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By G. Vernon Byrd
and
Dennis W. Woolington

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ECOLOGY OF ALEUTIAN CANADA GEESE AT BULDIR ISLAND, ALASKA

By

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Abstract

The only known breeding population of the endangered Aleutian Canada goose (*Branta canadensis leucopareia*) was studied from 1974 to 1977 at Buldir Island, Alaska. Geese began arriving at Buldir in early May, and laying peaked during the last week of May or early June. Most eggs hatched in late June or early July, and goslings fledged by 21 August. Most geese left Buldir during September.

Unlike many other populations of Canada geese, the Aleutian birds did not nest near water. Nest sites were on steep, densely vegetated slopes of the volcanic island, generally below 300 m elevation. Geese exhibited distinct preferences for certain plant communities. The effects of various habitat characteristics and proximity to predators on reproductive success of geese were evaluated.

The nesting population of geese at Buldir was estimated with a stratified random sampling method, and observations of marked birds allowed determination of the age composition of the population. Reasons for observed population increases are discussed.

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The endangered Aleutian Canada goose (Fig. 1) once nested on most of the Aleutian Islands as far east as the Islands of Four Mountains Group (Turner 1886, Clark 1910, Bent 1912, Jochelson 1933, Murie 1959), in the Commander Islands (Stejneger 1885), and in the Kuril Islands (Snow 1897) (Fig. 2). As a result of predation by introduced arctic foxes (Alopex lagopus) in the Aleutian and Kuril islands and dogs in the Commander Islands, this subspecies was extirpated everywhere except Buldir Island where foxes were never introduced (Murie 1959, Jones 1963, Jones and Byrd 1979).

In 1974 a multi-faceted program was initiated to restore the Aleutian Canada goose population to a non-endangered level (Byrd and Springer 1976, Springer et al. 1978). Due to the lack of knowledge about this subspecies, the first requirements of the program were to determine the breeding biology, habitat requirements, and size and structure of the remnant wild breeding population on Buldir. This paper summarizes the results of that study.

STUDY AREA

Location

Buldir (52°21' N, 175°56' E) is in the western Aleutian Islands, Alaska (Fig. 2). The 2,000-ha island is approximately 115 km from the nearest neighboring island, the most isolated of the Aleutians. Local place names used in the text are shown in Fig. 3.

Physiography

Buldir is the westernmost Aleutian volcano (Fig. 4) that was active in the late Quaternary or Recent time (Coats 1953). Characteristic physiographic features of the island are boulder-strewn beaches, talus slides, and volcanic peaks. The tallest peak, Buldir Eccentric, is 655 m high. A relatively flat alluvial deposit, Camp Valley, occurs near Northwest Point; otherwise the island's interior is composed primarily of steep slopes and plateaus. Nearly vertical sea cliffs form over half the island's 20 km-long coastline. The remainder of the coast consists of rock slides, earth slides, or steep vegetated slopes. Buldir has a single body of freshwater, Kittiwake Pond, with a 1.2-ha surface area. Other surface water includes five ponds less than 15 m in diameter and four small streams that flow all summer. Buldir is approximately 6.4 km long and 3.2 km wide.

Weather

Weather near sea level at Buldir during the summers was cool, humid, cloudy, and windy. Average monthly summer temperatures at Shemya Island (closest U.S. Weather Service station to Buldir, 115 km) ranged from 3.2° C in May to 9.5° C in August, and records at Buldir indicated temperatures there were similar; average daily maximums and minimums ranged from 11° C and 5° C in June to 14° C and 8° C in August. The average relative humidity near sea level at Buldir ranged from 90.5 percent in June to 97.4 percent in August during the study. Precipitation was recorded on 69 percent of the days in June, 62 percent in July, and 84 percent in August. The average amount of precipitation 1974 to 1976 ranged from 62 mm in June to 131 mm in August. Daily cloud cover averaged 82 percent in June and just over 90 percent in July and August. The monthly average wind velocity (1974-1976) was approximately 25 km/h June through August. Of the three years of the study, 1974 was the mildest spring. That year phenological events (e.g. flower blooming) was earlier than in 1975 and 1976.

Vegetation

The vegetation of the Aleutian Islands is classified as "maritime tundra" (Amundson and Clebsch 1971). Two major vegetative associations occur at Buldir: the Lowland Tall-plant and the Upland Short-plant (Fig. 5).

The Lowland Tall-plant association, usually below 300 m elevation, was composed of 8 plant communities (Byrd in press). The two most widespread communities were the beach rye-umbel (Fig. 6) and the beach rye-umbel-fern. The former community was dominated by *Elymus arenarius*, *Heracleum lanatum*, and *Angelica lucida*. The beach rye-umbel-fern community was similar, but it also contained significant concentrations of *Athyrium felix-femina*.

The Upland Short-plant association, usually above 300 m elevation, contained three communities (Byrd in press), the most extensive being the moss-willow tundra which contained several species of Salix, mosses, and other dwarf plants.

Fauna

Terrestrial mammals were absent from Buldir, but marine mammal populations averaged 5,000 Steller's sea lions (Eumatopias jubata), 100 sea otters (Enhydra lutra), and 50 harbor seals (Phoca vitulina). Buldir supports one of the most diverse seabird nesting colonies in the Northern Hemisphere, with at least 20 breeding species and nearly two million birds (Sowls et al. 1978). Aside from Aleutian Canada geese, few waterfowl bred at Buldir, presummably due to absence of suitable nesting habitat. Bald eagles (Haliaeetus leucocephalus), peregrine falcons (Falco peregrinus), and snowy owls (Nyctea scandiaca) breed on the island as do five species of passerines. During spring and fall migration, over 60 species of birds were recorded at Buldir, many of Asiatic origin (Byrd et al. 1978).

Human Activity

Buldir was once occupied by Aleuts, as indicated by the remains of an Aleut seasonal hunting camp near North Bight (A.P. McCartney, Dept. of Anthropology, Univ. of Arkansas, pers. comm.).

During World War II a small military weather station was constructed on Buldir and up to 12 men were stationed there (U.S. Department of Defense records). Remnants of the camp and related equipment remain. Since WW II, few humans have visited the island.

METHODS

Breeding Biology

We were on Buldir from 9 May (although we circled the island aboard ship on 30 April) to 6 September 1974, 17 May to 5 September 1975, 19 May to 28 September 1976, and 25 May to 2 July 1977. Breeding biology data were collected from 1974 to 1976 by two to five researchers who systematically searched vegetated areas that could be reached without climbing paraphenalia. In 1977, four researchers censused sample plots for breeding population estimation.

Canada geese may abandon their nests if disturbed during the early part of incubation more readily than if disturbance occurs later (Hanson and Eberhardt 1971, Cooper 1978); therefore, after 1974 when we learned the general nesting chronology, searching was conducted after geese began incubation. Nest searching was terminated when it was suspected that clutches were near hatching because young goslings scattered by investigators may be killed by glaucous-winged gulls (*Larus glaucescens*) and parasitic jaegers (*Stercorarius parasiticus*)

(MacInnes 1962, Mickelson 1975).

Most nests were discovered either by observing incubating geese or by flushing unseen hens from nests. Inaccessible slopes were scanned from an Avon sport boat moving along the base of cliffs or from land through 20 power spotting scopes. At nests the clutch size was recorded, nest material was noted, and at least two eggs in a sample of nests were floated to determine the stage of incubation (±3 days) using Westerkov's method (1950) as modified for use with Canada geese (C.J. Lensink, U.S. Fish and Wildlife Service, pers. comm.). Onset of incubation was determined by back-dating. The date of clutch initiation was then determined by subtracting one day for each egg in the clutch, plus one additional day. This laying rate was based on other populations of small Canada geese that nest at northern latitudes and lay one egg per day, but often skip one day after egg number four or five in large clutches (MacInnes 1962, Mickelson 1975).

The locations of nests were plotted on 1:25,000 scale maps, and 2 m-long stakes were erected 5 m uphill from nests to facilitate relocation. Nests were rechecked two to five weeks after projected hatching dates to determine their fates. Intact egg membranes that had separated from the shells were counted to determine hatching success (cf Mickelson 1975, Bromley 1976). Like Cooper (1978) and others we considered a nest successful if at least one egg hatched.

Habitat Use

General Vegetation Analysis

From subjective observations of plant communities in 1974, broad plant associations were mapped by walking over the island's surface and locating boundaries with the aid of a pocket altimeter and compass. U.S. Geological Survey bench marks provided references. Community boundaries were refined in 1975, and the surface area of each plant community was calculated by measuring the map area with a planimeter and then applying a correction factor for slope (determined by estimating the average slope in each community with a simple random sample). In 1975 and 1976 the relative importance (expressed in percent cover) of plant species in each community was determined quantitavely by means of a two-stage systematic sampling design. Strip transects 1-m wide were located randomly in each community from a grid placed over the vegetation map. Randomly chosen 1-m x 1-m secondary sample units were replicated as many times as the transect length dictated.

Within each sample unit the vegetation was stratified according to relative height. Overstory was defined as the layer of plants that overshadowed all layers below it. The middle story was the level of plants that overshadowed the ground layer plants, but which was overshadowed by taller plants. Generally, only those plants which were overshadowed by all other layers were considered in the ground story. Ther percent coverage of each species was estimated visually in each story. All plant nomenclature follows Hultén (1968).

Vegetation Around Goose Nests

At each goose nest the percent of coverage of each plant species in each of the height catagories was recorded in two quadrats, 1-m x 1-m and 5-m x 5-m, having the nest as their center. Cover values in the 1-m x 1-m nest plots were expanded proportionately to total 100 percent to compensate for the opening created by the nest. This was necessary to compare data from the 1-m x 1-m plots with data from the 5-m x 5-m plots around nests and with the 1-m x 1-m plots in the communities.

Physical Characteristics of Nest Sites

The slope at each nest was measured with a distance-height measurer. Physical surroundings were noted, aspects were measured with a compass, and elevation was determined with a pocket altimeter.

Population Size and Structure

Banding

Conventional banding drives (Cooch 1953, 1955) were not possible at Buldir because flightless geese seldom formed large flocks. Instead, birds were in isolated family groups, occasionally including yearlings, or in groups of two to four adults, presumably non-breeders. Geese were captured by hand or with long-handled nets, usually after foot chases. Birds were marked with standard U.S. Fish and Wildlife Service size 7 B leg bands and plastic leg bands (34 mm high, 14 mm inside diameter) with color and numerical codes.

