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Assessment of bird populations in the Rasmussen Lowlands, Nunavut

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Abstract

We undertook a study of the breeding bird populations in the Rasmussen Lowlands, Nunavut, in order to assess the area's appropriateness for status as a National Wildlife Area. In 1994 and 1995, we determined habitat types and numbers and breeding status of birds in 118 plots in the lowlands. Shorebird species richness and densities were compared to results from published studies carried out elsewhere in the Arctic.

We recorded 35 bird species including 22 confirmed breeding species during surveys. Of 12 shorebird species recorded, Red Phalaropes *Phalaropus fulicaria*, Pectoral Sandpipers *Calidris melanotos*, and White-rumped Sandpipers *Calidris fuscicollis* were most common. Other confirmed breeders were Semipalmated Sandpipers *Calidris pusilla*, American Golden-Plovers *Pluvialis dominica*, Dunlin *Calidris alpina*, Black-bellied Plovers *Pluvialis squatarola*, Baird's Sandpipers *Calidris bairdii*, Stilt Sandpipers *Micropalama himantopus*, and Semipalmated Plovers *Charadrius semipalmatus*. Breeding was probable but not confirmed for Buff-Breasted Sandpipers *Tryngites subruficollis* and not suspected for Ruddy Turnstones *Arenaria interpres*.

Habitat types were distributed unevenly throughout the lowlands, and shorebirds were distributed unevenly among habitat types. Peak shorebird densities (pairs/km^2) were recorded from low tundra and high-centre polygon habitats. Approximately 60% of the lowlands is composed of good quality shorebird habitat, and a further 30% contains habitat used by upland nesters. We estimate the total population of shorebird pairs in the Rasmussen Lowlands to be 94 557 ± 32 423.

In terms of species richness, the lowlands compare favourably with other sites across the Arctic. Densities of all shorebird species and of individual species are lower in our study than those reported from the lowlands in the 1970s (McLaren et al. 1977), and from other "most similar" sites, though estimates for seven species are more than 1% of national population estimates. We discuss findings from Gratto-Trevor et al. (1998) which demonstrate a significant decrease in the densities of three shorebird species and one seaduck species between the mid-1970s and the mid-1990s. We suggest that the declines noted for the lowlands may also be occurring at other, similar sites but are unrecorded.

Other studies contemporaneous with ours demonstrate that the lowlands contain significant populations of waterfowl. Densities of Peregrine Falcons *Falco peregrinus* in the adjacent escarpment are similar to high-density populations elsewhere in the Northwest Territories and Nunavut.

We conclude by recommending National Wildlife Area status for the Rasmussen Lowlands on the basis of high shorebird species richness, its position in an ecological transition zone, diverse and suitable bird habitat, and nationally significant populations of five shorebird species, plus Greater White-fronted Geese *Anser albifrons*, Tundra Swans *Cygnus columbianus*, Peregrine Falcons, and likely King Eiders *Somateria spectabilis*. We also recommend a suitable boundary for a future protected area.

Résumé

Nous avons entrepris une étude des populations d'oiseaux nichant dans les basses terres de Rasmussen (Nunavut) afin d'évaluer la pertinence de désigner cette région comme Réserve nationale de faune. En 1994 et en 1995, nous avons déterminé les types d'habitat, ainsi que le nombre et la situation des oiseaux nicheurs dans 118 parcelles des basses terres. La richesse en espèces d'oiseaux de rivage et leurs densités ont été comparées aux résultats d'études publiées, effectuées ailleurs en Arctique.

Pendant les relevés, nous avons recensé 35 espèces aviaires, y compris 22 dont la nidification a été confirmée. Des 12 espèces d'oiseaux de rivage consignées, le Phalarope à bec large (*Phalaropus fulicaria*), le Bécasseau à poitrine cendrée (*Calidris melanotos*) et le Bécasseau à croupion blanc (*Calidris fuscicollis*) étaient les plus communs. La nidification du Bécasseau semipalmé (*Calidris pusilla*), du Pluvier bronzé (*Pluvialis dominica*), du Bécasseau variable (*Calidris alpina*), du Pluvier argenté (*Pluvialis squatarola*), du Bécasseau de Baird (*Calidris bairdii*), du Bécasseau à échasses (*Micropalama himantopus*) et du Pluvier semipalmé (*Charadrius semipalmatus*) a été confirmée. Il est possible que le Bécasseau roussâtre (*Tryngites subruficollis*) niche dans la région, mais cela n'a pas été confirmé. Nous ne croyons pas que le Tournepierre à collier (*Arenaria interpres*) y niche.

Les types d'habitat ne sont pas répartis également dans les basses terres et les oiseaux de rivage ne sont pas répartis également dans les types d'habitat. Les plus hautes densités d'oiseaux de rivage (couple/km^2) ont été notées dans les habitats des basses toundras et les habitats des polygones à centre convexe. Environ 60 p. 100 des basses terres fournissent des habitats de bonne qualité aux oiseaux de rivage, et 30 p. 100 du reste renferment des habitats utilisés par les oiseaux qui nichent en milieux secs. Nous estimons que la population totale de couples d'oiseaux de rivage dans les basses terres de Rasmussen s'élève à 94 557 ± 32 423.

Au chapitre de la richesse en espèces, les basses terres se comparent favorablement aux autres sites arctiques. Selon notre étude, les densités de toutes les espèces d'oiseaux de rivage et celles d'espèces individuelles sont plus basses que celles signalées dans les basses terres au cours des années 1970 (McLaren *et al*. 1977) et à d'autres sites « très semblables », bien que les estimations pour sept espèces sont supérieures de plus de 1 p. 100 des estimations pour la population nationale. Nous discutons des résultats de Gratto-Trevor *et al*. (1998) qui démontrent un déclin considérable de la densité de trois espèces d'oiseaux de rivage et d'une espèce de canard de mer, du milieu des années 1970 au milieu des années 1990. Nous proposons que ce déclin remarqué dans les basses terres pourrait se répéter dans d'autres sites similaires, mais qu'il n'a pas été consigné.

D'autres études contemporaines de la nôtre démontrent que les basses terres contiennent des populations importantes de sauvagine. Les densités de Faucon pèlerin (*Falco peregrinus*) de l'escarpement voisin sont analogues à celles trouvées ailleurs dans les Territoires du Nord-Ouest et le Nunavut.

Nous concluons en recommandant que les basses terres de Rasmussen soient désignées Réserve nationale de faune, compte tenu de leur grande richesse en espèces d'oiseaux de rivage, de leur emplacement dans une zone écologique de transition, des habitats d'oiseaux divers et appropriés et des populations d'importance nationale de cinq espèces d'oiseaux de rivage, en plus de l'Oie rieuse (*Anser albifrons*), du Cygne siffleur (*Cygnus columbianus*), du Faucon pèlerin et probablement de l'Eider à tête grise (*Somateria spectabilis*). Nous recommandons également une délimitation convenable pour une aire protégée future.

ᐃᓄᒃᑎᑐᑦ ᐅᓂᒃᑳᖅᑕᐅᔪᖅ ᓇᐃᓪᓕᒋᐊᖅᑕᐅᑉᓗᓂ

ᐅᑭᐅᑦ ᖁᓕᑦ ᐅᖓᑖᓄᑦ ᑲᓇᑕᒥ ᐆᒪᔪᓕᕆᔨᕐᔪᐊᒃᑯᑦ ᖃᐅᔨᒪᓕᖅᐳᑦ ᕿᒪᓐᓴᓐ ᓄᓇ ᐊᑦᑎᖕᓂᐅᔪᖅ ᑎᖕᒥᐊᓄᑦ ᐱᓪᒪᕆᐅᓂᖓᓂᒃ. ᓄᓇ ᐊᑦᑎᖕᓂᐅᔪᖅ ᐅᖃᐅᓯᐅᔪᖅ ᐃᓚᐅᖃᑕᐅᕗᖅ ᓄᓇᕗᑦ ᓇᖕᒥᓂᖅᑖᕆᔭᖓᓐᓂ ᓄᓇᒥ ᐊᖏᕈᑎᒥ ᐃᓱᒪᖕᓇᖅᐳᖅ ᐊᑐᓗᐊᖅᑕᐃᓕᒪᕝᕕᐅᓕᖅᑎᑕᐅᓛᓇᐊᒃᓴᖓᓂᒃ. ᐃᓕᑕᕆᔭᐅᓯᒪᓂᖃᕆᕗᖅ ᖃᐅᓯᕈᔭᖕᓂᐅᓂᖓᓂᒃ ᐱᓪᒪᕆᐅᑎᑕᐅᓪᓗᓂ ᓯᓚᕐᔪᐊᓕᒫᒥ (RAMSAR ᐃᓂᒋᔭᖓ). ᑭᓯᐊᓂ, ᒪᓕᒐᖅᑎᒍᑦ ᓴᐳᓐᓂᐊᖅᑕᐅᙱᓚᖅ ᒫᓐᓇᐅᔪᒃᑯᑦ, ᐊᒻᒪ ᖃᖓᑲᓪᓛᓗᒃ ᑎᖕᒥᐊᑦ ᐅᓄᕐᓂᖏᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᐳᑦ. ᑲᓇᑕᒥ ᐆᒪᔪᓕᕆᔨᕐᔪᐊᒃᑯᑦ ᖃᐅᔨᒋᐊᕈᒪᓚᐅᖅᐳᑦ ᓄᓇᐅᔪᖅ ᐊᑦᑎᖕᓂᐅᔪᖅ ᐱᓪᒪᕆᐅᓂᖃᕐᓂᖓ ᐱᓪᒪᕆᐅᓪᒪᕆᒋᐊᒃᓴᖓᓂᒃ ᑕᐃᔭᐅᓇᔭᖅᓗᓂ ᐊᑐᓗᐊᖅᑕᐃᓕᒪᕝᕕᐅᓕᕐᓂᕐᒥᒃ (ᐱᓗᐊᖅᑐᒥᒃ, ᑲᓇᑕᓕᒫᒥ ᐸᒡᕕᓴᖅᑕᐃᓕᕝᕕᐅᓕᕐᓗᓂ ᐃᓂᐅᓕᕐᓗᓂ ᐆᒪᔪᓄᑦ).

ᖃᐅᔨᓴᐃᓚᐅᖅᐳᑦ ᑎᖕᒥᐊᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ ᕿᒪᓐᓴᓐ ᐊᑦᑎᖕᓂᖓᓂ ᓄᓇᒥ, ᓄᓇᕗᒥ. ᐱᓗᐊᖅᑐᒥᒃ ᖃᐅᔨᔪᒪᓚᐅᖅᐳᑦ 1) ᖃᑉᓯᐅᑉᓗᑎᒃ ᑎᖕᒥᐊᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᓄᓕᐊᖃᑦᑕᓇᐊᒃᓴᖏᓐᓂᒃ ᓄᓇᒥ ᐊᑦᑎᖕᓂᐅᔪᒥ, ᐊᒻᒪ ᓇᓕᐊᑦ ᐃᓂᒋᔭᐅᒐᔪᓖᖑᒋᐊᒃᓴᖏᓐᓂᒃ ᐊᒻᒪ ᓄᓇᓂ ᓇᓕᐊᑦ ᐊᑐᖅᑕᐅᒐᔪᓖᖑᒋᐊᒃᓴᖏᓐᓂᒃ; 2) ᖃᓄᖅ ᓯᒡᔭᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᓄᓕᐅᔪᑦ ᓴᓂᓕᖃᓇᐊᒃᓴᖏᓐᓂᒃ ᐊᓯᐊᓂ ᐅᑭᐅᖅᑕᖅᑐᑉ ᐃᓂᒋᔭᖏᓐᓂ ᖃᓄᖅ ᐊᔾᔨᖃᖅᑎᒋᕙᑦ. ᖃᐅᔨᔪᒪᓗᐊᓚᐅᖅᐳᑦ ᓯᒡᔭᒥᐅᑕᓂᒃ ᑎᖕᒥᐊᓂᒃ ᖃᐅᔨᒪᔭᐅᓗᐊᙱᓐᓂᖏᑦ ᐱᔾᔪᑎᒋᓗᒋᑦ ᓄᓕᐅᖃᑦᑕᕐᓂᖏᑦ ᓯᒡᔭᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ. ᐊᒻᒪ ᓴᓂᓕᓈᓕᖅᑎᑦᑎᓚᐅᓇᕗᑦ ᑎᖕᒥᐊᑦ ᐅᓄᕐᓂᓇᔭᖏᓐᓂᒃ ᓄᓕᐅᔪᓂᒃ 1994-ᒥ ᐊᒻᒪ 1995-ᒥ ᖃᐅᔨᓴᐃᓚᐅᖅᑐᑦ ᐅᑭᐅᑦ 20 ᖃᓂᒋᔭᖓᓂ ᐊᓂᒍᖅᑐᑦ ᖃᐅᔨᓚᐅᖅᑕᖏᓐᓄᑦ.

ᕿᒪᓐᓴᓐᒥ ᐊᑦᑎᖕᓂᐅᔪᑦ ᓄᓇᐃᑦ ᐅᕙᓃᑉᐳᑦ ᐅᖁᐊᓂ ᕿᐃ ᓯᑐᓇᑦ ᐃᒪᖓᑕ ᐊᒻᒪ ᕿᒪᓐᓴ ᐃᒪᖓᑕ, ᓂᓪᒋᐊᓂᑦ ᓇᑦᑎᓕᒃ ᓕᒃ ᑕᓯᐅᑉ ᖃᓂᒋᔭᖓᓂᑦ 45 ᑭᓛᒥᑕ ᐅᐊᖕᓇᖓᓂᑦ ᐅᒃᑯᓯᒃᓴᓕᒃ ᐃᑎᓪᓈᕐᔪᑉ (ᑎᑎᕋᐅᔭᖅᓯᒪᔪᖅ 1). ᑕᒪᐃᓐᓂᖃᔭᖅ ᓄᓇᐅᔪᖅ ᐊᑦᑎᖕᓂᐅᕗᖅ, ᒪᓂᕿᐅᑉᓗᓂ, ᐊᒻᒪ ᖁᕕᕆᓪᓕᐊᓗᐊᖓᓪᓗᓂ, ᐃᒪᖅᓱᐃᑦ ᐊᒥᓱᑉᓗᑎᒃ. ᐃᓂᐅᔪᑦ ᑕᐃᒪᐅᖓᑦ ᓄᓇᒥ ᐱᕈᖅᑐᖃᕐᓂᐅᔪᑦ, ᐸᓂᕐᓂᐅᔪᑦ, ᐊᒻᒪ ᓄᓇᒥ ᐱᕈᖅᑐᖃᓪᒪᕆᖕᓂᐅᔪᑦ ᖃᐅᓯᕐᓂᐅᔪᓂ. ᓄᓇᐃᑦ ᐊᑦᑎᒃᑐᑦ ᐃᓂᒋᔭᐅᕙᒃᐳᑦ ᐊᑯᓐᓂᖓᓗ ᐆᓇᕈᔪᖕᓂᐅᔪᑉ, ᐊᒻᒪ ᐱᕈᖅᑐᖅᑲᐅᑦᑎᐊᖅᑐᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐊᒻᒪ ᓂᓛᓱᖕᓂᖅᓴᐅᔪᒧᑦ, ᐱᕈᖅᑐᖅᑲᐅᙱᓐᓂᖅᓴᐅᔪᓄᑦ ᐅᐊᖕᓇᖓᓂ ᓄᓇᐅᔪᑉ.

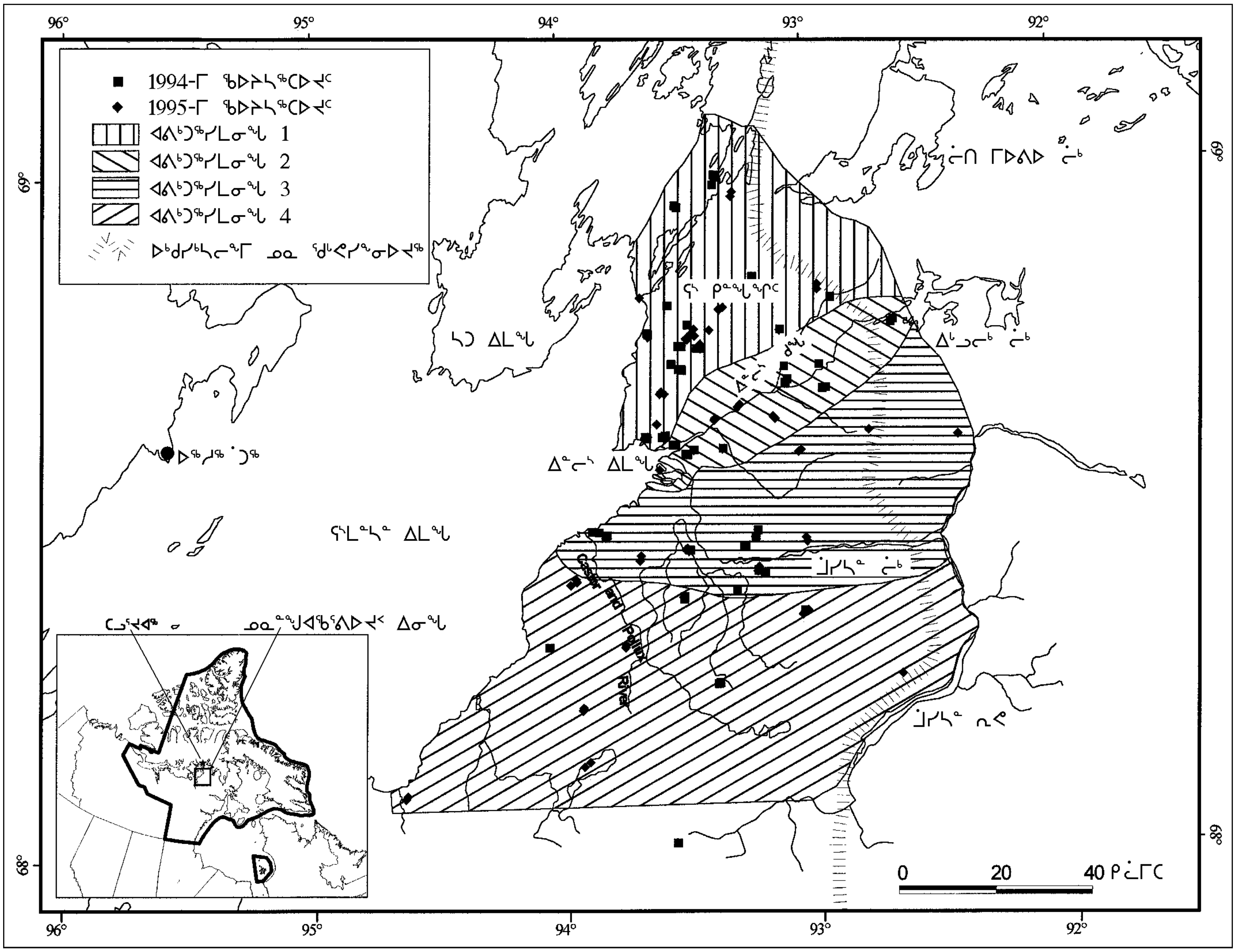
ᐅᖅᑲᓪᓚᖅᑲᑎᖅᑲᖅᑲᑦᑕᖅᑎᓪᓗᑕ ᑕᓗᕐᔪᐊᒥ ᐊᒻᒪ ᐅᖅᓱᖅᑑᒥ ᑐᑭᓯᓚᐅᖅᐳᒍᑦ ᐃᓂᐅᔪᖅ ᑕᒪᓐᓇ ᐊᑐᖅᑕᐅᖃᑦᑕᕐᓂᖓᓂᒃ ᑲᖑᖅᓯᓪᓕᕕᐅᑉᓗᓂ ᔫᒥ, ᐊᒻᒪ ᐊᖏᓂᖅᓴᐃᑦ ᑕᓯᑦ (ᓲᖅᓗ ᒧᑦᓯᓴᓐ ᓕᒃ) ᐊᒻᒪ ᑰᑦ ᐃᖅᑲᓪᓕᐊᕐᕕᐅᖅᑲᑦᑕᖅᐳᑦ ᑕᕆᐅᕐᒥᐅᑕᓂᒃ ᐃᖅᑲᓗᖕᓂᒃ ᐊᒻᒪ ᐃᓗᖅᖅᓱᓪᓕᕕᐅᑉᓗᑎᒃ ᓯᑉᑕᓪᐳᓇᒥ ᐊᒃᑐᐳᓇᒥᓗ. ᐃᑖᓐᓂ ᓯᑯᒥ ᐃᖅᑲᓗᓚᓱᖅᑲᑦᑕᖅᐳᑦ ᒪᐃᒥ ᔫᓐᒥᓗ. ᐅᖅᓱᖅᑑᒥ ᐊᖑᓇᓱᒃᑎᑦ ᑐᒃᑐᖅᑲᑦᑕᖅᐳᑦ ᓄᓇᒥ ᐊᑦᑎᖕᓂᐅᔪᒥ ᐅᑭᐊᒃᓵᖑᖅᓵᖅᑎᓪᓗᒍ ᐊᒻᒪ ᐅᑭᐅᒃᑯᑦ. ᐊᑐᖅᑕᐅᑦᑎᐊᖅᑲᑦᑕᖅᑐᖅ ᐅᑭᐅᒃᑯᑦ ᐅᐱᓐᖓᒃᓵᒃᑯᓪᓗ ᐃᓂᐅᔪᖅ ᓯᑭᑐᒃᑯᑦ ᑕᐃᒪᐅᖓᑦ ᐊᑯᓐᓂᖓᓂ ᐅᖅᓱᖅᑑᑉ ᐊᕕᑦᑐᐃᐊᑉᓗ ᐊᖅᑯᓯᐅᖅᑲᑦᑕᖅᐳᖅ ᑕᒪᓐᓇ ᐃᓂ ᐊᑐᖅᑕᐅᑎᓪᓗᒍ ᐊᑦᑎᖕᓂᐅᔪᒥᒃ ᓄᓇᓂᒃ. ᐃᑦᑕᕐᓂᑕᐃᑦ ᐃᓂᑐᖅᑲᖅᑲᕝᕕᖓᑦ ᓯᓐᔭᕐᓗᒃᑲᖏᑦ ᒍᓯᐊ ᑕᓯᓪᓚᑕ ᐊᒻᒪ ᕿᒥᓇᐃᔨᒥ, ᐊᓯᖏᓪᓗ ᑕᐃᒪᐅᖓᑦ ᓯᓚᒥ ᓇᓂᑐᐃᓐᓈᖅᑐᓂᒃ.

ᐃᓂᐅᔪᖅ ᖃᐅᔨᒪᔭᐅᓂᖓ ᖃᑉᓗᓈᓂᑦ ᑕᑯᔭᐅᑉᓗᓂ ᐸᓚᓯᕝᕕᓕᑕᐃᓐᓇᓚᐅᖅᐳᖅ 1970-ᓂ, ᐅᖅᓱᐊᓗᑉ ᓱᑉᓗᐊᓗᓕᐊᖓ ᐱᓕᕆᐊᖑᔪᒪᑉᓗᓂ ᒐᓴᒥᒃ ᓱᑉᓗᐊᓗᓕᐅᕐᓗᑎᒃ ᐅᖃᐅᓯᐅᑎᓪᓗᒍ ᕿᑎᐊᒎᓴᓯᓂᖓᓂᒃ ᓄᓇᐅᑉ ᐊᑦᑎᖕᓂᐅᔪᑉ. ᑕᒪᓐᓇ ᐊᑐᖅᑐᐃᓐᓇᕐᑎᓪᓗᒍ ᓴᕿᑎᑦᑎᑕᐅᓕᖅᐳᖅ ᐊᒥᓱᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᓂᒃ ᓄᓇᒥᒃ, ᓄᓇᒥ ᐱᕈᖅᑐᓂᒃ, ᐃᖅᑲᓗᖕᓂᒃ ᑎᖕᒥᐊᓂᓪᓗ. ᑎᖕᒥᐊᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖏᑦ ᖃᐅᔨᔭᖅᑎᑕᐅᓚᐅᖅᐳᑦ ᓄᓇ ᐊᑦᑎᖕᓂᐅᔪᖅ ᐊᒥᓱᓄᑦ ᓄᓕᐅᔪᓄᑦ ᖁᓪᓕᕐᓂᐅᓄᑦ, ᐊᖑᑎᕕᐊᓄᑦ ᒥᑎᖕᓄᑦ, ᐊᒻᒪ ᐋᐋᖑᐃᕐᓄᑦ, ᐊᒻᒪ ᐊᒥᓱᓕᒪᓇᐅᓚᐅᖅᐳᑦ ᓯᒡᔭᒥᐅᑕᐃᑦ (ᐊᐅᐸᓗᒃᑐᐊᔪᑦ ᓯᓪᓚᐃᑦ, ᑐᓪᓕᓗᐊᖅᔪᐊᑦ, ᓴᕿᕐᔪᐊᖅ ᑐᓪᓕᓗᖅᔪᐃᑦ, ᓴᕿᐃᑦ, ᓯᓚᓇᐊᕐᔪᐊᖅ, ᐊᒻᒪ ᓴᐅᓴᐃᑦ) ᓂᖏᑦ ᓂᓇᖅᑲᖅᑐᓗ ᑎᖕᒥᐊᖕᒍᑲᖕᓂᖕᒥᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ 1980-ᓂ ᑕᑯᓴᐅᑎᑦᑎᑕᐅᓚᐅᖅᐳᑦ ᓄᓇᐃᑦ ᐊᑦᑎᖕᓂᐅᔪᑦ ᐊᒥᓱᓕᒪᓐᓂᒃ ᓂᕿᖅᑕᖅᑲᐅᕐᓂᖅᑐᓂᒃ ᐊᒻᒪ ᑭᓪᓕᕕᐊᓯᖅᑲᐅᕐᓂᖅᑐᓂᒃ (ᑭᓪᓕᖅᑕᕐᓂ ᓄᓇᐅᑉ ᐊᑦᑎᖕᓂᐅᔪᑉ).

ᖃᐅᔨᓴᐃᓚᐅᖅᐳᒍᑦ ᓄᓇᒥ ᐊᑦᑎᖕᓂᐅᔪᓂ ᔫᒥ ᐊᒻᒪ ᔪᓚᐃᒥ, 1994-ᒥ ᐊᒻᒪ 1995-ᒥ. ᖃᐅᔨᓴᖅᑕᕗᑦ ᒪᓂᕿᒥ ᑕᒪᐃᓐᓂᖅᑲᔭᖅ ᐱᓱᑐᖅᑐᑕ ᖃᐅᔨᓴᓚᐅᖅᐸᕗᑦ ᐊᒻᒪ ᓇᓗᓇᐃᖅᓯᓪᓗᑕ ᑎᑎᕋᖅᓗᑕᓗ ᑎᖕᒥᐊᓂᒃ ᑕᒪᐃᓐᓂ ᑕᑯᔭᑉᑎᓐᓂᒃ. ᐊᒻᒪ ᐅᖅᑲᓚᐅᓇᕗᒍᑦ ᓄᓕᐅᒥᐊᖃᖓᓂᒃ ᓄᓕᐅᓐᖏᑦᑕᓇᐊᖓᓂᒃ. ᑕᐃᒪᓐᓇᐃᓕᐅᖅᑎᓪᓗᑕ, ᐅᓂᒃᑳᓚᐅᓇᕗᒍᑦ ᐃᓂᐅᔪᑦ ᖃᓄᐃᓐᓂᓇᔭᖓᓂᒃ (ᒪᓂᕿᒥ ᐊᑦᑎᖕᓂᐅᔪᒥ, ᐅᔭᕋᓱᖕᓂ, ᐅᖅᐱᑲᖅᐳᖅᑐᓂ, ᐊᒻᒪ ᐊᓯᖓᓂ). ᑳᒃᑯᐊ ᐅᓂᒃᑳᖅᑕᕗᑦ ᐊᑐᓚᐅᓇᕗᑦ ᖃᖓᑦᑕᖅᑎᑕᐅᓯᒪᔭᒃᑯᑦ ᐊᔾᔨᓕᐊᖑᔪᓂᒃ ᓄᓇ ᐊᑦᑎᖕᓂᐅᔪᖅ ᐊᔾᔨᓕᐅᖅᑕᐅᑎᓪᓗᒍ ᖃᐅᔨᔭᐅᓇᓱᒃᑎᓪᓗᒋᑦ ᖃᓄᐃᑦᑐᑦ ᐊᒻᒪ ᖃᓄᖅ ᐃᓂᒋᔭᐅᑎᒋᒋᐊᒃᓴᖏᓐᓂᒃ ᓄᓇᒥ ᐊᑦᑎᖕᓂᐅᔪᑦ.

