearing period.

Brant (*Branta bernicla*)

Distribution and Status

Brant breed along the Beaufort coast, generally in colonies. In NPR-A, brant were found breeding near the Meade River Delta and in the Teshekpuk region but not at the southern edge of the coastal plain. Derksen et al. (1981) suggest brant may not breed further than 40 km inland along the Arctic Coastal Plain. Brant regularly nest on four islands in the eastern Colville Delta; 242 nests were counted in 1982 and 293 nests in 1983 (Simpson et al. 1982, Renken et al. 1983). Considered an uncommon breeder in basin-complex wetlands in ANWR, a small colony of 15 pairs was found at the Okpilak River Delta in 1981 but not in 1982 (Spindler et al. 1984). Single pairs with broods have been reported at the Canning River Delta (Martin and Moitoret 1981) and have been listed as rare breeders at the Jago Delta (Miller et al. 1985). A small colony regularly breeds near Prudhoe Bay (Bergman et al. 1977) and brant with young have been sighted in the Kuparuk region.

Brant are common to abundant migrants along the Beaufort coast and have been observed traveling along inland routes during spring migration (Martin and Moitoret 1981). Fall migration seems confined to the coast and Brant are common to abundant in coastal wetlands in the fall (Johnson et al. 1975, Salter et al. 1980, Derksen et al. 1981, Martin and Moitoret 1981).

Large concentrations of non-breeding brant and failed breeders molt in the vicinity of Teshekpuk Lake (Derksen et al. 1979b, Derksen et al. 1982). Approximately 20,000 and 30,000 molting brant were in the region in 1977 and 1978 respectively. An estimated 20 percent of the world population of Brant molt in this area (Gilliam and Lent 1982). Peak use of the molting area occurred on 24 July 1978 and most birds had departed by 5 August (Derksen et al. 1981). Molting concentrations of hundreds of birds were recorded in Kasegaluk Lagoon, near Icy Cape, in 1981 (Lenhausen and Quinlan 1981).

Breeding Biology

Brant nest in *Arctophila fulva* wetlands (Class IV) and prefer to nest on islands away from predators (Johnson et al. 1975, Bergman et al. 1977). Nests are shallow scrapes lined with down. In general, clutches consist of four to eight eggs and incubation takes approximately 24 days. Clutches ranged from one to six on the Colville Delta in 1983 with a mean of 3.8 and mode of 4.0. Brant are determinate layers and will not renest if the first attempt fails. Brant generally are not able to defend their nests from foxes (Mickelson 1975,

J. Helmericks pers. comm.). Adults with broods move from Class IV wetlands to deep open lakes or to tidal sloughs and flats (Mickelson 1975, Bergman et al. 1977, Derksen et al. 1981). Adults molt during the brood rearing period and are flightless for about three weeks.

Brant feed in salt marshes during migration (Kiera 1984), primarily on Carex subspathacea and Puccinellia phryganodes. Kiera (1984) estimated food intake at 283 g dry weight of vegetation/day and that geese foraged about 77 percent of the day. Use of salt marshes by Brant coincides with peak production of the salt marsh.

Migration

Brant congregate in Izembek Lagoon in late April. Migration continues north along the coast to the Yukon-Kuskokwim Delta, where many birds are thought to leave the coast and migrate overland along the Yukon River and through Anaktuvuk Pass (Irving 1960, Johnson et al. 1975). Others continue north to the Kobuk and Noatak Rivers and follow these overland, presumably crossing the Brooks Range and traveling down the Colville River. Some continue north along the coast, passing around Pt. Barrow. Only small numbers of birds passed Icy Cape prior to mid-June in 1980, supporting the idea of overland migration routes (Lenhausen and Quinlan 1981). In a review of historical evidence, Cade (1955) found conclusive evidence that Brant migrate overland through the Yukon Basin during spring, but not in the fall. Brant arrive along the Beaufort coast during the first week in June, with some incidental records of birds during the last week in May (Johnson et al. 1975, Salter et al. 1980). Migration in the Beaufort region follows a broad front along the coast with many flocks seen nearshore (Salter et al. 1980). Low numbers of birds were observed migrating past Oliktok Point during spring migration watches (Johnson and Richardson 1981). Large numbers passed the Canning River between 30 May and 8 June in 1980 (Martin and Moitoret 1981). Brant were considered a common spring migrant the first week of June at Okpilak Delta in 1982 (Spindler et al. 1983) but not in 1983, although the lack of observations in 1984 probably reflect the late start (June 12) of the field camp (Moitoret et al. 1985). They were a common spring migrant at Sadlerochit Delta and a fairly common migrant at Jago Delta in 1984 (Miller et al. 1985).

From mid-June to mid-July, an estimated 35,000 Brant passed Icy Cape (Lenhausen and Quinlan 1981). These were presumed non-breeders on their way to Teshekpuk for molting.

Fall migration seems confined along the coast and birds are rarely seen inland (Johnson et al. 1975, Salter et al. 1980). Migration begins the second or third week in August, although some birds remain along the coast until September. Migration was noted past the Canning River during the third week of August in 1979 and was confined to a narrow band along the coast. Fall migration was not observed in 1980 prior to camp closure the first week of September. Strong west winds prevailed during the latter part of August and incidental observations at Barter Island indicated that a heavy migration occurred when east winds resumed in early September (Martin and Moitoret 1981). Birds during fall migration are thought to wait in coastal salt marshes for favorable wind conditions. Fall migration at Icy Cape peaked between 4 and 15 September 1980. Most birds flew down Avak Inlet, bypassing Icy Cape. Salt marshes were used extensively for feeding and resting (Lenhausen and Quinlan 1980).

Susceptibility

Local concentrations of Brant on the North Slope include coastal salt marshes during migration, Teshekpuk region for molting, and a few large nesting colonies (south of Camp Lonely, western portion of Teshekpuk Lake and northeastern portion of the Colville Delta).

Coastal salt marshes are a limited and important habitat for Brant during migration (Derksen et al. 1979, Connors et al. 1983, Johnson et al. 1983, Kiera 1984). Brant use may be approching the carrying capacity of the salt marshes (Kiera 1984) and the ability of other areas to absorb displaced birds seems unlikely. As they are low-lying areas, salt marshes are susceptible to oil spills in the marine environment.

The molting area at Teshekpuk is a unique area used by a significant portion (an estimated 20 percent; Gilliam and Lent 1982) of the world Brant population. Brant are sensitive to aircraft overflights during molt, displaying intense escape behavior. Activities that alter water levels in the wetlands could decrease their value for feeding. Brant are also sensitive to human disturbance during the molting period (Derksen et al. 1979, Derksen et al. 1982, Gilliam and Lent 1982).

Brant are sensitive to disturbance during nesting and brood rearing. Activity near nesting colonies may drive adults off nests, exposing the eggs to predation by gulls and foxes. Colonies are particularly susceptible to disturbance as large numbers of nesters may be affected (Gililam and Lent 1982).

Canada Goose (*Branta canadensis*)

Distribution and Status

Two nesting populations of Canada Geese occur along the Arctic Coastal Plain, in the Prudhoe Bay area, and along the Colville River (Kessel and Cade 1958, Gavin 1980). An estimated 200 to 300 pairs nest along the Colville River (Kessel and Cade 1958) and nesting densities ranging between 0.32/km^2 and 0.73/km^2 have been reported for the Prudhoe Bay area (Murphy et al. 1986). Nesting densities on the Canning River were 0.25/km^2 and 0.30/km^2 in 1979 and 1980, respectively (Martin and Moitoret 1981). Canada Geese are considered uncommon breeders in the ANWR (U.S. Fish and Wildlife Service 1982). Molting concentrations are recorded for the Teshekpuk Lake area (approximately 10,000 birds; Dirksen et al. 1981) and the Sagavanirktok River Delta (approximately 100 birds; Troy 1984). Salter et al. (1980) consider Canada Geese uncommon spring and fall migrants along the Beaufort Sea coast.