Population Estimation

Each fall from mid-August until our departure, we recorded the ratio of banded to unbanded geese and the family group sizes. Plastic leg marker codes were read to determine the presence of known individuals. In 1976 we remained at Buldir later than in previous years, and a Questar field telescope (60 X to 130 X) made it possible to read plastic leg band codes up to 250 m away. Breast and neck plumage (Hanson 1962, Higgins and Schoonover 1969) were used to identify fledglings.

In 1977 a stratified random sampling design was employed to estimate the number of breeding pairs of geese at Buldir. The goose nesting habitat was divided into four strata (south-facing sea slopes, north-facing sea slopes, inland slopes, and uplands covered by the moss-willow tundra community). Habitats obviously not used for breeding, such as large slide areas, the sparcely-vegetated highest elevations, and Camp Valley were excluded from the area sampled. A total of 30 randomly selected 200-m x 200-m sample plots were examined. The allocation of plots among strata was seighted to reflect the relative variability of goose nesting density.

The plots were located by visual orientation from map reference and altimeter readings. Boundaries were determined with a compass and a 50-m steel tape. Researchers walked abreast 5-15 m apart over each plot to locate all nests. To aid in future plot location, a 2 m-long aluminum marker, tipped with "day-glo" orange paint, was placed in the most conspicuous corner of the plot.

In addition to surveying the sample plots, we censused two areas, a seaslope near Gull Slide and the Northwest Point peninsula, because their irregular shapes made it impossible to use normal sample plots.

BREEDING BIOLOGY

Arrival of Geese at Buldir

Aleutian Canada geese began arriving at Buldir during the first week of May based on the following observations. In 1974 no geese were seen on 30 April during our initial circumnavigation of the island. On 9 May, our next chance to survey Buldir, 44 geese were counted in an incomplete survey. In 1975 and 1976 geese were present when we arrived on 17 and 19 May respectively. In the only previous spring survey at Buldir, King (Kenyon and King 1965) counted 52 geese on 5 May 1965, an aerial count he called incomplete.

The early May arrival at Buldir suggests a rapid movement from spring staging grounds. From 1975 to 1978 geese left Crescent City, California during the last half of April (Woolington et al. 1979).

Most breeders presumably are present by mid-May, 10 to 14 days before laying. The average time elapsed between peaks of arrival and nest initiation is 12 days in *B. c. interior* (Raveling and Lumsden 1977) and 10 to 15 days in *B. c. minima* (Raveling 1978, Dau and Mickleson 1979).

Breeding Phenology

The mean onset-of-laying date ranged from 25 May (1974) to 30 May (1975). All clutches were initiated within a 16-day period in 1974 and within an 11-day period during the late 1975 season. Onset-of-laying extended for 25 days in 1976, but 92 percent of the clutches were initiated within an 18-day period (Fig. 7). The ranges in initiation dates, except in 1975, were generally longer than those observed for Canada geese further north, similar to those at nearly the same latitude, and shorter than those further south (MacInnes 1962, Vermeer 1970, Hanson and Eberhardt 1971, Mickelson 1975, Bromley 1976, Raveling and Lumsden 1977). In 1975 the range was similar to that of geese nesting at 8° to 9° higher latitude.

On the Yukon-Kuskokwim Delta, Alaska *B. c. minima* began nesting earlier in 1974 and 1976 than in 1975 (Dau and Mickelson 1979), and on the Copper River Delta, Alaska B. c. occidentalis nested 10 days earlier in 1974 than in 1975 (Bromley 1976).

Extensive snow cover, low temperatures, and violent storms at nesting areas delay the onset of laying in northern breeding geese (Cooch 1958, Collias and Jahn 1959, MacInnes 1962, Ryder 1967 and 1972, Mickelson 1975, Raveling and Lumsden 1977, Cooper 1978). The usual effect of a late spring at northern latitudes is to shorten the length of the nesting period (Ryder 1972, Mickelson 1975) as it did at Buldir.

The presence of snow during nest-site selection would probably delay nesting only if it covered the nest site. Elsewhere Canada geese selected nest sites from the first snow-free areas (NacInnes 1962, Mickelson 1975, Bromley 1976). If it is assumed that this phenomenon occurred at Buldir, snow cover was not a significant influence on the timing of laying, but it probably affected the distribution of nests (see Habitat Use).

Since no major storms occurred during the period of nest-site selection and laying during this study, temperature may have been responsible for delayed laying in 1975. No records of temperature during the first three weeks of May are available for Buldir, but data from Shemya Island indicate that May temperatures in 1975 were lower than in 1974 and 1976. Furthermore, the 1975 average for May was raised by warm temperatures during the last week of the month. At Buldir this period was also warmer in 1975 than in the other two years. An additional indication of the difference in temperatures is the last date freezing temperatures were recorded; 1 May 1974 and 4 May 1976 compared to 25 May 1975.

The incubation period was recorded to the nearest day for only three nests at Buldir: 27, 28, and 29 days. Aleutian Canada goose eggs hatched after 27 to 28 days (avg.) in incubators (F.B. Lee, U.S. Fish and Wildlife Service, pers. comm.). Average incubation periods for other Canada geese ranged from 26 to 28 days (Bellrose 1978).

At Buldir the distribution of hatching dates (Fig. 6) was determined by adding 28 days to the incubation initiation dates of successful nests. The average hatching dates for 1974, 1975, and 1976 were 27 June, 3 July, and 29 Jjne, respectively. Most nests hatched from 19 June to 6 July in 1974 and 1976, but in 1975 hatching occurred from 28 June to 9 July. Thus, the nesting season (first egg laid to the last egg hatched) was 45 to 51 days for Aleutian Canada geese. Raveling and Lumsden (1977) discuss nesting periods relative to the size of the goose and the nesting latitude. The Buldir birds nest in about the length of time expected of small Canada geese, using more days than populations at higher latitudes and less than those farther south (cf Raveling and Lumsden 1977).

Post-hatching Movements

Soon after hatching, Aleutian Canada goose families moved from nest sites to brood rearing areas which were generally higher than the nesting areas (see HABITAT USE), and within 5 km of their nests. Similar but generally longer movements of broods away from nest sites have been described by others (Geis 1956, MacInnes 1962, Hanson and Ebergardt 1971, Mickelson 1975, and Bromley 1976).

Non-breeding Adults

At Buldir flocks of 3 to 40 geese were dispersed over the island, including the breeding areas, during the summer. Marked yearlings and two-year-olds were included.

One to four geese were observed within territories of breeding pairs at Buldir. Some groups were tolerated by territorial males but other groups were chased away. Too few observations of marked birds were made to definately demonstrate that groups tolerated in a particular territory were previous years' young of that breeding pair, but we suspected that was true. Elsewhere family bonds are usually broken when pairs begin active sexual behavior in spring (Hanson and Smith 1950, Balham 1954, Collias and Jahn 1959, MacInnes 1966, Sherwood 1967, and Hanson and Eberhardt 1971). Parental intolerance of young usually begins before establishment of nest territories (Collias and Jahn 1959, Hanson and Eberhardt 1971). In some populations most yearlings are excluded from families before adults arrive on the breeding grounds (MacInnes 1966), but in others family breakup occurs after arrival (Sherwood 1967). Yearlings and other non-breeders combine in flocks which usually leave the nesting areas, but in some areas a few may remain (Martin 1964, Sherwood 1967, Hanson and Eberhardt 1971).

Wing Molt

The timing of the wing molt appeared similar in 1974 and 1976, but was slightly later in 1975 (Table 1). Few flying geese were seen during the last week of July and the first two weeks of August, but most adults and young were flying by 22 to 25 August. The age at which captive reared goslings attained flight was 55 days (F.B. Lee pers. comm.), and probably a similar time is required for wild geese at Buldir. The timing of the molt was similar to that recorded for other populations of Canada geese nesting in Alaska (Mickelson 1975, Bromley 1976).

During the wing molt one to three flightless non-breeders (females lacking bare or refeathered brood patches) were frequently found with goslings after a pair of adults, presumably the parents, flushed. Also isolated groups of two to three flightless non- or failed breeders were found. These observations demonstrate that at least a portion of the non-breeding population of Aleutian Canada geese molted at Buldir.

It is possible that some non-breeding Aleutian Canada geese molted at areas other than Buldir on the basis of the following observations: five geese 10 km west of Buldir flying westerly on 26 July 1975 (G. Putney, U.S. Fish and Wildlife Service, pers. comm.), up to 14 geese at Amchitka Island in mid to late June 1977 (F.B. Lee and R.P. Schulmeister, U.S. Fish and Wildlife Service, pers. comm.), and four birds in late June and three in early July 1961 at Amchitka (R.D. Jones, U.S. Fish and Wildlife Service, pers. comm.). It is possible that these were wondering subadults that might have returned to Buldir to molt. If these geese became flightless on most of the islands in the Aleutians they would have been subject to predation by arctic foxes. In other populations of Canada geese, at least some of the non-breeders migrate to distant molting grounds (Kuyt 1962, Martin 1964, Hanson 1965, MacInnes 1966, Sherwood 1967, Hanson and Eberhardt 1971).

Departure of Geese From Buldir

Geese began leaving Buldir during the first week of September in 1976. By 22 September the population was down from an estimated pre-migrational total of 1,200 to 1,400 birds to about 500 geese. By 26 September less than 250 geese remained, and when field work terminated on 29 September less than 100 were present.

The timing of departure from Buldir in 1976 seemed to be similar to other years on the basis of the few records available (Table 2).

HABITAT USE

Availability of Nest Sites

During the middle two weeks of May, when most females selected nest sites, the Upland Short-plant association was mostly snow-covered and thus unavailable for nesting. The amount of snow remaining in the Lowland Tall-plant association varied among years. In 1974 the lowland was mostly snow-free during nest site selection, although drifts persisted on north-facing slopes and in shaded gullies or creek banks. Approximately 50 percent of the lowland was still snow-covered in mid-May 1975 and 1976. The percentage of the area that was snow-free increased proportionally to reduced elevation, reaching 100 percent at sea level.