ᖃᐅᔨᓴᐃᓚᐅᖅᐳᒍᑦ ᑎᖕᒥᐊᓂᒃ ᖃᐅᔨᔪᒪᑉᓗᑕ ᖃᓄᖅ ᐊᖏᑎᒋᔪᒥᒃ ᐃᓂᐅᔪᒥᒃ ᑲᑎᓪᓗᒋᑦ ᑕᒪᐃᓐᓂᒃ ᓄᓕᐅᔪᑦ ᐅᓄᕐᓂᖅᓴᐅᔪᓂᒃ ᐊᑐᓂ ᑎᖕᒥᐊᑦ ᓄᓇᒥ ᐊᑦᑎᖕᓂᐅᔪᓂᑦᑐᑦ; ᖃᐅᔨᔪᒪᑉᓗᑕᓗ ᑎᖕᒥᐊᑦ ᖃᓄᐃᑦᑐᑦ ᑕᑯᒃᓴᐅᑎᑦᑎᖅᑲᑦᑕᓇᐊᒃᓴᖓᓂᒃ ᐱᐅᒥᓂᖅᓴᐅᔪᖓᓂ ᐃᓂᐅᔪᒥᒃ ᐊᓯᖓᓂ ᐱᐅᒍᓱᙱᓐᓂᖅᓴᐅᔪᑉᓗᑎᒃ; ᖃᐅᔨᔪᒪᑉᓗᑕᓗ ᐅᓄᕐᓂᖏᑦ ᑎᖕᒥᐊᑦ ᖁᓪᓕᓯᖕᓂᖅᓴᐅᒥᐊᒃᓴᖏᓐᓂᒃ ᐃᓚᖏᓐᓂ ᐃᓂᒋᔭᐅᕙᒃᑐᓂ ᐊᓯᖏᓐᓂ ᐃᓂᒋᔭᐅᕙᒃᑐᓂ ᐱᐅᒥᓴᐅᓂᖅᓴᐅᒥᐊᒃᓴᖏᓐᓂᒃ ᖃᐅᔨᓴᐃᓚᐅᖅᐳᒍᑦ. ᑭᖑᓪᓕᖅᐹᒥᒃ, ᐅᓄᕐᓂᓇᔭᐅᑦ ᐅᕙᒍᑦ ᖃᐅᔨᔭᕗᑦ ᓴᓂᓕᖅᑎᓚᐅᖅᐸᕗᑦ ᐊᓯᖏᓐᓂ ᐃᓂᐅᔪᓂ ᐅᑭᐅᖅᑕᖅᑐᒥ ᑐᑭᓯᐅᒪᔭᒪᑉᓗᑕ ᐱᓪᒪᕆᐅᓂᕋᔭᖓᓂᒃ ᓄᓇᐃᑦ ᐊᑦᑎᖕᓂᐅᔪᒥᑦᑐᑦ ᑐᑭᓯᐅᒪᔭᒪᑉᓗᑕ ᐱᓪᒪᕆᐅᑎᑕᐅᔪᓂᒃ ᐊᑦᑎᖕᓂᐅᔪᓂ ᓄᓇᓂᒃ ᓄᓕᐅᔪᓄᑦ ᑎᖕᒥᐊᓄᑦ ᓯᒡᔭᒥᐅᑕᓄᑦ. ᑕᒪᓐᓇ ᖃᐅᔨᓴᖅᑕᐅᔪᖅ

ᑎᑎᕐᐅᓯᖅᓯᒪᓂᖓ 1.
ᕿᒪᖅᓴ ᓄᓇ ᐊᑦᑎᖕᓂᐅᔪᖅ ᖃᐅᔨᓴᖅᑕᐅᓂᖓ.



ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒍ, ᐊᓯᖏᑦ ᖁᓕᒥᒎᓕᒃᑯᑦ ᖃᐅᔨᓴᐃᓚᐅᖅᐳᑦ ᓂᕐᓕᑦ ᐊᒻᒪ ᑭᒡᓚᕖᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ ᖃᐅᔨᔪᒪᓪᓗᑎᒃ.

ᒪᓂᕆᒃᑯᑦ ᖃᐅᔨᓴᐃᓚᐅᖅᐳᑦ 1888 ᕼᐊᑕᐃᑦ ᐅᖓᑖᓄᑦ ᒪᓂᕆᐅᔪᒥ ᐊᖏᑎᑦᓯᓂᐅᔪᒥ, ᐊᒻᒪ 9-ᖑᔪᓂᒃ ᐃᓂᒋᔭᐅᕙᒃᑐᓂᒃ ᖃᐅᔨᓚᐅᖅᐳᑦ ᖃᐅᔨᓴᖅᑕᑎᓐᓂ. ᓇᐸᖃᔭᖏᑦ ᑕᒪᐃᓐᓂ ᐃᓂᐅᕝᑕᖅᑐᑦ ᖃᐅᔨᓴᖅᑎᓐᓂ ᖃᐅᓯᕐᓂᐅᔪᒥ ᓄᓇᖃᐅᕐᓂᐅᔪᒥᒑᓚᐅᖅᐳᖅ (ᐃᓚᖓ ᖃᑎᖕᓂᖃᐅᖅᓱᓂ) ᖃᐅᔨᓴᐃᓚᐅᓇᓱᑦ ᓄᓇᐅᔪᒥᒃ ᐃᕕᖃᐅᕐᒥᐅᔪᒥᒃ, ᓯᕗᐅᔪᑉ ᓯᓂᖏᓐᓂ ᐊᒻᒪ ᕿᖓᐅᓚᕐᓂ, ᐅᔭᕐᓯᖕᓂ, ᓯᐅᕐᐅᓂᐅᔪᓂ ᐃᕕᖃᐅᕐᓂᐅᔪᖅ ᐃᒪᕐᒥᒃ ᓴᕝᕙᐅᓂᐅᔪᓂᒃ ᐊᕙᓗᖃᐅᖅᓱᑎᒃ ᓄᓇᒥᒃ, ᖁᓪᓚᕐᓯᒃᑐᒥ ᓄᓇᒥ ᐸᓂᕐᓂᐅᔪᒥ, ᐊᒻᒪ ᖃᐅᓯᕐᓂᐅᔪᒥ ᓄᓇᒥ ᐱᕈᕐᕕᐅᓗᐊᖏᓐᓂᐅᔪᒥ. ᐊᔾᔨᖕᖏᑦᑐᑦ ᐃᓂᒋᔭᐅᔪᑦ ᐊᑯᓐᓂᖓᓚᔪᓚᐅᖅᐳᑦ.

ᐃᓂᐅᔪᑦ ᐊᑦᑎᖕᓂᐅᔪᒥ ᓇᓕᒧᒌᒃᑐᐃᓐᓇᐅᓚᐅᖏᓚᑦ. ᑕᒪᐃᓐᓂᖃᔭᖅ ᐃᕕᖃᐅᕐᓂᐅᔪᖅ ᐃᒪᕐᒥᒃ ᓴᕝᕙᐅᓂᐅᔪᓂᒃ ᐊᕙᓗᖃᐅᖅᓱᑎᒃ ᓄᓇᐅᔪᖅ ᑕᒃᖃᐅᓚᐅᖅᐳᖅ 20 ᑭᓛᒥᑕᓂᒃ ᐅᖓᓯᖕᓂᓕᖏᒃ ᒎᓯᓴ ᓇᕙᒥ. ᐃᕕᖃᐅᕐᓂᐅᔪᖅ ᓄᓇᐅᔪᖅ ᑕᑯᔭᐅᓚᐅᓚᐅᖅᐳᖅ ᓂᕐᒥᐊᓂ ᓱᓯᓴ ᓇᕙᐸ, ᓯᐅᕐᐅᓂᐅᔪᑦ ᑲᑎᒪᐅᓚᐅᖅᐳᑦ ᑰᖕᓂ ᐊᒻᒪ ᑰᑦ ᓴᕝᕙᐅᕝᕕᒋᔭᖏᓐᓂ. ᓯᕗᐃᑦ ᓯᓂᖏᑦ ᓯᕗᔭᐸ ᓯᐋᓂ ᐊᔾᔨᖕᖏᑦᑐᓂᓚᐅᖅᐳᑦ. ᖃᐅᓯᖅᑐᖅ ᐊᑦᑎᒃᑐᖅ ᓄᓇ ᐊᒻᒪ ᖃᑎᖕᓂᖃᐅᕐᓱᓂ ᓄᓇ ᒪᓂᕿᒥ ᐊᑦᑎᖕᓂᐅᔪᒥᒋᔭᐅᓚᐅᖅᐳᖅ.

87-ᖑᔪᑦ ᓄᓇᕐᐃᑦ ᐃᕕᓪᓗ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᐳᑦ ᕿᒪᖅᓴ ᐊᑦᑎᖕᓂᕆᔭᖓᓂ ᓄᓇᒥ.

ᑎᑎᕋᓚᐅᖅᐳᑦ 37-ᖑᔪᓂᒃ ᐊᔾᔨᖕᖏᑦᑐᓂᒃ ᑎᖕᒥᐊᓂᒃ ᖃᐅᔨᓴᖅᑕᑎᓐᓂ ᖃᐅᔨᓴᐃᑎᓪᓗᑕ. 22-ᖑᔪᑦ ᓄᓕᐅᖃᑦᑕᖅᐳᑦ ᐊᑦᑎᖕᓂᐅᔪᓂ ᐅᑉᐸᓘᓐᓂᑦ ᖃᓂᖏᔭᖓᓂ. ᖃᐅᔨᓚᐅᖅᐳᑦ 12-ᖑᔪᓂᒃ ᑎᖕᒥᐊᓂᒃ ᐊᔾᔨᖕᖏᑦᑐᓂᒃ ᓯᓪᓱᒥᐅᑕᓂᒃ, ᐊᒻᒪ ᑕᒪᐃᓐᓂᒃ ᓄᓕᐅᔪᐃᓐᓇᓚᐅᖅᐳᑦ ᑭᓯᒥ ᓴᕐᕙᐃᑦ ᓄᓕᐅᓐᖏᑦᑐᑦᑐᐊᖑᔾᔪᑎᒃ ᐊᒻᒪ ᑐᓪᓕᐅᔫᖅᑐᑦ ᓯᓪᓱᓇᕐᔪᐃᑦ. ᑕᑯᓚᐅᖅᐳᑦ, ᐅᑯᓂᖓ; ᐊᐅᐸᓘᑦᑐᐊᕐᔪᑦ ᓯᓪᓚᐃᑦ, ᓯᓪᓱᓇᕐᔪᐃᑦ, ᓴᕐᕙᐃᑦ, ᓴᐅᕙᕐᐃᑦ, ᑐᓪᓕᓪᓱᐃᑦ, ᓯᓪᓱᓇᐊᑦ, ᑐᓪᓕᓪᓚᔪᑦ, ᓴᐅᕙᕐᐃᑦ, ᓕᕕᓕᕖᑦ, ᓵᕙᐃᑦ, ᖁᓪᓕᖁᓪᓕᐊᕐᔪᐃᑦ, ᑐᓪᓕᐅᔫᖅᑐᑦ ᓯᓪᓱᓇᕐᔪᐃᑦ. ᓯᕗᓪᓕᖅᐹᒥᒃ ᓵᕙᐃᑦ ᑕᑯᔭᐅᒋᐅᖅᐳᑦ ᓄᓕᐅᔪᑦ ᑕᒫᓂ ᐃᓂᐅᔪᒥ.

ᕿᓂᖅᑕᖏᐊᑦ ᓯᓪᓱᒥᐅᑕᐅᖕᖏᑦᑐᓂ ᑕᑯᔭᐅᓚᔪᕝᖑᓚᐅᖅᐳᑦ ᑎᖕᒥᐊᓂ. ᓂᕐᓕᑦ, ᒥᑭᓂᖅᓴᐃᑦ ᑲᑯᖏᑦ ᐊᒻᒪ ᓂᕐᓕᑐᐃᓇᐃᑦ, ᐊᒻᒪ ᐊᖑᑎᕕᐊᑦ ᒥᑏᑦ ᑕᑯᔭᐅᓚᐅᖅᐳᖅ.

ᐊᑦᑎᒃᑐᑦ ᖃᐅᓯᖅᑐᑦ ᓄᓇ ᐊᒻᒪ ᐃᕕᖃᐅᕐᓂᐅᔪᖅ ᐃᒪᕐᒥᒃ ᓴᕝᕙᐅᓂᐅᔪᓂᒃ ᐊᕙᓗᖃᐅᖅᓱᑎᒃ ᓄᓇᒥᒃ ᓯᓪᓱᒥᐅᑕᓂᒃ ᑎᖕᒥᐊᓂᒃ ᐱᑕᖃᐅᕐᕿᔪᓚᐅᖅᐳᖅ, ᐊᔾᔨᖕᖏᑦᑐᑦ ᑎᖕᒥᐊᑦ ᐃᓂᖏᑦ ᑕᐃᒪᐃᓪᓗᐊᖅᑎᓪᓗᒋᑦ ᐃᓂᒋᔭᐅᓚᐅᖅᑐᑦ. ᐱᓗᐊᖅᑐᒥᒃ, ᐊᐅᐸᓘᑦᑐᐊᕐᔪᐃᑦ ᐊᒻᒪ ᓯᓪᓱᓇᕐᔪᐃᑦ ᐊᒥᒧᑖᖑᖃᑦᑕᖅᐳᑦ ᐊᑦᑎᒃᑐᓂ, ᖃᐅᓯᖅᑐᓂ ᓄᓇᒥ; ᓯᓪᓱᓇᐊᑦ ᐊᒻᒪ ᓵᕙᐃᑦ ᖁᓪᓕᕈᓯᖑᓚᐅᖅᐳᑦ ᐃᕕᖃᐅᕐᓂᐅᔪᖅ ᖃᑎᖕᓂᐅᔪᓂ ᓄᓇᓂ; ᓴᐅᕙᕐᐃᑦ ᐊᒻᒪ ᓴᕐᕙᕐᔪᐊᑦ ᑑᓕᕐᔪᐃᑦ ᑕᑯᔭᐅᓚᔪᓚᐅᖅᐳᑦ ᐃᕕᖃᐅᕐᓂᐅᔪᖅ ᐃᒪᕐᒥᒃ ᓴᕝᕙᐅᓂᐅᔪᓂᒃ ᐊᕙᓗᖃᐅᖅᓱᑎᒃ ᓄᓇᓂᒃ; ᖁᓪᓕᖁᓪᓕᐊᕐᔪᐃᑦ ᐸᓂᕐᓂᐅᔪᓂ ᓇᓂᓯᐅᓚᔪᓚᐅᖅᐳᑦ;

ᖁᒻᕙᓯᖕᓂᐅᔭᓂ; ᓚᕕᓚᕕᓛᑦ ᐊᒻᒪ ᓵᕿᐃᑦ ᓯᒃᔪᐅᑉ ᓯᓈᓃᓕᔭᓚᐅᖅᐳᑦ ᕿᖕᒐᐅᒐᕐᓂᓗ.

ᕿᕐᓂᖅᑕᕆᐊᑦ ᖁᐸᓄᐊᑦ ᑕᑯᔪᐅᓕᔭᓚᐅᖅᐳᑦ ᐃᓂᖃᖅᑎᓪᓗᒋᑦ ᓯᐅᕋᐅᓂᐅᔭᓂ, ᓯᒃᔪᐃᑦ ᓯᓂᖕᒋᓐᓂ ᐊᒻᒪ ᕿᖕᒐᐅᒐᕐᓂ, ᐅᔪᕋᓱᖕᓂᓗ. ᐃᒪᕐᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᑕᑯᔪᐅᓕᔭᓚᐅᖅᐳᑦ ᖁᒻᕙᓯᓖᖑᓂᐅᔭᓂ ᒪᓂᕋᕐᒥ ᐊᑦᑎᖕᓂᐅᔭᓂ.

ᑲᔪᓯᐅᒪᐃᓐᓇᖅᑐᒥᒃ ᐊᔾᔨᙳᙱᓂᖃᓚᐅᙱᓚᑦ ᑎᖕᒥᐊᑦ ᐃᓂᕆᕙᒃᑕᖕᒋᑦ 1994-ᒥ ᐊᒻᒪ ᐃᓂᕆᕙᒃᑕᖕᒋᑦ 1995-ᒥ. ᐊᔾᔨᙳᓚᐅᖅᐳᓪᓚ ᓯᒃᔪᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᐊᑯᓐᓂᖕᒐᓂ ᔫ ᐊᒻᒪ ᔪᓚᐃ ᑕᒪᐃᓐᓂ ᐅᑭᐅᖑᔪᓂ. ᐃᓱᒪᒍᑦ ᑖᑯᐊ ᐊᔾᔨᙳᙱᓂᓇᔪᖕᒋᑦ ᐃᓚᖁᓯᐅᓕᔪᕆᐊᒃᓴᖕᒋᓐᓂᒃ - ᑕᐃᒪᓐᓇᐃᖃᑦᑕᖅᐳᑦ ᑎᖕᒥᐊᑦ ᓄᓚᐅᓐᖏᑦᑐᑦ ᐊᒻᒪ ᑎᖕᒥᐊᑦ ᐅᐸᒍᖕᒋᑦ ᓱᖁᒃᑕᐅᔪᑦ ᓄᓚᐅᕝᕕᐅᔪᓂᑦ ᕿᒪᐃᓵᓚᖅᑕᑦᑕᕐᒪᑕ. ᐊᒻᒪᓗ, ᐃᓚᖕᒋᓐᓂ ᓯᒃᔪᒥᐅᑕᓂ ᓇᓚᑐᐃᓐᓇᖕᒐᑦ ᐊᕐᓇᕕᐊᖅ ᐊᖑᑎᕕᐊᕐᓘᓐᓃᑦ ᕿᒪᐃᖃᑦᑕᕐᒪᑦ ᐅᐸᓗᖅᑲᕐᕕᕆᔭᖕᒐᓂ ᐱᖃᑖ ᒪᓐᓂᖕᓂᒃ ᐃᕙᑎᓪᓗᒍ. ᑕᒪᓐᓇᐃᑎᓪᓗᒍ ᓈᓴᐃᑎᓪᓗᑕ ᔪᓚᐃᒥ ᐃᓄᐃᓴᖕᓂᖅᓴᐅᖃᑦᑕᖅᐳᑦ ᔫᒥ ᑎᖕᒥᐊᑦ ᐅᖓᓯᖕᒋᓐᓂᑦ ᓈᓴᖅᑕᕗᑦ.

ᐃᓱᒪᒍᑦ ᖃᓂᒋᔪᖓᓂ 94 000 (+/- 32 000) ᓯᒃᔪᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᑲᑎᒪᐅᖅᑐᑦ ᐊᑦᑎᖕᓂᐅᔪᒥ ᓄᓇᒦᓚᐅᖅᐳᑦ ᖃᐅᔨᓴᐃᑎᓪᓗᑕ (ᑕᑯᓗᒍ ᑎᑎᕋᐅᔭᖅᓯᒪᔪᖅ 1 ᐅᓄᕐᓂᖓᔪᐅᔪᑦ ᐱᔪᑎᒋᓗᒋᑦ ᑕᒪᐃᓐᓂ ᑎᖕᒥᐊᑦ ᐊᔾᔨᙳᙱᑦᑐᑦ). ᐊᐅᐸᓗᒃᑐᐊᕐᔪ ᓯᒃᓚᐃᑦ ᐊᒥᓲᓛᖑᓚᐅᖅᐳᑦ ᓯᒃᔪᒥᐅᑕᓂ ᑎᖕᒥᐊᓂ, ᑐᓪᓚᖓᔪᐅᐸᓗᑎᒃ ᓵᕙᕐᓄᑦ ᐊᒻᒪ ᓯᒃᔪᖓᐊᕐᔪᖕᓄᑦ. ᓇᓚᐅᑦᑖᓚᐅᓇᕗᒍᑦ ᐅᓄᕐᓂᓇᔪᖕᒋᓐᓂᒃ ᓯᒃᔪᒥᐅᑕᐅᓐᖏᑦᑐᑦ ᑎᖕᒥᐊᑦ. ᑭᓯᐊᓂ, ᖃᐅᔨᓴᖅᑕᐅᔾᔪᓯᐅᔪᖅ ᐊᖕᒋᓂᖅᓴᓄᑦ ᑎᖕᒥᐊᓄᑦ ᓈᒻᒪᙱᓚᖅ ᐱᓚᓇᔾᔪᓯᓇᔪᐅᓇᓱᒃᑎᓪᓗᒍ, ᓇᓚᐅᑦᑖᖅᑕᕗᑦ ᑎᖕᒥᐊᓄᑦ ᑑᓪᓚᓪᔪᐊᓄᑦ ᐊᒻᒪ ᐃᒪᕐᒥᐅᑕᓄᑦ ᑎᖕᒥᐊᓄᑦ ᓇᓚᐅᓯᒪᓂᖅᑎᕆᙱᓚᑦ ᒥᑭᓂᖅᓴᐃᑦ ᑎᖕᒥᐊᑦ ᕿᕐᓂᖅᑕᕆᐊᑦ ᖁᐸᓄᐊᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖕᒋᑦᑎᑐᑦ. ᑎᖕᒦᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐊᑐᐃᓐᓇᐅᑎᑦᑎᒍᑦ ᐋᖅᑭᐅᒪᓂᖅᓴᓂᒃ ᐅᓄᕐᓂᓇᔪᐅᓇᓯᕆᔪᐅᔪᑦ ᓈᐅᑎᖕᒋᓐᓂᒃ ᐃᒪᕐᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᐊᒻᒪ ᑭᒡᓕᕕᐊᕐᔪᐃᑦ (ᑕᑯᓗᒍ ᑎᑎᕋᐅᔭᖅᓯᒪᓂᖕᒐ 2).

ᖀᔅᒪᓐᓴᓐ ᓄᓇ ᐊᑦᑎᖕᓂᖓ ᐊᒥᓲᓂᖅᓴᓂᒃ ᓯᒃᔪᒥᐅᑕᓂᒃ ᓂᕐᓚᐅᔪᓂᒃ ᐱᑕᖃᐅᖅᐳᑦ ᐅᑭᐅᖅᑕᖅᑐᑉ ᐃᓂᕆᕙᒃᑕᖕᒋᑦᑕ ᐊᓯᖕᒋᓐᓂ ᖃᐅᔨᓴᖅᑕᐅᕝᕕᐅᓯᒪᔪᓂ. ᑭᓯᐊᓂ, ᑲᑎᒪᐅᕐᓂᖅᑕᑦ ᐊᒥᓲᓂᖅᑕᑦ ᖁᒻᕙᓯᓐᖏᓐᓂᖅᓴᐅᔪᑦ ᐊᒥᓱᓂ ᐃᓂᐅᕙᒃᑐᓂ. ᑕᒪᓐᓇ ᓱᓕᔪᓇᖅᐳᖅ ᓱᓕᙱᑦᑐᓐᓇᖅᐳᕐᓗ, ᓯᓚᐅᑉ ᐃᓕᖁᓯᖓ ᐊᒻᒪ ᖃᐅᔨᓴᐃᔭᕐᓯᐅᑉ ᓴᓂᓕᓈᒃᑎᑦᑎᔾᔪᑕᐅᑦᑎᐊᕐᓂᖅ ᐊᔪᓇᕐᒪᑕ. ᑭᓯᐊᓂ, ᐃᒪᓐᓇᐃᓕᖏᓐᒍᑦ ᐊᒥᓱᑦ ᓯᒃᔪᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᐃᓂᕆᔭᖏᑦ ᓄᓇᒥ ᐊᑦᑎᖕᓂᕐᒦᑉᐳᑦ, ᐊᒻᒪ ᐅᓄᕐᓂᖏᑦ 7-ᖑᔪᑦ ᓯᒃᔪᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᐊᔾᔨᙳᙱᑦᑐᑦ ᐊᖏᓂᖏᑦ ᐅᖃᐅᓯᖅᑐᕐᒥᑦ ᐱᓪᓚᕆᐅᓂᕿᓐᓇᖅᐸᐳᑦ ᓯᓚᕐᔪᐊᓕᒫᒧᑦ ᐊᒃᑐᐊᓂᖃᖅᑎᓪᓗᒍ (ᐊᑖ ᑕᑯᓗᒍ).

ᑎᖕᒦᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᑕᑯᒃᓴᐅᑎᑦᑎᒍᑦ ᐊᑦᑎᖕᓂᐅᔪᒥ ᓄᓇᐃᑦ 5%-ᒥᒃ ᑲᑎᒪᐅᖅᑐᑦ ᓂᕿᑦ ᐊᒻᒪ ᖁᒡᔪᐃᑦ. ᓄᓇ ᐊᑦᑎᖕᓂᐅᔪᖅ ᐃᓗᓕᖃᕈᖅ 1%-ᒥᒃ ᐅᕐᖁᒥᐅᑦ ᑎᖕᒥᐊᖏᑦᑕ ᐅᓄᕐᓂᖏᓐᓂᒃ ᐊᖑᑎᕙᐊᑦ ᒥᑎᑦ. ᑭᒡᓕᕖᐊᕐᔪᐊᑦ ᓄᓇᐅᔪᓂ ᐊᑦᑎᖕᓂᐅᔪᓂ ᐅᐸᓗᒃᑲᖅᑲᖅᐳᑦ.

ᐊᑕᐅᓯᐅᕝᕙᓗᑦ 80 ᑭᓛᒥᑕᓕᑦ, ᐊᔾᔨᒋᔭᐅᕐᓚᒃᑐᖅ ᐅᑭᐅᖅᑕᖅᑐᒧᑦ ᐃᓱᒪᒋᔭᐅᔪᓂ "ᖁᒻᕙᓯᕆᐊᒃᓴᖑᓂᒃ ᓇᕚᖅᑕᐅᖃᑦᑕᕐᓂᖓ".