Breeding Biology

In Prudhoe Bay, Canada Geese nest on small islands in lakes and ponds (Gavin 1980, Troy 1985b, Murphy et al. 1986). Geese along the Colville River nest on cliff ledges. The young tumble down the cliffs shortly after hatching and brood rearing takes place along the river (Kessel and Cade 1958). Clutch size ranges from 4 to 8 and incubation takes between 24 and 30 days (Bellrose 1976). Geese remained paired throughout the breeding season. The male helps guard the nest but the female does all of the incubation (Johnson et al. 1975, Troy 1984). The geese are able to defend the nest from most predators but the nest is left when the female feeds and eggs are subject to predation (Murphy et al. 1986).

Family groups move to large wetland complexes for brood rearing and the adults molt during the brood rearing period. Several families may form a group during this period. Sedges are the primary food, which the young supplement with insects picked off the vegetation (Johnson et al. 1975, Troy 1984).

Migration

Canada Geese arrive on the North Slope during the last two weeks in May (Johnson et al. 1975, Salter et al. 1980). Studies at Icy Cape and at Peard Bay noted few Canada Geese during spring migration watches and conclude that the majority of migrants follow inland routes along the Mackenzie River and other major North Slope drainages (Lenhausen and Quinlan 1981, Gill et al. 1985). A westward molt migration of non-breeding birds and failed breeders to the Teshekpuk Lake area begins in late June and early July (Derksen et al. 1981, Margin and Moitoret 1981). Fall migration begins in late August and continues through mid-September. Birds either move east to the Mackenzie River and then south to the overwintering areas in New Mexico, Texas, and Mexico or migrate straight south to overwintering areas along the Arctic Flyway (Johnson et al. 1975, Troy 1985b).

Susceptibility

Canada Geese are usually able to successfully defend their nests from predators, however, disturbances that flush the birds from their nests leave the nest vulnerable to predation, notably by Glaucous Gulls (Mickelson 1975, Murphy et al. 1986). Nests within 100 m of roads in the Prudhoe Bay area were not successful, while those 100 to 200 m from roads were the most successful (Murphy et al. 1986).

Northern Pintail (*Anas acuta*)

Distribution and Status

The majority of Northern Pintails on Alaska's North Slope are non-breeders, although they are a regular breeder (Pitelka 1974, King 1979, Derksen and Eldridge 1980). At Point Storkersen, an estimated 50-75 percent of the pintails present were non-breeders (Bergman et al. 1977). Pintails are generally considered a rare breeder on the ANWR (U.S. Fish and Wildlife Service 1982), although they were a common breeder on the Okpilak River Delta (Spindler and Miller 1983).

Northern Pintails are abundant during drought years in the Prairie Potholes region (Derksen and Eldridge 1980). An estimated 6 percent of the continental population summered on the North Slope in 1977. Usually, females outnumber males, but in drought years the ratio is nearly equal. When breeding, females molt on the breeding grounds while the males always leave and molt elsewhere.

No breeding was observed at Icy Cape although non-breeders remained throughout the summer (Lenhausen and Quinlan 1981). Densities at Icy Cape were high in 1980 (6.3/km^2 on the tundra), which may reflect drought conditions on the prairies that year (Lenhausen and Quinlan 1981).

Breeding Biology

Egg laying begins in mid-June and clutch size ranges from 7 to 10. Females do all of the incubation, which lasts 22 to 24 days. Fledging takes place by September and fall migration immediately follows (Gabrielson and Lincoln 1959, Johnson et al. 1975). Pintails preferred basin complexes and shallow Arctophila wetlands for molting. Arctophila and sedges in these wetlands provided cover for the birds and feeding was their primary activity (Bergman et al. 1977). Troy (1985a) found pintails preferred wet tundra/strangmoor, Arctophila wetlands, and impoundments. Numbers of pintails decline during the middle of the summer, then increase prior to fall migration. The decline may be due to molting birds being secretive (Derksen et al. 1979a, Lenhausen and Quinlan 1981).

Migration

Northern Pintails follow the Arctic and Central Flyways and follow several routes to the North Slope: the Mackenzie River drainage, through interior Alaska and across the Brooks Range, and some follow the coast. They arrive by the end of May and are one of the first ducks to reach the North Slope (Johnson et al. 1975, Salter et al. 1980, Lehnhausen and Quinlan 1981, U.S. Fish and Wildlife Service 1982). Fall migration also follows a broad front and a major movement of pintails to the east was noted at the Canning River Delta between 14 and 20 August (Martin and Moitoret 1981).

Susceptibility

The Arctic Coastal Plain is important to Northern Pintails during drought years in the Prairie Potholes (Derksen and Eldridge 1980). Within the region, pintails are wide-spread and use a variety of habitats (Bergman et al. 1977, King 1979). Along a lightly travelled road in Prudhoe Bay, pintails preferred impoundments, which are the most extensive type of development impact (Troy 1985a). It appears that pintails as a population would not be susceptible to development except for massive oilspills or other wetland contamination.

Common Eider (Somateria mollissima)

Distribution and Status

Common Eiders breed along portions of the Beaufort coast, primarily on barrier islands (Johnson et al. 1975, Salter et al. 1980). They are common breeders in the Jones Islands and Prudhoe Bay area, notably on Cross, Egg, Thetis and Pole Islands (Divoky 1983). They are an uncommon breeder along the ANWR coast, but are common in the lagoons during molt (US Fish and Wildlife Service 1982).

Breeding Biology

Common Eiders prefer to nest on islands and spits that offer some protection from Arctic foxes (Gollop and Richardson 1974, Johnson et al. 1975, Schamel 1977). Nesting begins after a moat forms around the island, breaking any connection with the land (Schamel 1977). Nests are often placed in association with gulls. Most nesting is colonial or semi-colonial and nests are placed in sites that offer some protection from wind and sea spray, commonly amongst driftwood. Clutches range from 1 to 10 with an average of 4. Incubation takes 28 to 30 days and is done exclusively by the females. The females do not feed during incubation. Young are led straight to water upon hatching and suffer heavy mortality from gulls while travelling from the nest to the lagoon. Brood rearing is done in groups, termed creches, where one female guards several broods. Fledging occurs approximately 8 weeks after hatching. Males leave when incubation begins and migrate to molting areas near Icy Cape and Point Lay (Johnson et al. 1975, Schamel 1977, Johnson and Richardson 1981, Divoky 1983, Troy 1985b).

Migration

Common Eiders winter in the Bering Sea, near the ice edge. Similar to King Eiders, they migrate north following the lead from the Bering Strait to Barrow. They pass Barrow in early June (Divoky 1983). In years of severe spring weather, massive die-offs have been recorded (Barry 1968). Common Eiders also follow off-shore leads in the Beaufort Sea and are not seen along the coast between Barrow and Cape Dalhousie (Johnson et al. 1975, Salter et al. 1980, Divoky 1983).