In snow-free areas *Ranunculus occidentalis*, *Festuca rubra*, and *Fritillaria camschatcensis* were the only green plants present during nest site selection. Dried stalks of *Heracleum lanatum* and *Angelica lucida* and hummocks of dried *Elymus arenarius* offered the only cover. Since Buldir had no lakes in the lowland, timing of freshwater thaw was not important in nest site selection.

In the lowland plant association, the beach rye-umbel and the beach rye-umbel-fern communities covered 68 percent of the area. The sedge-fescue meadow community accounted for 24 percent of the association and was confined largely to the higher elevations of the Lowland Tall-plant association, often in the transition area between the two associations (see Byrd in press for description of communities). Less than 1-ha patches of sedge-fescue meadow were intersperced among the beach rye-umbel and beach rye-umbel-fern communities.

Vegetation Selection for Nest Sites

Geese nested almost exclusively in the beach rye-umbel and beach rye-umbel-fern communities. In both communities geese selected areas with dense concentrations of *Elymus arenarius* in the overstory and *Festuca rubra* in the middle story (Table 3). The nest territories (5-m x 5-m plots) had significantly higher densities of these plants than did the communities at large, and the nest sites (1-m x 1-m plots) had significantly higher densities of *Elymus* but not *Festuca* than did the nest territories (Table 3). There may have been a slight selection against *Angelica lucida*, and birds clearly avoided areas with high concentrations of *Heracleum lanatum* at nest sites. *Claytonia sibirica* was also avoided. The percentage of fern in the overstory or moss in the ground story was not important in nest site selection.

Elymus must have been favored for its value as nest cover because dried hummocks provided protection from wind and rain. Green shoots usually appeared by the end of egg-laying (Fig. 9), and by mid- to late incubation the new growth provided substantial cover. Elymus was also the major plant used in nest construction, occurring in all nests. Based on observations of feeding geese and the abundance of cropped stems, Festuca rubra was the major food item taken by geese during incubation. It was not favored for nest material however, occurring in only five percent of the nests. Heracleum and Angelica developed later than Elymus, and their value as nesting cover was relatively low. Furthermore, Heracleum collected considerable water, which was dumped to the ground during frequent high winds, an undesirable situation at a nest. Claytonia sibirica formed dense slippery mats which may have made travel for geese difficult.

Physiographic Selection for Nest Sites

Slope

Of a wide range of physiographic types available (Fig. 10), sea slopes were selected most frequently as nest sites. Essentially all vegetated sea slopes had nesting geese, and the concentration of nests on the south side of the island (Fig. 11) reflects the relatively large area of sea slopes there.

Birds nesting on slopes steeper than 40° had significantly (p .05) higher hatching success than those nesting on less steep slopes (Table 4). Although success appeared to be lowest on slopes of 11° to 20° differences in success between pairs using the lower four slope catagories (Table 4) were not significant. Nevertheless, the lowest nesting success was also recorded for birds using 11° to 20° slopes.

Steep slopes were probably selected because they afforded good visibility. Only on these steep slopes would geese be able to view approaching predators over tall vegetation (average 31.4 cm tall during late incubation). Additionally, over 60 percent of the nests had a depression of at least 0.5 m within 2 m of the front of the nest which increased visibility.

Visibility has been recognized by others as an important factor in nest site selection by Canada geese, e.g. B.c. occidentalis selected areas of above average plant densities for nesting except in characteristically dense plant communities where they preferred sites with less than average density (Bromley 1976).

Aspect

Nesting success was lowest on north-facing slopes where the fewest nests were found (Table 4). The relative high abandonment by birds nesting on northern exposures may have been related to weather. These areas were most exposed to severe spring storms, and snow lingered longest here, resulting in less vegetative cover early in the season.

The only significant differences revealed in a test of the hatching success of nests on different aspects were: significantly (p .05) lower success on eastern and southwestern slopes than on northwestern slopes. The differences are inexplicable and may have been related to factors other than aspect.

Elevation

Nests ranged from 30 m to 320 m in elevation indicating a broad use of available habitats. The lowest available nesting habitat was usually over 25 m elevation, and areas above 300 m were usually unavailable for nesting because of persistent snow cover.

Above 300 m elevation a smaller percentage of nests apperared to be successful than at lower elevations, but the sample size of high nests was small (Table 4). No significant differences were found in hatching success in nests at different elevations.

Nesting Density

In 1975 all 45 goose nests we found were in the beach rye-umbel and beach rye-umbel-fern communities, and in 1976, 97 percent (65 of 67) of the nests were in the same communities. Of the two communities, beach rye-umbel was more widespread at Buldir, and it contained about 75 percent of the nests (Table 5).

In 1976 an estimated 138 pairs of geese bred on Buldir (see POPULATION SIZE AND STRUCTURE). If it is assumed that 133 nests (97 % of the total) were in the beach rye-umbel and beach rye-umbel-fern communities and were distributed in the relative proportions indicated by the sample, respective densities were 0.35 and 0.16 nest per ha for these two communities. The combined estimate was 0.27 nest per ha (Table 5).

Cooper (1978:34) summarized nest densities of Canada geese at different locations. Of 14 mean nest densities, nine were lower than Buldir (range 0.02 to 0.25 nests per ha) and five were higher (range 0.52 to 12.36).

<u>Brood-rearing and Molting Areas</u>

Soon after hatching, families with Class I goslings (Yocom and Harris 1965) moved inland from nest sites to higher elevations. Most of these areas were at the upper edge of the Lowland Tall-plant association where beach rye-umbel and beach rye-umbel-fern communities provided cover and sedge-fescue meadows and moss-willow tundra provided food. As broods became older and presumably large enough to be safe from predation by gulls and jaegers, families gradually moved farther from cover. Some flocks of one or two flight-capable adults and one (usually) to four (occasionally) broods, were seen in the upland. Apparently, flightless adults remained near cover.

Pre-migrational Use Areas

During late August and September, Aleutian Canada geese used the Upland Short-plant association almost exclusively. Based on observations of feeding geese and examination of droppings and cropped stems in feeding areas, favored fall food items appeared to be the fruits of Carex spp. and Empetrum nigrum and the stems of newly-emerged, succulent plants of various species. The high plateaus (Dry Lake, Extra Plateau, and Foggy Plateau) and the area around Kittiwake Pond were major feeding areas.

Killtiwake Pond was frequently used for bathing by flocks containing up to 500 birds, including families (occasionally with pre-flight goslings) and non-breeders (marked yearlings and two-year-olds not associated with families). Geese were seen in salt water only 10 times during the study-just prior to, during, or immediately after the molt when the birds were probably losing or gaining flight capability.

POPULATION SIZE AND STRUCTURE

Production

Clutch Size

Clutches ranged from two to eight eggs, but 82 percent of them contained five to seven eggs. The overall average was 5.6 with only slight variation among years (Table 6). These clutch sizes may not be exact because our first visit to nests occurred after incubation had begun, and eggs may have already been lost. Moreover, we did not identify or eliminate continuation nests (subsequent nests after first clutches were lost usually containing smaller clutches) (Cooper 1978). These factors probably did not have a major effect on our estimate inasmuch as the average at Buldir was similar to the highest clutch sizes recorded for Canada geese elsewhere (Hanson 1965:165).

Nesting and Hatching Success

The 1974 data were not used to calculate the average nesting and hatching success because, due to inadequate marking, we were unable to relocate 30 percent of the nests to determine fates. The probability of finding a deserted nest that sitll contained eggs was much greater than finding a successful nest.

Nesting success in 1975 and 1976 at Buldir was 89 and 93 percent, respectively. The overall average (91 %) is the highest recorded for wild Canada geese (Table 7).

In 1975 and 1976 an average of 74.8 percent of all eggs hatched (Table 8). Hatching success in successful nests (80.7 %) averaged only a little higher than that in all nests. Ther percentage of eggs of unknown fate was higher in 1976 than in 1975, accounting for most of the difference in hatching success.

Fledging Success

Family group counts, conducted from 19 August to 24 September, were used to calculate the fledging success. Approximately four goslings per successful pair of geese reached flight stage at Buldir in 1976 (Table 9). This family group size is large compared to other populations: 3.7 and 3.2 for B.c. maxima at Seney National Wildlife Refuge (calculated from Sherwood 1965), 3.0 and 2.8 for the same subspecies in Colorado (calculated from Szymczak 1975), and 3.7 for B.c. minima on the Yukon-Kuskokwim Delta, Alaska (Mickelson 1975).

For our method of calculating fledging success to be accurate, individual broods must be distinguishable. Several flocks containing multiple broods were recorded at Buldir, but most flightless groups were probably intact on the basis of the uniform weights and stage of plumage development of the young.

Groupings of broods have been recorded in other Canada goose populations (Williams and Marshall 1937, Naylor 1953, Miller and Collins 1953, Geis 1956, Sherwood 1967, and Hanson and Eberhardt 1971); yet MacInnes (1962) and Mickelson (1975) did not consider brood flocks common in the populations of small northern Canada geese they studies. Hanson and Eberhardt (1971) found mixing mainly after goslings were four to five weeks old. Geis (1956) suggested crowded conditions in the rearing areas might increase brood flocking.

A comparison of the average number of goslings per brood (3.99) with the average number of goslings hatched per successful pair (4.2) indicates a maximum gosling survival rate of 95 percent. The actual rate might have been lower because the fate of over 18 percent of the eggs in 1976 was unknown. The low hatching to fledging mortality (5 %) at Buldir is probably due to the absence of mammalian predators and the abundance of buffer prey species for avian predators. Canada goose gosling survival rates of 90 percent or greater were found at four of th six locations cited by MacInnes (1962).

There has been considerable discussion about the use of family group counts to estimate waterfowl production. Sherwood (1967) found that pairs with grouped broods remained together in winter and exhibited family behavior. He pointed out that counts of such assemblages would bias estimates of productivity. In a different study area, Raveling (1969) demonstrated that families of Canada geese remained intact in winter, and Raveling and Lumsden (1977) presented the rationale for using such counts to predict production.

At Buldir, most broods were probably with their own parents when they fledged on the basis of observations of color-marked birds, the size of broods (one to seven goslings per family), and the behavior of groups thought to be families (alighting together-Raveling 1968).