ᑕᒪᐃᓐᓂᖃᔪᖅ, ᓯᒃᔪᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᐊᑦᑎᖕᓂᐅᔪᓂ ᓄᓇᓂ 1970-ᓂ ᖁᒻᕙᓯᖕᖏᓐᓂᖅᓴᐅᕗᑦ ᖃᐅᔨᔭᐅᑉᐱᓐᓂ 1990-ᒥ (ᑎᑎᕋᐅᔭᖅᓯᒪᔪᖅ 3). ᐊᐅᐸᓗᒃᑐᐊᕐᔪᐃᑦ ᓯᒃᓚᐃᑦ, ᓴᕿᕙᔪᐊᑦ ᑑᓪᓚᓪᔪᐊᑦ, ᐊᒻᒪ ᑑᓪᓕᑦ ᑑᓪᓚᓪᔪᐊᑦ ᑳᑯᓇᓂ ᐅᑭᐅᓂ ᒥᑭᓂᖅᓴᐅᓕᖅᐳᑦ. ᓯᒃᔪᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᑕᒪᐃᓐᓂᒃ ᐃᓄᐃᓴᒃᓯᓂᖅᓴᐅᓂᖏᑦ ᑕᒪᐃᓐᓂ ᐃᓂᕆᔭᐅᕙᒃᑐᓂ ᐃᓄᐃᓴᒃᓯᓚᐅᖅᐳᑦ. ᐃᓱᒪᒍᑦ ᑳᑯᐊ ᐃᓄᐃᓴᒃᓯᓂᖏᑦ ᐱᓪᓚᕆᐅᓇᓱᒋᐊᓪᓗᒋᑦ ᑭᓯᐊᓂ ᖃᐅᔨᒪᙱᑦᑐᒍᑦ ᓱᓇᒥᒃ ᐱᔪᑎᖃᕐᒪᖔᑦ. ᖃᐅᔨᓴᖅᑕᐅᖃᑦᑕᕐᒪᑦ ᖃᐸᓕᓐᓇᑯᓗᒫᓪᓚᑦ ᕿᑎᕐᒥᐅᓂ ᑎᖕᒥᐊᑦ ᓄᓚᐅᑦ ᐃᓂᕝᕕᖏᓐᓂ ᖃᐅᔨᔭᐅᓂᖁᑎᕕᓂᕐᓂᒃ ᐱᓯᒪᙱᓐᓇᕐᓂᖅ ᓱᓇᒥᒃ ᐱᔪᑎᖃᕐᒪᑦ ᒥᑭᓂᖅᓴᐅᓕᕐᓂᖓ ᐱᔪᑎᖃᕐᓂᖅᑲᕐᓂᖓ. ᑭᓯᐊᓂ, ᓂᐅᓴᖅ ᑕᑭᖅ,

ᐊᖑᓇᓱᒃᑎ ᐅᖅᓱᖕᒥᑦ, ᐅᖃᓚᐅᖅᐳᖅ ᐅᓄᕐᓂᖏᑦ ᑎᖕᒥᐊᑦ ᒥᑭᓂᖅᑎᑕᐃᑦ (ᓯᒃᔪᒥᐅᑕᐃᑦ) ᖃᐅᔨᒪᔭᕆᓂᖅ ᑕᒪᕐᒥᓂᑦ ᐃᓄᐃᓴᖅᓯᒪᓂᖅᓴᐅᕗᑦ ᑕᒪᓐᓇᓕᒫᖅ ᐃᓄᐃᑦ ᐃᓚᖃᖅᑏᑦ ᖃᐅᔨᓴᓂᕐᒧᑦ ᑎᖕᒥᐊᑦ ᐊᓯᐊᓄᑦ ᓂᕿᒃᓴᖃᐅᖃᑦᑕᕐᓂᖏᓐᓂ ᖃᕆᑕᐅᔭᖕᒥᒃ ᐊᒻᒪ ᒥᕐᖑᐃᑦ. ᐊᖑᔪᖅᑐᖅᑐᑦ ᓄᓇᕐᔪᐊᓂ ᐅᑭᐅᖅᑕᖅᑐᒥ, ᐊᒥᓱᑦ ᖃᐅᔨᓴᖅᑕᐅᕙᑦᑐᑦ ᐃᓄᐃᓴᒃᓯᓂᖅᓴᐅᓕᖅᐸᓐᓂᖏᑦ ᓯᒃᔪᒥᐅᑕᓂᒃ ᑎᖕᒥᐊᓂᒃ ᐊᓯᐊᓂ ᐃᓂᓂᒃ ᐊᑦᑎᖕᓂᕐᒥᐅᑕᓂᒃ.

ᐊᖑᓇᓱᒃᑎ ᐅᖅᓱᖕᒥᑦ, ᐅᖃᓚᐅᖅᐳᖅ ᑎᖕᒥᐊᑦ ᓯᒃᔪᒥᐅᑕᐃᑦ (ᓯᒃᔪᒥᐅᑕᐃᑦ) ᑕᑯᔭᐅᓂᖅᓴᐅᔾᔪᒋᓂᖏᑦ ᐅᓪᓗᒥ ᑕᑯᔭᐅᕙᑦᑐᑦ ᐃᓄᐃᓴᖅᓯᒪᓂᖅᓴᐅᓕᖅᐳᑦ. ᐅᐃᕆᕙᑦᑐᑦ ᐃᓕᑎᕆᐊᕐᓂᖅ, ᐃᑲᔪᖅᑎᒃᑯᑦ ᐱᓱᒃᑎᑕᐅᓕᖅᑎᓪᓗᒋᑦ.

ᐊᖑᔪᖅᑐᖅᑐᑦ ᐃᓄᐃᓴᒃᓯᓂᖅᓴᐅᖃᑦᑕᕐᓂᖏᑦ ᑎᖕᒥᐊᑦ ᐊᓯᖏᓐᓂ ᐊᒻᒪ ᐊᔾᔨᙳᙱᑦᑐᓂ ᐅᑭᐅᓂ, ᑕᑯᔭᐅᓚᐅᖅᐳᑦ ᐃᓄᐃᑦ ᓂᕿᒃᓴᖏᓐᓂ.

ᐊᒻᒪᓗ ᐱᔾᔪᑎᖃᖅᑐᖅ ᑎᖕᒥᐊᑦ ᐊᒥᓲᓂᖅᓴᐅᔪᒥ ᓄᓇᒦᑦᑐᑦ ᐃᓄᐃᓴᖅᓯᒪᓂᖅᓴᐅᒐᓗᐊᖅᑐᑦ.

ᐊᖑᔪᖅᑐᖅᑐᑦ ᐊᔾᔨᒋᔭᐅᙱᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᑎᖕᒥᐊᑦ ᓄᓇᓂ ᐊᑦᑎᖕᓂᐅᔪᓂ.

ᐊᖑᓇᓱᒃᑎ ᐅᖅᓱᖕᒥᑦ ᐅᖃᓚᐅᖅᐳᖅ ᑎᖕᒥᐊᑦ ᐊᒥᓲᓂᖅᓴᐅᓕᖅᐳᑦ ᐃᓄᐃᓴᖅᓯᒪᓂᖅᓴᐅᔪᑦ.

ᐃᓄᐃᓴᒃᓯᓂᖅᓴᐅᔪᑦ ᐊᒥᓲᓂᖅᓴᐅᓕᖅᐳᑦ ᐃᓂᖏᓐᓂ ᐊᑦᑎᖕᓂᕐᒥᐅᑕᐃᑦ.

ᐊᖑᔪᖅᑐᖅᑐᑦ ᒥᑭᓂᖅᓴᐅᓕᖅᐳᑦ.

ᐊᖑᓇᓱᒃᑏᑦ ᐅᖃᓚᐅᖅᑐᑦ ᑎᖕᒥᐊᑦ ᐊᑦᑎᖕᓂᐅᔪᒥ.

ᓈᓴᐅᑎᓪᓚᒃ 1.
ᐅᓄᕐᓂᖏᑦ ᐊᕕᒃᑐᖅᓯᒪᓂᐅᔪᓂ ᓯᒡᔫᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᕿᓪᒪᓐᓴᓐ ᓄᓇᖓᓂ ᐋᒃᑎᖕᓂᐅᔪᓂ +95% ᑭᒡᓕᒋᔭᖏᑦ (ᑎᑎᕋᐅᔭᖅᓯᒪᔪᖅ 1 ᓄᓇᖑᐊᒧᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᐅᔪᒧᑦ)

ᖃᓄᐃᑦᑑᓂᖏᑦ		ᐊᕕᒃᑐᖅᓯᒪᓂᖓ 1 (102 683 Hᐊᒃᑕᐃᑦ)	ᐊᕕᒃᑐᖅᓯᒪᓂᖓ 2 (67 436 Hᐊᒃᑕᐃᑦ)	ᐊᕕᒃᑐᖅᓯᒪᓂᖓ 3 (178 490 Hᐊᒃᓴᐃᑦ)	ᐊᕕᒃᑐᖅᓯᒪᓂᖓ 4 (321 952 Hᐊᒃᓴᐃᑦ)	ᑕᒪᖏᓐᓂᒃ ᑲᑎᑦᔪᒋᑦ (670 561 Hᐊᒃᓴᐃᑦ)
ᓕᕕᓕᕕᓛᑦ	ᐃᓛᒃᑰᖓᔪᑦ	919 ± 1 025	416 ± 979	1 091 ± 2 216	1 913 ± 3 986	4 339 ± 3 797
	ᑲᑎᒪᔪᒃ	881 ± 959	369 ± 843	985 ± 1 940	1 719 ± 3 473	3 954 ± 3 353
ᑐᓪᓕᒡᔪᐊᑦ	ᐃᓛᒃᑰᖓᔪᑦ	879 ± 1 587	476 ± 1 352	1 202 ± 3 132	2 128 ± 5 596	4 685 ± 5 431
	ᑲᑎᒪᔪᒃ	428 ± 853	307 ± 809	737 ± 1 834	1 323 ± 3 296	2 795 ± 3 144
ᓴᕐᕙᐃᑦ	ᐃᓛᒃᑰᖓᔪᑦ	759 ± 2 075	548 ± 2 775	1 316 ± 5 943	2 364 ± 10 856	4 987 ± 9 866
	ᑲᑎᒪᔪᒃ	390 ± 1 085	259 ± 1 409	630 ± 3 029	1 128 ± 5 527	2 407 ± 5 042
ᓯᒡᔭᓇᐊᖅ	ᐃᓛᒃᑰᖓᔪᑦ	656 ± 671	805 ± 1 394	1 808 ± 2 832	3 311 ± 5 253	6 580 ± 4 553
	ᑲᑎᒪᔪᒃ	656 ± 671	805 ± 1 394	1 808 ± 2 832	3 311 ± 5 253	6 580 ± 4 553
ᑐᓪᓕᒃ ᑑᓪᓕᒡᔪᐊᖅ	ᐃᓛᒃᑰᖓᔪᑦ	1 153 ± 2 315	593 ± 1 762	1 513 ± 4 184	2 672 ± 7 428	5 931 ± 7 347
	ᑲᑎᒪᔪᒃ	958 ± 1 325	464 ± 1 091	1 198 ± 2 545	2 108 ± 4 540	4 728 ± 4 430
ᓴᕐᕙᖅ	ᐃᓛᒃᑰᖓᔪᑦ	3 690 ± 2 748	3 212 ± 3 790	7 506 ± 8 080	13 586 ± 14 780	27 994 ± 13 381
	ᑲᑎᒪᔪᒃ	2 621 ± 2 298	2 285 ± 3 004	5 339 ± 6 453	9 664 ± 11 777	19 909 ± 10 735
ᐊᐅᐸᓗᒃᑐᐊᕐᔪᒃ	ᐃᓛᒃᑰᖓᔪᑦ	4 238 ± 2 989	4 595 ± 5 322	10 457 ± 10 989	19 074 ± 20 289	38 364 ± 17 847
	ᑲᑎᒪᔪᒃ	2 846 ± 1 904	2 998 ± 3 147	6 844 ± 6 553	12 472 ± 12 069	25 160 ± 10 700
ᑐᓪᓕᐅᔫᖅᑐᖅ ᓯᒡᔭᓇᐊᕐᔪᒃ	ᐃᓛᒃᑰᖓᔪᑦ	72 ± 225	37 ± 195	292 ± 1 403	554 ± 2 696	955 ± 2 028
	ᑲᑎᒪᔪᒃ	n/a	n/a	n/a	n/a	n/a
ᖁᓪᓕᖁᓪᓕᐊᕐᔪᒃ	ᐃᓛᒃᑰᖓᔪᑦ	235 ± 424	70 ± 213	205 ± 565	349 ± 976	859 ± 1 045
	ᑲᑎᒪᔪᒃ	235 ± 424	70 ± 213	205 ± 565	349 ± 976	859 ± 1 045
ᓴᕐᕿᖅ	ᐃᓛᒃᑰᖓᔪᑦ	2 181 ± 2 729	1 580 ± 3 781	3 790 ± 8 055	6 809 ± 14 736	14 360 ± 13 334
	ᑲᑎᒪᔪᒃ	1 537 ± 1 896	1 174 ± 2 415	2 794 ± 5 209	5 030 ± 9 496	10 535 ± 8 685
ᑕᑭᓂᖅᓴᑦ ᓵᕐᕿᐃᑦ	ᐃᓛᒃᑰᖓᔪᑦ	412 ± 524	122 ± 263	359 ± 698	611 ± 1 205	1 504 ± 1 291
	ᑲᑎᒪᔪᒃ	235 ± 324	70 ± 163	205 ± 432	349 ± 746	859 ± 799
ᖃᑯᖅᑑᓖᑦ ᓵᕐᕿᐃᑦ	ᐃᓛᒃᑰᖓᔪᑦ	3 495 ± 3 233	3 083 ± 5 032	7 191 ± 10 558	13 021 ± 19 401	26 790 ± 17 316
	ᑲᑎᒪᔪᒃ	2 234 ± 2 054	1 919 ± 3 164	4 492 ± 6 648	8 126 ± 12 211	16 771 ± 10 911
ᑲᑎᓪᓗᒋᑦ ᓯᒡᔫᒥᐅᑕᐃᑦ[a]	ᐃᓛᒃᑰᖓᔪᑦ	**18 689 ± 9 862**	**15 537 ± 13 161**	**36 730 ± 29 143**	**66 392 ± 53 383**	**137 348 ± 48 060**
	ᑲᑎᒪᔪᒃ	**13 021 ± 6 579**	**10 720 ± 8 761**	**25 237 ± 19 723**	**45 579 ± 36 174**	**94 557 ± 32 423**

[a] ᐃᓚᖃᖅᐳᑦ ᓱᓇᐅᒋᐊᒃᓴᖏᓐᓂᒃ ᖃᐅᔨᒪᔭᐅᙱᑦᑐᓂᒃ ᓯᒡᔫᒥᐅᑕᓂᒃ ᑎᖕᒥᐊᓂᒃ

ᓇᓴᐅᑎᓪᓚᒃ 2.
ᐅᓄᕐᓂᖏᑦ ᑎᖕᒥᐊᑦ ᐊᖏᔪᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᕿᓪᒪᓐᓴᓐ ᓄᓇᖓᓂ ᐊᑦᑎᖕᓂᕐᒥ, 1975/76 ᐊᒻᒪ 1994/95

ᖃᓄᐃᑦᑑᓂᖏᑦ ᑎᖕᒥᐊᑦ	ᐅᓄᕐᓂᕆᔭᖏᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ 1975–76[a]	1994–95[b]	ᖃᓄᐃᑉᐸᓪᓕᐊᔾᔪᓯᖏᑦ	%-ᒋᔭᖏᑦ ᑲᓇᑕᒥ ᐅᓄᕐᓂᖏᑦᑕ
ᓂᕐᓚᖅ ᐊᖏᓂᖅᓴᖅ	6 941	15 374	↑(+220)	4.6 (ᕿᑎᐊᓂ ᐅᓄᕐᓂᐅᔪᑦ)
ᓂᕐᓚᖅ	521	3 709	↑(+712)	2.2 (ᐃᕕᖃᖅᑐᒥ ᐅᓄᕐᓂᐅᔪᑦ)
ᖁᓪᔪᒃ	3 818	3 822	=	3.8 (ᐅᖁᕐᒥᐅᓂ ᐅᓄᕐᓂᐅᔪᑦ)
ᒥᕿᓐᓂᖅᓴᐃᑦ ᑲᖑᐃᑦ	3 818	38 294	↑(+1003)	1.0 (ᕿᑎᐊᓂ ᐅᓄᕐᓂᐅᔪᑦ)
ᐊᖑᑎᕕᐊᖅ ᒥᑎᖅ ᐊᒪᐅᓕᒡᔪᐊᖅ	22 560	6 187	↓(-27)	ᐃᒻᒪᖄ 1% ᐃᓚᓂᖓ ᐅᖁᕐᒥᐅᓂ ᐅᓄᕐᓂᐅᔪᑦ)
ᐊᐋᙱᖅ	8 677	1 990	↓(-23)	?
ᖁᖑᓯᓂᕐᒧᑦ ᐊᐅᐸᓗᒃᑐᓕᒃ ᖃᖅᓴᐅᖅ	486	4 07[c]	=	?
ᐸᓯᕕᖕᒥ ᖃᖅᓴᐅᖅ	764	870	=	?
ᑕᑎᒡᒐᕐᔪᐊᖅ	764	896	=	?

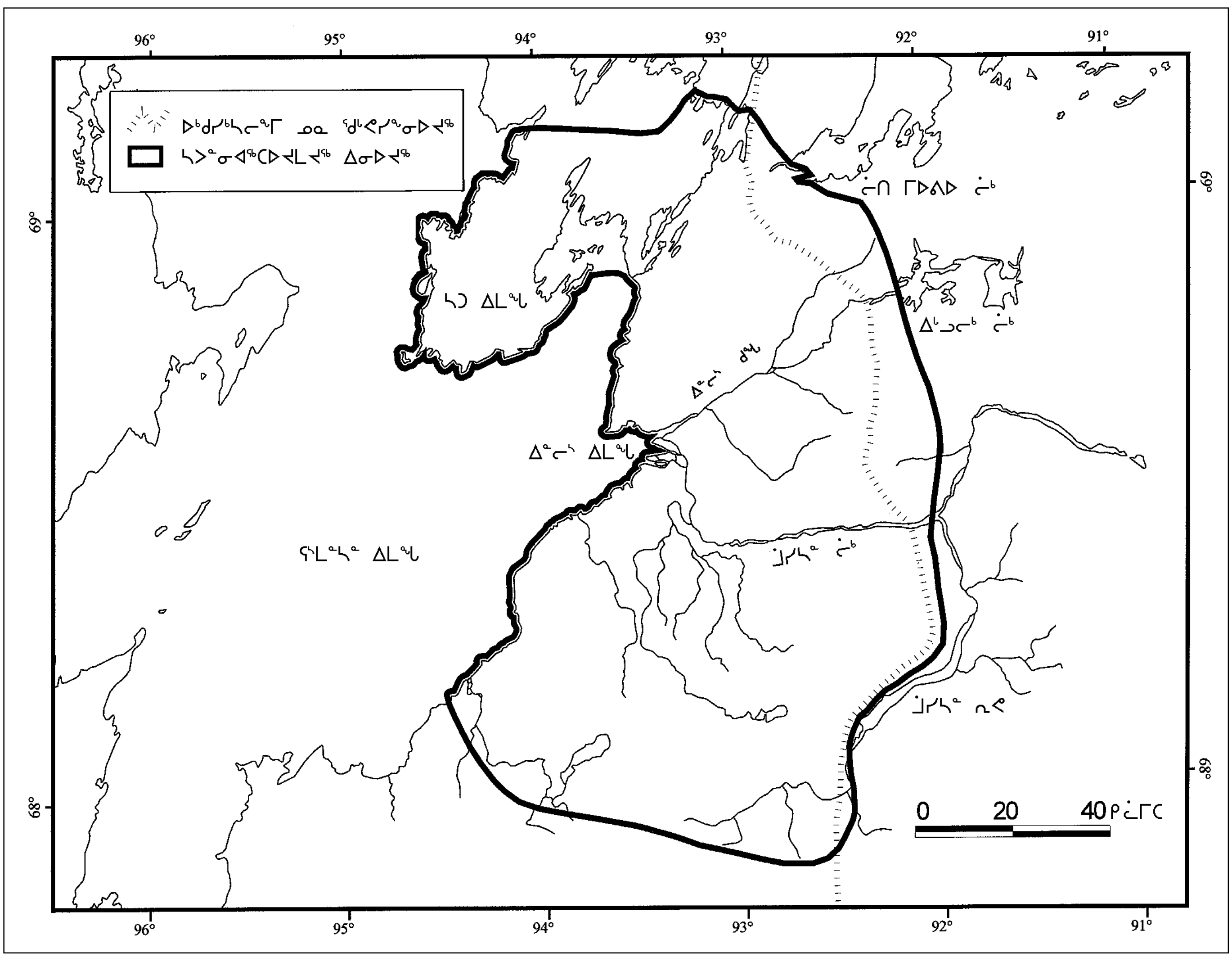
[a] ᒪᒃᓚᕋᓪᓗ ᐊᓯᖏᑦᑕᓗ ᐅᓂᒃᑳᖅᑕᖏᑦ (1977). ᐋᖅᑭᐊᕐᔪᒋᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᒧᑦ (ᐅᓄᕐᓂᖏᑦ ᐃᓚᔪᒋᑦ 0.69-ᒥᒃ)
[b] Hᐃᓐᒥᑦ ᐊᒻᒪ ᑲᖏᒥᑦ (ᐅᓂᒃᑳᓕᐅᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᑐᓴᒃᓴᖏᓐᓂᑦ)
[c] 1994-ᒥ ᑐᓴᒃᓴᑐᐃᓐᓇᕐᓂᑦ

ᓇᓴᐅᑎᓕᒃ 3.
ᐅᓄᕐᓂᖏᑦ ᓯᒻᔭᒥᐅᑕᐃᑦ ᑎᖕᒥᐊᑦ ᓇᓚᐅᑦᑖᕐᑕᐅᔪᑦ ᕿᓪᒪᓯᓐ ᓄᓇᖓᓂ ᐊᑦᑎᖕᓂᕐᒥ. 1975/76 ᐊᒻᒪ 1994/95[a]

ᖃᓄᐃᑦᑑᕙᑦ[b]	ᐅᓄᕐᓂᖏᑦᑕ ᓇᓚᐅᑦᑖᕐᑕᐅᓂᖏᑦ 1975	1976	1994-95	ᖃᓄᐃᑉᐸᓪᓕᐊᓂᖏᑦ (%-ᒥᔭᖓ ᐊᔾᔨᒌᓐᖏᓐᓂᖓᑕ)[c]
ᓴᕐᕙᕐᔪᐊᖅ ᑑᓪᓚᒡᕐᔪᒃ	37 164	33 356	4 686	↓(-87)*
ᑐᓪᓚᒡᕐᔪᒃ ᑑᓪᓚᒃᔪᐊᖅ	33 649	23 993	5 932	↓(-75 to -82)*
ᓴᐅᑉᕿᖅ	23 993	11 997	14 369	= (-40 to +16)
ᖃᐅᓪᓗᖅᑐᓕᒃ ᓴᐅᑉᕿᖅ	61 153	43 012	26 813	↓(-38 to -56)
ᓕᕕᓕᕕᓛᖅ	13 168	878	4 340	= (-67 to +80)
ᓴᕐᕙᖅ	17 263	50 620	28 017	= (+38 to -44)
ᓯᒡᔭᓇᐊᖅ	13 167	6 730	6 589	= (-2 to +50)
ᓴᐅᑉᕿᖅ	13 167	2 633	4 990	= (-42 to +47)
ᐊᐅᐸᓗᒃᑐᐊᕐᔪᒃ	133 133	193 409	38 406	↓(-71 to -80)*

[a] 1975 ᐊᒻᒪ 1976 ᓈᓴᐅᑎᖏᑦ ᒪᓚᓇᓐᒥᑦ ᐊᓯᖏᓐᓂᓪᓗ (1977); 1994/95 ᖃᐅᔨᓴᖅᑕᐅᓂᑯᐃᑦ ᑕᒪᐃᓐᓂᑦ ᑖᕝᕙᓐᖓᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐊᑯᑉᓕᓇᒃᑐᑦ.
[b] ᑭᓯᒥ ᑎᖕᒥᐊᑦ ᒪᓚᓇᓐᒥᑦ ᐊᓯᖏᓐᓂᓪᓗ ᐅᓂᒃᖄᖅᑕᐅᔪᑦ 1975 ᐊᒻᒪ 1976-ᒥ ᐃᓚᐅᑎᑕᐅᕗᑦ.
[c] *ᓇᓗᓇᐃᖅᓯᕗᖅ ᓈᓴᖅᑕᐅᓯᒪᔪᓂ ᓈᒻᒪᒃᑐᓂ (ᒪᒃᐱᒐᖓ < 0.05) ᐊᔾᔨᒋᔭᐅᓐᖏᑦᑐᑦ 1975/1976 ᐊᒻᒪ 1994/1995.

ᑎᑎᕋᐅᔭᖅᓯᒪᓂᖓ 2.
ᐊᑐᓕᖁᔭᐅᔪᖅ ᑲᓇᑕᓕᒫᒥ ᐸᒃᕕᓴᖅᑕᐃᓕᕝᕕᓕᐊᖑᔪᒪᔪᑉ ᑭᒡᓕᒋᓇᔭᖅᑕᖓ, ᕿᓪᒪᓴᓐ ᓄᓇᐃᑦ ᐊᑦᑎᖕᓂᐅᔪᑦ.



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The Taloyoak and Gjoa Haven Hunters and Trappers Organizations offered comments on our study proposal and approved our research in the Rasmussen area. We thank Declan Troy and Guy Morrison for thorough reviews of an earlier draft of this paper.

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1. Introduction

The Rasmussen Lowlands, Nunavut, has been recognized as a key migratory bird habitat site for more than 10 years (McCormick et al. 1984). The biological importance of the area is alluded to in the *Nunavut Land Claims Agreement*, where it is listed as a site that may receive protected status in the future. This area is the only Ramsar site (Wetland of International Importance) in Nunavut and the Northwest Territories that does not have legislative protection. The Rasmussen Lowlands have also been suggested as a potential site for a future pan-arctic shorebird monitoring program (Gratto-Trevor et al. 1998; Morrison, pers. commun.).

Since the late 1950s, migratory birds and their habitats in the area that is now Nunavut have been protected through a growing network of migratory bird sanctuaries and national wildlife areas. The bulk of these conservation areas (15/19) were created in the 1950s and 1960s to protect nesting and staging areas of white geese. The remaining four were established to protect seabird colonies. No bird sanctuaries or national wildlife areas have yet been designated in the Northwest Territories or Nunavut for the protection of shorebird nesting or staging habitat, though most species of North American shorebirds are arctic breeders (Godfrey 1986). Though some of the larger bird sanctuaries provide *de facto* protection for wetlands, none was created expressly for the conservation of wetland ecosystems. These two elements represent significant gaps in the conservation area network in the Northwest Territories and Nunavut (Canadian Wildlife Service 1993). A 1992 analysis of key migratory bird habitat sites indicated that the Rasmussen Lowlands should be a priority for designation as a national wildlife area (Canadian Wildlife Service 1993). However, because the lowlands' status as a key site is based on limited field studies (see below), the analysis also called for a further field assessment before any national wildlife area proposal is developed.

The main objective of our study was to assess the appropriateness of the Rasmussen Lowlands for protected status. With the exception of McLaren et al.'s (1977) bird survey in 1976, virtually no ground-based biological studies had been completed in the lowlands prior to ours. Our study furnished up-to-date bird (especially shorebird) information. Specifically, we investigated the following:

- distribution and abundance of breeding birds in the lowlands, by habitat type and by geographic location;
- a comparison between breeding shorebird abundance and species richness in the Rasmussen Lowlands and that found at other sites across the Arctic.

The results of these investigations form the bulk of this paper. A second objective was to compare numbers of breeding shorebirds with estimates from McLaren et al. nearly 20 years earlier. This is the basis for a separate publication (Gratto-Trevor et al. 1998), but the findings are relevant to assessment of the lowlands' conservation status and so will be discussed later in this paper.

The final objective of the study was to attempt to identify migratory routes of shorebirds breeding in the Rasmussen Lowlands. Blood samples were collected from 49 shorebirds of seven species in 1994, as part of an international project that uses DNA analysis to identify breeding origin of shorebird migrants in North America. Some of the results have been analysed and form part of a separate publication (Haig et al. 1997).