Males migrate west to molt near Point Lay and Icy Cape beginning by the end of June and continue through July. Most males have left the Beaufort Sea by the end of August. Females and young head west at the end of August and in early September. They pass Barrow until the end of October. Westward migration follows a path between the outer edge of the barrier islands and the 20 m isobath (Divoky 1983).

Susceptibility

Common Eiders are susceptible to oilspills in the spring lead between the Bering Strait and Barrow as they congregate in the lead system during spring migration (Divoky 1983). Nesting colonies on Cross, Egg, Pole and Thetis Islands are also susceptible to disturbance during the nesting season (Divoky 1983).

King Eider (*Somateria spectabilis*)

Distribution and Status

The majority of King Eiders that migrate through the Beaufort Sea, nest in arctic Canada (Johnson et al. 1975, Salter et al. 1980). They are a common breeder in the Prudhoe Bay area (Bergman et al. 1977) and an uncommon breeder in the ANWR (U.S. Fish and Wildlife Service 1982). King Eiders may be excluded from breeding in some areas by the larger, more aggressive Common Eider (Schamel 1977).

Breeding Biology

King Eiders mate on breeding areas or just prior to their arrival. They arrive on their breeding areas in late may and early June (Johnson et al. 1975, Bergman et al. 1977). Males remain with the females only until the clutch is started at which time they leave for molting areas. Females do all incubation, which lasts 22 to 23 days. Young hatch during the second and third weeks in July. Brood rearing takes place on ponds and lakes, with a lot of movement between different water bodies (Gabrielson and Lincoln 1958, Johnson et al. 1975).

Migration

King Eiders winter in the Bering Sea along the ice edge and near the Aleutian Islands. Spring migration follows a major lead system from the Bering Strait north to Barrow. An estimated 800,000 birds passed Barrow in a 30 day period, with most birds passing between 26 May and 4 June. Males migrate slightly earlier than females (Divoky 1983). Relatively few spring migrants were observed at Icy Cape (Lenhausen and Quinlan 1981) and at Peard Bay (Gill et al. 1985) due to ice ridges that blocked observation of open leads. Massive die-offs have been recorded in years with severe spring weather (Barry 1968). Migrants pass Barrow and head north-east, possibly following leads in the ice pack as large numbers of birds are not seen along the Beaufort coast between Barrow and Herschel island during spring (Johnson et al. 1975, Salter et al. 1980, Johnson and Richardson 1981, U.S. Fish and Wildlife Service 1982).

Molt migrations of males begin in the end of June and peak past Barrow in mid-July (Divoky 1983). Females and young of the year migrate at the end of August and beginning of September. Fall migrants remain primarily between the outer edge of the barrier islands and the 20 m isobath in the Beaufort (Divoky 1983).

Susceptibility

King Eiders are most susceptible in the spring when they are concentrated in the lead system from the Bering Strait to Barrow (Divoky 1983). Breeding birds nest in low densities and at a population level that does not seem susceptible during the nesting season.

Oldsquaw (<u>Clangula</u> <u>hyemalis</u>)

Distribution and Status

Oldsquaw have a circumpolar distribution. They are one of the most common ducks on the tundra and are common breeders along the Beaufort coast (Johnson et al. 1975, Salter et al. 1980, Derksen et al. 1981, U.S. Fish and Wildlife Service 1982). Oldsquaw are abundant in nearshore lagoons in the Beaufort with the highest concentrations recorded in Simpson Lagoon (Johnson and Richardson 1981, Divoky 1983). They are also abundant during molt in Peard Bay (Gill et al. 1985) and at Icy Cape (Lenhausen and Quinlan 1981).

Breeding Biology

Oldsquaw nest singly or in loose colonies (Alison 1975). Nesting begins in mid-June and clutch size ranges from 5 to 8. Females do all of the incubating, which takes 23 to 26 days (Alison 1975, Johnson et al. 1975). Nests are usually located near small, non-vegetated ponds and the females lead their young to water immediately following hatching (Bergman et al. 1977). Females molt during brood rearing. Communal brood rearing groups form and groups often move between ponds and lakes (Alison 1976). Fledging takes place by September.

Males depart the tundra by late June and move to lagoons to molt. Large congregations form in lagoons and peak molt is between mid-July and mid-August. Along the Beaufort coast, the area south of Flaxman Island and Elson and Simpson Lagoons consistently have the highest concentrations and numbers of molting birds (Divoky 1983). During molt, Oldsquaw prey on amphipods and mysids and take the most abundant species (Johnson and Richardson 1981, Gill et al. 1985).

Migration

Oldsquaw winter in the Bering Sea and, like the eiders, migrate north along the lead from the Bering Strait to Barrow. They also follow interior routes over the Brooks Range. They arrive as soon as open water is available (Johnson et al. 1975, Salter et al. 1980, Divoky 1983). Oldsquaw pass Icy Cape and Peard Bay offshore over the open lead, which was largely out of site of observers (Lenhausen and Quinlan 1981, Gill et al. 1985).

Fall migration continues through September. Birds leave as lagoons freeze. Migration tends to follow a leap-frog pattern along the coast (Divoky 1983).

Susceptibility

Oldsquaw would be susceptible to oilspills in the nearshore during the molting period. Susceptibility would be highest during the latter half of July when the birds are flightless and unable to avoid a spill (Divoky 1983). Oldsquaw are also susceptible to activities, e.g. docks and causeways, that may alter lagoon processes and productivity (Johnson and Richardson 1981, Johnson et al. 1983).

Lesser Golden-Plover (Pluvialis dominica)

Distribution and Status

Lesser Golden-Plovers are common breeders on the North Slope. Reported nesting densities range from 1.3 pairs/km^2 at the Canning River delta (Martin and Moitoret 1981) to 5-10 pairs/km^2 in the foothills near Franklin Bluffs (Jones et al. 1980, Garrot et al. 1981, McCaffrey et al. 1982). Other reported densities are 2-4 pairs/km^2 in Prudhoe Bay and 7.7 pairs/km^2 in Barrow. During fall migration, plovers are more common near the coast than at inland sites (U.S. Fish and Wildlife Service 1982, Spindler and Miller 1983, Spindler et al. 1984, Miller et al. 1985).

Breeding Biology

Male Lesser Golden-Plovers have a conspicuous aerial courtship display accompanied by a two-note call. Males display over large territories, from 5-20 ha in size, and pairing takes place on the territory. Nests are in dry habitats, either in upland areas or dry microsites of wet areas. Clutches consist of four eggs and both adults incubate and care for the young. Males may assume a majority of parental duties following hatching, allowing the females more time to feed. Adults leave the tundra and begin migration prior to the young. The adults do not snow a pronounced coastal shift, although fall migrants are more common near the coast than inland. The young move towards the coast and begin migration in mid-August (Martin and Moitoret 1981, Connors 1982, U.S. Fish and Wildlife Service 1982, Connors et al. 1983, Spindler and Miller 1983, Spindler et al. 1984, Miller et al. 1985, Troy 1985b).

Larval chironomids and tipulids are the primary prey during the breeding season and other surface active insects, notably coleoptera, are also utilized. Berries (Empetrum nigrum) are eaten both early and late in the season (Baker 1977, Byrkjedal 1980, Connors 1982).

Troy (1985) found that Lesser Golden-Plovers preferred moist and dry tundra with low-relief, high-centered polygons during the breeding season. Preferences during the post-breeding season remaiend the same with the addition of aquatic strangmoor.