Mortality Factors - Eggs

Loss of Entire Clutches

In most populations of Canada geese, predators caused losses of 5.0 to 64.6 percent (Table 7). No Aleutian Canada goose nests were found completely destroyed by predators; desertion accounted for all the unsuccessful nests (9 %). This rate is intermediate compared to other populations (Table 7). In 1974 one nest was lost in an earth slide, a potentially serious hazard on the unstable volcanic island.

Loss of Partial Clutches

Gulls were observed eating goose eggs once, and 10 eggs with large holes like those expected after gull predation (Mickelson 1975) were found. Gulls are also known to swallow whole eggs (D. Raveling, Univ. of California, Davis, pers. comm.). Most eggs with holes were found away from nests and would have been recorded as "unknown fate". A comparison of hatching success of goose nests at various distances from gull concentrations, e.g., nesting colonies and loafing areas, indicates no significant differences, but nesting success increased slightly as the distance from gulls increased (Table 10). Abundant prey items were available to gulls. Gulls took at least eight species of birds, several species of fish, insects, and berries (Trapp 1979).

Large gulls e.g., Larus argentatus, L. glaucescens, and L. hyperboreous) and parasitic jaegers were major predators of goose eggs at other areas (Barry 1956, Angstadt 1961, MacInnes 1962, Mickelson 1975, Bromley 1976, Raveling and Lumsden 1977). Proximity of geese to areas frequently used by the predators (Cooper 1978), abundance of buffer prey species (Angstadt 1961), and disturbance of incubating geese by humans (MacInnes 1962, Mickelson 1975) are factors that affect predation rates.

Mortality Factors - Goslings and Adults

Predation

We were unable to directly assess the extent of gull and jaeger predation on young goslings because we avoided the nesting areas from onset of hatching until most broods were two to three weeks old. Nevertheless, we saw a gull pick up and drop, apparently unharmed a Class I b gosling, and a parasitic jaeger was seen diving at a brood of Class I b goslings.

On the Yukon-Kuskokwim Delta, Alaska most losses of B.c. minima goslings occurred during their first two weeks of life (Mickelson 1975). In the same study parasitic jaegers were able to take only Class I a goslings and were not serious predators. Gulls and jaegers affected gosling similarly in the Northwest territories (MacInnes 1962).

Bald eagles took pre-flight goslings at Buldir occasionally. Food remains from the single active eagle eyrie were examined periodically throughout the summer and fall of 1974 and 1975. The remains of only one goose, a banded gosling in 1975, were found. Three wings of adult geese were found in an eagle eyrie at Buldir in 1963 (Jones 1963). As many as five eagles hunted geese frequently in early to mid-September after most other prey species had left Buldir. The fresh remains of five molting geese killed by eagles were found during the study, and old bones and wing feathers of 10 geese were also found. Peregrine falcons and snowy owls may have taken geese, but no direct evidence was found.

Disease and Accidents

Diseases and accidents are not usually considered important in breeding Canada geese, and they were not major causes of mortality during our study. Nevertheless, these factors were examined at Buldir because the goose is endangered.

In 1975, goslings captured at Buldir to replenish captive stocks were heavily infested with coccidia when they arrived at the Patuxent Wildlife Research Center, Laural Maryland (R. Erickson, U.S. Fish and Wildlife Service, pers. comm.). Analysis of goose droppings subsequently collected at Budlir in 1975 showed a high percentage of the wild birds were carrying coccidia

(J. Carpenter, U.S. Fish and Wildlife Service, pers. comm.). Apparently under normal conditions the birds suffer no detrimental effects, but under the stress conditions incurred during shipping the parasitic infection overwhelmed them. It is not known if conditions of stress occur in the wild sufficient to induce coccidiosis.

A female with a bare brood patch was found dead in June 1976. A necropsy indicated the bird had died from generalized peritonitis caused by a ruptured egg in the oviduct (L.N. Locke, U.S. Fish and Wildlife Service, pers. comm.).

Two goslings that had apparently fallen from the slope above were found dead on a Buldir beach (Kenyon 1963). In 1975 we found a dead Class I c gosling with a swelling and discoloration in the area of the wrist. The injured bird may have died from infection.

In 1976 we saw at least 11 geese that were either limping or dragging a leg in flight. We captured two recently-fledged goslings that were either injured as the result of an accident or had been hit by predators. One had a broken ulna, the other a crippled foot. Perhaps accidents occur while goslings are learning to fly. We observed some possibly injurious landings made by fledglings during high-velocity, gusty winds.

1976 Populations

At Buldir, 510 goslings were calculated to have fledged in 1976 (Table 11). Given an average brood size of 3.99 (Table 9), 128 breeding pairs produced young. Since 93 percent of all nesting pairs were successful in 1976, 138 pairs laid clutches.

Given an April 1976 population of 900 Aleutian Canada geese (Woolington et al. 1979), and no correction factor for the unknown amount of adult mortality from April to September, the 1976 production would have increased the number of geese to 1,410. A population estimate of 1,200 to 1,400 geese was derived from flock counts at Buldir during the last week of August in 1976. This estimate is similar to the count of 1,280 Aleutian Canada geese, thought to include the entire population, made 12 November 1976 in California (Springer et al. 1978). If 1,300 is used as the pre-migration population at Buldir, the age structure was 21.2 percent breeders, 39.5 percent non-breeding yearlings and adults, and 39.3 percent fledglings (Table 12).

1977 Populations

We estimated that 171±13 (C.I. 90 %) pairs of geese nested at Buldir in 1977 (Table 13). It was not possible to collect data on nesting, hatching, and fledging success in 1977, so averages from previous years were used to estimate production and the fall population.

Based on the average nesting success for 1975 and 1976 (91 %) and the average fledglings per pair (3.99), 156 pairs (91 % of 171) raised 622 fledglings in 1977. The fall population of geese at Buldir would have been 1,770 if the 1977 production were added to the April 1977 population census in California (1,150 geese) (Woolington et al. 1979). We subjectively reduced the estimate to 1,700 geese to compensate for mortality which occurred at an unknown rate from April to September. In spite of the suppositions used to reach this estimate, it seems reasonable because 1,630 was the peak fall 1977 Aleutian Canada goose population in California (Woolington et al. 1979). The age structure of the pre-migration population at Buldir based on these calculations was 19.6 percent breeders, 44.8 percent non-breeding yearlings and adults, and 35.6 percent fledglings (Table 12).

Population Trends

The fall Aleutian Canada goose population was calculated to have increased 30.8 percent between 1976 and 1977 (1,300 to 1,700 birds. Presumably the age structure also changed during the study.

The population increase and accompanying change in age structure of Aleutian Canada geese is attributed to reduced mortality resulting from hunting closures on Canada geese initiated in 1975 in Aleutian Canada goose concentration areas in California to protect this endangered subspecies (Springer et al. 1978). Fledglings sustain disproportionately high mortality from hunting (Moffitt 1935, Chapman et al. 1969, and others), explaining the especially high increase (13.4 %) in the non-breeding yearling and adult age category into which the 1976 fledglings would enter by spring 1977 (Table 12). The trend would be for the non-breeding yearling and adult category to increase at a proportionally higher rate until cohorts that have benefited particularly from hunting closures reach the breeding age.

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Table 1.-- Timing of the wing molt of Aleutian Canada geese at Buldir Island, Alaska.

Event	1974	1975	1976
First flightless birds	18 July	23 July	19 July
Last flying geese before the molt	24 July	30 July	23 July
First flying geese after the molt	18 Aug.[1]	17 Aug.	13 Aug.
Most adults and goslings flying[2]	22 Aug.	25 Aug.	22 Aug.

[1] Fog obscured the area in mid-August, so birds were probably flying earlier than the date recorded.

[2] Subjective estimate.

Table 2.--Fall observations of migrating Aleutian Canada geese in the Aleutian Islands, Alaska

Date	Location	No. of Geese	Reference
26 Aug 1965	Amchitka I.	40	R. Wade (*in litt.*)
4 Sept 1974	At sea east of Shemya I.	40-50[1]	G. Putney (pers. comm.)
5 Sept 1975	At sea 16 km east of Buldir I.	17	G. Putney (pers. comm.)
7 Sept 1976	Kiska I.	12	T. Dowell (pers. comm.)
7 Sept 1976	Unalga I. (east)	34[2]	W. Hoffman (pers. comm.)
22 Sept 1976	Unimak I.	9[2]	J. Nelson (pers. comm.)

[1] Probably birds released at Agattu I. in May 1974 (cf. Springer et al. 1978)

[2] Probably *B. c. leucopareia*

Table 3.- A comparison of percent cover values (PCV) of major plants at goose nests ($1\ m^2$ and $25\ m^2$ plots) and in plant communities at Buldir Island, Alaska

Plant	Story	A PCV in $1\ m^2$	B PCV in $5\ m^2$	C PCV in community	Level of significance[1] A-B	 B-C	 A-C
Beach rye-umbel	N=	45	45	143			
Elymus arenarius	over	65.6(19.3)[2]	45.9(18.0)	37.6(3.5)	.001	.01	.001
Angelica lucida	over	13.0(13.0)	15.8(6.7)	16.5(2.3)	--	--	.1
Heracleum lanatum	over	8.7(13.1)	20.7(14.2)	20.9(3.1)	.001	--	.001
Festuca rubra	middle	32.4(20.4)	29.1(16.0)	16.9(3.3)	--	.001	.001
Claytonia sibirica	middle	10.3(12.4)	14.8(14.7)	22.3(3.8)	--	.01	.001
Carex macrochaeta	middle	9.5(17.5)	11.5(14.3)	3.5(1.6)	--	.001	.05
Moss	ground	32.0(25.9)	38.1(23.0)	36.1(3.6)	--	--	--
Beach rye-umbel-fern	N=	16	16	95			
Athyrium felix-fem.	over	33.7(22.0)	27.1(17.1)	24.4(4.9)	--	.1	--
Elymus arenarius	over	38.0(19.6)	29.7(16.4)	16.6(3.6)	--	.01	.001
Angelica lucida	over	12.5(15.6)	12.5(6.1)	12.9(2.3)	--	--	--
Heracleum lanatum	over	9.2(15.1)	23.7(10.1)	20.6(4.0)	.01	--	.01
Festuca rubra	middle	30.3(30.8)	28.4(17.7)	3.4(1.5)	--	.001	.01
Claytonia sibirica	middle	14.2(16.8)	24.4(14.3)	40.1(4.8)	.1	.001	.001
Moss	ground	33.6(31.7)	31.0(19.9)	40.4(5.6)	--	.1	--

[1] Student's "t-distribution" used to calculate highest critical probability at which a significant difference existed. (-- indicates no significant difference).