2. Study area

2.1 Physical description and biological resources

The Rasmussen Lowlands (68°40'N, 93°00'W) extend along the east side of Rae Strait and Rasmussen Basin, from the south shore of Netsilik Lake to approximately 45 km north of Chantrey Inlet (Fig. 1). Much of the lowlands is flat, poorly drained, and underlain by marine silts and sand. Eskers and rock outcrops occur infrequently throughout the area. In eastern and northern portions of the lowlands, the terrain is more rugged and gives way to the gently rolling Ross Hills in the north and the escarpment of the Wager Highlands to the east. Habitats in the lowlands vary from partially vegetated, dry tundra to richly vegetated sedge wetlands. Tundra ponds are common.

A number of biological and ecological classifications place the lowlands in various zones. Polunin (in Bird 1967) considered that the lowlands were in the low-arctic vegetation zone. Ritchie (1993) classified all of the Northwest Territories mainland above the treeline as the Low Arctic, yet he published a map where the division between Low and Mid Arctic bisects the lowlands. Rouse (1993) places the lowlands into a "Low and Middle Arctic" climatic zone. The Northern Land Use Information Series (Wiken et al. 1987) broke the lowlands roughly into coastal and inland ecoregions without indicating what broader ecological zones the area fits into. Finally, a new Canadian ecological framework developed in the 1990s classifies the southern portions of the lowlands as "southern Arctic" and the northern reaches as "northern Arctic" (Ecological Stratification Working Group 1996). Whatever classification is used, the lowlands consistently fall at or near the boundary between the warmer, well vegetated Low Arctic and the colder, sparsely vegetated regions to the north.

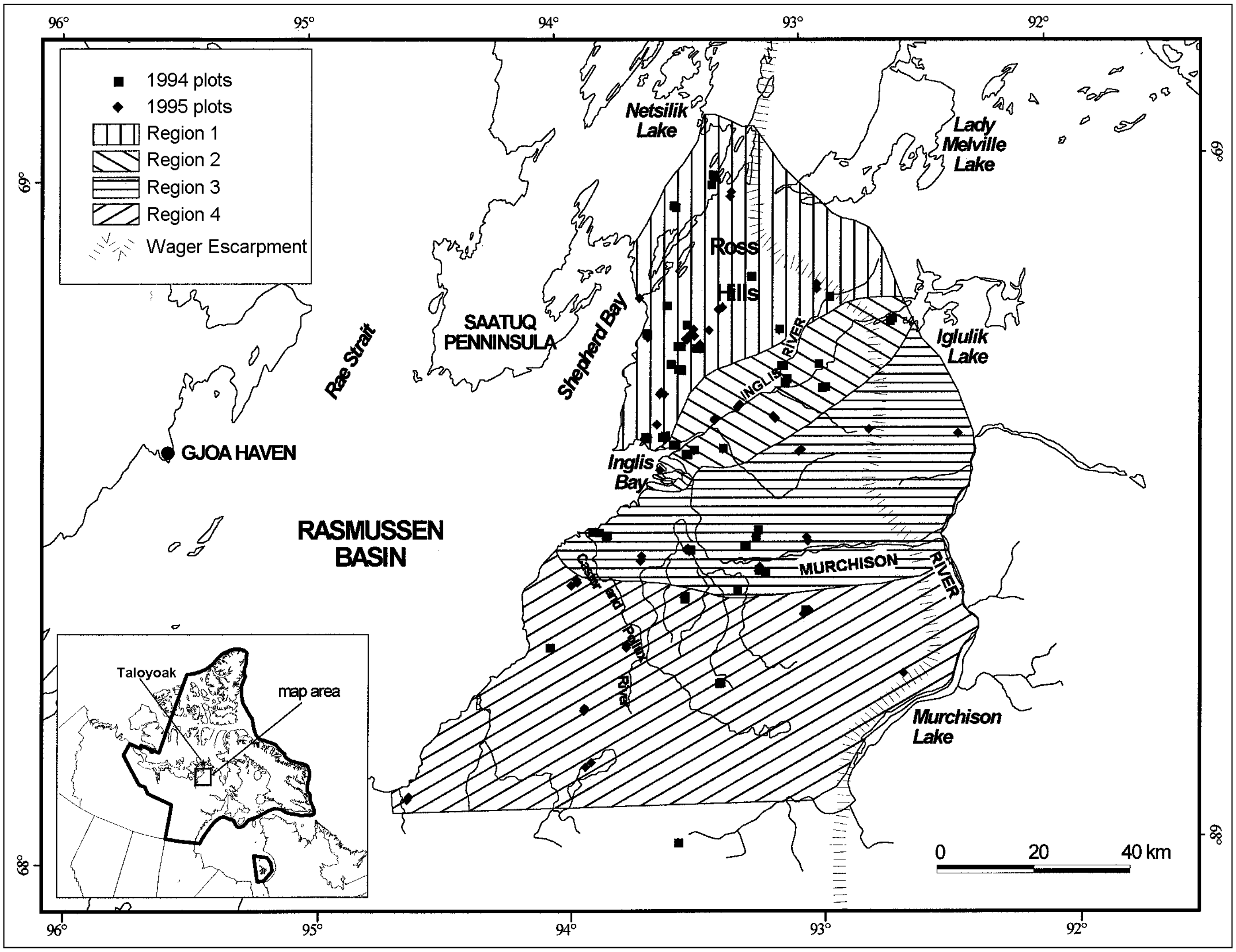
This area was largely unknown to the scientific community until the 1970s when the Polar Gas Project proposed the construction of a pipeline to transport gas from the High Arctic to northern Ontario. The pipeline would have bisected the lowlands. A spate of biological studies was prompted by the proposal, including several ornithological surveys. Three of these (McLaren et al. 1976; Zdan and Brackett 1977; Allen and Hogg 1979) were aerial surveys that provided information about populations of larger birds in the lowlands. Information about the hydrology and physiology of the Murchison and Inglis rivers (Lawrence et al. 1978) and the fisheries resources of several lakes and rivers in the lowlands (Way and Thorne 1978) was also collected in response to the Polar Gas proposal. Several surveys of the geomorphology and vegetation of the northeastern Keewatin region, including the Rasmussen area, have been undertaken (e.g. Zoltai and Johnson 1979; Thompson 1980; Edlund 1982).

A detailed ornithological study in the lowlands was undertaken by LGL Limited in 1976. They conducted aerial and ground surveys from mid June to September, and their data formed the basis for the lowlands' subsequent designation as a Wetland of International Importance, or Ramsar site (IUCN 1987) and as a Canadian Wildlife Service (CWS) key migratory bird habitat site (Alexander et al. 1991). McLaren et al. (1977) found 35 bird species nesting in the lowlands: at least five of these had numbers great enough to comprise 1% or more of the national population. Their data indicated that the lowlands were a major breeding area for the eastern arctic population of the Tundra Swan *Cygnus columbianus* (McLaren and McLaren 1984). The lowlands were also an important summering and moulting area for King Eider *Somateria spectabilis* and Oldsquaw *Clangula hyemalis*. Their 1976 study demonstrated that the area provided important breeding habitats for large populations of Red Phalarope *Phalaropus fulicaria*, American Golden-Plover *Pluvialis dominica*, Black-bellied Plover *Pluvialis squatarola*, Pectoral Sandpiper *Calidris melanotos*, White-rumped Sandpiper *Calidris fuscicollis*, and Semipalmated Sandpiper *Calidris pusilla*. In the early 1980s, surveys by the territorial Department of Renewable Resources confirmed McLaren's suggestion that the escarpments bordering the lowlands provided important nesting habitat for Peregrine Falcons *Falco peregrinus* (L. Wakelyn, pers. commun.). Surveys by Bromley and Stenhouse (1989) highlighted the area's importance for Greater White-fronted Geese *Anser albifrons* and Lesser Snow Geese *Anser caerulescens*.

2.2 Human use

Discussions with residents of Taloyoak and Gjoa Haven (Johnston, pers. commun.) provided more information about the biological resources of the lowlands, and how they are used by local people. There are significant numbers of caribou in the area, and hunters from Gjoa Haven harvest them in early fall and through the winter. The larger inland lakes (particularly Murchison Lake) and rivers are fished for arctic char and lake trout in September and October, and

Figure 1
The Rasmussen Lowlands study area



coastal fishing from the sea ice occurs in May and June. Some local people are very familiar with the birds in the lowlands, particularly waterfowl populations. Geese are taken by people from both communities in June. Nelson Takkiruq, a hunter from Gjoa Haven, stated his impression that populations of "small birds" [shorebirds] seem to have declined over his lifetime. He considers that flocks of shorebirds now are smaller than they used to be.

There is a well-used winter and spring snowmobile route between Gjoa Haven and Pelly Bay that passes through the lowlands (Riewe 1992). Archaeological sites are located along the shores of Murchison Lake and on the Qiminayuq Esker, and others are scattered along the coast (Johnston, pers. obs. and Riewe 1992).

A Distant Early Warning (DEW) site was constructed at Shepherd Bay in the late 1950s. It operated until 1989 when it was converted to a North Warning defense site. At this time and through the 1990s studies were conducted to determine the level of environmental contamination and to specify actions needed to clean up the site. The staff was gradually reduced until 1995, when the station was automated. Today it operates unstaffed with annual visits to maintain equipment.

3. Methods

3.1 Weather data

We obtained mean daily temperatures from the Shepherd Bay North Warning Site for the years 1975–92 inclusive, and for 1995. Data for 1994 were not available from this station. We substituted data from nearby Taloyoak after demonstrating that the two datasets exhibited very similar fluctuations and that there was no significant difference between them for 1995 (t-test; $p = 0.09$).

3.2 Habitat survey

Habitats were determined by conducting ground-based surveys at the same time and in the same locations as the bird censuses. The surveys enabled us to classify the habitat into categories ("types"). The categories were later used to draw inferences regarding shorebird habitat use and/or habitat preferences. By relating the ground-determined habitat types to classified satellite data, we were able to map habitats throughout the lowlands and produce some overall bird population estimates for the study area.

3.2.1 Ground surveys

One person recorded habitat variables (Table 1) at the beginning of each study plot and whenever there was a marked change in one or more of the variables. The same person determined habitat types within the plot. Habitat types were identified on the basis of dominant vegetation type, surficial expression, percent vegetative cover, and ground moisture (Table 2). Each observer drew a sketch map delimiting the extent of each habitat type within the plot, and the location and behaviour of the birds that they saw. The locations and extent of lakes, streams, and ponds were also drawn on the sketch maps. In 1994, observers did not make a composite map of each plot immediately after the field work was completed. This occasionally resulted in uncertainty about the habitat type of each bird observation, and the extent of the habitat types. In 1995, each evening, the observers consolidated their data to produce a single map of the plot and a list of bird observations for each habitat type (Fig. 2).

In 1994, we made a complete plant collection and sent it to W.J. Cody (Centre for Land and Biological Research, Agriculture Canada, Ottawa) for identification. In 1995, we identified plant species in the field; problematic species were collected and sent away for identification.

Table 1
Habitat variables recorded in the Rasmussen Lowlands

Habitat variable	Description
Location	Latitude and longitude — determined by GPS
Weather	Estimates of temperature, cloud cover, wind speed, and amount and type of precipitation
General aspect	Overall description of surrounding area including prominent landmarks — e.g. "Low flat area with intermittent large ponds and many recently dried up runoff ponds."
Surficial expression	Categories: hummocky, tussocky, polygons, low and flat, raised, beach ridge, rock outcrop, esker, interrupted, other (describe)
Substrate	Categories: clay, sand, gravel, bedrock, mineral soil, peat, other (describe)
Substrate moisture	Categories: standing water, saturated, moist, dry
Percent vegetative cover	Estimates of total vegetative cover on ground, to the nearest 5%
Percent coverage by water	Estimates of the coverage of the plot by water bodies (flooded terrestrial vegetation is not included in this estimate)
Dominant species	Plant species that make up >20% of vegetative cover, with an estimate of their percentage coverage to the nearest 5%
Other species present	Species present but not dominant

3.2.2 Classification of satellite imagery

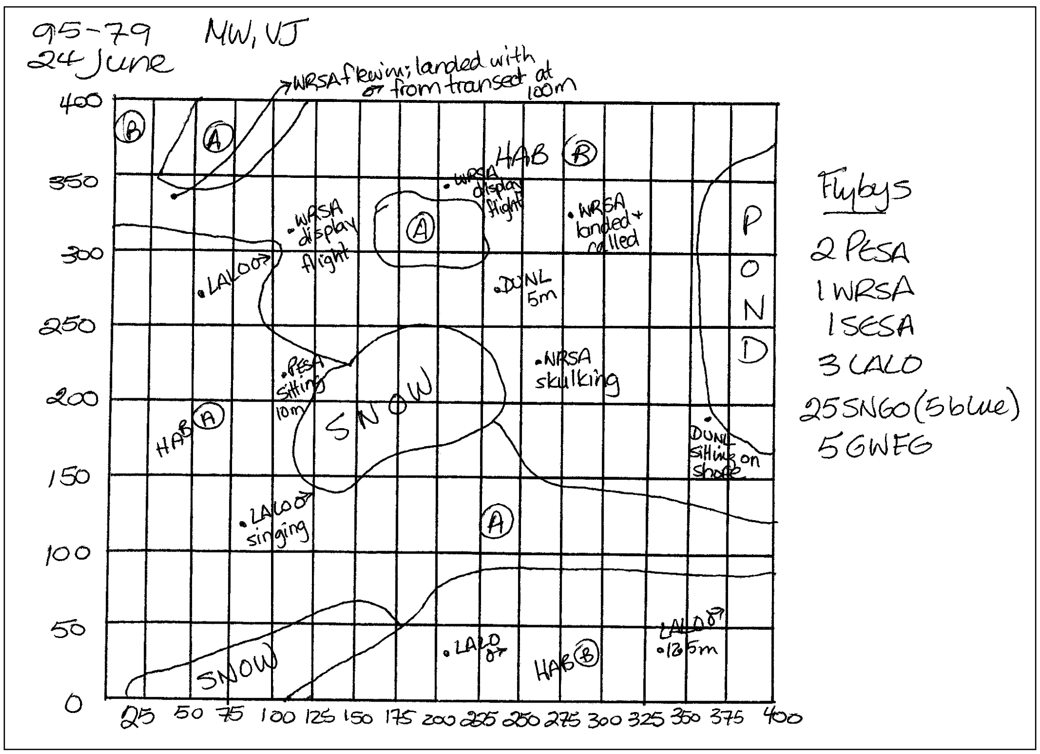
Prior to the study, we purchased LANDSAT Thematic Mapper (TM) scene 036-012 (recorded on 2 August 1991). Fifty-four ground control points taken from 1:50 000 NTS map sheets were used to georeference the image to UTM zone 15, NAD 27 projection. A third-order polynomial transformation was applied and the imagery was resampled to 25-m pixels. The root mean square error was less than one pixel.

The unclassified data were plotted on sheets corresponding to NTS 1:50 000 maps using channels 5 (middle infrared), 4 (near infrared), and 3 (visible red). We used these

Table 2
Habitat types and their characteristics, Rasmussen Lowlands

Habitat type	Surficial expression	Vegetative cover (%)	Dominant vegetation	Moisture	Standing water (%)
Low tundra	low tundra	most >80% cover; 25% have 50–80% cover	Sedge (usually *Carex*) and grass	saturated or standing	most >20%
Hummocky tundra	hummocky or hummocky/tussocky	most >50% cover	a mixture of sedge and dwarf shrub	80% saturated or standing; 20% moist or mixed	most have >0%, <20%
High-centre polygons	high-centre polygons	almost all >80% cover	most dominated by moss/lichen	variable	almost all <20%
Beach ridge/esker	beach ridge/esker	66% have <50% cover; 33% have >50% cover	varies, but not sedge	dry to moist	<5%
Interrupted tundra	interrupted (>50% frost boils or frost-shattered rock)	<50% cover	mostly dwarf shrub	saturated to standing or patchy	most <20%
Tussocky tundra	tussocky	>50% cover	*Eriophorum*	most saturated or standing	<20%
Raised tundra	raised tundra	most >50% cover	dwarf shrub and moss	mixture, but none with standing water	<20%
Sandflats	sandflats	<20% cover	*Carex* or dwarf shrub	moist	variable
Rock outcrop	rock outcrop	<20% cover	lichen	dry	none

Figure 2
Sample of map used to record habitats and bird sightings, Rasmussen Lowlands



maps during a reconnaissance of the lowlands in summer 1993 to get a general idea of what the imaged colours corresponded to on the ground. Then, in 1994, we used the maps to select bird census plots in areas that appeared to support different types of habitat.

Our original intent was to perform a supervised classification of the satellite data, using our 1994 shorebird plots for training areas for habitat classes. A supervised classification uses class statistics based on average pixel values and standard deviations for each satellite channel within the training areas. Several habitat types observed in our study plots had two or more distinct spectral appearances on the imagery. The accuracy of a supervised classification is usually improved if these subclasses are treated as separate classes in the training area phase. However, the training statistics from one subclass often overlapped substantially with those from another habitat type. Using our plot data for training areas would have reduced the likelihood that some of the key habitat classes were mapped correctly. Consequently, we performed an unsupervised classification of the satellite data to map the distinct spectral classes in the satellite imagery.

We isolated water and ice pixels into one water class using a density slice of channel 5 (middle infrared) and eliminated these pixels from further analysis. We used PCI's ISOCLUS unsupervised classification procedure (PCI 1996) to create groups of pixels with similar digital values for channels 2 (visible green), 3 (visible red), 4 (near infrared), and 5 (middle infrared). This resulted in 39 classes, many corresponding to highly reflective areas of unvegetated land that were of minor interest. We amalgamated the unvegetated groups into three classes and further classified the vegetated classes.

We evaluated the rest of the classes using the satellite maps and our descriptions of habitat from shorebird plots. Some classes were homogenous in terms of colour and habitat characteristics, and some were not. Homogenous groups were set aside as distinct classes. The pixels from the heterogeneous classes were run through the ISOCLUS procedure a second time to produce 23 classes.

The results from both iterations of the ISOCLUS procedure were examined and further combined to produce a grouping of pixels into 17 classes including a class for water, three for unvegetated land and one for unclassified pixels (cloud cover). The remaining 12 groups comprised vegetated habitats. We assigned a colour to each of these 17 classes and produced maps based on the classified data, at scales of 1:50 000 and 1:250 000.

After the 1995 field season, we outlined all plots on the classified satellite imagery. The 17 classes could not always be individually identified on the ground, so we lumped them into four broad categories: water and unclassified pixels (subsequently excluded from analyses), unvegetated (low shorebird densities: sandflats and rock outcrops), habitats dominated by dwarf shrubs or herbs (medium shorebird densities: raised tundra, interrrupted tundra, beach ridges, and eskers), and sedge or moss-dominated habitats (high shorebird densities: low tundra, high-centre polygons, hummocky tundra, and tussocky tundra) (Fig. 3). We used pixel-counting software to determine the area of each of the three broad habitat categories in the plots and within the entire study area.

3.3 Shorebird census

Line transects and study plots are the two census techniques commonly used to determine shorebird distribution and abundance. Straight line transects have the advantage of providing coverage of a greater area than study plots (Bibby and Burgess 1992), but they may underestimate numbers of small secretive birds (e.g. incubating shorebirds). Within the same season and habitats, comparisons between plots and transects may produce similar estimates of density, but in plot configurations a significantly larger number of species can be detected (Edwards et al. 1981). We used a combination of plot and transect methodology for this study that permitted us to sample a considerable area yet maintain high detectability for secretive species. A plot configuration was also more appropriate for defining and estimating the amount of habitat.

We employed a stratified random design to place sample plots throughout the lowlands (Fig. 3). Plot locations were stratified by results from McLaren et al.'s study (i.e. more plots placed in areas that were expected to contain higher densities of shorebirds). We placed some of our plots as close as possible to transects that McLaren et al. surveyed in 1976. Over two years we surveyed 118 different 400 X 400-m plots (1888 ha). We surveyed 11 plots in both years, and in 1995, we surveyed six plots twice.

In both 1994 and 1995, we placed a numbered, flagged bamboo stake at the corner of each shorebird plot so it could be re-censused at a later date. In 1995, coordinates of all four corners were recorded. These coordinates (recorded by Global Positioning System[GPS]) were later used in concert with sketch maps and descriptions to superimpose plot outlines on the classified maps of the lowlands. Figure 4 illustrates the census methodology. Groups of two or three observers surveyed each 400 X 400-m plot by walking along parallel lines 25 m apart. We chose 25 m because previous studies show that inter-observer distances of 50 m fail to detect some incubating shorebirds (Gratto-Trevor 1994a). Observers paused every 50 m to check their headings with compasses, scan the area around them, listen for birds, and update their sketch maps. All birds seen or heard were recorded. Birds seen outside the plot or flying overhead were recorded but were not used in statistical analyses.

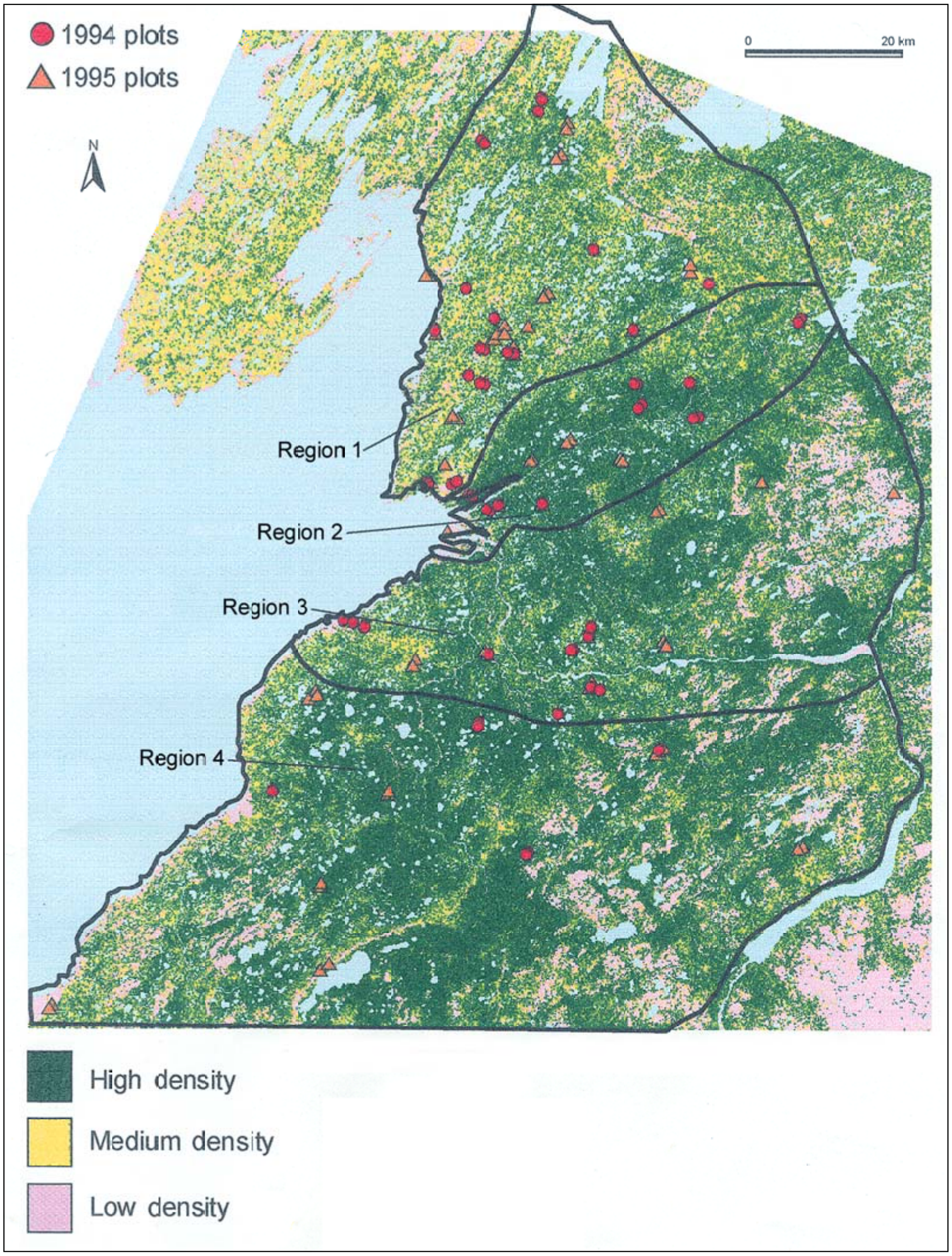
We determined the breeding status of individual shorebirds on the basis of their behaviour, numbers seen together, and the breeding system of that particular species. For bi-parental incubating species (Baird's Sandpiper *Calidris bairdii*, Semipalmated Plover *Charadrius semipalmatus*, Black-bellied Plover, American Golden-Plover, Dunlin *Calidris alpina*, Ruddy Turnstone *Arenaria interpres*, Semipalmated Sandpiper, and Stilt Sandpiper *Micropalama himantopus*), two birds displaying in close proximity, or one bird displaying on its own counted as one breeding pair. For uni-parental species (White-rumped Sandpiper, Pectoral Sandpiper, Buff-breasted Sandpiper *Tryngites subruficollis*, and Red Phalarope), a lone displaying adult counted as one breeding pair. For all shorebirds, two or three birds displaying together during the pre-nesting period constituted one breeding pair. "Display" included distraction displays, alarm calls, territoriality displays, and skulking.

We wished to enumerate the *potential* shorebird breeding population in the lowlands. Thus, birds of the appropriate sex exhibiting the appropriate behaviour at the correct time in the season were considered potential breeders. Numbers of both individual birds and indicated breeding pairs were used to calculate density indices. Breeding status of non-shorebird species was not determined.

3.4 Analyses of bird distribution and calculation of population estimates

We calculated mean densities and standard errors for bird species per hectare (ha) of a given habitat type, where n = the number of habitat-plots in a given habitat type (some plots comprised more than one habitat type). Densities were weighted by hectares to create unbiased means. In that way, a bird seen in a small piece of habitat would not have an undue influence on mean density. Area of each habitat type excluded ponds and streams. Although the presence or absence of ponds may determine the attractiveness of a given habitat to certain bird species, the presence or absence of ponds is already accounted for by definition of that habitat type. Because it was our intent to estimate density of birds or pairs per hectare of available nesting habitat, it was

Figure 3
Location of shorebird plots and satellite image ground truthing sites, Rasmussen Lowlands, 1994 and 1995



appropriate to exclude ponds prior to calculating densities. Areal extent of ponds depicted on our field sketch maps was highly correlated with the number of water pixels on satellite maps of the same areas (r = 0.84, p = 0.0001, 1994; r = 0.75, p = 0.0001, 1995).

We analysed the data to determine if birds (particularly shorebirds) were preferentially using some habitats in the lowlands. Because of small sample sizes we pooled data from structurally similar habitats (Table 3). We performed ANOVAs (1994 and 1995 data combined) to test for differences among habitat types, and GT2 family error tests to determine specifically where those differences occurred. Sample units were indicated pairs for shorebirds and individuals for all other species.

We used a three-way ANOVA (unbalanced design) to test for significant differences in bird densities between years and between months over both years. To increase sample sizes for these tests (and to calculate population estimates; see below), habitats identified from ground surveys were divided into habitats of high (hummocky, tussocky, and low tundra, and high-centre polygons), medium (raised and interrupted tundra, and beach ridges/eskers), and low (sandflats, rock outcrops) densities of birds. We then used t-tests to compare densities by year (e.g. Dunlin densities in high-density habitats, 1994 versus 1995), and month (e.g.