Migration

Peak arrival on the North Slope is during the first week of June. The birds that breed along the Beaufort coast winter in South American grasslands and migrate north along the Central Flyway. Fall migration retraces the spring route and most birds have left the North Slope by the end of August (Salter et al. 1980, Connors 1982, Troy 1985b).

Susceptibility

Lesser Golden-Plovers are not dependent on coastal habitats during fall migration and therefore have a low susceptibility to coastal oilspills (Connors et al. 1983). As nesting densities are low and plovers are common across the North Slope, sensitivity to tundra disturbances should be low (Connors et al. 1983). Troy (1985) showed that plovers did not avoid impoundments along a lightly traveled road. Densities adjacent to the road were lower than expected based on habitat availability, however densities between 100 and 300 m from the road were higher than expected, which suggests displacement of birds to adjacent areas (Troy 1985a).

Semipalmated Sandpiper (Calidris pusilla)

Distribution and Status

Semipalmated Sandpipers are common breeders across the North Slope and are often the most abundant breeding shorebird (Pitelka 1974, Norton et al. 1975, Spindler 1978, Salter et al. 1980, U.S. Fish and Wildlife Service 1982, Spindler and Miller 1983, Spindler et al. 1984, Miller et al. 1985). An average density of 36.7 birds/km^2 during the breeding season has been reported in Prudhoe Bay (Troy 1985).

Breeding Biology

Semipalmated Sandpipers nest in moist upland habitats, areas that become snow-free early (Troy 1985b). Males do an aerial display over their territories and mating takes place on their territories (Ashkenazie and Safrial 1979a). Clutches consist of four eggs, both adults incubae, and incubation takes about 21 days. Females feed heavily during the egg laying period (Ashkenazie and Safriel 1979b). Semipalmated Sandpipers are site tenacious, returning to the same area (within 100 m) to breed (Hanson and Eberhardt 1981). Females depart once the eggs are hatched. The males stay with the young, leading them to food and brooding them when necessary. Once the young have developed to the point where brooding is no longer necessary, the males leave. Young leave as soon as they fledge, usually within three weeks of hatching.

Baker (1977) found Semipalmated Sandpipers one of the most selective feeders in a community of shorebirds. Chironomids and tipulids made up the majority of their diet (Baker 1977, Maclean 1980). Hatching coincided with the peak of adult insect emergence, the time of greatest food availability for the young as their bills are too soft for probing (Maclean and Pitelka 1971, Maclean 1980).

In Prudhoe Bay, Semipalmated Sandpipers preferred dry habitats and moist and wet strangmoor. Preferred nesting habitat was in moist, low-relief, low-centered polgons and in wet strangmoor (Troy 1985a).

Migration

Arrival on the North Slope generally peaks during the first week in June and is related to snow melt (Norton et al. 1975, Myers and Pitelka 1980, Salter et al. 1980). Departure occurs in waves with first the females in early July, males in mid-July, then young by mid-August moving to the coast for staging prior to fall migration (Connors et al. 1983).

Susceptibility

Semipalmated Sandpipers are common nesters and, in a regional sense, are not at risk to development, but their site tenacity may make local populations susceptible to disturbance. Along a lightly traveled road, this species avoided the road, in particular, they avoided impoundments (Troy 1985a). They are moderately susceptible to oilspills along the coast due to the staging of young along the coast prior to fall migration (Connors et al. 1983).

Pectoral Sandpiper (*Calidris melanotos*)

Distribution and Status

Pectoral Sandpipers are common at Barrow and are widely distributed across the North Slope (Pitelka 1959, Pitelka 1974). They are a common breeders on the eastern portion of the Coastal Plain and were the most abundant breeding shorebird at many of the study sites in the ANWR (Spindler 1978, U.S. Fish and Wildlife Service 1982, Spindler and Miller 1983, Spindler et al. 1984, Miller et al. 1985).

Breeding Biology

Pectoral Sandpiper males are obvious in the spring with their chest-inflated, hooting aerial display and prominant perching on hummocks and other raised sites. Peak of male display occurs during mid-June and territories are used for pairing, mating, roosting, and sometimes for feeding. Pair bonds are brief and males may mate with several females. Nests are located on male territories only incidentally, with females preferring areas with heavy grass or sedge cover for nest sites. Most clutches (usually four eggs) are laid during the latter half of June and females do all incubation and parental care. Males flock and leave the tundra by the first week in July. Females leave prior to fledging of the young, usually by early August. Birds shift toward the coast but are not prominent users of the coastline. Pectoral Sandpipers are noted for their high annual and spatial variability (Pitelka 1959, Myers and Pitelka 1980, Connors et al. 1983).

In Prudhoe Bay, Pectoral Sandpipers preferred wet tundra/non-patterned ground, aquatic tundra/non-patterned ground, and aquatic tundra/strangmoor during the breeding season (Troy 1985a).

Migration

Pectoral Sandpipers arrive on the North Slope during the latter part of May and the first week of June (Pitelka 1959, Johnson et al. 1975, Salter et al. 1980).

Susceptibility

Pectoral Sandpipers do not seem highly sensitive to disturbance as no avoidance of a lightly traveled road was observed (Troy 1985a). The same study demonstrated that the sandpipers used impoundments in proportion to their availability during the breeding season and preferred impoundments during the post-breeding season. Coastal susceptibilty to the effects of an off-shore oilspill is considered low as Pectoral Sandpipers primarily use tundra areas and not coastal wetlands (Connors et al. 1983).

Buff-breasted Sandpiper (Tryngites subruficollis)

Distribution and Status

Buff-breasted Sandpipers are listed as a rare to uncommon migrant, summer visitant, and breeder along the Beaufort Sea coast of northern Alaska between late May and early June, and in late August (Kessel and Gibson 1978). They were rare at Icy Cape in 1980 (Lenhausen and Quinlan 1981) and classified as an occasional breeder -- visitant some years and a breeder other years -- at Barrow (Pitelka 1974). They are uncommon and rare breeders at some inland sites -- Square Lake (Derksen et al. 1981), Aichilik River (Miller et al. 1985), but common breeders at Franklin Bluffs (Hanson and Eberhardt 1980). They are common breeders in the Prudhoe Bay region (Troy 1985). Annual variation has been high at some sites, ranging from uncommon to fairly common breeder at Jago Delta and Okpilak Delta (Spindler et al. 1983, Moitoret et al. 1984, Miller et al. 1985). They were listed as an uncommon summer visitant at Sadlerochit Delta (Miller et al. 1984).

Breeding Biology

Buff-breasted Sandpipers have a promiscuous type of mating system (Pitelka et al. 1974). Males concentrate in small areas -- leks -- to display. Leks at the Canning River Delta were in drier areas, along lake bluffs and ridges (Martin and Moitoret 1981). The display behavior consists primarily of wing flashes, flutter jumps and postures that expose the silver wing linings (Myers 1979). Females visit the leks to mate, then nest alone. Clutches are generally four eggs. Males presumably leave breeding areas in early July and females and young leave the latter part of August. Incubation for one nest at the Canning River Delta was 23 days and hatching occurred during the second and third weeks in July (Martin and Moitoret 1981). Nests were found in dry upland tundra sites, in Dryas dominated tundra and in riparian areas (Martin and Moitoret 1981, Moitoret et al. 1984, Miller et al. 1985).

On the Canning River Delta, the majority of lek activity occurred during the second and third weeks in June (Martin and Moitoret 1981). An increase in sitings of males displaying in the first week of July was thought to be a coastal movement of males following break-up of leks at inland sites.