[2] Standard deviation in parenthesis

Table 4.--Nesting and hatching success of Aleutian Canada goose nests with different physiographic characteristics at Buldir Island, Alaska 1974 to 1976.

Habitat Characteristic	Total Nests		Percent Nesting Success	Percent Hatching Success		
	Number	Percent		Avg.	St. Dev.	Deg. Fr.
Slope (°)						
0-10	22	(17)	95	79.4	21.2	20
11-20	11	(09)	73	70.8	25.1	8
21-30	29	(23)	86	79.2	19.7	26
31-40	54	(42)	89	83.8	19.0	50
41-50	12	(09)	100	92.8	11.5	11
Aspect (°)						
338-022 N	12	(09)	75	87.6	16.3	8
023-067 NE	18	(13)	91	85.6	13.1	15
068-112 E	13	(10)	92	71.6	23.4	11
113-157 SE	29	(22)	86	82.8	22.1	24
158-202 S	29	(22)	86	75.1	22.8	26
203-247 SW	19	(14)	94	85.5	16.0	17
248-292 W	11	(08)	100	91.0	13.2	10
293-337 NW	4	(03)	100	85.0	19.2	3
Elevation (m)						
0-60	19	(13)	90	87.6	17.5	17
61-120	50	(35)	90	82.2	20.4	41
121-180	36	(25)	92	81.4	19.2	33
181-240	23	(16)	87	81.7	22.0	19
241-300	10	(07)	90	75.3	18.3	9
301-360	4	(03)	75	72.3	25.4	3

Table 5.--Estimated density of goose nests in favored plant communities at Buldir Island, Alaska

Community	Surface Area (ha)	Percent of Combined Area (A)	Percent of Total Nests 1975-1976 1975	1976	Ave.	Estimated No. of Nests 1976	Nests Per ha (B)
Beach rye-umbel	288	58.7	76.7	73.8	75.3	100	0.35
Beach rye-umbel-fern	203	41.3	23.3	26.2	24.7	33	0.16
Total	491	100	100	100	100	131[1]	0.27[2]

[1] Total from sampling strata only

[2] Weighted average A X B

Table 6.--Distribution of clutch sizes in Aleutian Canada geese at Buldir Island, Alaska, 1974 to 1976

No. of Eggs	Year 1974	1975	1976	1977	Total
2		1[1] (02)[2]	2 (03)		3 (02)
3	3 (10)		5 (06)		8 (04)
4	2 (07)	4 (09)	7 (09)	7 (19)	20 (11)
5	5 (17)	10 (22)	22 (28)	11 (31)	48 (26)
6	14 (48)	19 (42)	32 (41)	11 (31)	76 (40)
7	5 (17)	9 (20)	10 (13)	6 (17)	30 (16)
8		2 (05)		1 (03)	3 (02)
Total eggs	161	261	419	207	1048
Total nests	29	45	78	36	188
Average clutch	5.6	5.8	5.4	5.5	5.6
Standard deviation	1.14	1.17	1.05	1.08	1.11

[1] Number of clutches

[2] Percentages in parenthesis

Table 7.--Nesting and hatching success of various populations of Canada geese

Subspecies	Nesting Success	Percent of Nests Destroyed by Predators	Percent of Nests Deserted	Hatching Success all Nests (%)	Hatching Success, Successful Nests Only	Reference
B. c. hutchinsii and *parvipes*				75-90		MacInnes 1962
B. c. moffitti	70	12	14	65	88.7	Hanson and Browning 1959
B. c. moffitti	51-73	16-28	11-17	62	86-90	Geis 1956
"large race"	27.2-79.6	14.2-50.4	4.1-20.9		76.5-89.4	Vermeer 1970
B. c. occidentalis	31.6-82.7	14.8-64.6	2.5-3.7	27.7-66.8		Bromley 1976
B. c. occidentalis				79.6		Trainer 1959
B. c. maxima	65-82	5	11	67		Cooper 1978
B. c. interior	78-83	17-22	1		78-85	Raveling and Lumsden 1977
B. c. minima	72.3	27.7				Eisenhauer and Kirkpatrick 1977
B. c. minima	64.8	28.1		67.6		Mickelson 1975
B. c. leucopareia	91		9	74.8	80.7	This study

Table 8.--Fate of Aleutian Canada goose eggs at Buldir Island, Alaska, 1975 and 1976

Fate	1975		1976		Both years	
	Number of eggs	Percent of total	Number of eggs	Percent of total	Number of eggs	Percent of total
Hatched (all nests)	204	78.2	276	72.5	473	74.8
(successful nests)		86.1		77.1		80.7
Fate unknown[1]	28	10.7	67	18.1	97	15.3
Deserted[2]	13	5.0	14	3.8	27	4.3
Infertile[3]	8	3.1	14	3.8	22	3.5
Embryo death[3]	8	3.1	6	1.6	14	2.2
Total eggs	261		371		632	

[1] Eggs recorded when nests were found that were not accounted for during rechecks. Possible explainations include predators carrying eggs away from nests, scavenging gulls removing membranes of hatched eggs, and wind blowing membranes from nests.

[2] Eggs left in nests where no eggs hatched

[3] Eggs left in successful nests

Table 9.--Family group counts of geese at Buldir Island, Alaska, August through September 1976

	No. of Fledglings Per Pair							
	1	2	3	4	5	6	7	Ave
No. of families	9	28	66	49	66	31	6	3.99
n=255								

Table 10.--Nesting and hatching success of Aleutian Canada geese at various distances from glaucous-winged gull colonies, Buldir Island, Alaska, 1975 to 1976

Distance to Gull Colony (m)	No. Nests	Nesting Success (%)	No. Nests	Hatching Success[1] (%)
0-500	70 (56)[2]	87	63 (56)	81
51-100	34 (27)	91	29 (26)	80
Over 100	21 (17)	95	20 (18)	77
Total	125		112	

[1] Successful nests only

[2] Percent of total in parenthesis

Table 11.--Technique used to estimate the number of fledglings produced at Buldir Island, Alaska in 1976

After the formula of Ricker (1958):

$$N = \frac{M(C + 1)}{R + 1}$$

where N = estimate of the total population of fledglings
M = number of goslings marked with color bands in 1976 = 105
C = total number of fledged goslings seen on census = 962
R = number of color marked fledged goslings seen on census = 197

It is estimated that:

$$N = \frac{105\ (962 + 1)}{197 + 1}$$

N= 510 fledglings

Table 12.--The age structure of fall Aleutian Canada goose populations at Buldir Island, Alaska, 1976 and 1977

	1976		1977	
Age Class	Total Birds	Percent of Population	Total Birds	Percent of Population
Breeders	276	21.2	342	19.6
Non-breeding adults	514	39.5	783	44.8
Fledglings	510	39.3	622	35.6

Table 10.--Estimate of breeding pairs of Aleutian Canada geese at Buldir Island, Alaska in 1977

	North-facing Sea Slopes	South-facing Sea Slopes	Inland Tall-Plant Slopes	Moss-Willow Tundra	Sub-total	Census Areas[1]	Total
Total sample plots	3	20	5	2	30	2	32
Total nests found	0	20	1	0	21	12	33
Average nests per plot	0	1[2]	0.2[3]	0			
Average nests per ha	0	0.25	0.05	0			
Area in stratum (ha)	150	560	370	510	1590	10	1600
Estimated total pairs	0	140	19	0	159[4]	12	171

1 The census plot by Gull Slide (8 nests) and the 1974 to 1976 average number of nests at Northwest Point (4 nests) are added

2 C.I. = 0.45 (90% level)

3 C.I. = 0.31 (90% level)

4 C.I. (for all strata) = ± 12.8 nests (90% level)

Fig. 1. Photograph of Aleutian Canada goose. Note broad white ring at the base of the black neck.