Figure 4
Plot methodology employed in Rasmussen Lowlands, 1994 and 1995

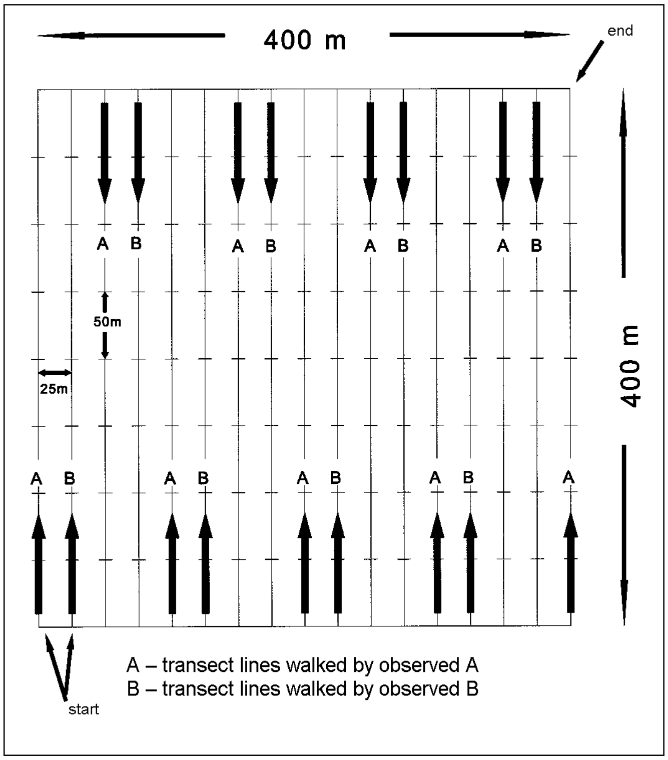


Table 3
Significant differences in use of combined habitat types[a] by birds in the Rasmussen Lowlands

Species[b]	Overall differences (ANOVA; p< 0.05)	Specific differences (GT-2 family error tests; p< 0.05)
Baird's Sandpiper	significant	beaesk vs. all other habitats
Dunlin	not significant	hictus vs. hitint
Red Phalarope	significant	lowtun vs. all other habitats
Semipalmated Plover	not significant	hitint vs. lowtun
Stilt Sandpiper	significant	hitint vs. hictus, hummoc, and lowtun
Total shorebird pairs	significant	lowtun vs. hummoc, hitint, and rocsan
Lapland Longspur	significant	hictus vs. all other habitats
Passerines	significant	hictus vs. lowtun, and beaesk hummoc vs. lowtun, and beaesk
All birds	significant	lowtun vs. hitint, beaesk, and rocsan

[a] Nine original habitat types were used to create six combined habitat types:
beaesk = beach ridge/esker
hictus = high-centre polygons + tussocky tundra
hitint = raised tundra + interrupted tundra
hummoc = hummocky tundra
lowtun = low tundra
rocsan = outcrop + sandflats

[b] ANOVAs and GT2 tests for Black-bellied Plover, Buff-breasted Sandpiper, American Golden-Plover, Pectoral Sandpiper, Ruddy Turnstone, Semipalmated Sandpiper, White-rumped Sandpiper, waterfowl, total non-shorebirds, Greater White-fronted Goose, and King Eider were p > 0.05.

Dunlin densities in high-density habitats, June versus July 1994).

Eleven plots surveyed in 1994 were again censused in 1995. We compared total numbers of shorebird pairs, passerines, and all birds in these plots. We did the same comparison for six plots that were censused twice within the 1995 season.

We calculated the mean weighted density of breeding pairs for each shorebird species in habitats with high, medium, and low shorebird densities. We calculated only the overall mean weighted densities for non-shorebird species.

The overall mean weighted density for each species was calculated using the following equation:

$$\text{weighted mean density} = \frac{(\text{mdhh} \times \text{area high}) + (\text{mdmh} \times \text{area medium}) + (\text{mdlh} \times \text{area low})}{\text{total area}}$$

$$\text{where area} = \text{no. of pixels per } 25\text{ m}^2$$

mdhh = mean density high habitat
mdmh = mean density medium habitat
mdlh = mean density low habitat

We estimated the total Rasmussen Lowlands population for a given species by multiplying the weighted mean density by the total area of the study site. To be able to propose an appropriate boundary for a conservation area, we needed a more precise idea of how population size varied from north to south. To do this, we divided the lowlands into four regions. Boundaries were chosen to roughly approximate changes in habitat associations as one moved from north to south. Population estimates were calculated by multiplying the weighted mean densities by the area of each region.

3.5 Comparison with other arctic breeding sites

The simplest way to determine the relative significance of an arctic site for one or a community of shorebird species is to compare bird densities or population estimates with other sites within the breeding range of those species. Sites hosting the same breeding population, if known, or those near the site being evaluated are used for comparisons. Sites from across the breeding range are also included, to give a broad perspective of how the site ranks.

We compared breeding densities of individual shorebird species, and all species together, with densities reported in the literature from other sites in the North American Arctic (Table 4, Fig. 5). There is a great range of methodologies and geographical locations portrayed in the studies listed in Table 4. The most reliable (and useful) comparisons should be with those studies that most closely parallel ours in terms of biogeographic region, species complement, and survey methods. We ranked other studies (Table 5) to give us a more realistic appraisal of the relative importance of the lowlands to shorebirds. In our ranking we considered sites in the Mid Arctic that had been censused using systematic, plot-based methods to be “most similar” to the Rasmussen site.

Table 4
Comparison of Rasmussen Lowlands shorebird densities with densities at other arctic breeding sites. The location numbers correspond to the numbered sites shown on Figure 5. See Appendix 3 for key to four-letter species codes

Location	Shorebird species[a]		Habitat	Length of study in years (time of year)	Survey method	Reference
	Birds/km^2	Pairs/km^2				
A. Subarctic sites						
1. La Perouse Bay, Manitoba		SESA- 50.0 (only SESA presented)	Mixed sedge/ grass/ dwarf shrub	3 (June, July)	Nest search	Gratto and Cooke (1987)
2. La Perouse Bay, Manitoba		SESA- 7.7 (only SESA presented)	Mixed sedge/ grass/ dwarf shrub	1 (June, July)	Nest search	Hitchcock and Gratto-Trevor (1997)
3,4. Churchill, Manitoba		AMGP- 6.4 (only AMGP presented)	Most nests in lichen tundra	1 (start 24 June)	Nest search, then regular visits to plot	Byrkjedal (1989)
B. Low-arctic sites						
5. Stokes Point, Yukon	AMGP- 9.9 SEPL- 2.6 STSA- 6.2 PESA- 35.2 BASA- 0.4 SESA- 18.9 REPH- 2.4 ALL (12)- 97.6		All[b]	1 (9–29 June)	Ground transects	Dickson et al. (1988)
6. Phillips Bay, Yukon	AMGP- 17.4 STSA- 1.4 PESA- 19.8 BASA- 0.3 SESA- 23.9 REPH- 0.7 ALL (13)- 92.0		All[b]	1 (9–29 June)	Ground transects	Dickson et al. (1988)
7. King Point, Yukon	AMGP- 9.7 STSA- 1.2 PESA- 20.7 SESA- 2.4 ALL (9)- 59.6		All[b]	1 (9–29 June)	Ground transects	Dickson et al. (1988)
8. Promise Island, Chesterfield Inlet		SEPL- 1.0 DUNL- 0.4 SESA- 4.0 REPH- 2.0 ALL (5)- 7.8	*Carex* marsh, some lichen/heath tundra	1 (25 June – 11 July)	Whole count	Hohn (1968)
9. Mackenzie Delta		AMGP- 0.4 PESA- 0.4 SEPL- 2.7 SESA- 1.4 STSA- 1.6 ALL (10)- 21.4	Low-centre polygon/wet sedge; uplands; willow thicket; sedge/willow/ emergents; gravel pads	2 (16 June – 14 July)	Transects within plots; some repeated	Gratto-Trevor (1996)
10. Kugong Island, Hudson Bay	SEPL- 9.1 SESA- 6.1 ALL (11)[c]- 28.2		Bare rock (35%); lichen–*Dryas* uplands (20%); tussocky tundra (20%); lakes (15%); marsh (5%)	1 (6 May – 14 July)	No. of birds per hour of walking	Manning (1976)
12. Islands near Cape Dorset, Baffin Island		SEPL- 0.6 ALL (2)- 0.7	Coastal outcrop, beach ridges, sparse vegetation	1 (11 June – 22 July)	No. of pairs per hour of walking	Macpherson and McLaren (1959)
13. Adelaide Peninsula	AMGP- 0.8 BBPL- 0.6 PESA- 2.2 BASA- 1.9 REPH- 2.6 ALL (10)[d]- 8.1		Tussock marsh (65%); dry stony ridges (12%); outcrop/boulder plains/barren areas (13%); lakes and rivers (10%).	1 (June–Sept.)	No. of birds per hour of walking	MacPherson and Manning (1959)

Continued

Table 4 (*cont'd*)
Comparison of Rasmussen Lowlands shorebird densities with densities at other arctic breeding sites. The location numbers correspond to the numbered sites shown on Figure 5. See Appendix 3 for key to four-letter species codes

	Shorebird species[a]					
Location	Birds/km^2	Pairs/km^2	Habitat	Length of study in years (time of year)	Survey method	Reference
14. Babbage River, Yukon	AMGP- 5.0 PESA- 3.1 SESA- 0.6 BBSA- 1.9 ALL (8)- 14.4		Tussocky tundra	1 (30 May – 25 June)	Territory mapping in six plots, repeated 11 times	Richardson and Gollop (1974)
15. Babbage River, Yukon	AMGP- 6.6 PESA- 3.1 SESA- 3.1 BBSA- 3.1 ALL (7)- 37.8		Tussocky tundra	1 (28 May – 7 July)	Plot census repeated over season	Gunn et al. (1974)
16. Firth River, Yukon	AMGP- 12.7 BBSA- 6.6 ALL (4)- 19.3		?	1 (24 May – 2 July)	Plot census repeated over season	Gunn et al. (1974)
C. Mid-arctic sites						
11. Bowman Bay, Baffin Island (3 sites)	SEPL- 0.7 BBPL- 2.9 RUTU- 3.3 WRSA- 7.5 SESA- 2.6 REPH- 11.5 ALL (7)- 28.8		Grass tundra with granite outcrops	1 (1–11 July)	Whole census?	Soper (1940)
17. S. Boothia Penin.—Middle Lake (2 sites)	AMGP- 11.9 PESA- 8.9 WRSA- 33.9 BASA- 2.8 SESA- 6.0 BBSA- 3.9 STSA- 5.2 REPH- 19.2 ALL (8)- 91.8		All[e]	1 (5–14 July)	Ground transect	Patterson and Alliston (1978)
18. S. Boothia Penin.—Sanagak Lake (4 sites)	AMGP- 14.1 WRSA- 8.4 BASA- 16.4 REPH-1.5 ALL (5)- 40.5		All[e]	1 (5–14 July)	Ground transect	Patterson and Alliston (1978)
19. Jenny Lind Island		WRSA- 5.24 (only WRSA presented)	Nearly all in marsh with many lakes and ponds	1 (June–August)	Repeat visits to plot; nest search with rope drag in favoured habitats	Parmelee et al. (1968)
20. Sarcpa Lake, Melville Peninsula		AMGP- 3.8 SEPL- 0.3 SESA- 0.1 WRSA- 1.5 BASA- 3.9 PESA- 0.1 DUNL- 0.1 REPH- 0.3 ALL (8)- 7.1	All[f]	2 (May–August)	Territory mapping; nest search	Montgomerie et al. (1983)

Continued

Table 4 (*cont'd*)
Comparison of Rasmussen Lowlands shorebird densities with densities at other arctic breeding sites. The location numbers correspond to the numbered sites shown on Figure 5. See Appendix 3 for key to four-letter species codes

Location	Shorebird species[a] Birds/km^2	Pairs/km^2	Habitat	Length of study in years (time of year)	Survey method	Reference
21. Storkerson Point, Alaska	AMGP- 0.1–3.8 BBPL- 0.0–0.6 RUTU- 0.0–3.2 BBSA- 0.0–10.0 PESA- 3.8–22.0 DUNL- 9.0–21.2 BASA- 0.0–4.0 SESA- 11.0–20.0 REPH- 15.6–37.0 ALL (17)- 81.6		All[g]	5 (1 June–August) (only June densities shown here)	Weekly plot census	Bergman et al. (1977)
22. Prince Charles Island, Foxe Basin		BBPL- 1.7 AMGP- 0.3 RUTU- 3.5 SESA- 1.2 WRSA- 15.7 REPH- 16.6 ALL (6)- 39.0	All[h]	1 (5–13 July)	Transects within plots	Morrison (1997)
23. Igloolik Island		BBPL- 0.5 AMGP- 0.3 SEPL- 0.1 RUTU- 0.8 SESA- 1.5 WRSA- 3.5 REPH- 5.0 ALL (9)-12.1	Wet meadow (65%) *Dryas*/heath slope (25%) Rocky shoreline (5%) Dry ridge (4%) Disturbed area (1%)	1 (1 June – 31 August)	Ground transects, repeated weekly	Forbes et al. (1992)
24. Prudhoe Bay, Alaska		BBPL- 0.6 AMGP- 2.7 RUTU- 0.1 SESA- 12.5 WRSA- 0.6 BASA- 0.7 PESA- 8.7 DUNL- 7.5 STSA- 0.7 BBSA- 0.9 REPH- 6.8 ALL (14)- 43.2	Saline tundra; nonsaline tundra; dry tundra	10 (June – August)	Transects in plots, repeated 8 times annually	TERA (1993)
25. Rasmussen Lowlands	BBPL- 0.5 AMGP- 0.8 SEPL- 0.1 RUTU- 0.2 SESA- 1.7 WRSA- 3.0 BASA- 0.7 PESA- 3.3 DUNL- 0.9 STSA- 0.2 BBSA- 0.5 REPH- 4.2 ALL (12)- 15.2	BBPL- 0.4 AMGP- 0.7 SEPL- 0.1 RUTU- 0.2 SESA- 1.2 WRSA- 1.9 BASA- 0.7 PESA- 2.5 DUNL- 0.9 STSA- 0.1 BBSA- 0.2 REPH- 2.8 ALL (11)- 11.7	All[i]	2 (16 June – 13 July)	Transects within plots	Present study
26. Rasmussen Lowlands	BBPL- 2.5 AMGP- 4.2 SESA- 1.7 WRSA- 4.2 BASA- 0.2 PESA- 5.0 DUNL- 0.4 REPH- 17.4 ALL (14)- 32.1		All[j]	2 (30 June – 17 July)	Ground transects	McLaren et al. (1977)

Continued

Table 4 (*cont'd*)
Comparison of Rasmussen Lowlands shorebird densities with densities at other arctic breeding sites. The location numbers correspond to the numbered sites shown on Figure 5. See Appendix 3 for key to four-letter species codes

	Shorebird species[a]			Length of study in years		
Location	Birds/km^2	Pairs/km^2	Habitat	(time of year)	Survey method	Reference
27. Barrow, Alaska		PESA- 5.0	Old beach ridge	5 (5 June – 15 July)	Plot census	Pitelka (1959)
28. Barrow, Alaska		PESA- 6.0	Mosaic of wet and dry tundra	3 (13 June – 29 July)	Plot census	Pitelka (1959)
29. Barrow, Alaska		PESA- 1.2	Marsh tundra	3 (13 June – 29 July)	Plot census	Pitelka (1959)
D. High-arctic sites						
30. Creswell Bay/Stanwell-Fletcher Lake, Somerset Island (6 sites)	AMGP- 8.1 PESA- 5.0 WRSA- 12.3 BASA- 5.4 REPH- 6.6 ALL (7)- 39.6		All[e]	1 (5–14 July)	Ground transect	Patterson and Alliston (1978)
31. N. Boothia Peninsula (2 sites)	BBPL- 2.8 AMGP- 1.4 PESA- 1.4 WRSA- 12.0 REPH- 18.1 ALL (6)- 37.1		All[e]	1 (5–14 July)	Ground transect	Patterson and Alliston (1978)
32. Southeast Somerset Island (4 sites)	BBPL- 5.1 AMGP- 0.8 WRSA- 18.6 BASA- 5.7 RUTU- 11.1 REPH- 15.4 ALL (8)- 58.5		All[e]	1 (5–14 July)	Ground transect	Patterson and Alliston (1978)
33. Polar Bear Pass, Bathurst Island	WRSA- 8.0	BBPL- 1.25 REPH- 7.00 ALL (3) - 8.75	Sedge/moss meadow	4 (June–July)	Nest search	Mayfield (1983)
34. Polar Bear Pass, Bathurst Island		BBPL- 0.13 ALL (2)- 1.1	upland *Saxifraga* semi-desert	4 (June–July)	Nest search	Mayfield (1983)
35. Polar Bear Pass, Bathurst Island		REPH- 4.9 (only REPH presented)		7 (June–July)	Nest search	Mayfield (1974)
36. Lake Hazen, Ellesmere Island		RUTU- 3.04 – 5.0 (only RUTU presented)	All[k], with most nests in *Dryas* hummocks or clay –*Dryas,* and close to wet area	1 (June–August)	Nest search	Nettleship (1973)
37. Northeast Greenland (10 sites)		RUTU- 0.56 DUNL- 0.56 REPH- 0.02 ALL (8)- 3.27	Varied by site[l]	1 (June: Sites 1–3, 6, 8–10. After 6 July: sites 4,5,7)	Nest search? Throughout breeding season except in 4,5,7.	Meltofte (1985)
38. Northeast Greenland (2 sites)		RUTU- 2.92 DUNL- 2.72 REPH- 0.39 ALL (6)- 11.2	One site low and wet; other site combined vegetated boggy plains with well-vegetated slopes	1 (June)	Nest search? Throughout breeding season	Meltofte (1985)
39. Peary Land, Greenland		RUTU- 0.93 ALL (3)- 1.86	Barren gravel plains, clay slopes	1 (June)	Nest search? Throughout breeding season	Meltofte (1985)

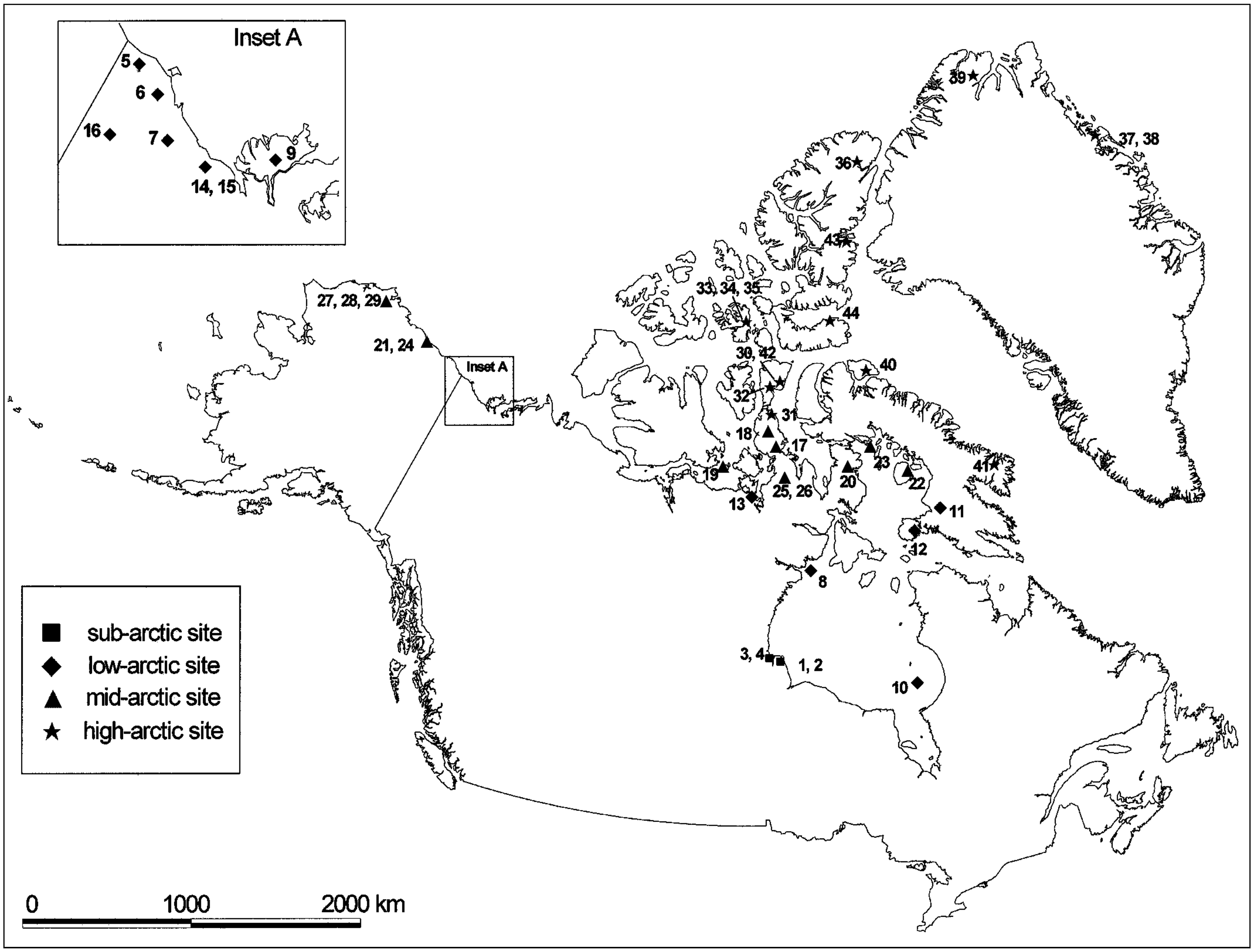
Continued

Table 4 (*cont'd*)
Comparison of Rasmussen Lowlands shorebird densities with densities at other arctic breeding sites. The location numbers correspond to the numbered sites shown on Figure 5. See Appendix 3 for key to four-letter species codes

Location	Shorebird species[a] Birds/km²	Pairs/km²	Habitat	Length of study in years (time of year)	Survey method	Reference
40. Southwest Bylot Island		AMGP- 6.4 BASA- 1.9 WRSA- 0.9 BBPL- 0.3 REPH- 0.1 ALL (6)- 9.6	Sparse heath tundra (77%); sedge meadow (15%); heath/herb slope, dry barrens, gravel/sand flood plains (8%)	1 (27 June – 12 July)	nonsystematic transects within study plot, repeated twice	Crockford (1994)
41. Penny Highland, Baffin Island		BASA- 0.4 ALL (1)- 0.4	Wet sedge lowland (62); sedge/dwarf shrub uplands (23%); grassland (15%) (BASA in grassland only)	1 (mid June – mid July)	Whole count	Watson (1957)
42. Creswell Bay, Somerset Island	AMGP- 1.3 BBPL- 2.2 WRSA- 11.1 PESA- 4.3 BASA- 0.7 SESA- 0.2 BBSA- 1.3 RUTU- 1.1 REPH- 12.3 ALL (10)- 35.0		All[m]	1 (16 June – 4 July)	Transects within plots	Latour (1996)
43. Alexandra Fiord, Ellesmere Island		BASA- 0.9 ALL (2)- 0.94	Mesic heath (49%) Lichen outcrop (37%) Herbaceous outwash plain (9%) Wet sedge meadow (5%)	2 (20 June – 21 July)	Total count, repeated 3 times	Freedman and Svoboda (1982)
44. Truelove Lowlands, Devon Island		BBPL- 0.68 (only BBPL presented)	As above	5 (June–August)	Nest search	Hussell and Page (1976)

[a] Species not found in Rasmussen Lowlands during present study omitted, but "ALL" includes all species recorded at site.
[b] Main habitats sampled: wet sedge/polygonal tundra; wet sedge tundra; tussocky tundra; graminoid/dwarf shrub tundra; tussocky/polygonal tundra.
[c] Includes only those species considered as breeding on Kugong Island.
[d] Mininum estimate. Densities not calculated for less common breeding species.
[e] Main habitats sampled: evergreen shrub (closed, open, and sparse); sedge marsh (closed); sedge meadow (closed); evergreen shrub/sedge (open).
[f] Main habitats sampled: solifluction zones (30%); boulder fields/outcrop (25%); *Dryas*–lichen ridges (20%); disturbed areas (10%); wet sedge meadow (10%); ponds/small lakes (5%).
[g] Flooded tundra; *Carex* ponds (shallow and deep) ; *Arctophila* ponds (shallow and deep); deep, open ponds; mixed open and vegetated lakes; beaded streams; coastal wetlands.
[h] Ponds and streams; saltmarsh; grassland (2 types); marsh (wet and saturated); tundra (vegetated, poorly vegetated, and unvegetated); flats (lower and upper); beach ridge; gravel barrens (coastal and interior); rock outcrop.
[i] Low tundra; hummocky tundra; tussocky tundra; interrupted tundra; raised tundra; high-centre polygons; beach ridges/eskers; sandflats; rock outcrop.
[j] Closed cottongrass tundra (wet and dry); closed *Carex* tundra (wet and dry); dwarf shrub tundra (closed, open, and sparse); graminoid/dwarf shrub tundra (closed, open, and sparse); closed lichen/moss tundra; closed graminoid/lichen tundra.
[k] Main habitats sampled: *Dryas* hummocks and tundra; clay–*Dryas* tundra; clay plain/slope; marsh (*Carex, Eriophorum, Arctagrostis, Polygonum, Dryas,* moss); gravel or sand.
[l] Habitats at site: tundra heath slopes; well vegetated tundra; part well vegetated/ part poorly vegetated tundra; sparse tundra heath with extensive marsh areas; gravel plains, sparse tundra heath; tundra heath; coastal slopes, lowland; barren gravel slopes, vegetated beach ridges; barren coastal slopes and plains.
[m] Main habitats sampled: dry sedge tundra; wet sedge tundra; sparsely vegetated gravel outwash; sparsely vegetated *Dryas* tundra; *Dryas/Salix/*sedge tundra.

Figure 5
Locations of other arctic shorebird studies cited in the text



1, 2	La Perouse Bay	3, 4	Churchill
5	Stokes Point	6	Phillips Bay
7	King Point	8	Promise Island
9	Mackenzie Delta	10	Kugong Island
11	Bowman Bay	12	Islands near Cape Dorset
13	Adelaide Peninsula	14, 15	Babbage River
16	Firth River	17, 18	Southern Boothia Peninsula
19	Jenny Lind Island	20	Sarcpa Lake
21	Storkerson Point	22	Prince Charles Island
23	Igloolik Island	24	Prudhoe Bay
25, 26	Rasmussen Lowlands	27, 28, 29	Barrow
30, 42	Creswell Bay	31	Northern Boothia Peninsula
32	Southeast Somerset Island	33, 34, 35	Polar Bear Pass
36	Lake Hazen	37, 38	Northeast Greenland
39	Peary Land	40	Southwest Bylot Island
41	Penny Highland	43	Alexandra Fiord
44	Truelove Lowlands		

Table 5
Similarity rankings relative to this study and shorebird population characteristics of other studies/sites

Site (see Table 4)	Site no. on Fig. 5	Similarity rating[a]	No. of breeding species	Total no. of species present	Pair density (pairs/km^2)	Density (ind./km^2)
Rasmussen (this study)	25	15	11	12	11.7	15.2
Rasmussen (McLaren et al.)	26	14	13	14	n/a	32.1
Sarcpa Lake	20	12	8	13	7.1	n/a
Prudhoe Bay	24	12	14	17	43.2	n/a
Creswell Bay	42	11	10	11	n/a	35.0
Igloolik Island	23	10	9	13	12.1	n/a
Storkerson Point	21	10	10	17	n/a	81.6
Prince Charles Island	22	9	6?	6?	39.0	n/a
Mackenzie Delta	9	9	10	10	21.4	n/a
S. Boothia	17	8	8	8	n/a	91.8
SW Bylot Island	40	8	6	8	9.6	n/a
Creswell Bay	30	8	7?	7	n/a	39.6
S. Boothia	18	7	5?	5	n/a	40.5
Adelaide Peninsula	13	7	8	10	n/a	8.1
SE Somerset Is.	32	7	8?	8	n/a	58.5
Churchill	3,4	6	7	10	n/a	56.0
Phillips Bay	6	6	?	13	n/a	92.0
King Point	7	6	?	9	n/a	59.6
Babbage River	15	6	?	7	n/a	37.8
Stokes Point	5	6	?	12	n/a	97.6
N. Boothia	31	6	6?	6	n/a	37.1
Bowman Bay	11	4	4	7	n/a	28.8
Promise Island	8	4	5	9	7.8	n/a
Babbage River	14	4	7	8	n/a	37.8
Firth River	16	4	4?	4	n/a	19.3
Alexandra Fiord	43	4	2	5	0.94	n/a
Polar Bear Pass	33,34,35	4	2	2	1.1	n/a
NE Greenland	38	3	8	8	11.2	n/a
NE Greenland	37	3	6	6	3.27	n/a
Penny Highland	41	3	1	1	0.4	n/a
Kugong Island	10	2	4	11	28.2	n/a
Cape Dorset	12	2	2	2	0.7	n/a
Peary Land	39	1	3	3	1.86	n/a

[a] Higher number denotes greater similarity to this study. Rankings based on points awarded for: location (same ecological zone as Rasmussen Lowlands) = 1 point; exclusion of water bodies in density calculations = 1 point; densities weighted = 1 point; survey systematic = 1 point; same survey methodology as present study = 1 point; study conducted over two or more years = 1 point; and 1 point for each breeding species common with this study.