In the Prudhoe region, Buff-breasted Sandpipers strongly preferred the following habitat types with these reported densities: moist tundra/low relief-high centered polygons (13.3/km^2), Moist tundra/frost scar (15.9/km^2), and wet tundra/strangmoor (11.0/km^2); average density was 6.4/km^2 (Troy 1985a).

Migration

Birds migrate through the interior and arrive on the breeding grounds from the end of May through the first week in June. Males depart the breeding areas first and may move to the coast prior to migrating south (Johnson et al. 1975, Salter et al. 1980, Martin and Moitoret 1981).

Susceptibility

Buff-breasted Sandpipers are generally uncommon and do not congregate in any particular or restricted habitat type and are not considered vulnerable other than to massive habitat loss or alteration.

Dunlin (Calidris alpina)

Distribution and Status

Dunlin are common breeders at sites along the outer coastal plain from Barrow through NPR-A (Myers and Pitelka 1980, Derksen et al. 1979a). They are fairly common breeders in the Prudhoe Bay region (Norton et al. 1975, Hanson and Eberhardt 1980, Troy 1985a). They are fairly common to uncommon breeders at inland coastal plain sites (Derksen et al. 1979a). Dunlin decrease in abundance to the east and are listed as a rare visitor in the Yukon Arctic Coastal Plain (Salter et al. 1980). They are a fairly common breeder and migrant at the Canning River Delta, which may be near the eastern limit of their breeding distribution (Martin and Moitoret 1981). Some breeding has been reported east of the Canning River at Jago River Delta: courtship flights were observed in early June and three nests were subsequently found (Miller et al. 1985). Breeding was suspected at the Katakturuk River based on the behavior of one individual (Moitoret et al. 1984). During migration, Dunlin are uncommon at Jago River Delta and Katakturuk and are common at Sadlerochit (Miller et al. 1985, Moitoret et al. 1984).

Breeding Biology

Holmes (1966, 1970, and Holmes and Pitelka 1968) studied Dunlin extensively on their breeding grounds in Barrow and at the Kolomak River, in the west-central portion of the Yukon-Kuskokwim Delta. Dunlin arrived on their breeding grounds in early June during snow-melt. Territories were established and actively defended until the eggs hatched. All courtship, nesting and feeding occurred on the territory. Territory size at Barrow was relatively constant during four years of census work and ranged from 5.5 to 7.5 ha, averaging 15 pairs/km^2. Clutches consisted of four eggs and both adults incubated (Norton 1972). Eggs were laid by the third week in June and hatched by the second week in July. The precocial young left the nest soon after hatching.

Dunlin are insectivorous, feeding primarily on Tipulidae and Chironomidae. Tipulid larvae are most abundant in the diet in June, adult tipulidae in early July and chionomid larvae in August (Holmes 1970). Nesting and foraging during the early part of the breeding season (June and early July) is on drier, upland sites. After hatching, family groups move to low lying marshy areas where chironomid larvae and emerging adults are more numerous. By late July and early August, adults begin flocking on the tundra, to feed and molt prior to migration. Juveniles move to the coast as soon as they can fly and feed on chironomid larvae. Juveniles are somewhat more common in littoral areas than on the tundra in August (Connors et al. 1983). Dunlin remain along the Beaufort coast much longer than other shorebirds.

In Prudhoe Bay, Dunlin preferred moist, wet tundra/low-relief low-centered polygons. They also preferred moist tundra/strangmoor, wet tundra/strangmoor, and wet, moist tundra/strangmoor. The highest nesting densities occurred in moist tundra/strangmoor.

Migration

Dunlin that breed along the west coast of Alaska, on the Yukon-Kuskokwim Delta and the Seward Peninsula belong to the race C. alpina pacifica and winter along the pacific coast of north America. Dunlin that breed along the Beaufort coast, at Barrow and to the east, belong to the race C. alpina sakhalina, and winter along the Pacific coast of Asia (Maclean and Holmes 1971). The latter race migrates north along the coast of Asia and crosses the Bering Strait, arriving on the North Slope in late May and early June. Dunlin migrate in a series of long flights with few stopovers along the coast (Senner and West 1978). Fall migration retraces spring migration routes.

Susceptibility

Dunlin do not nest in concentrations and the population is therefore not considered sensitive to development impacts on the tundra. They do concentrate and depend on food resources in the littoral zone and are considered moderately at risk to oil spills in the marine environment (Connors et al. 1983). As Dunlin nesting densities have low annual variability, they may be a useful indicator species for studies concerned with long term impacts to tundra wetlands.

Red-necked Phalarope (Phalaropus lobatus)

Distribution and Status

Red-necked Phalaropes are found throughout the circumpolar region. On the North Slope, they are more common to the east along the coast of the Arctic National Wildlife Refuge (Salter et al. 1980, Martin and Moitoret 1981, Spindler and Miller 1983, Spindler et al. 1984, Miller et al. 1985). Densities reported for Prudhoe Bay were 7.3 birds/km^2 and 1.4 nests/km^2 (Troy 1985a). In the fall, Red-necked Phalaropes are less abundant in coastal lagoons and nearshore areas of the Alaskan Beaufort than are Red Phalaropes (Divoky 1983).

Breeding Biology

Traditional roles are reversed in phalaropes and female Red-necked Phalaropes are slightly larger and more brightly colored than males. Mating takes place on the breeding area and the pair bond lasts until the female completes the clutch and then leaves. Males take over and do all of the incubation and care of the young. Phalaropes feed in shallow water and along pond margins. Chironomids are the primary prey (Johnson et al. 1975, Baker 1977, Troy 1985b).

In Prudhoe Bay, Red-necked Phalaropes preferred aquatic tundra/strangmoor, water/ponds with emergent vegetation and impoundments but avoided water/ponds without emergent vegetation during the breeding season. No habitat preferences were demonstrated during the post-breeding season or for nest sites, the latter may relate to the low number of nests found (Troy 1985a).

Migration

Red-necked Phalaropes arrive on the North Slope in early June. Few were seen during spring migration at Icy Cape (Lenhausen and Quinlan 1981) and at Peard Bay (Gill et al. 1985), and they were not common in the Bering Sea lead (Divoky 1983). Phalaropes stage along the coast in the fall, concentrating in lagoons and along barrier islands. Red-necked and Red Phalaropes form mixed flocks, with Red Phalaropes more common along the Alaskan Beaufort than Red-necked Phalaropes. Large concentrations of phalaropes occur near the Plover Islands, Pitt Point, and Jones Island/Prudhoe Bay (Divoky 1983). Copepods and amphipods are the primary food source (Johnson and Richardson 1981, Connors et al. 1983).

Susceptibility

Red-necked Phalaropes occurred in high densities near a lightly traveled road in Prudhoe Bay, which reflected their selection for impoundments (Troy 1985a). Based on these observations, Red-necked Phalaropes do not seem sensitive to disturbance on the tundra. During fall staging they are susceptible to oilspills in the marine environment, particularly in areas where they concentrate (Connors et al. 1983).

Red Phalaropes (Phalaropus fulicaria)

Distribution and Status

Red Phalaropes occur throughout the circumpolar region (Johnson et al. 1975, Salter et al. 1980, Tracy and Schamel 1982) and are more numerous than Red-necked Phalaropes along the Alaskan Beaufort. Large between years variation in abundance has been noted in Barrow and related to snow melt patterns (Myers and Pitelka 1980). They are a common to abundant breeder near the coast but are less common inland (Bergman et al. 1977, Derksen et al. 1981, Martin and Moitoret 1981). In the ANWR, they were common breeders on Okpilak, Jago, and Canning River deltas, and generally uncommon to rare inland and east of Barter Island (Spindler and Miller 1983, Spindler et al. 1984, Miller et al. 1985).