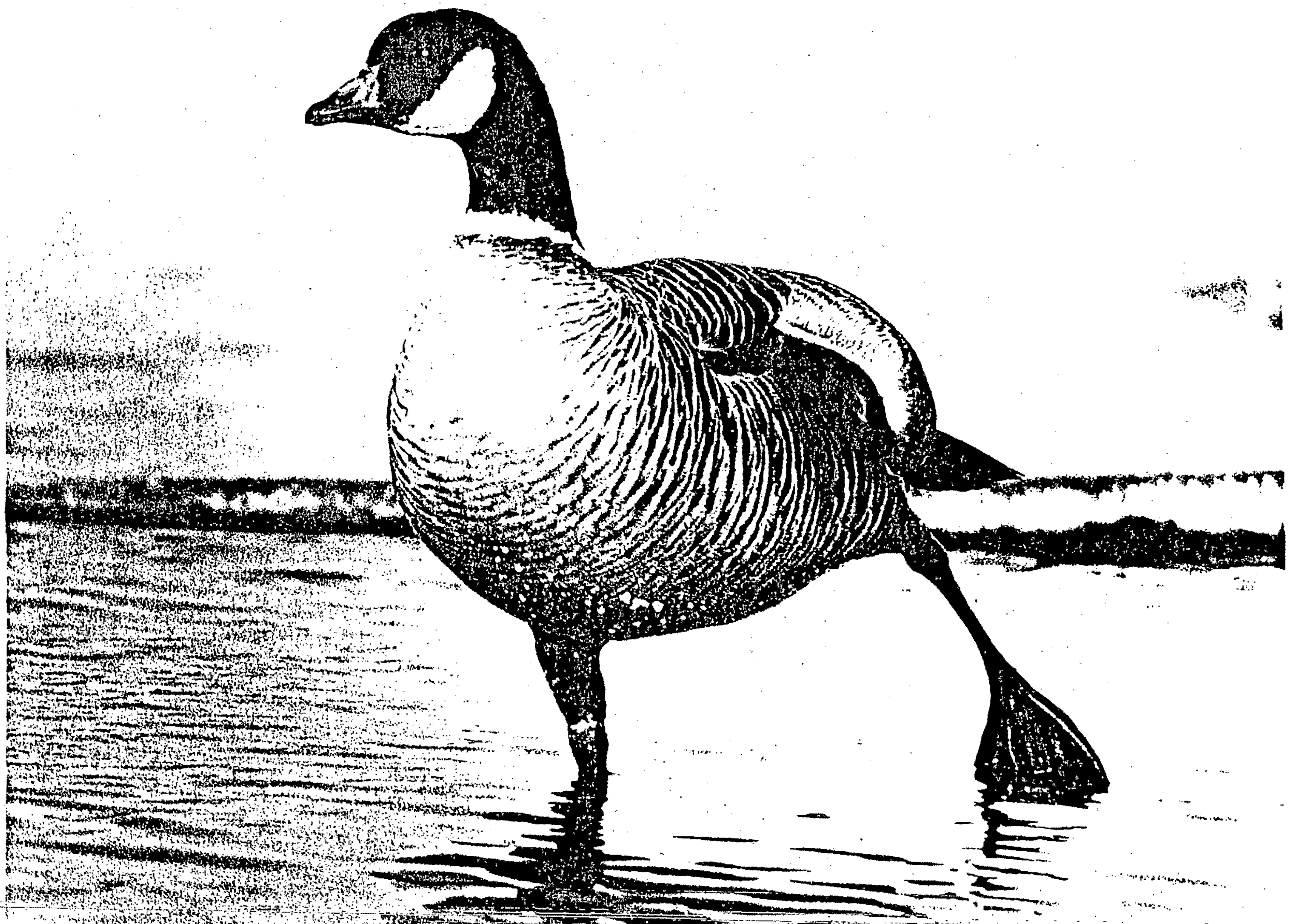


Fig. 1. Map of the Aleutian Islands, Alaska with an enlargement of Buldir Island

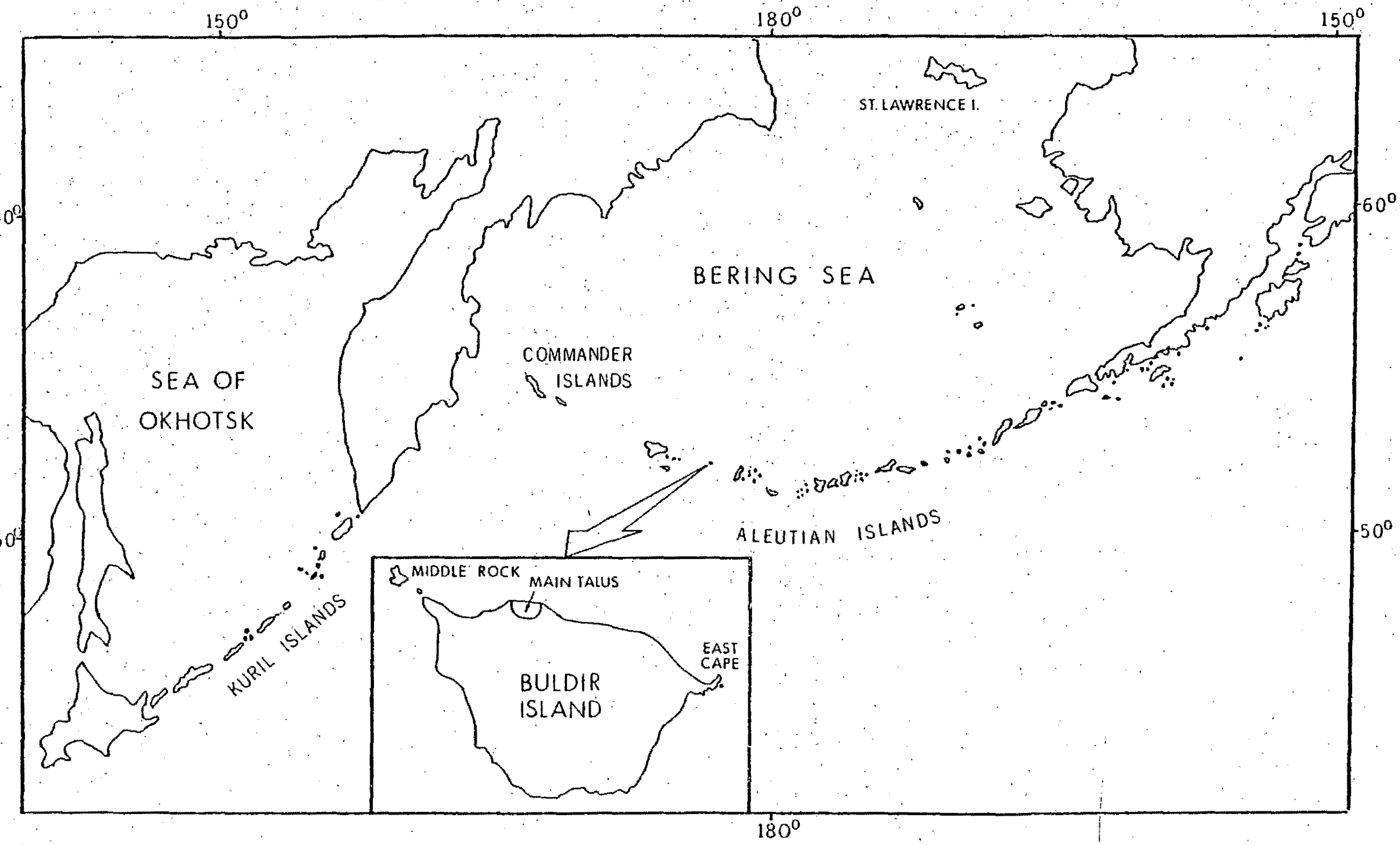

150⁰
180⁰
150⁰
60⁰
60⁰
50⁰
50⁰
ST. LAWRENCE I.
BERING SEA
SEA OF
OKHOTSK
COMMANDER
ISLANDS
ALEUTIAN ISLANDS
KURIL ISLANDS
MIDDLE ROCK
MAIN TALUS
EAST
CAPE
BULDIR
ISLAND
180⁰

Fig. 3. Map of Buldir Island, Alaska showing place names

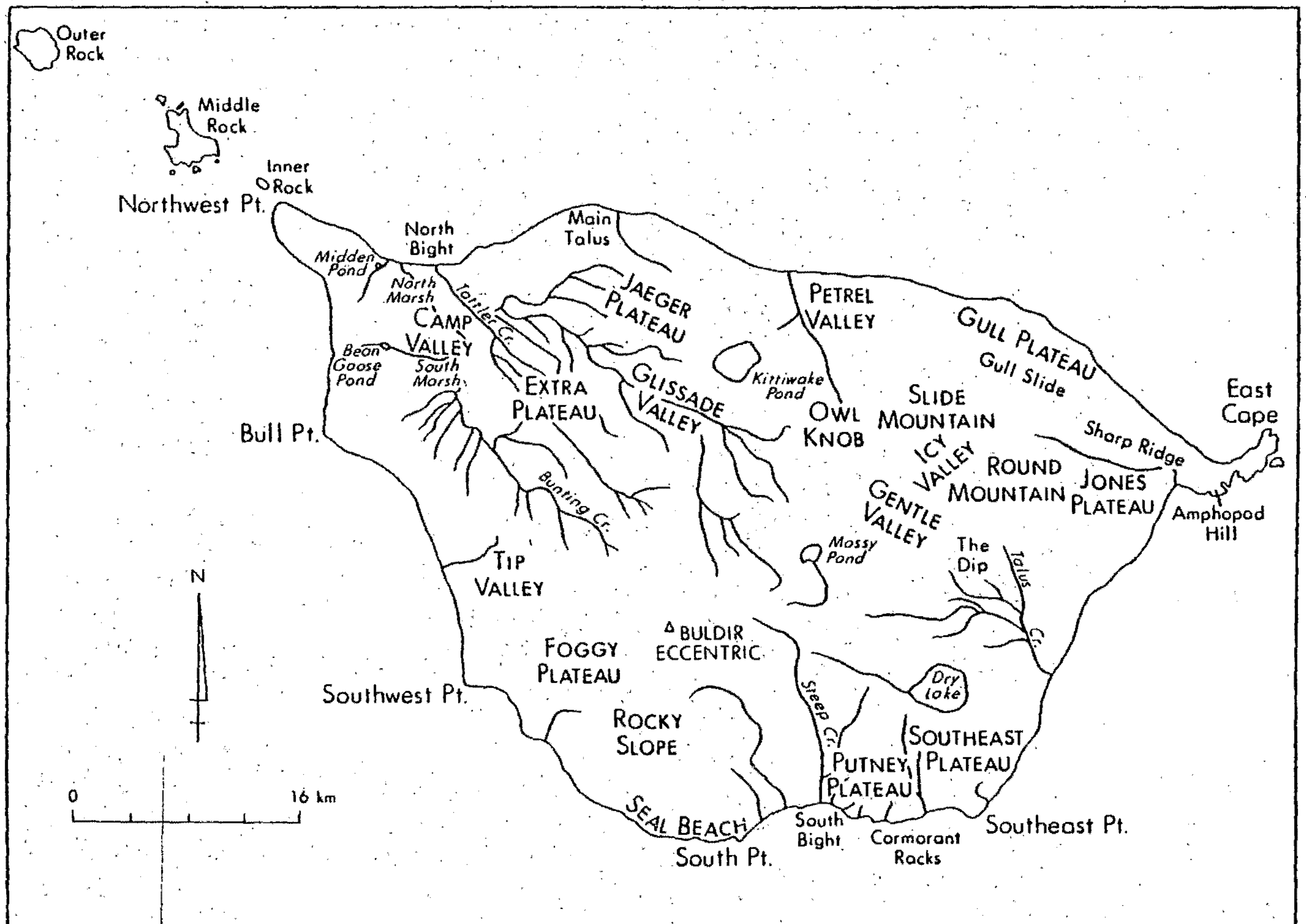

Outer Rock
Middle Rock
Inner Rock
Northwest Pt.
North Bight
Main Talus
Midden Pond
North Marsh
Camp Valley
Tattler Cr.
Jaeger Plateau
Petrel Valley
Gull Plateau
Gull Slide
Bean Goose Pond
South Marsh
Extra Plateau
Glissade Valley
Kittiwake Pond
Owl Knob
Slide Mountain
Icy Valley
Round Mountain
Jones Plateau
Sharp Ridge
East Cape
Amphopod Hill
Bull Pt.
Bunting Cr.
Gentle Valley
Mossy Pond
The Dip
Talus Cr.
Tip Valley
N
Buldir Eccentric
Foggy Plateau
Southwest Pt.
Rocky Slope
Steep Cr.
Dry Lake
Southeast Plateau
Putney Plateau
0
16 km
Seal Beach
South Pt.
South Bight
Cormorant Rocks
Southeast Pt.