4. Results

4.1 Weather

For the years 1975 to1992 inclusive, the mean daily temperature in the breeding season (June 1 to August 7) in the Rasmussen Lowlands was 4.5 °C. In 1994 and 1995, the means were 6.3° and 3.6° C, respectively (Fig. 6). Mean temperatures for the same period in 1975 and 1976 were 6.9º and 2.5º C, respectively.

We divided the summer breeding season into four periods for analysis: pre-laying (1–14 June), incubation (15 June – 12 July), brood-rearing (1–30 July), and post-fledge (31 July – 7 August). We performed Wilcoxon paired sample tests to compare each period of each breeding season (1994 and 1995) to the average mean daily temperature (1975–92). We performed similar tests on weather data from 1975 and 1976 to compare temperatures during our study with those measured during McLaren et al.'s 1975 and 1976 field seasons.

In 1994, pre-laying and incubation periods were significantly warmer than average ($p < 0.0001$; $n = 14$ and $p < 0.0113$, $n = 28$). Average temperatures prevailed for brood-rearing and post-fledge ($p > 0.7038$, $n = 18$ and $p > 0.1267$, $n = 8$). In 1995, temperatures were near average until the second week of the incubation period, when they cooled off to values that were significantly below average ($p < 0.0377$, $n = 26$). Temperatures stayed below average through the brood-rearing period ($p < 0.0002$, $n = 17$).

The 1975 breeding season was significantly warmer than average during pre-laying and incubation ($p < 0.0001$, $n = 14$ and $p < 0.0008$, $n = 28$). The brood period was significantly cooler than average ($p < 0.0017$; $n = 18$). In contrast, 1976 temperatures in the pre-lay and incubation periods were significantly and markedly below average ($p < 0.0001$, $n = 14$ and $p < 0.0012$, $n = 28$). Temperatures climbed to average values by mid July ($p > 0.9117$; $n = 18$).

Thus, 1975 and 1994 were warmer than average during the critical pre-lay and incubation stages. Temperatures in 1995 were average during these periods, and in 1976 were cooler than average.

4.2 Habitat

A total of 1888 ha of habitat was surveyed in 1994 and 1995 (Table 6). On the basis of ground survey data, we developed nine habitat types for the Rasmussen Lowlands. The amount of each habitat type surveyed reflects both its general abundance in the lowlands, and its perceived value to shorebirds. We surveyed proportionately more "good" shorebird habitat.

In both years, roughly half of all habitat sampled was classified as low tundra or hummocky tundra. Other habitats sampled were raised tundra, high-centre polygons, interrupted tundra, tussocky tundra, beach ridges/eskers, sandflats, and rock outcrops (see Table 2 for characteristics of each habitat type).

In the lowlands, gradations between habitats are subtle and it is not unusual to find patches of one habitat within another. This is caused by slight differences in elevation or surficial expression. We frequently found mosaics of low, hummocky, and raised tundra. Hummocky and tussocky tundra, however, were generally distinct from one another.

The geographical distribution of habitat types across the lowlands varied. Frequent traverses of the study area showed that the majority of high-centre polygons occurred within 20 km of the Murchison River. Tussocky tundra tended to be located south of the Murchison River. Beach ridges/eskers and sandflats were scattered along the coast and on river banks and river deltas (sandflats). Rock outcrops were mainly found in the highlands that formed the eastern border of the study area. Isolated rock outcrops also occurred in the southern and eastern portions of the study area. The heterogeneous, heavily ponded terrain north and west of the Inglis River lowlands held the majority of the interrupted and raised tundra habitats. Low tundra and hummocky tundra were widespread throughout the study area.

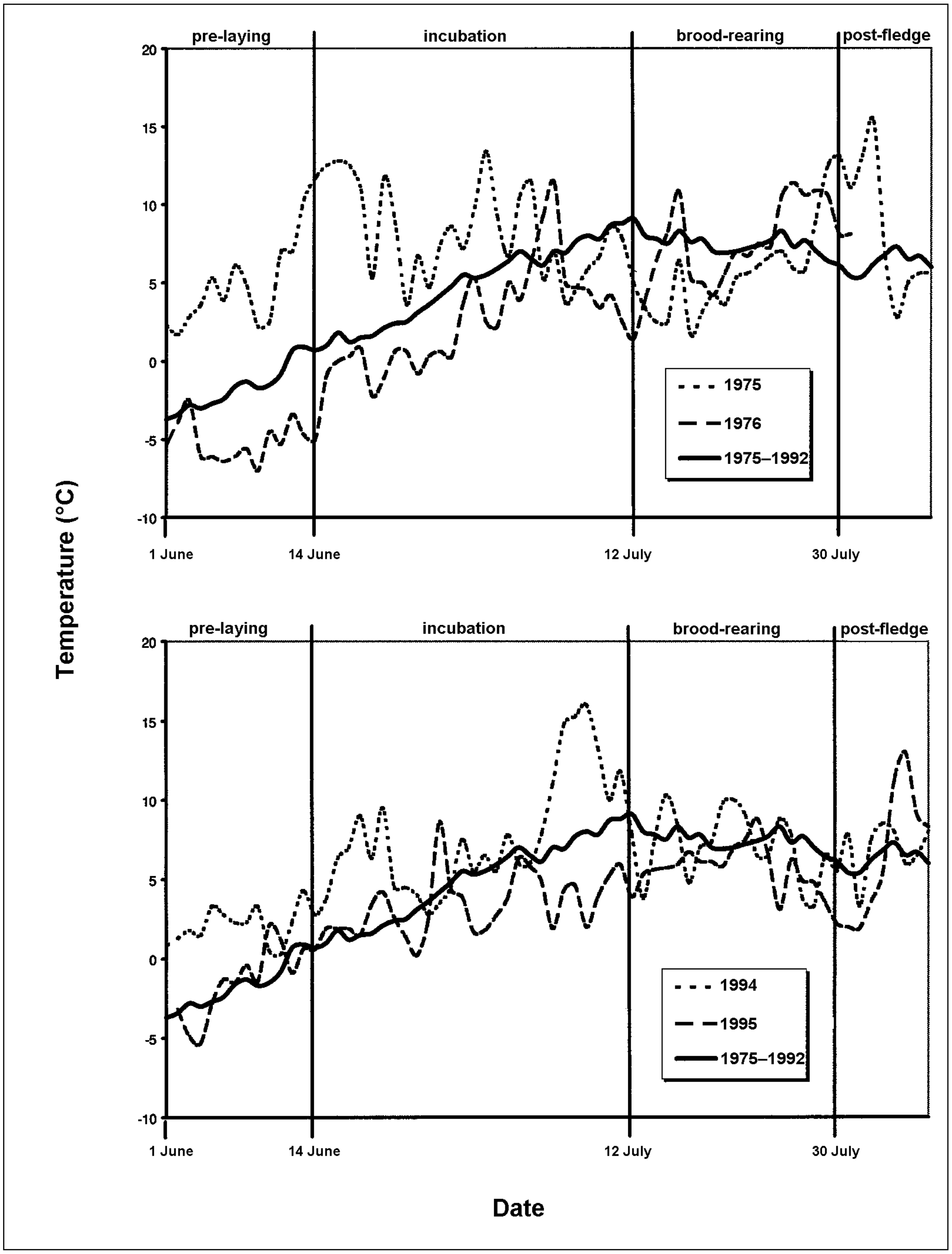
Eighty-five vascular plants were identified from the Rasmussen Lowlands (Appendix 1). Our collection furnished extensions of known range for eight species (Cody 1996 and Appendix 2).

4.3 Bird census

Thirty-seven bird species were recorded over the course of the study (Appendix 3). We confirmed 22 of these as breeders in the lowlands or on the adjacent escarpments. Table 7 shows phenological data.

Twelve shorebird species were recorded; breeding was confirmed for all species except Buff-breasted Sandpiper and Ruddy Turnstone (Appendix 3). In decreasing order of abundance, shorebird species seen in the lowlands were Red Phalarope, White-rumped Sandpiper, Pectoral Sandpiper,

Figure 6
Mean daily temperature, Rasmussen Lowlands, 1970s and 1990s



Semipalmated Sandpiper, American Golden-Plover, Dunlin, Black-bellied Plover, Buff-breasted Sandpiper, Baird's Sandpiper, Stilt Sandpiper, Semipalmated Plover, and Ruddy Turnstone.

Ours is the first confirmed record of breeding for Stilt Sandpipers in this area. We first noted an adult with four chicks (approximately two days old) in hummocky sedge habitat near our camp (68°37'57"N, 93°29'36"W) on 2 July 1994. The same brood was seen again with both parents on 3 July. On 10 July, we found a Stilt Sandpiper nest near one of our study plots (68°45'40"N, 93°28'37"W). The parent flushed off the nest, which contained three eggs. No eggs were pipped. The nest was situated in hummocky/rocky tundra very close to a small, shallow pond. It was nestled in a hummock and was wound with *Dryas*, moss, lichen, and sedge. The nest cup was lined with dead lichen.

The two adults attending the brood and one adult from the nest were captured with mist nets, banded, weighed, and measured. The eggs were also measured (Appendix 4).

Lapland Longspur *Calcarius lapponicus* was by far the most common non-shorebird species observed in the plots (n = 469). Greater White-fronted Geese, Lesser Snow Geese, Canada Geese *Branta canadensis*, and King Eiders were also seen frequently. Our sightings of all-male flocks of Red-breasted Mergansers *Mergus serrator* and Northern Pintails *Anas acuta* are interesting; the lowlands are well

Table 6
Number of plots and percentage of area surveyed, by habitat type within regions, Rasmussen Lowlands

	Region 1 (102 683 ha)			Region 2 (67 436 ha)			Region 3 (178 490 ha)			Region 4 (321 952 ha)		
Habitat type	area (ha)	n	%	area (ha)	n	%	area (ha)	n	%	area (ha)	n	%
1. Low tundra	265	26	30	248	16	66	50	4	11	32	5	8
2. Hummocky tundra	297	23	34	76	5	20	103	8	23	109	9	27
3. High-centre polygons	26	2	3	0	0	0	188	13	42	0	0	0
4. Tussocky tundra	4	1	1	0	0	0	21	2	5	130	11	32
High-density habitats (1–4 above)	*592*	*52*	*68*	*324*	*21*	*86*	*362*	*27*	*81*	*271*	*25*	*67*
5. Beach ridge/esker	44	4	5	0	0	0	29	3	7	32	2	8
6. Interrupted tundra	166	12	19	9	1	2	16	1	4	12	1	3
7. Raised tundra	71	10	8	23	3	6	6	1	1	78	7	19
Medium-density habitats (5–7 above)	*281*	*26*	*32*	*32*	*4*	*8*	*51*	*5*	*12*	*122*	*10*	*30*
8. Sandflats	0	0	0	15	1	4	19	2	4	16	1	4
9. Rock outcrop	0	0	0	7	1	2	16	1	4	0	0	0
Low-density habitats (8–9 above)	*0*	*0*	*0*	*22*	*2*	*6*	*35*	*3*	*8*	*16*	*1*	*4*
Total	**873**	**78**	**100**	**378**	**27**	**100**	**448**	**35**	**101**	**409**	**36**	**101**

Table 7
Breeding phenology at selected years and locations in the Canadian Arctic

Event	Rasmussen 1994[a]	Rasmussen 1995[a]	Rasmussen 1975[b]	Rasmussen 1976[b]	Sarcpa Lake 1981[c]	Cambridge Bay 1960–62[d]	Creswell Bay 1995[e]
1st Lapland Longspur nest found	16 June	19 June	?	20 June	12 June	9–11 June	20 June
1st shorebird nest found	17 June	20 June	9 June	28 June	12 June	first week June	17 June
1st goose nest found	15 June	20 June	early June	13 June	n/a	13 June	17 June
1st Lapland Longspur hatch	4 July	4 July	?	20 July	approx. 1 July	23 June	2 July
1st shorebird hatch	29 June	10 July	6 July	25 July	approx. 2 July	last week June	3 July
1st goose hatch	10 July	13 July	7 July	?	n/a	2 July	?
Study start date	15 June	19 June	?	20 June	May	1 June	16 June
Breeding season conditions	average to slightly warm	average to cool	warm	cool	average	average or warm	warm

[a] Present study.
[b] McLaren et al. (1977).
[c] Montgomerie et al. (1983).
[d] Parmelee et al. (1967).
[e] Latour (1996).

north of the breeding range for these species and small numbers likely come to the area to moult (McLaren et al. 1977; J. Hines, pers. commun.). Appendix 3 lists other species observed.

4.3.1 Habitat use by birds

Habitat use by shorebirds varied considerably among species (Table 8). Low tundra and high-centre polygon habitats supported the highest densities of shorebirds (27 and 21 pairs/km², respectively), though no one habitat type was clearly favoured by all species. Mean numbers of pairs of Red Phalaropes and White-rumped Sandpipers were highest in low tundra, and Dunlin and Pectoral Sandpiper pair densities peaked in tussocky tundra. High-centre polygons supported the highest densities of Semipalmated Sandpipers and Black-bellied Plovers. American Golden-Plovers were most often found on raised tundra, and the highest densities of Baird's and Buff-breasted sandpipers were on beach ridges and eskers. Stilt Sandpipers and Semipalmated Plovers were most common on interrupted and raised tundra. Only Ruddy Turnstones were present on sandflats. No shorebirds were seen on rock outcrops.

Densities of shorebird pairs and individuals generally followed the same patterns (Fig. 7). The most marked differences were observed for Semipalmated Sandpipers (individuals most common on beach ridges/eskers, pairs most common on high-centre polygons) and Black-bellied Plovers (density of individuals was highest on interrupted tundra, that of pairs on high-centre polygons).

Passerines, the vast majority of which were Lapland Longspurs, were found in all habitats except sandflats (and only rarely on beach ridges/eskers). They were common in other habitats. The extremely high density calculated for passerines in rock outcrop habitat is an artifact of low sample size and the fact that Snow Buntings *Plectrophenax nivalis* were the only birds encountered in that habitat. Waterfowl densities were highest in low tundra. Non-shorebirds as a

Table 8
Mean density[a] of shorebirds by habitat type, Rasmussen Lowlands[b], 1994 and 1995

Habitat type (n)[c]	Baird's Sandpiper ind. (SE)	Baird's Sandpiper pairs[d] (SE)	Black-bellied Plover ind. (SE)	Black-bellied Plover pairs (SE)	Buff-breasted Sandpiper ind. (SE)	Buff-breasted Sandpiper pairs (SE)	Dunlin ind. (SE)	Dunlin pairs (SE)	American Golden-Plover ind. (SE)	American Golden-Plover pairs (SE)	Pectoral Sandpiper ind. (SE)	Pectoral Sandpiper pairs (SE)
Beach ridge/esker (13)	4.0 (4.5)	4.0 (4.5)	0.0 (0.0)	0.0 (0.0)	1.0 (2.4)	1.0 (2.4)	0.0 (0.0)	0.0 (0.0)	1.0 (1.9)	1.0 (1.9)	3.0 (3.2)	2.0 (3.1)
High-centre polygons (14)	0.6 (2.2)	0.6 (2.2)	1.2 (2.5)	1.2 (2.5)	0.0 (0.0)	0.0 (0.0)	1.2 (4.0)	1.2 (4.0)	1.8 (4.6)	1.2 (2.8)	4.1 (8.8)	3.5 (8.8)
Raised tundra (28)	0.0 (0.0)	0.0 (0.0)	1.1 (4.7)	0.6 (2.4)	1.1 (4.0)	0.6 (2.0)	0.0 (0.0)	0.0 (0.0)	2.8 (8.2)	2.3 (4.3)	3.9 (4.8)	2.8 (4.5)
Hummocky tundra (48)	0.2 (0.9	0.2 (0.9	0.4 (1.4	0.2 (0.7)	2.1 (6.4)	0.8 (3.2)	1.0 (1.6)	1.0 (1.6)	0.4 (0.9)	0.4 (0.9)	5.6 (4.7)	3.7 (3.1)
Interrupted tundra (15)	1.1 (3.9)	1.1 (3.9)	1.6 (4.6)	0.6 (2.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.6 (2.0)	0.6 (2.0)	0.6 (2.0)	0.6 (2.0)
Low tundra (54)	0.6 (1.2)	0.4 (0.7)	0.8 (1.2)	0.6 (0.9)	0.2 (0.5)	0.2 (0.5)	2.0 (2.3)	2.0 (2.3)	0.8 (1.4)	0.6 (0.9)	7.0 (5.8)	4.7 (4.2)
Rock outcrop (2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Sandflats (5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Tussocky tundra (16)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	4.1 (6.4)	4.1 (6.4)	0.0 (0.0)	0.0 (0.0)	5.5 (9.7)	5.5 (9.7)

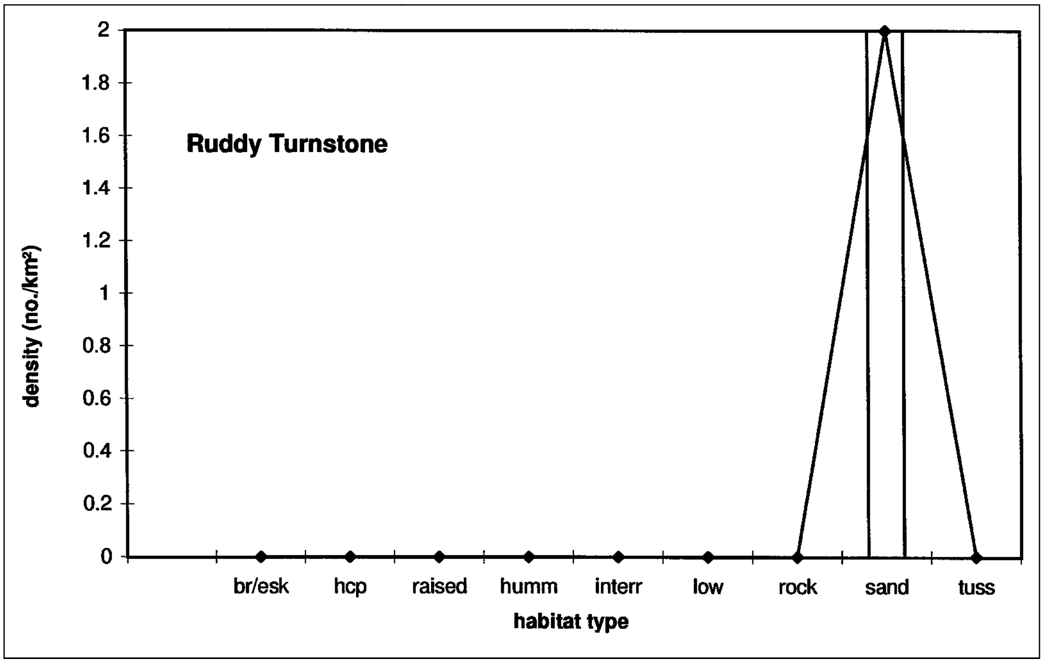
Habitat type (n)	Red Phalarope ind. (SE)	Red Phalarope pairs (SE)	Ruddy Turnstone ind. (SE)	Ruddy Turnstone pairs (SE)	Semipalmated Plover ind. (SE)	Semipalmated Plover pairs (SE)	Semipalmated Sandpiper ind. (SE)	Semipalmated Sandpiper pairs (SE)	Stilt Sandpiper ind. (SE)	Stilt Sandpiper pairs (SE)	White-rumped Sandpiper ind. (SE)	White-rumped Sandpiper pairs (SE)	All shorebirds ind. (SE)	All shorebirds pairs (SE)
Beach ridge/esker (13)	1.0 (2.2)	1.0 (2.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	4.0 (9.9)	1.0 (7.5)	0.0 (0.0)	0.0 (0.0)	2.0 (4.5)	1.0 (2.2)	18.1 (22.2)	12.1 (12.8)
High-centre polygons (14)	10.6 (13.3)	6.5 (7.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.9 (5.0)	2.9 (5.0)	0.0 (0.0)	0.0 (0.0)	4.7 (7.5)	3.5 (5.2)	27.1 (24.7)	20.6 (18.6)
Raised tundra (28)	2.25 (2.08)	1.7 (1.9)	0.0 (0.0)	0.0 (0.0)	0.6 (1.5)	0.6 (1.5)	0.0 (0.0)	0.0 (0.0)	0.6 (0.9)	0.6 (0.9)	2.3 (3.5)	1.1 (1.8)	15.2 (15.4)	10.7 (10.1)
Hummocky tundra (48)	3.7 (4.4)	2.3 (2.8)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	3.3 (7.9)	2.1 (3.6)	0.0 (0.0)	0.0 (0.0)	4.1 (6.2)	2.1 (3.2)	21.4 (17.0)	13.3 (9.9)
Interrupted tundra (15)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.6 (2.0)	0.6 (2.0)	2.7 (4.2)	2.7 (4.2)	1.1 (3.9)	0.6 (1.9)	2.2 (4.1)	2.2 (4.1)	11.0 (10.6)	9.0 (9.6)
Low tundra (54)	16.6 (10.4)	10.7 (5.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.5 (3.6)	2.3 (3.4)	0.0 (0.0)	0.0 (0.0)	8.4 (8.5)	5.3 (5.7)	39.4 (19.1)	27.3 (12.6)
Rock outcrop (2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Sandflats (5)	0.0 (0.0)	0.0 (0.0)	2.0 (22.6)	2.0 (22.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.0 (22.6)	2.0 (22.6)
Tussocky tundra (16)	3.4 (10.4)	2.7 (8.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	3.4 (15.5)	2.1 (9.3)	17.2 (27.0)	15.1 (22.6)

[a] Mean number per square kilometre.
[b] 1994 and 1995 combined, ponds excluded.
[c] Number of habitat/plot combinations containing habitat type.
[d] Indicated breeding pairs (see Methods for definition).

group, like passerines, were cosmopolitan in distribution (Table 9).

Baird's Sandpiper, Red Phalarope, Stilt Sandpiper, and shorebird pairs as a group showed significant differences in use among habitats (ANOVA, $p < 0.05$; Table 3). Shorebird pairs overall, and Red Phalaropes in particular, showed a preference for low tundra ($p < 0.05$, GT2 family error test). Baird's Sandpipers used beach ridges/eskers significantly more often than other habitat types, and Stilt Sandpipers preferred raised and interrupted tundra over high-centre polygons and low, hummocky, or tussocky tundra ($p < 0.05$, GT2 test). Although the overall ANOVA was not significant for Dunlin, in pairwise comparisons, high-centre polygons and tussocky tundra were used more often than raised and interrupted tundra.

Figure 7
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk = beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra



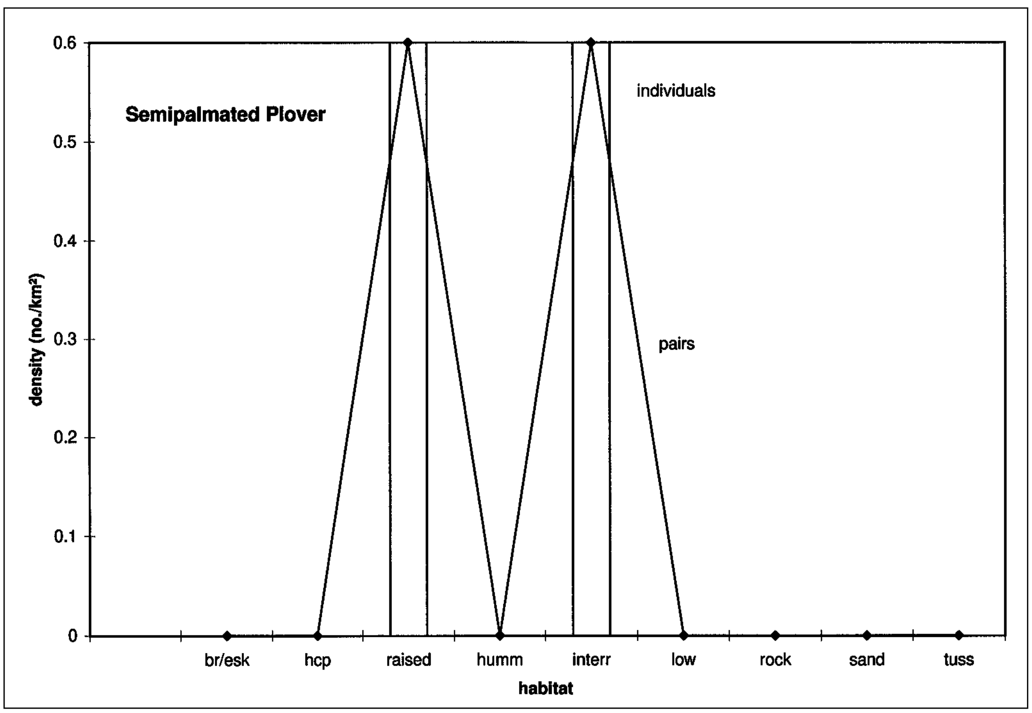


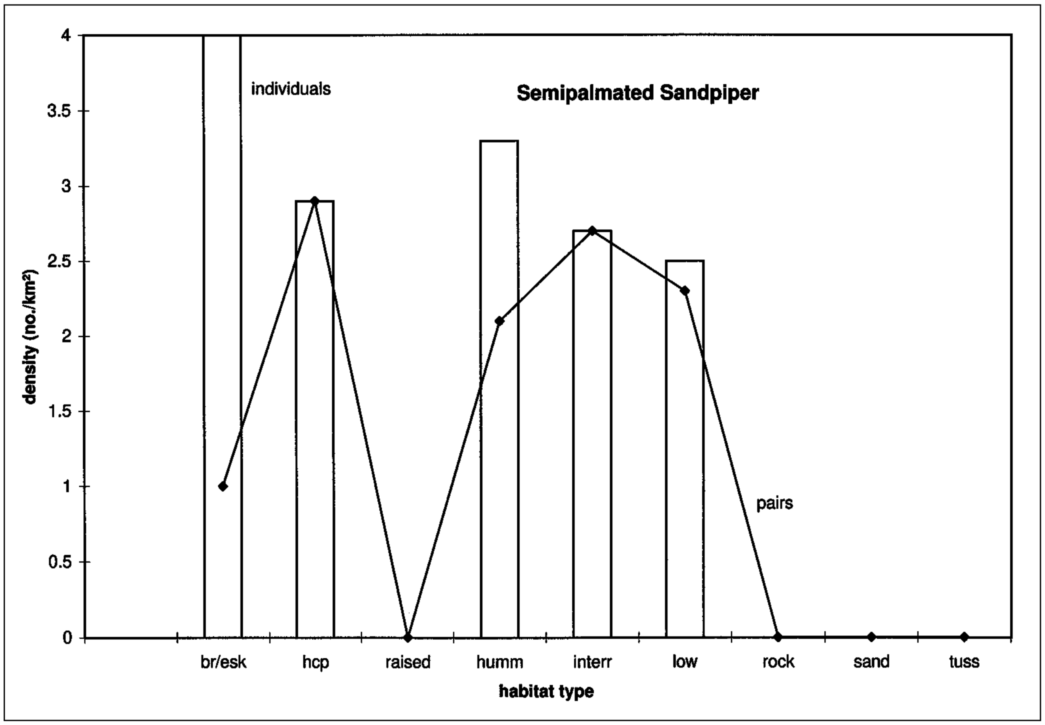
Figure7 continues

All birds taken as a group preferred low tundra to other habitat types (ANOVA, GT2, $p < 0.05$; Table 3). Passerines, particularly Lapland Longspurs, were found in high-centre polygons and raised, interrupted, and tussocky tundra more often than low tundra, beach ridges/eskers, sandflats, or rock outcrops (ANOVA, GT2, $p < 0.05$). Waterfowl did not exhibit a significant preference in habitat. Sample sizes for most other non-shorebird species were too small for statistical analysis.