Breeding Biology

Females are brightly colored and are larger than the males. Pairing takes place on the breeding grounds, which is immediately followed by nesting. The females lay the clutch and depart, leaving the male to incubate and raise the brood. Females have the potential to lay more than one clutch and can either replace a lost clutch for a mate or lay a clutch for a second mate. Nests are located in a variety of areas, generally close to wet sedge marshes that are primary foraging habitat. Nesting begins later than most other shorebirds (past mid-June) as the wet habitats are the last to become snow free. Incubation takes 19 days, fledging 18 to 21 days, and the males stay with the brood until they are nearly fledged. Foraging is concentrated in aquatic habitats and chironomids and tipulids are the primary prey (Schamel and Tracy 1977, Mayfield 1978, Tracy and Schamel 1982).

Phalaropes stage in coastal lagoons and nearshore areas in the fall and feed on marine copepods and amphipods. Feeding is important for pre-migratory fat deposition. Foraging patterns in the nearshore seem to depend on zooplankton availability and weather conditions. In a year of low zooplankton densities, phalaropes fed on under-ice amphipods that became available when ice piled-up along windward shores. When zooplankton densities were high, phalaropes foraged along protected shorelines (Johnson and Richardson 1981, Connors et al. 1983).

Red Phalaropes preferred all types of wet and aquatic habitats in Prudhoe Bay, including impoundments, during the breeding season. Dry habitats were avoided, as were lakes with no emergent vegetation. Preferred nesting habitat was moist, wet tundra/low-relief, low-centered polygons, and wet tundra/non-patterned ground. No post-breeding habitat preferences were demonstrated (Troy 1985a).

Migration

Red Phalaropes arrive on the North Slope in early June. They are not common in the Bering Sea lead (Divoky 1983). They were the most commonly identified shorebird during spring migration at Icy Cape but less than 550 birds were recorded during that period (Lenhausen and Quinlan 1981) and were the most common shorebird passing Peard Bay (95 percent of the birds during the peak of migration (Gill et al. 1985).

Phalaropes stage in coastal lagoons and nearshore areas prior to fall migration, concentrating around gravel beaches and spits. High pelagic densities were recorded near the Plover Islands and high nearshore densities adjacent to the Plover Islands, Pitt Point areas, and Jones Islands/Prudhoe Bay area. Phalaropes may move westward rapidly during migration and congregate in the Plover Island area prior to moving offshore for the winter (Divoky 1983).

Susceptibility

Red Phalaropes did not show any response to a lightly traveled road in Prudhoe Bay and preferentially used impoundments during the breeding season (Troy 1985a). In contrast, mortality of Red Phalaropes due to powerlines has been observed in Barrow (Tracy and Schamel 1982). The overall effect on phalaropes is therefore difficult to jduge but since gravel placement causes the majority of habitat alteration, it seems likely that susceptibility of Red Phalaropes to tundra development impacts is low.

Oilspills in the marine environment could affect birds staging in lagoons either directly or by adversely affecting their prey (Divoky 1983, Connors et al. 1983). In an artificial setting, juvenile phalaropes were exposed to light oil films on water. The juveniles learned to avoid the oil and the author tentatively concluded that the phalaropes could learn to avoid spills if non-polluted alternatives were available (Connors et al. 1983).

Lapland Longspur (Calcarius lapponicus)

Distribution and Status

Lapland Longspurs have a circumpolar distribution and are one of the most common breeding birds on Alaska's North Slope. Nest densities range from 15 to 35 nests/km^2 (Salter et al. 1980, Troy 1985a).

Breeding Biology

Lapland Longspurs arrive as soon as snow melt begins and are one of the first birds to initiate nesting (Troy 1985a). Males defend territories with aerial song displays (Seastedt and Maclean 1979). Nests are made of woven grasses and lined with white feathers. A preference for nest sites with a southern exposure was noted at the Firth and Babbage Rivers in 1972 (Salter et al. 1980). Clutches usually consist of 5 or 6 eggs and both adults incubate. Incubation is rapid, 10 or 11 days, and the female does all of the incubation. The young are altricial, totally dependent upon the adults for food, both adults help feed. Prey is largely insects and seldom includes seeds, which are a major component of the adult's diet (Custer and Pitelka 1977, Seastedt and Maclean 1979). Longspurs fledge when 10 days old, before they are able to fly, and while still dependent upon the adults for food.

Longspurs nest and feed in a variety of habitats, from dry to fairly wet providing the wet areas are interspersed with dry sites. Longspurs avoided impoundments during the nesting season (Troy 1985b).

Longspur nests suffer heavy predation, largely due to Arctic foxes and jaegers. If a nest is lost early in the season, a pair will renest. Second clutches are usually smaller (Troy 1984).

Migration

Lapland Longspurs migrate along the Central Flyway and winter in north-central North America (Troy 1985b). Spring migration is early with most birds arriving by the end of May (Salter et al. 1980). Fall migration begins in August and most longspurs are gone by September (Salter et al. 1980).

Susceptibility

Lapland Longspurs are ubiquitous across the coastal plain and, at a population level, do not seem at risk from development.

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APPENDIX C.

COMMON AND SCIENTIFIC NAMES FOR NORTH SLOPE BIRDS AND PLANTS

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Rosa Meehan, U.S. Fish and Wildlife Service, Alaska
Investigations, Wetlands and Marine Ecology

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1. NORTH SLOPE BIRDS -- SCIENTIFIC AND COMMON NAMES (From Troy 1987)

Birds recorded in northern Alaska (north of the continental divide) are listed below. Species marked with asterisks (*) have been found nesting, while species marked with a plus (+) have only been found infrequently on the North Slope.

Common Names	Scientific Names
*Red-throated Loon	Gavia stellata
*Pacific Loon	G. pacifica
Common Loon	G. immer
*Yellow-billed Loon	G. adamsii
*Horned Grebe	Podiceps auritus
*Red-necked Grebe	P. grisegena
Northern Fulmar	Fulmarus glacialis
Short-tailed Shearwater	Puffinus tenuirostris
Pelagic Cormorant	Phalacrocorax pelagicus
+Great Blue Heron	Ardea herodias
*Tundra Swan	Cygnus columbianus
*Trumpeter Swan	C. buccinator
*Greater White-fronted Goose	Anser alibfrons
*Snow Goose	Chen caerulescens
+Ross' Goose	C. rossii
+Emperor Goose	C. canagica
*Brant	Branta bernicla
*Canada Goose	B. canadensis
*Green-winged Teal	Anas crecca
+Baikal Teal	A. formosa
*Mallard	A. platyrhynchos
*Northern Pintail	A. acuta
+Blue-winged Teal	A. discors
*Northern Shoveler	A. clypeata
+Gadwall	A. strepera
+Eurasian Wigeon	A. penelope
*American Wigeon	A. americana
+Canvasback	Aythya valisineria
+Redhead	A. americana