Fig. 4. Photograph of Buldir Island from the sea. (PENDING)

Fig. 5. Map of Buldir Island, Alaska showing the distribution of associations and plant communities. The following patterns were used to designate specified communities: beach rye-umbel, beach rye-umbel-fern, sedge-fescue meadow, other lowland communities, rock or earth slides, moss-willow tundra.

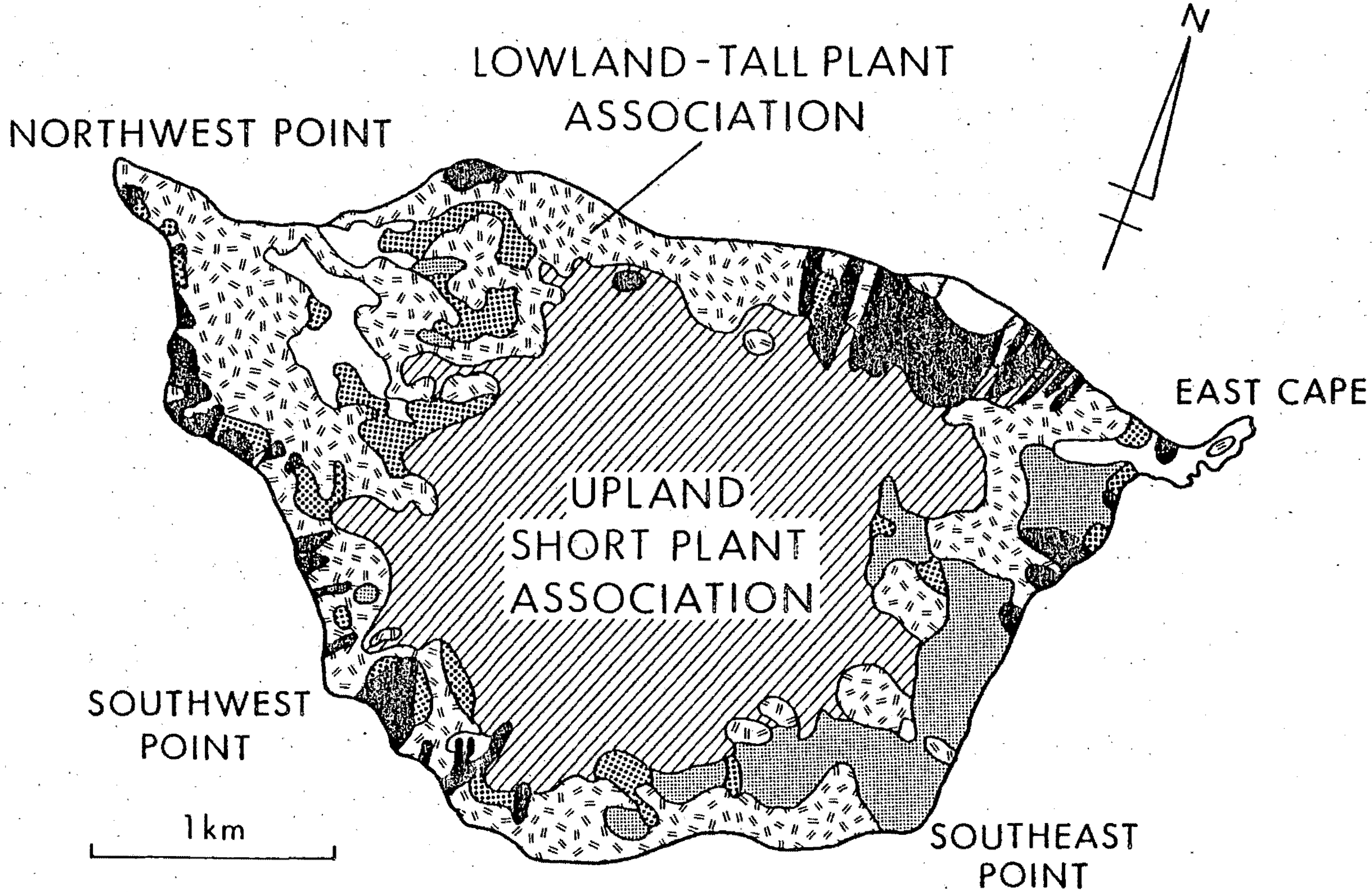

LOWLAND-TALL PLANT ASSOCIATION
NORTHWEST POINT
N
EAST CAPE
UPLAND SHORT PLANT ASSOCIATION
SOUTHWEST POINT
SOUTHEAST POINT
1km

Fig. 6. Photograph of one of the investigators standing in a typical stand of beach rye-umbel. Not lushness and height of overstory.

Fig. 7. Distribution of onset of laying dates for Aleutian Canada geese at Buldir Island, Alaska, 1974 to 1976

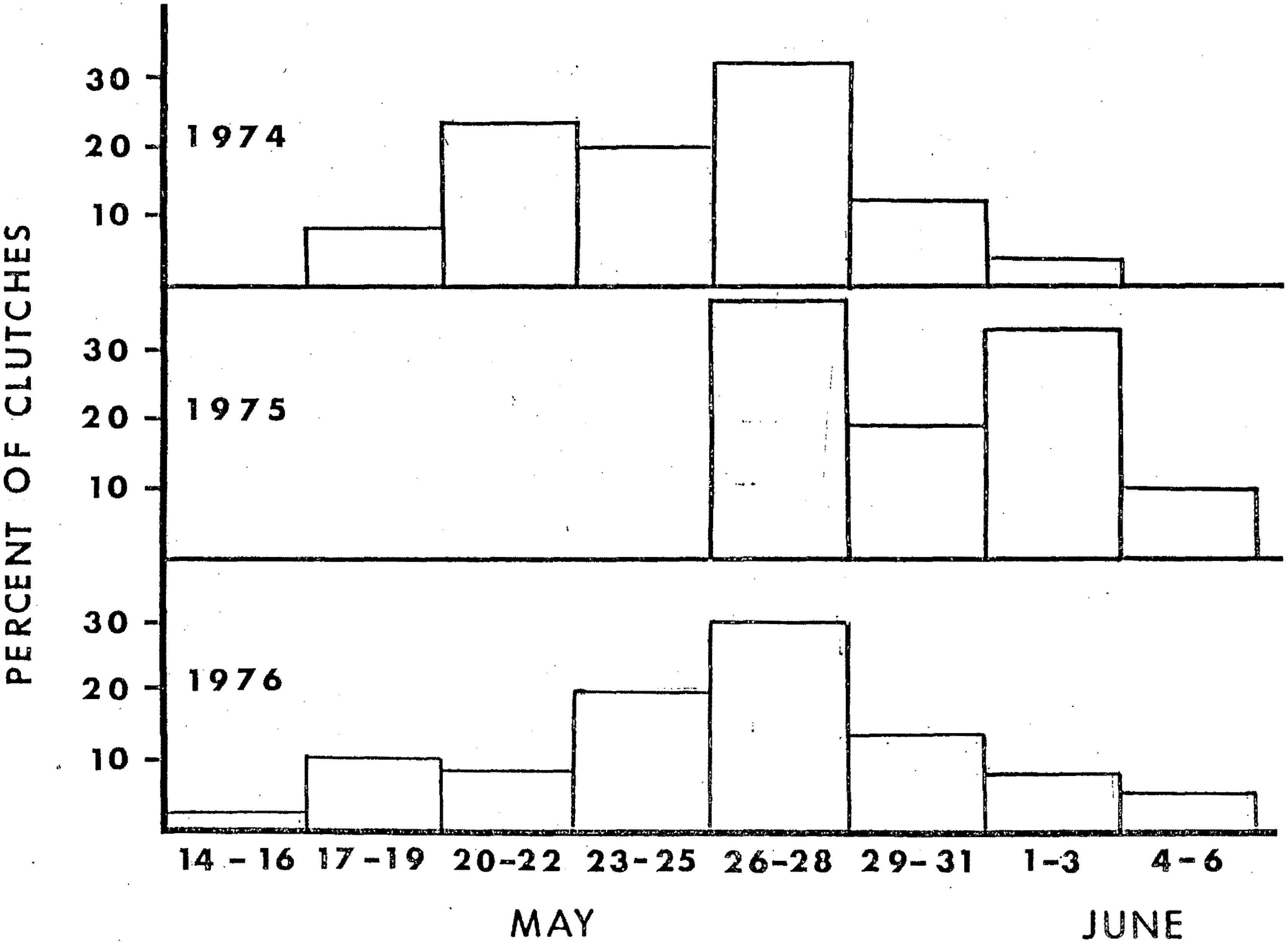

PERCENT OF CLUTCHES
30
20
10
1974
1975
1976
14 - 16
17 - 19
20-22
23-25
26-28
29-31
1-3
4-6
MAY
JUNE

Fig. 8. Distribution of hatching dates for Aleutian Canada geese at Buldir Island, Alaska, 1974 to 1976