4.3.2 Differences in bird populations between years

The first observed shorebird hatch was 11 days earlier in 1994 than in 1995 though nests were found within a day of start of study in both years. First observed hatch for Lapland Longspurs was identical in both years, and slightly (three days) earlier for waterfowl in 1994 (Table 7). There were no significant differences in bird densities between years. In a three-way ANOVA (unbalanced design) comparing habitat types, month, and year, year was never significant

Figure 7 (*cont'd*)
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk = beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra



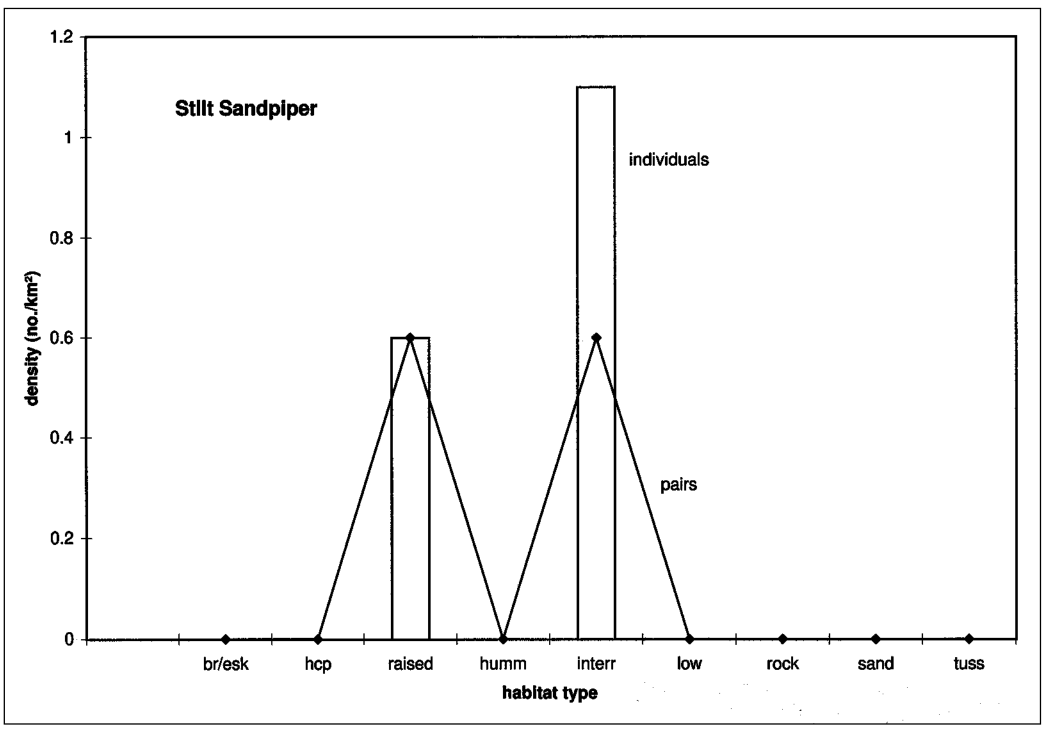
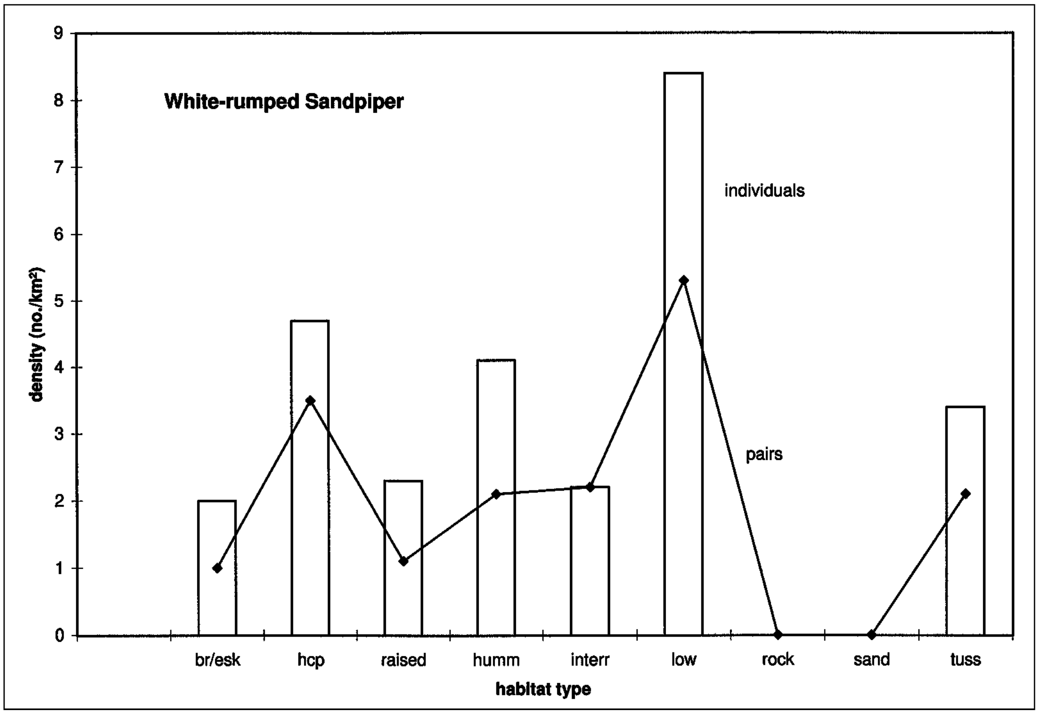


Figure 7 continues

($p > 0.05$). In pairwise comparisons, Red Phalaropes showed a significant decrease in medium-density habitats between June 1994 and June 1995 ($p = 0.009$). For non-shorebirds, Greater White-fronted Geese decreased in high-density habitats between July 1994 and July 1995 ($p < 0.05$).Two significant differences in bird density out of a possible total of 44 is no more than one would expect by chance (2/44 = 0.045). Therefore, we conclude that there were no consistent differences in bird densities between years of this study.

In nearly half of the nine most common shorebird species, however, there was a significant difference in pair densities by month ($p < 0.05$). Pairwise comparisons showed that these differences occurred between months in

Figure 7 (*cont'd*)
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk = beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra



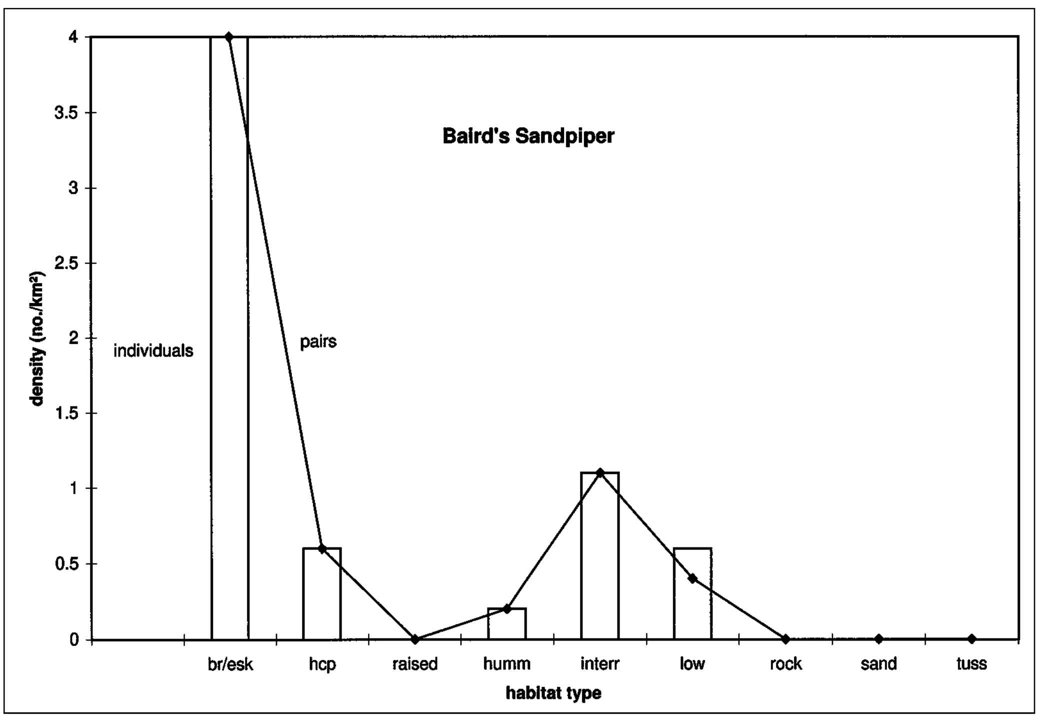
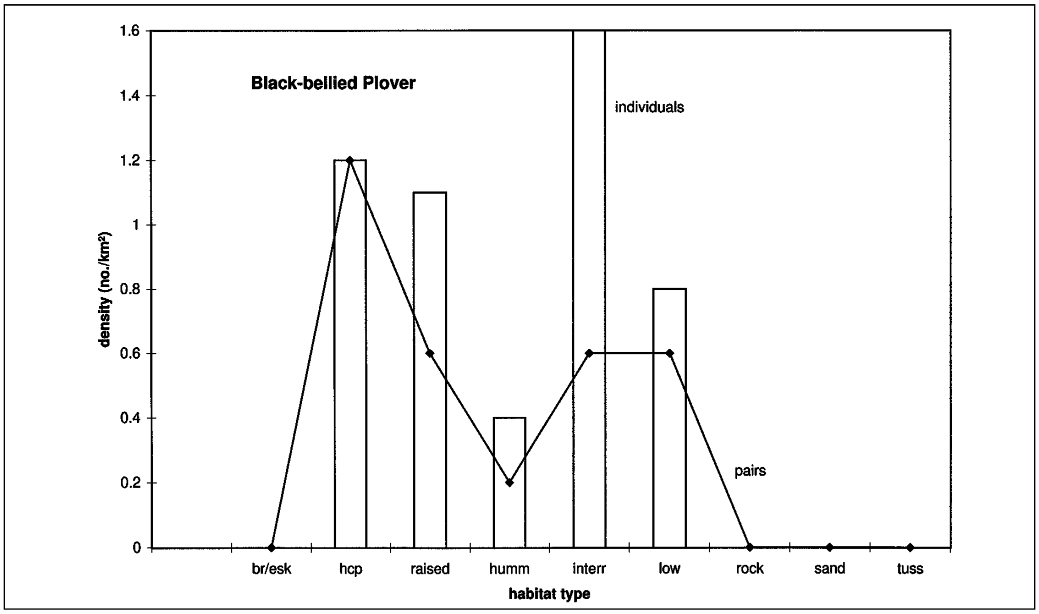


Figure 7 continues

high-density habitats for Dunlin ($p = 0.031$), Pectoral Sandpipers ($p = 0.0001$), Red Phalaropes ($p = 0.011$), and White-rumped Sandpipers ($p = 0.049$). Month was also a significant factor for passerines and for waterfowl ($p < 0.05$). In most cases (14/17), densities decreased between June and July. This is not unexpected because most shorebirds do not attempt to renest in the Arctic unless eggs are lost very early in the season. Failed breeders join nonbreeders and migrate south earlier than successful birds. The non-incubating parent of polygynous and polyandrous species leave the breeding areas early as well, and even in bi-parentally incubating species one parent (usually the female) often deserts the brood earlier than its mate (Gratto-Trevor 1991, 1994b).

Figure 7 (*cont'd*)
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk = beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra



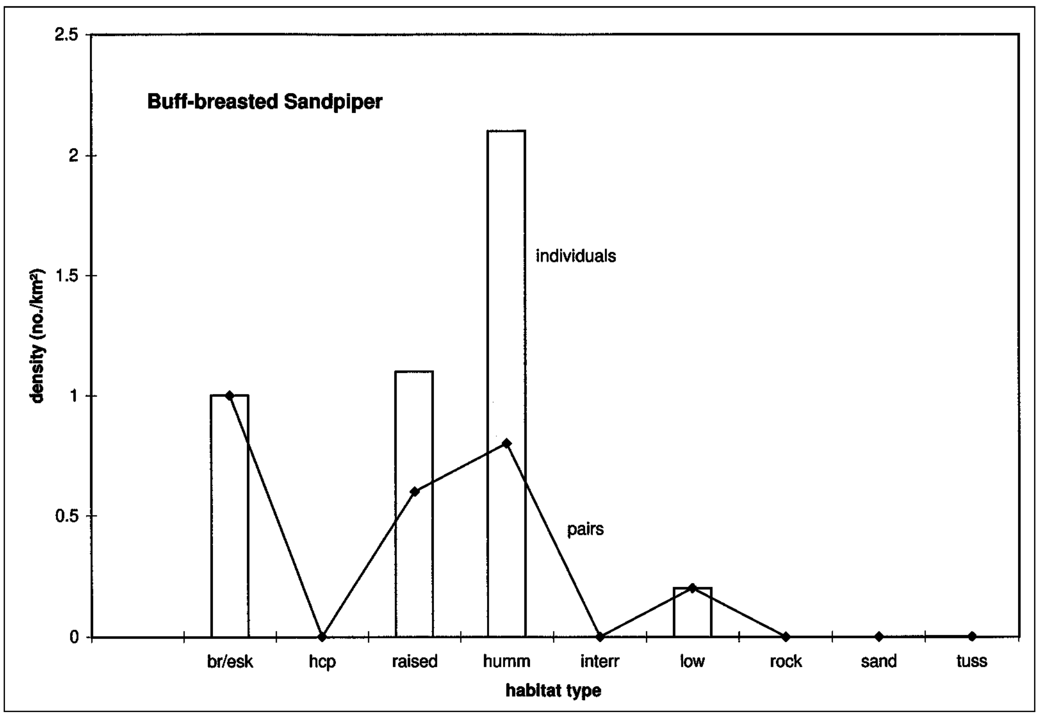


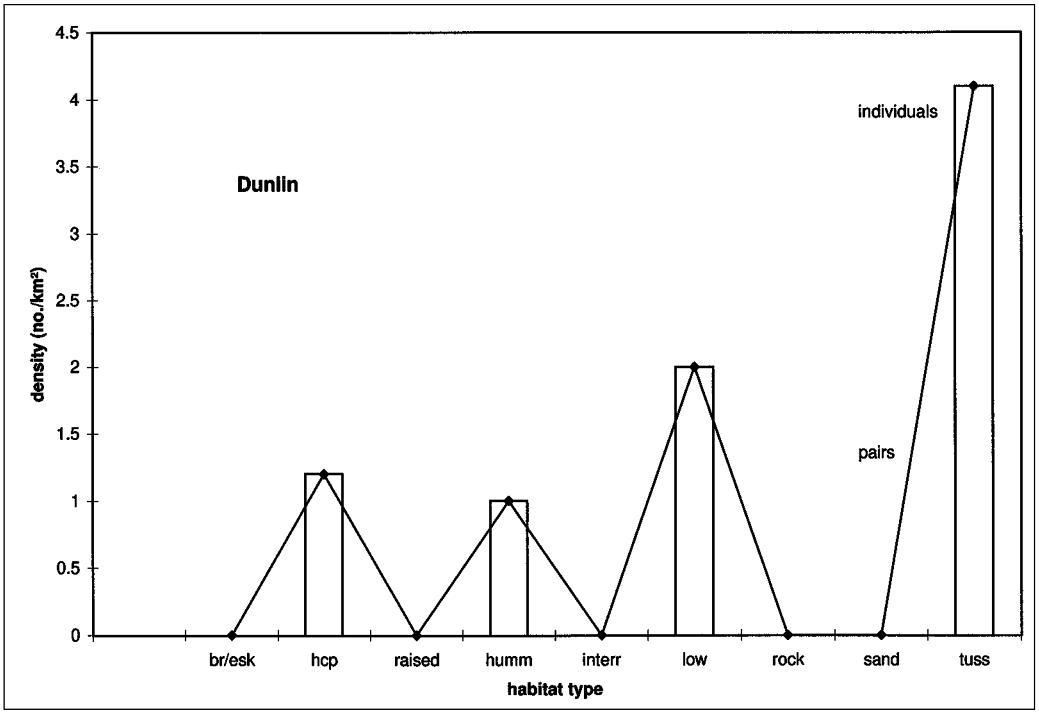
Figure 7 continues

4.3.3 Differences within plots

Eleven plots surveyed in 1994 were censused again in 1995. Overall there was a significant decrease in shorebird pairs ($p = 0.02$; mean difference = -2.8 pairs per plot, SD = 3.5) and total number of birds ($p = 0.01$; mean difference = -7.4 birds per plot, SD = 8.3), and a near-significant decrease in passerine numbers ($p = 0.06$; mean difference = -2.2 birds per plot, SD = 3.5) between 1994 and 1995 (paired t-tests). However, most (8/11) of the 1994 plots were censused in June, and most (8/11) of those same plots were censused in July in 1995 (Fig. 8). Month (June versus July) had much more effect on bird numbers in this study than did year (3-way ANOVA with habitat type, year, and month as main effects).

Similarly, in plots that were censused twice in 1995, there tended to be increasing differences in bird numbers as the time between survey dates lengthened (Fig. 9). Plots surveyed later in the same season tended to yield fewer birds.

Figure 7 (*cont'd*)
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk = beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra



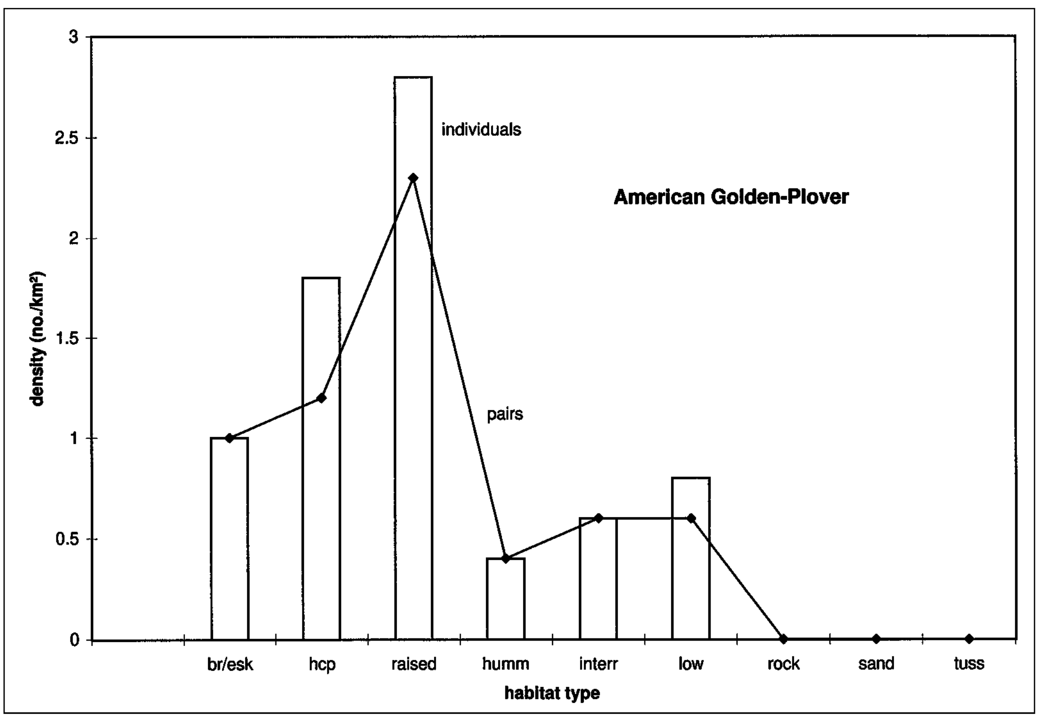


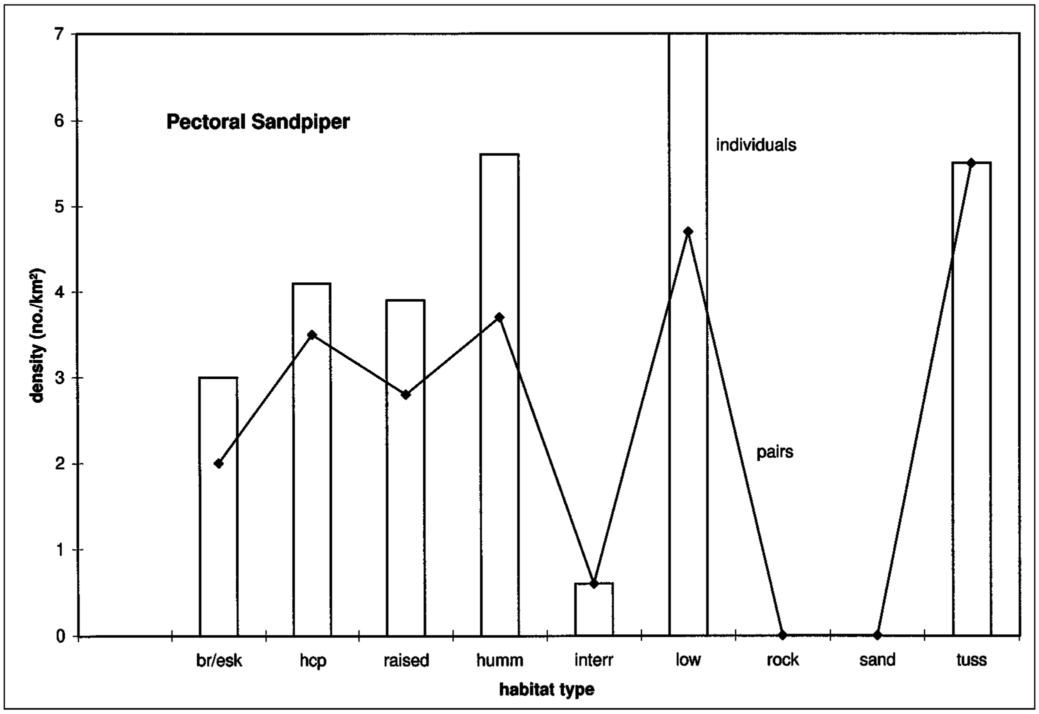
Figure 7 continues

4.4 Population estimates

Total population estimates of shorebird species breeding in our study area are presented in Table 10. Confidence intervals for each species are wide. Red Phalaropes were the most numerous shorebird in the lowlands followed by Pectoral Sandpipers and White-rumped Sandpipers. We estimate the total number of shorebird pairs of all species in the study area to be 94 557 ± 32 423.

Compared to other regions, Region 4 appears to have the most shorebirds of all species (Table 10). This is not surprising because Region 4 is nearly as large as the other three regions combined (3220 km² and see Table 6). However, it also had large proportions of habitat with high densities of shorebirds (60.5% and see Table 11). The relative abundance

Figure 7 (*cont'd*)
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk= beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra



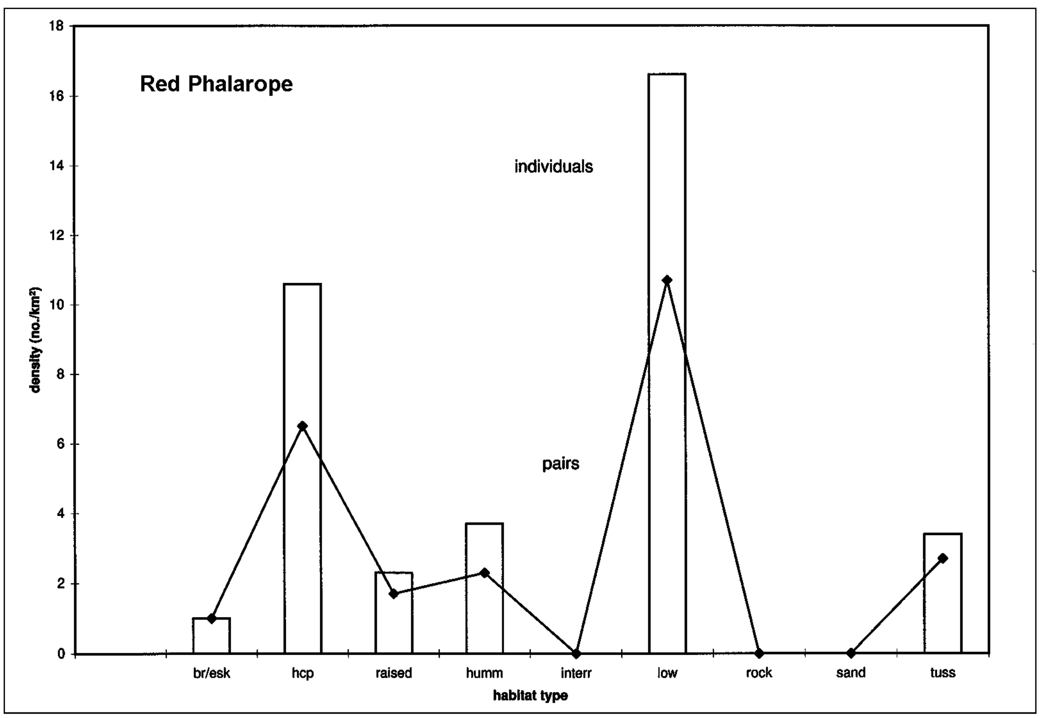


Figure 7 continues

of shorebird species in each region was consistent with rankings overall, except in Region 1 where Dunlin were more numerous than Semipalmated Sandpipers. In other regions and in the lowlands as a whole, Semipalmated Sandpipers were more numerous than Dunlin. Interestingly, though relative abundance of species was consistent, the region with the lowest amount of high-density habitat contained the highest number of observed shorebird species of any region (Region 1, 12 species). This region had the most even mix of high- and medium-density habitats, and so provided nesting sites for upland and lowland nesters. Conversely, Region 2 had the highest proportion of "good" habitat (70%) and the lowest observed shorebird species richness (6).