Common Names	Scientific Names
+Ring-necked Duck	A. collaris
+Tufted Duck	A. fuligula
*Greater Scaup	A. marila
+Lesser Scaup	A. affinis
*Common Eider	Somateria mollissima
*King Eider	S. spectabilis
*Spectacled Eider	S. fischeri
*Steller's Eider	Polysticta stelleri
*Harlequin Duck	Histrionicus histrionicus
*Oldsquaw	Clangula hyemalis
Black Scoter	Melanitta nigra
Surf Scoter	M. perspicillata
*White-winged Scoter	M. fusca
Common Goldeneye	Bucephala clangula
+Barrow's Goldeneye	B. islandica
+Bufflehead	B. albeola
*Red-breasted Merganser	Mergus serrator
Osprey	Pandion haliaetus
Bald Eagle	Haliaeetus leucocephalus
*Northern Harrier	Circus cyaneus
Sharp-shinned Hawk	Accipiter striatus
Northern Goshawk	A. gentilis
+Red-tailed Hawk	Buteo jamaicensis
*Rough-legged Hawk	B. lagopus
*Golden Eagle	Aquila chrysaetos
*American Kestrel	Falco sparverius
*Merlin	F. columbarius
*Peregrine Falcon	F. peregrinus
*Gyrfalcon	F. rusticolus
*Willow Ptarmigan	Lagopus lagopus
*Rock Ptarmigan	L. mutus
+American Coot	Fulica americana
*Sandhill Crane	Grus canadensis
*Black-bellied Plover	Pluvialis squatarola
*Lesser Golden-Plover	P. dominica
+Mongolian Plover	Charadrius mongolus
*Semipalmated Plover	C. semipalmatus
+Killdeer	C. vociferus
*Eurasian Dotterel	C. morinellus
+Greater Yellowlegs	Tringa melanoleuca
*Lesser Yellowlegs	T. flavipes
+Wood Sandpiper	T. glareola
*Solitary Sandpiper	T. solitaria
*Wandering Tattler	Heteroscelus incanus
+Gray-tailed Tattler	H. brevipes
*Spotted Sandpiper	Actitis macularia
*Upland Sandpiper	Bartramia longicauda
+Eskimo curlew	Numenius borealis
*Whimbrel	N. phaeopus
Hudsonian Godwit	Limosa haemastica
*Bar-tailed Godwit	L. lapponica

Common Names	Scientific Names
*Ruddy Turnstone	Arenaria interpres
*Black Turnstone	A. melanocephala
*Red Knot	Calidris canutus
*Sanderling	C. alba
*Semipalmated Sandpiper	Calidris pusilla
*Western Sandpiper	C. mauri
*Rufous-necked Stint	C. ruficollis
+Little Stint	C. minuta
*Least Sandpiper	C. minutilla
*White-rumped Sandpiper	C. fuscicollis
*Baird's Sandpiper	C. bairdii
*Pectoral Sandpiper	C. melanotos
+Sharp-tailed Sandpiper	C. acuminata
*Dunlin	C. alpina
*Curlew Sandpiper	C. ferruginea
*Stilt Sandpiper	C. himantopus
+Spoonbill Sandpiper	Eurynorhynchus pygmeus
*Buff-breasted Sandpiper	Tryngites subruficollis
+*Ruff	Philomachus pugnax
*Long-billed Dowitcher	Limnodromus scolopaceus
*Common Snipe	Gallinago gallinago
+Wilson's Phalarope	Phalaropus tricolor
*Red-necked Phalarope	P. lobatus
*Red Phalarope	P. fulicaria
*Pomarine Jaeger	Stercorarius pomarinus
*Parasitic Jaeger	S. parasiticus
*Long-tailed Jaeger	S. longicaudus
+South Polar Skua	Catharacta maccormicki
+Common Black-headed Gull	Larus ridibundus
+Bonaparte's Gull	L. philadelphia
*Mew Gull	L. canus
*Herring Gull	L. argentatus
Thayer's Gull	L. thayeri
Slaty-backed Gull	L. schistisagus
Glaucous-winged Gull	L. glaucescens
*Glaucous Gull	L. hyperboreus
Black-legged Kittiwake	Rissa tridactyla
Ross' Gull	Rhodostethia rosea
*Sabine's Gull	Xema sabini
Ivory Gull	Pagophila eburnea
*Arctic Tern	Sterna paradisaea
+*Aleutian Tern	S. aleutica
+Dovekie	Alle alle
Common Murre	Uria aalge
Thick-billed Murre	U. lomvia
*Black Guillemot	Cepphus grylle
Kittlitz's Murrelet	Brachyramphus brevirostris
Parakeet Auklet	Cyclorrhynchus psittacula
Least Auklet	Aethia pusilla
Crested Auklet	A. cristatella
Tufted Puffin	Fratercula cirrhata
Horned Puffin	F. corniculata

Common Names	Scientific Names
+Band-tailed Pigeon	Columba fasciata
Great Horned Owl	Bubo virginianus
*Snowy Owl	Nyctea scandiaca
*Northern Hawk-Owl	Surnia ulula
*Short-eared Owl	Asio flammeus
+Common Nighthawk	Chordeiles minor
+Belted Kingfisher	Ceryle alcyon
+Three-toed Woodpecker	Picoides tridactylus
+*Northern Flicker	Colaptes auratus
+Olive-sided Flycatcher	Contopus borealis
+Western Wood-Pewee	C. sordidulus
+Alder Flycatcher	Empidonax alnorum
+Hammond's Flycatcher	E. hammondii
+Dusky Flycatcher	E. oberholseri
*Say's Phoebe	Sayornis saya
+Eastern Kingbird	Tyrannus tyrannus
*Horned Lark	Eremophila alpestris
+Purple Martin	Progne subis
*Tree Swallow	Tachycineta bicolor
Violet-green Swallow	T. thalassina
+Northern Rough-winged Swallow	Stelgidopteryx serripennis
*Bank Swallow	Riparia riparia
*Cliff Swallow	Hirundo pyrrhonota
Barn swallow	H. rustica
*Common House-Martin	Delichon urbica
*Gray Jay	Perisoreus canadensis
+Black-billed Magpie	Pica pica
*Common Raven	Corvus corax
+Black-capped Chickadee	Parus atricapillus
*Siberian Tit	P. cinctus
+Boreal Chickadee	P. hudsonicus
+Winter Wren	Troglodytes troglodytes
*American Dipper	Cinclus mexicanus
*Arctic Warbler	Phylloscopus borealis
Rudy-crowned Kinglet	Regulus calendula
*Bluethroat	Luscinia svecica
*Northern Wheatear	Oenanthe oenanthe
*Mountain Bluebird	Sialia currucoides
+Townsend's Solitaire	Myadestes townsendi
*Gray-cheeked Thrush	Catharus minimus
*Swainson's Thrush	C. ustulatus
+Hermit Thrush	C. guttatus
+Eye-browed Thrush	Turdus obscurus
+Dusky Thrush	T. naumanni
+Fieldfare	T. pilaris
*American Robin	T. migratorius
*Varied Thrush	Ixoreus naevius
+Brown Thrasher	Toxostoma rufum
+Siberian Accentor	Prunella montanella
*Yellow Wagtail	Motacilla flava
White Wagtail	M. alba