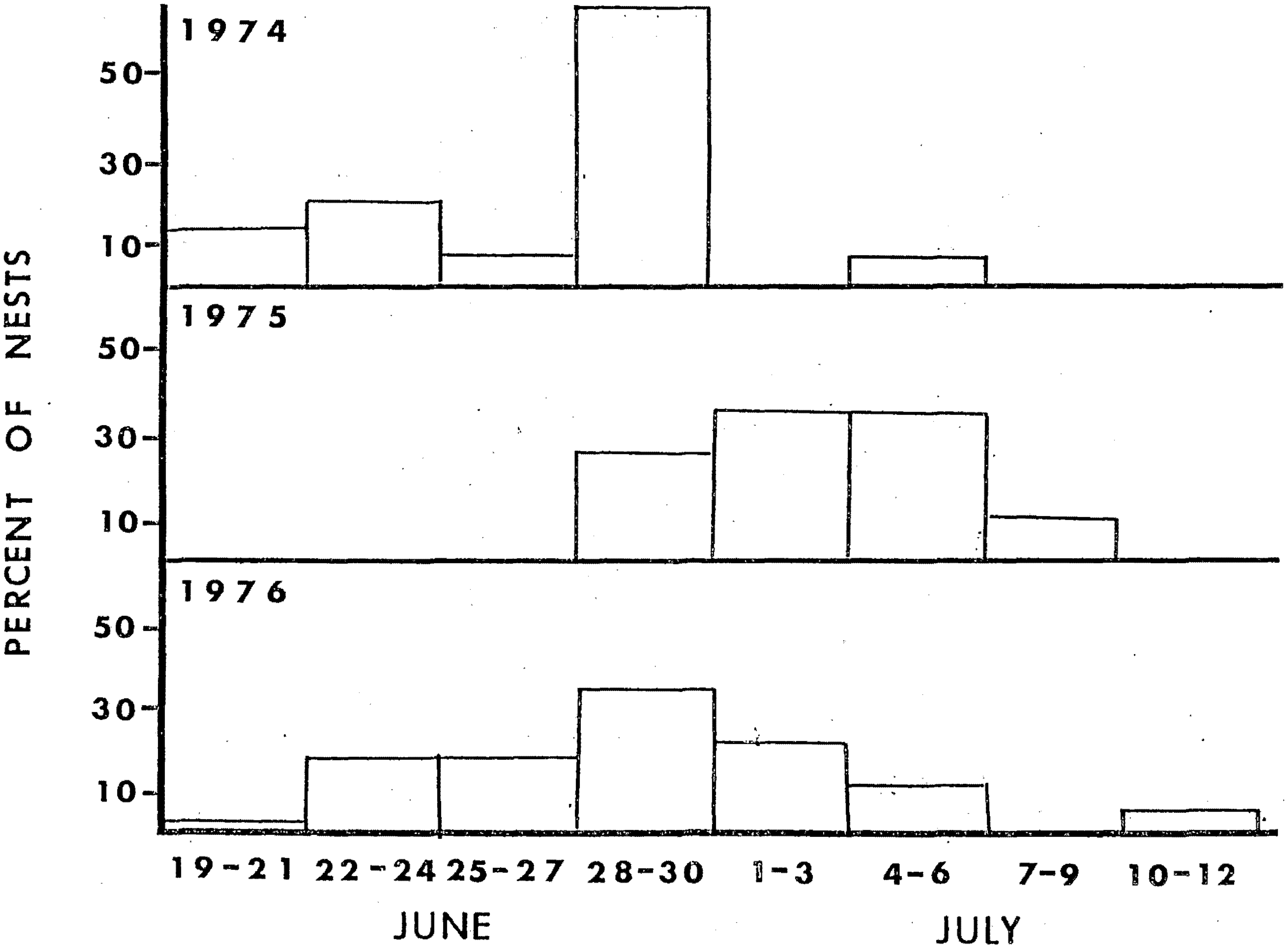
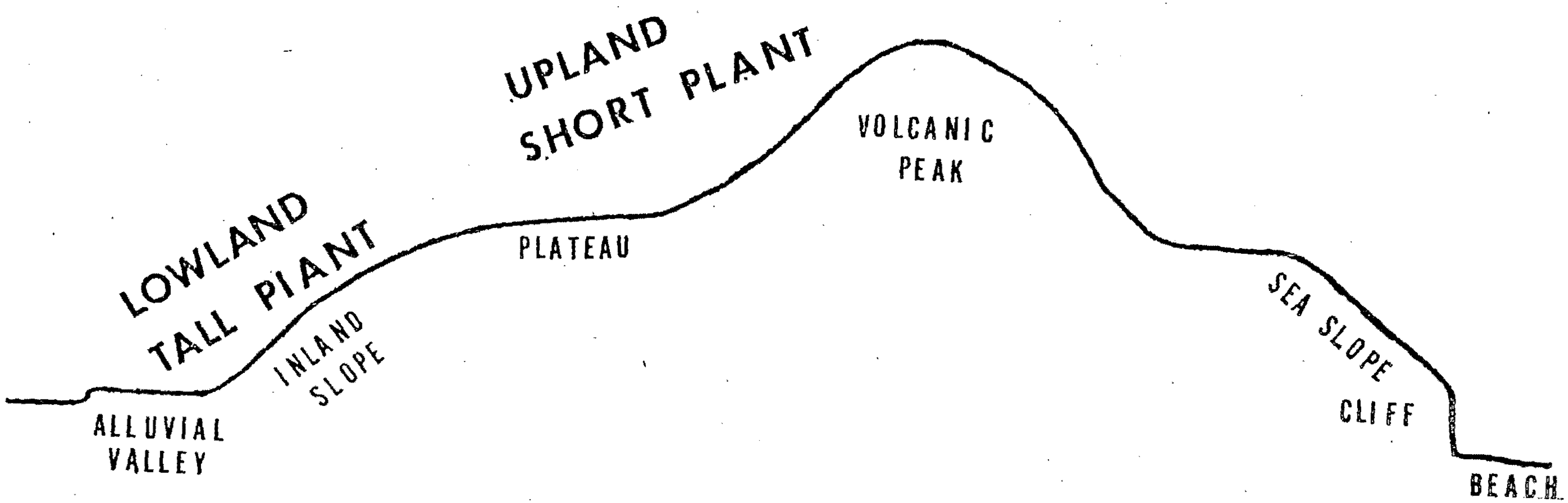

PERCENT OF NESTS
1974
1975
1976
50
30
10
19-21
22-24
25-27
28-30
1-3
4-6
7-9
10-12
JUNE
JULY

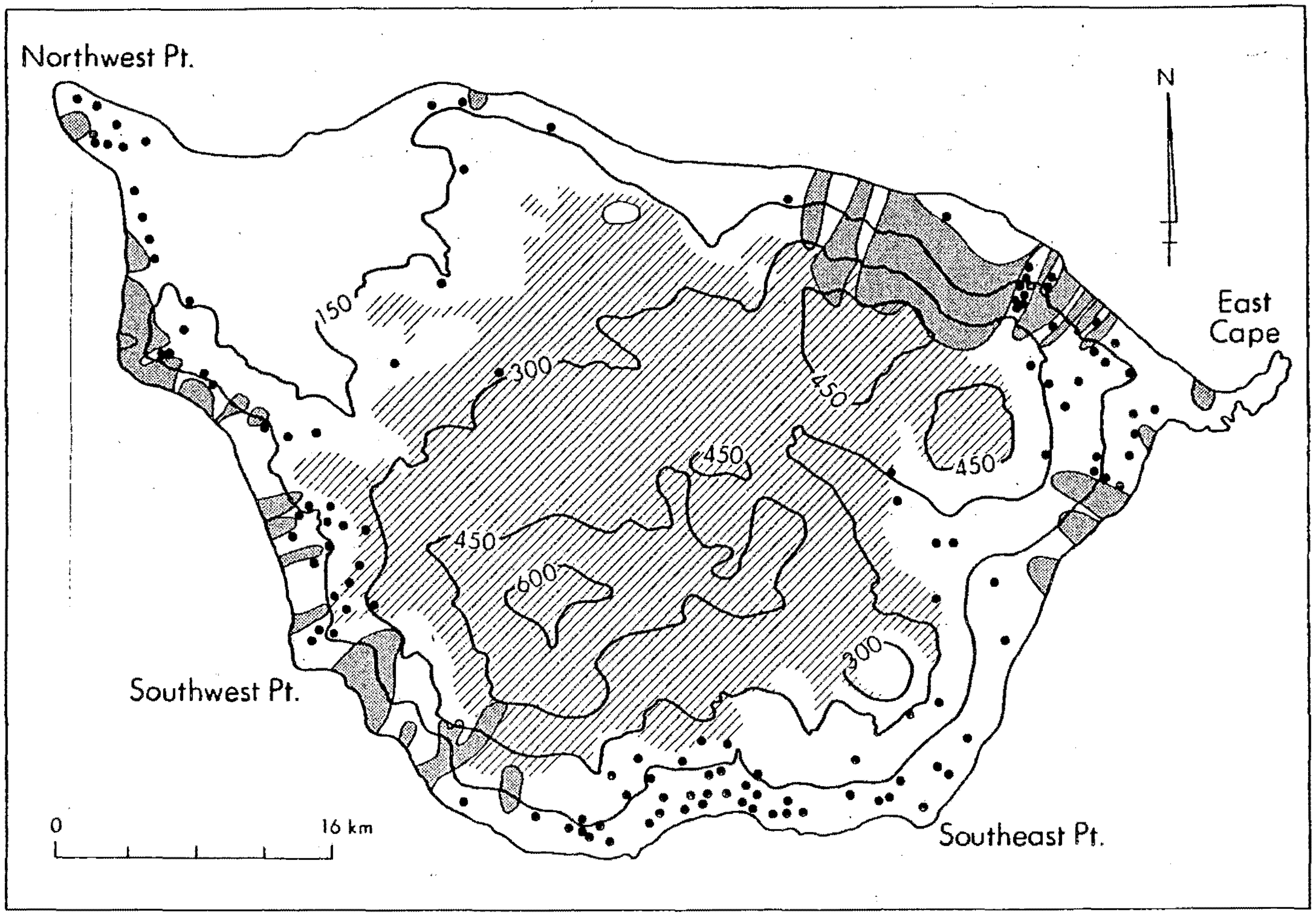
Fig. 9. Photograph of Aleutian Canada goose on a typical nest. Note green leaves of *Elymus arenarius*. The height of this and other plants would have been considerably higher at hatching.

Fig. 10. Cross-section of Buldir Island, Alaska showing physiographic types



UPLAND
SHORT PLANT
LOWLAND
TALL PIANT
VOLCANIC
PEAK
PLATEAU
INLAND
SLOPE
SEA SLOPE
CLIFF
ALLUVIAL
VALLEY
BEACH

Fig. 11. Map of Buldir Island, Alaska showing the distribution of goose nests 1974 to 1976. Black dots mark nest locations, stippled areas are unvegetated slides, cross-hatching indicates the approximate extent of the upland short-plant association, in contrast to the lowland tall-plant association where no cross-hatching occurs.



Northwest Pt.
N
East
Cape
150
300
450
450
450
450
600
300
Southwest Pt.
Southeast Pt.
0
16 km