Common Names	Scientific Names
+Red-throated Pipit	Anthus cervinus
*Water Pipit	A. spinoletta
+Bohemian Waxwing	Bombycilla garrulus
+Cedar Waxwing	B. cedrorum
*Northern Shrike	Lanius excubitor
Orange-crowned Warbler	Vermivora celata
*Yellow Warbler	Dendroica petechia
+Magnolia Warbler	D. magnolia
+Cape May Warbler	D. tigrina
Yellow-rumped Warbler	D. coronata
+Townsend's Warbler	D. townsendi
+Blackpoll Warbler	D. striata
+Black-and-white Warbler	Mniotilta varia
+American Redstart	Setophaga ruticilla
+Ovenbird	Seiurus aurocapillus
Northern Waterthrush	S. noveboracensis
+Kentucky Warbler	Oporornis formosus
+MacGillivray's Warbler	O. tolmiei
*Wilson's Warbler	Wilsonia pusilla
+Canada Warbler	W. canadensis
+Scarlet Tanager	Piranga olivacea
+Western Tanager	P. ludoviciana
*American Tree Sparrow	Spizella arborea
+Chipping Sparrow	S. passerina
+Clay-colored Sparrow	S. pallida
*Savannah Sparrow	Passerculus sandwichensis
*Fox Sparrow	Passerella iliaca
+Lincoln's Sparrow	Melospiza lincolnii
+White-throated Sparrow	Zonotrichia albicollis
Golden-crowned Sparrow	Z. atricapilla
*White-crowned Sparrow	Z. leuchophrys
+Harris' Sparrow	Z. querula
*Dark-eyed Junco	Junco hyemalis
*Lapland Longspur	Calcarius lapponicus
*Smith's Longspur	C. pictus
+Little Bunting	Emberiza pusilla
+Pallas' Reed-Bunting	E. pallasi
*Snow Bunting	Plectrophenax nivalis
+Bobolink	Dolichonyx oryzivorus
+Red-winged Blackbird	Agelaius phoeniceus
+Yellow-headed Blackbird	Xanthocephalus xanthocephalus
Rusty Blackbird	Euphagus carolinus
+Brewer's Blackbird	E. cyanocephalus
+Common Grackle	Quiscalus quiscula
+Brown-headed Cowbird	Molothrus ater
+Brambling	Fringilla montifringilla
*Rosy Finch	Leucosticte arctoa
Pine Grosbeak	Pinicola enucleator
White-winged Crossbill	Loxia leucoptera
*Common Redpoll	Cardeulis flammea
*Hoary Redpoll	C. hornemanni
+Pine Siskin	C. pinus

2. COMMON NORTH SLOPE PLANTS -- SCIENTIFIC AND COMMON NAMES

Scientific Names[1]	Common Names[2]
Achillea borealis	common yarrow
Androsace chamaejasme	grass-leafed androsace
Anemone parviflora	small-flowered anemone
Arctophila fulva	pendant grass
Arctostaphylos alpina	alpine bearberry
Arctostaphylos rubra	bearberry
Arnica alpina	alpine arnica
Artemisia arctica	arctic wormwood
Artemisia borealis	northern wormwood
Artemisia glomerata	glomerate wormwood
Artemisia tilesii	Tilesius' wormwood
Astragalus arboriginum	Indian milk-vetch
Astragalus alpinus	alpine milk-vetch
Astragalus umbellatus	tundra milk-vetch
Betula nana spp. exilis	dwarf birch
Braya purpurascens	purplish braya
Bromus pumpellianus	arctic brome-grass
Caltha palustris	marsh-marigold
Campanula uniflora	arctic harebell
Cardamine pratensis	cuckoo-flower
Carex aquatilis	aquatic sedge
Carex atrofusca	dark-brown sedge
Carex bigelowii	Bigelow's sedge
Carex chordorrhiza	cordroot sedge
Carex membranacea	fragile sedge
Carex misandra	short-leafed sedge
Carex ramenskii	Ramenski's sedge
Carex rariflora	loose-flowered alpine sedge
Carex rotundata	round-fruited sedge
Carex rupestris	rock sedge
Carex saxatilis	rocky sedge
Carex scirpoidea	northern single-spike sedge
Carex subspathacea	Hoppner sedge
Carex ursina	bear sedge
Cassiope tetragona	Lapland cassiope
Castilleja caudata	pale paintbrush
Cerastium beringianum	Beringian chickweed
Chrysanthemum bipinnatum	wing-leafed tansy
Chrysanthemum integrifolium	entire-leafed chrysanthemum
Cochlearia officinalis	common scurvy-grass
Deschampsia caespitosa	tufted hair-grass
Dryas integrifolia	arctic avens
Dupontia Fisheri	Fisher's tundragrass
Elymus arenarius	lyme-grass
Empetrum nigrum	crowberry

[1] Hulten (1968)
[2] Polunin (1959) and Hulten (1968)

Scientific Names[1]	Common Names[2]
Epilobium latifolium	river-beauty
Equisetum arvense	common horsetail
Equisetum variegatum	variegated horsetail
Eriophorum angustifolium	common cottongrass
Eriophorum russeolum	russet cottongrass
Eriophorum scheuchzeri	arctic cottongrass
Eriophorum vaginatum	sheathed cottongrass
Festuca rubra	red fescue
Gentiana prostrata	moss gentian
Gentianella propinqua	arctic gentian
Hippuris vulgaris	common mare's tail
Ledum palustre ssp. decumbens	narrow-leafed Labrador tea
Lloydia serotina	common alp-lily
Lupinus arctica	arctic lupine
Luzula arctica	arctic wood-rush
Melandrium apetalum	nodding lychnis
Minuartia arctica	arctic sandwort
Oxytropis borealis	pale oxytrope
Oxytropis nigrescens	blackish oxytrope
Oxytropis viscida	pale oxytrope
Papaver lapponicum	arctic poppy
Papaver macounii	Macoun's poppy
Parnassia kotzebuei	Kotzebue's grass-of-parnassus
Parnassia palustris	common grass-of-parnassus
Pedicularis capitata	capitate lousewort
Pedicularis kanei ssp. kanei	woolly lousewort
Pedicularis lapponica	Lapland lousewort
Pedicularis sudetica ssp. albolabiata	sudetan lousewort
Pedicularis sudetica ssp. interior	sudetan lousewort
Pedicularis verticillata	whorled lousewort
Polemonium acutiflorum	acutish Jacob's ladder
Polemonium boreale	boreal Jacob's ladder
Polygonum viviparum	alpine bistort
Potentilla palustris	marsh cinquefoil
Puccinellia phyrganodes	creeping alkali-grass
Ranunculus pallasii	Pallas's buttercup
Salix alaxensis	feltleaf willow
Salix arctica	arctic willow
Salix glauca	northern willow
Salix lanata ssp. richardsonii	woolly willow
Salix niphoclada	tongue-leafed willow
Salix ovalifolia	oval-leafed willow
Salix pulchra	diamond-leafed willow
Salix reticulata	net-veined willow
Salix rotundifolia	round-leafed willow
Saxifraga foliolosa	foliolose saxifrage
Saxifraga hirculus	bog saxifrage
Saxifraga oppositifolia	purple mountain saxifrage
Saxifraga punctata	brook saxifrage
Senecia atropurpureus	arctic senecio
Senecio lugens	black-tipped groundsel

Scientific Names[1]	Common Names[2]
Senecio resedifolius	mignonette-leafed groundsel
Silene acaulis	moss campion
Sparganium hyperboreum	northern bur-reed
Stellaria humifusa	low starwort
Stellaria laeta	long-stalked stitchwort
Thlaspi arcticum	arctic penny-cress
Trisetum spicatum	spiked trisetum
Utricularia vulgaris	common bladderwort
Vaccinium uliginosum	bog blueberry
Vaccinium vitis-idaea	lingonberry
Wilhemsia physodes	merckia

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