The most reliable non-shorebird population estimate was obtained for passerines; plot-based survey methods are

Figure 7 (*cont'd*)
Density of shorebird pairs in various habitats, Rasmussen Lowlands. Habitat types: br/esk = beach ridge/esker, hcp = high-centre polygons, raised = raised tundra, humm = hummocky tundra, interr = interrupted tundra, low = low tundra, rock = rock outcrop, sand = sandflats, tuss = tussocky tundra

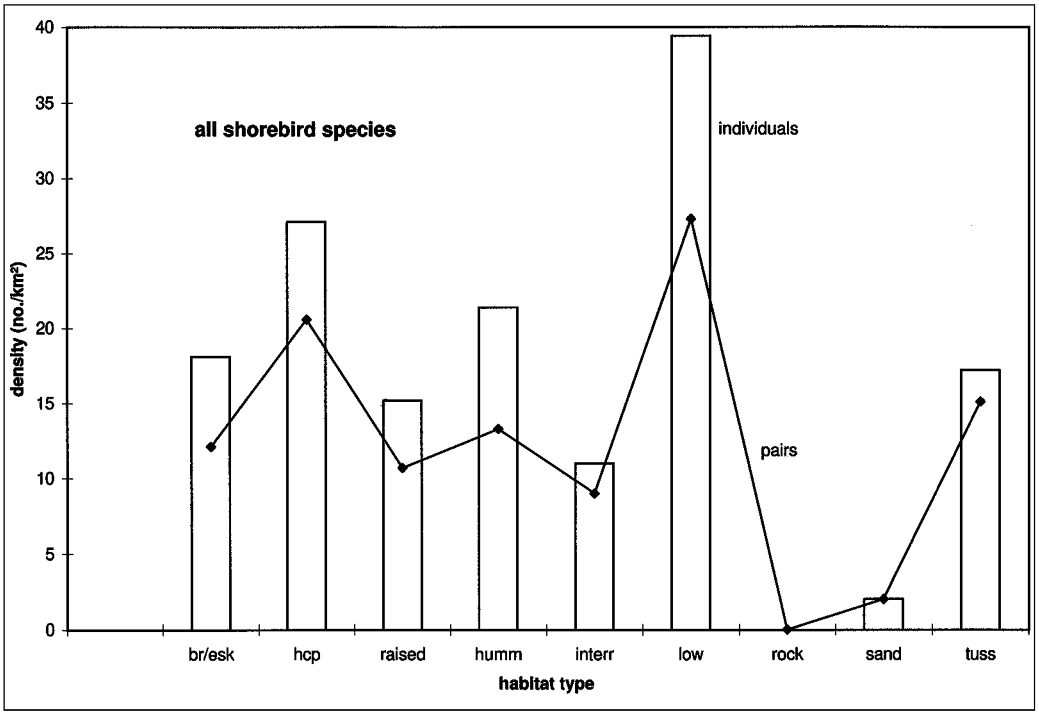


Table 9
Mean density[a] of non-shorebirds by habitat type, Rasmussen Lowlands, 1994 and 1995

	Passerines[b]		Waterfowl[c]		Loons[d]		Jaegers[e]		All non-shorebirds		All birds	
Habitat type (n)	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Beach ridge/esker (13)	9.1	12.5	2.0	4.8	0.0	0.0	0.0	0.0	13.1	14.7	31.2	28.1
High-centre polygon (14)	38.9	23.8	6.5	11.6	0.0	0.0	0.0	0.0	45.9	30.1	73.0	44.9
Raised tundra (28)	33.2	13.7	5.6	9.9	1.7	5.0	0.6	1.6	41.1	17.8	56.3	21.3
Hummocky tundra (48)	30.1	13.2	2.5	4.3	0.2	0.5	0.8	1.8	34.2	13.9	55.6	25.2
Interrupted tundra (15)	20.9	18.1	3.8	5.7	0.0	0.0	0.6	1.7	25.3	19.6	36.3	24.8
Low tundra (54)	17.4	11.4	11.7	14.5	1.6	4.2	1.6	3.0	35.3	20.0	74.6	33.2
Rock outcrop (2)	42.8	89.7	0.0	0.0	0.0	0.0	0.0	0.0	42.8	89.7	42.8	89.7
Sandflats (5)	0.0	0.0	6.0	45.0	0.0	0.0	0.0	0.0	6.0	45.0	8.0	67.5
Tussocky tundra (16)	31.0	14.1	1.4	5.1	0.0	0.0	0.0	0.0	33.0	15.8	50.2	36.7

[a] Mean number per square kilometre. Data for 1994 and 1995 combined.
[b] Lapland Longspur, Snow Bunting, and Horned Lark *Eremophila alpestris*.
[c] Greater White-fronted Goose, Canada Goose, Lesser Snow Goose, Oldsquaw, King Eider, and Sandhill Crane *Grus canadensis*.
[d] Pacific Loon *Gavia pacifica* and Red-throated Loon *Gavia stellata*.
[e] Long-tailed Jaeger *Stercorarius longicaudus* and Parasitic Jaeger *Stercorarius parasiticus*.

not well suited for many larger species such as waterfowl or loons. Lapland Longspurs were the most abundant birds in the Rasmussen area (Table 12). Greater White-fronted Geese were the second most numerous non-shorebird. The greatest number of individuals of all species were present in Region 4 (Table 12), though it had the lowest species richness. Relative abundance of non-shorebird species in each region was almost identical to their overall rankings in the lowlands.

4.5 Comparison with other arctic breeding sites

In terms of species richness, the Rasmussen Lowlands compares favourably with other studied sites; only Prudhoe Bay has more breeding shorebird species (Table 5). When densities of shorebird breeding pairs or individuals are compared, however, the lowlands rank lower than many other sites in the Mid and Low Arctic.

When comparisons are restricted to “most similar sites,” the Rasmussen Lowlands still rank high in terms of breeding species richness, and in the mid-range for total species richness. Again, they score low in terms of densities of shorebird pairs and densities of individuals (Table 13).

Figure 8
Changes in bird numbers within plots recensused in 1995, Rasmussen Lowlands

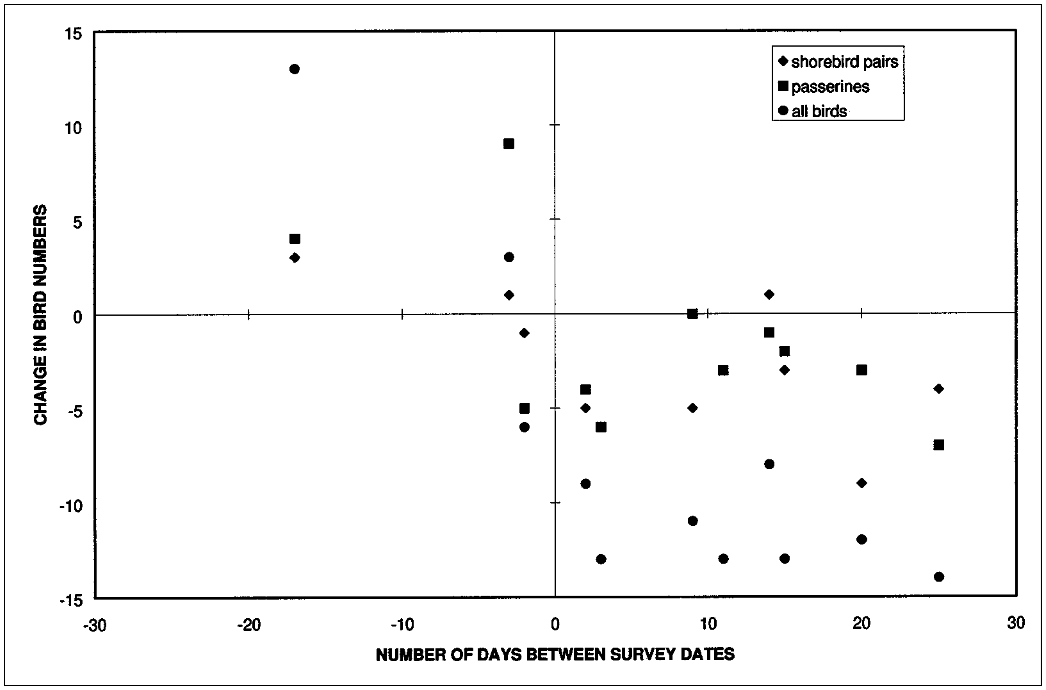
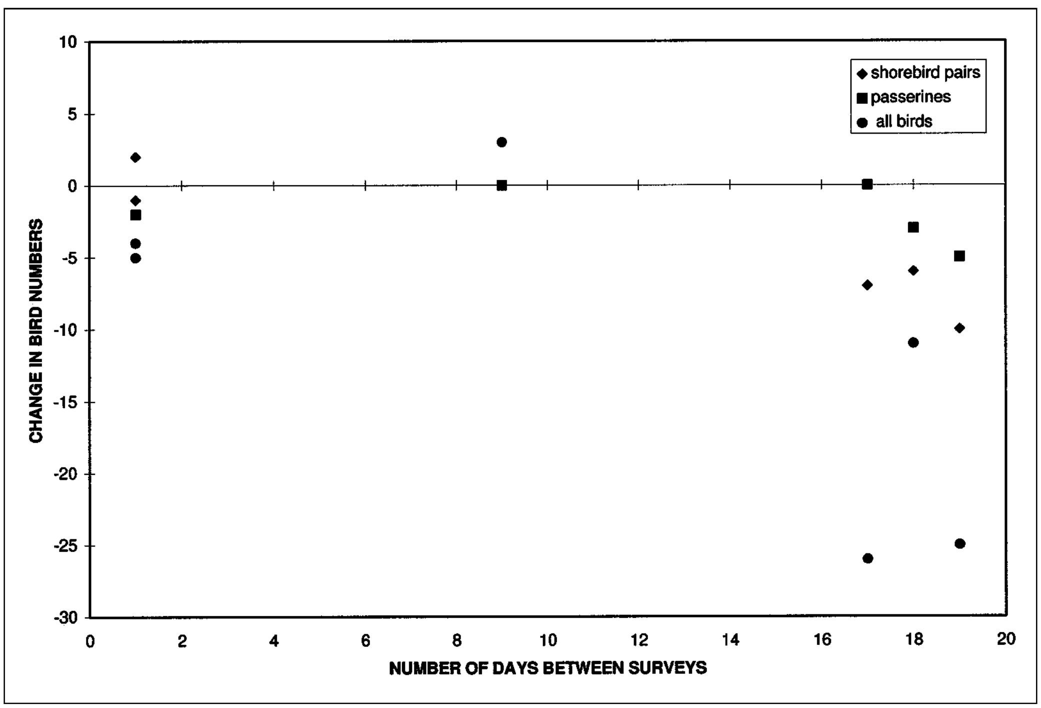


Figure 9
Changes in bird numbers in plots surveyed twice in 1995, Rasmussen Lowlands



On an individual shorebird species basis, the lowlands again rank low when compared to other sites, particularly "most similar" sites (Table 13). The exception is White-rumped Sandpipers, which bred in the lowlands in densities at the mid-range of other most similar sites. In most cases, shorebird densities reported for the lowlands in the 1970s (McLaren et al. 1977) rank distinctly higher relative to other sites than do our 1990s densities (Table 13).

Table 10
Population estimates by region for shorebirds in the Rasmussen Lowlands, ± 95% confidence limits (see Methods for calculations and Figure 1 for a map of the study area)

Species		Region 1 (102 683 ha)	Region 2 (67 436 ha)	Region 3 (178 490 ha)	Region 4 (321 952 ha)	Overall (670 561 ha)
Baird's Sandpiper	individuals	919 ± 1 025	416 ± 979	1 091 ± 2 216	1 913 ± 3 986	4 339 ± 3 797
	pairs	881 ± 959	369 ± 843	985 ± 1 940	1 719 ± 3 473	3 954 ± 3 353
Black-bellied Plover	individuals	879 ± 1 587	476 ± 1 352	1 202 ± 3 132	2 128 ± 5 596	4 685 ± 5 431
	pairs	428 ± 853	307 ± 809	737 ± 1 834	1 323 ± 3 296	2 795 ± 3 144
Buff-breasted Sandpiper	individuals	759 ± 2 075	548 ± 2 775	1 316 ± 5 943	2 364 ± 10 856	4 987 ± 9 866
	pairs	390 ± 1 085	259 ± 1 409	630 ± 3 029	1 128 ± 5 527	2 407 ± 5 042
Dunlin	individuals	656 ± 671	805 ± 1 394	1 808 ± 2 832	3 311 ± 5 253	6 580 ± 4 553
	pairs	656 ± 671	805 ± 1 394	1 808 ± 2 832	3 311 ± 5 253	6 580 ± 4 553
American Golden-Plover	individuals	1 153 ± 2 315	593 ± 1 762	1 513 ± 4 184	2 672 ± 7 428	5 931 ± 7 347
	pairs	958 ± 1 325	464 ± 1 091	1 198 ± 2 545	2 108 ± 4 540	4 728 ± 4 430
Pectoral Sandpiper	individuals	3 690 ± 2 748	3 212 ± 3 790	7 506 ± 8 080	13 586 ± 14 780	27 994 ± 13 381
	pairs	2 621 ± 2 298	2 285 ± 3 004	5 339 ± 6 453	9 664 ± 11 777	19 909 ± 10 735
Red Phalarope	individuals	4 238 ± 2 989	4 595 ± 5 322	10 457 ± 10 989	19 074 ± 20 289	38 364 ± 17 847
	pairs	2 846 ± 1 904	2 998 ± 3 147	6 844 ± 6 553	12 472 ± 12 069	25 160 ± 10 700
Ruddy Turnstone	individuals	72 ± 225	37 ± 195	292 ± 1 403	554 ± 2 696	955 ± 2 028
	pairs	n/a	n/a	n/a	n/a	n/a
Semipalmated Plover	individuals	235 ± 424	70 ± 213	205 ± 565	349 ± 976	859 ± 1 045
	pairs	235 ± 424	70 ± 213	205 ± 565	349 ± 976	859 ± 1 045
Semipalmated Sandpiper	individuals	2 181 ± 2 729	1 580 ± 3 781	3 790 ± 8 055	6 809 ± 14 736	14 360 ± 13 334
	pairs	1 537 ± 1 896	1 174 ± 2 415	2 794 ± 5 209	5 030 ± 9 496	10 535 ± 8 685
Stilt Sandpiper	individuals	412 ± 524	122 ± 263	359 ± 698	611 ± 1 205	1 504 ± 1 291
	pairs	235 ± 324	70 ± 163	205 ± 432	349 ± 746	859 ± 799
White-rumped Sandpiper	individuals	3 495 ± 3 233	3 083 ± 5 032	7 191 ± 10 558	13 021 ± 19 401	26 790 ± 17 316
	pairs	2 234 ± 2 054	1 919 ± 3 164	4 492 ± 6 648	8 126 ± 12 211	16 771 ± 10 911
Total shorebirds[a]	**individuals**	**18 689 ± 9 862**	**15 537 ± 13 161**	**36 730 ± 29 143**	**66 392 ± 53 383**	**137 348 ± 48 060**
	pairs	**13 021 ± 6 579**	**10 720 ± 8 761**	**25 237 ± 19 723**	**45 579 ± 36 174**	**94 557 ± 32 423**

[a] Includes unidentified shorebirds.

Table 11
Proportions of high-, medium-, and low-density shorebird habitat present in regions of the Rasmussen Lowlands

	Region 1		Region 2		Region 3		Region 4		Entire area	
Habitat	no. ha	% area	no. ha	% area	no. ha	% area	no. ha	% area	no. ha	% area
High density[a]	38 644	38	47 322	70	106 347	60	194 902	61	387 215	58
Medium density[b]	58 872	57	17 489	26	51 226	29	87 299	27	214 886	28
Low density[c]	5 167	5	2 625	4	20 917	12	39 751	12	68 460	10

[a] High-density habitats = low tundra, high-centre polygons, hummocky tundra, tussocky tundra.
[b] Medium-density habitats = raised tundra, interrupted tundra, and beach ridges/eskers.
[c] Low-density habitats = sandflats, rock outcrop.

Table 12
Population estimates by region for non-shorebird species in the Rasmussen Lowlands ± 95% confidence limits (see Methods for calculations and Figure 1 for extent of study area)

Species	Region 1 (102 683 ha)	Region 2 (67 436 ha)	Region 3 (178 490 ha)	Region 4 (321 952 ha)	Total (670 561 ha)
Lapland Longspur	22 973 ± 15 983	16 167 ± 18 933	40 121 ± 45 151	72 172 ± 82 694	151 525 ± 74 344
Horned Lark	1 191 ± 2 656	641 ± 2 724	1 619 ± 6 087	2 867 ± 10 985	6 319 ± 10 354
Snow Bunting	439 ± 1 112	227 ± 977	1 357 ± 3 877	2 547 ± 7 256	4 579 ± 6 020
Canada Goose	898 ± 3 005	619 ± 3 651	1 880 ± 11 664	3 433 ± 21 834	6 837 ± 18 167
Greater White-fronted Goose	3 446 ± 5 033	2 530 ± 9 852	6056 ± 20 137	10 885 ± 37 291	22 930 ± 32 496
Lesser Snow Goose	72 ± 96	37 ± 83	292 ± 598	554 ± 1 149	958 ± 864
King Eider	347 ± 1 396	426 ± 2 899	957 ± 5 890	1 753 ± 10 926	3 488 ± 9 469
Oldsquaw	195 ± 1 195	130 ± 1 749	315 ± 3 700	564 ± 6 783	1 204 ± 6 097
Tundra Swan	156 ± 750	82 ± 806	209 ± 1 787	369 ± 3 232	817 ± 3 025
Pacific Loon	605 ± 3 856	359 ± 4 387	890 ± 9 631	1 585 ± 17 469	3 440 ± 16 221
Red-throated Loon	77 ± 385	95 ± 800	213 ± 1 625	390 ± 3 014	775 ± 2 612
Sandhill Crane	154 ± 554	189 ± 1 149	426 ± 2 336	779 ± 4 333	1 550 ± 3 755
Snowy Owl	235 ± 1 052	70 ± 529	205 ± 1 402	349 ± 2 419	858 ± 2 591
Parasitic Jaeger	309 ± 1 123	379 ± 2 332	851 ± 4 739	1 558 ± 8 791	3 101 ± 7 618
Long-tailed Jaeger	313 ± 1 076	165 ± 945	418 ± 2 175	739 ± 3 894	1 633 ± 3 760
Glaucous Gull	309 ± 2 271	379 ± 4 714	851 ± 9 579	1 558 ± 17 770	3 101 ± 15 400
Rock Ptarmigan	77 ± 297	95 ± 616	213 ± 1 252	390 ± 2 323	775 ± 2 013

Table 13
Shorebird species densities[a] in sites "most similar" to the Rasmussen Lowlands

	Red Phalarope		White-rumped Sandpiper		Pectoral Sandpiper		Semi-palmated Sandpiper		American Golden-Plover		Dunlin		Black-bellied Plover		Buff-breasted Sandpiper		Baird's Sandpiper	
Study site	ind.	prs.	ind.	prs.	ind.	prs.	ind.	prs.	ind.	prs.	ind.	prs.	ind.	prs.	ind.	prs.	ind.	prs.
Rasmussen (1990s)	4.2	2.8	3.0	1.9	3.3	2.5	1.7	1.2	0.8	0.4	0.9	0.9	0.5	0.4	0.5	0.2	0.7	0.7
Rasmussen (1970s)	17.4	n/a	4.2	n/a	5.0	n/a	1.7	n/a	4.2	n/a	0.4	n/a	2.5	n/a	0.0	0.0	0.2	n/a
Sarcpa Lake	n/a	0.3	n/a	1.5	n/a	0.1	n/a	0.1	n/a	3.8	n/a	0.1	0.0	0.0	0.0	0.0	n/a	3.9
Prudhoe Bay	n/a	6.8	n/a	0.6	n/a	8.7	n/a	12.5	n/a	2.7	n/a	7.5	n/a	0.6	n/a	0.9	n/a	0.7
Creswell Bay	12.3	n/a	11.1	n/a	4.3	n/a	0.2	n/a	1.3	n/a	0.0	0.0	2.2	n/a	1.3	n/a	0.7	n/a
Igloolik Island	n/a	5.0	n/a	3.5	0.0	0.0	n/a	1.5	n/a	0.3	0.0	0.0	n/a	0.5	0.0	0.0	0.0	0.0
Storkerson Point #1	37.0	n/a	0.0	0.0	22.0	n/a	20.0	n/a	3.8	n/a	21.2	n/a	0.6	n/a	10	n/a	4.0	n/a
Storkerson Point #2	15.6	n/a	0.0	0.0	3.8	n/a	11.0	n/a	0.1	n/a	9.0	n/a	0.0	0.0	0.0	0.0	0.0	0.0
Prince Charles Island	n/a	16.6	n/a	15.7	0.0	0.0	n/a	1.2	n/a	0.3	0.0	0.0	n/a	1.7	0.0	0.0	0.0	0.0
Mackenzie Delta	0.0	0.0	0.0	0.0	n/a	0.1	n/a	1.4	n/a	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] Mean number per square kilometre.

5. Discussion

5.1 Shorebird distribution and abundance

The summer bird community of the Rasmussen Lowlands is a mix of species with high- and low-arctic, and even subarctic, affiliations. This is to be expected as the study area is categorised as a transition region between low- and mid-arctic vegetation and ecological zones (Bird 1967; Edlund 1982; Ecological Stratification Working Group 1996). The species composition of breeding shorebirds is very similar to that reported from Sarcpa Lake, at roughly the same latitude on the Melville Peninsula (Montgomerie et al. 1983; Fig. 5). Our discovery of nesting Stilt Sandpipers extends the breeding range of this species eastward from the Queen Maud Gulf area (Godfrey 1986). McLaren et al. (1977) suspected that the species nested in the Spence Bay area in the 1970s but were unable to confirm it.

Generally, shorebird species were found in their expected habitats, based on previous experience and other studies. Our estimates of pair densities by habitat show that in the Rasmussen Lowlands, as in most other breeding locations, low, well-vegetated habitats (low tundra, hummocky tundra, high-centre polygons) consistently contained the highest densities of shorebirds (Table 8). Red Phalaropes in particular exhibited a highly significant preference for low tundra habitat. On an individual species basis other habitats were clearly of importance too (see Section 4.3.1), and this is reflected in the diversity of species in a given area. For example, region 2 had a high proportion of "good" shorebird habitat, and consequently high densities of birds that favour this kind of habitat (Red Phalarope). However, birds that were found in medium-density habitats in smaller numbers were missing from the region, and it had a lower shorebird species diversity. Only rock outcrop was completely devoid of shorebirds.

5.2 Effects of weather on study results

Densities of pairs did not differ between years, and we have no real evidence that nesting began earlier in 1994, the warmer year. Weather conditions on arctic breeding grounds can have a pronounced effect on date of nest initiation, timing of hatch, and ultimately annual production of shorebird young (West and Norton 1975; Green et al. 1977; Mayfield 1983; Meltofte 1985; Gratto-Trevor 1994b). This occurred in the lowlands in 1976 (a season of late snowmelt and cool temperatures) when birds nested an average of two weeks later than in 1975 (a year characterised by early snowmelt and warm temperatures; McLaren et al. 1977). In extremely cold years with late snowmelt, breeding may be abandoned entirely (Green et al. 1977; Mayfield 1978). In 1994 and 1995, however, temperature differences (and related differences in timing of snowmelt) were apparently not great enough to invoke such a drastic response in nesting birds here. Montgomerie et al. (1983), whose study on the Melville Peninsula contrasted a "normal" season with one of late spring melt, found that average breeding shorebird densities and phenologies did not change appreciably from year to year (maximum one day difference). Farther south, near Churchill, in a year of very late snowmelt, nesting of Snow Geese was delayed almost a month, but Semipalmated Sandpipers nested on time and in normal numbers (Gratto-Trevor 1991). In that area and probably others, nest initiation of arctic shorebirds may be less dependent on timing of snowmelt than availability of food for egg production, which depends both on weather conditions early in the season and on water levels. Even one or two days of sunny weather was enough to increase invertebrate availability and initiate shorebird egg-laying.

5.3 Comparison with other arctic breeding sites

There are limited resources available for the establishment and ongoing management of national wildlife areas and migratory bird sanctuaries throughout Canada. These limitations are particularly acute in northern Canada where the logistical costs associated with protected area management are high. CWS's national habitat program uses a number of criteria to assess the eligibility of a given area for inclusion in the national wildlife area network (Canadian Wildlife Service 1994; Appendix 5). The Northern Conservation Division of CWS uses these criteria plus a community support component to priorise sites within the Northwest Territories and Nunavut (Appendix 5). Both sets of criteria employ "percentage of national population using site" as a major biological criterion in their assessments. This works well for better-studied species (e.g. waterfowl and some seabird species) but is inadequate for shorebirds, for whom breeding populations are often poorly delineated and total population estimates are very broad (Morrison et al. 1994a). For this study we elected to use a combination of species richness, density comparisons, assessment of available habitat, and percentage of national population as the biological criteria for shorebirds. Population percentages alone are used for other species.

5.3.1 Shorebirds

The lowlands is situated in a transition zone for breeding shorebirds, and has a high species richness relative to other sites. For at least seven of the species under study here, the Rasmussen Lowlands is near the edge of their breeding range. For these species, low densities relative to “core” breeding areas are not necessarily indicative of the importance of the lowlands to the species as a whole. Genetic variability is recognized for some shorebird species (Haig et al. 1997). There is considerable interest in the conservation community about the implications of genetic variability in “edge of range” individuals for continued maintenance of the species as a whole. From this perspective, the lowlands’ high diversity of breeding shorebird species makes it an area worthy of protection.

Variety among sites due to location, study timing and duration, and weather conditions during studies all play a confounding role in comparing densities among sites. For example, studies conducted over several seasons will average out the effect of weather on breeding bird numbers, yet will make a site rank low in comparison to an area where censuses were conducted only in a good breeding year. Choice of census sites and subsequent method for calculation of total densities can also have a marked influence on one’s interpretation of a site’s relative importance. If census plots or transects are chosen non-randomly, or if densities are not corrected for habitat availability in the entire area under study, total density estimates are biased upwards. Because our methodology accounts for these biases, our bird densities are minimum estimates. This may not be the case for some of the other studies that we cite in comparisons. We have attempted to account for these variables by focussing on comparisons with “most similar” sites, where methods of site selection and density calculation are used to rank sites (Table 5).

One must also consider the great variation in breeding biology among different shorebird species. Some species (e.g. Dunlin [Warnock and Gill 1996]; Semipalmated Sandpiper [Gratto et al. 1985]) are highly philopatric to their nesting areas and will breed there year after year. Others, such as Red Phalarope (Colwell et al. 1988), Buff-breasted Sandpiper (Lanctot and Laredo 1994), and Pectoral Sandpiper (D. Troy, pers. commun.), have little fidelity to a particular breeding ground and their numbers show large annual fluctuations in a given area. Comparisons between the site-constant species may be more reliable than others, because there should be less year-to-year variation in their numbers. However, the lowlands’ relative ranking does not change when one restricts density comparisons to these species (Table 13).

Finally, comparison of our study results with those of others is confounded by chronological time in which the study was conducted. Our overall shorebird densities declined by close to 50% from those recorded in the mid-1970s. Gratto-Trevor et al. (1998) concluded that conditions on the breeding grounds have changed little, so causes for this decline must lie outside of the lowlands. If this is the case, similar declines may have happened elsewhere in the Arctic but have gone unnoticed. Studies that we used for comparison were conducted over a wide time period (anywhere from 0 to approximately 50 years before our study). Nineteen of them occurred within 10 years of McLaren et al.’s study, whereas only four occurred within 10 years of our study (and none occurred after ours).

Although densities of breeding shorebirds in the Rasmussen Lowlands are only moderate when compared to results from other arctic studies, the lowlands contain extensive areas of good shorebird habitat. This results in population estimates of national importance for a number of shorebird species (see Section 5.5).

5.3.2 Other birds

The lowlands also compare favourably to other sites within the breeding range of several non-shorebird species. Surveys for waterfowl were conducted by J. Hines and M. Kay in 1994 and 1995 in the Rasmussen area. Results from those surveys indicate that lowlands populations of White-fronted Geese and Tundra Swans are at or near 5% of the total estimated populations of those species/races. The Rasmussen population of small Canada Geese is over 1% of the total estimated population (Table 14). The size of the eastern arctic (generally, those areas east of Coronation Gulf and north of Hudson Bay) King Eider population is unknown, but the lowlands appear to host more than 1% of the total eastern arctic population (Hines, pers. commun.).

Raptor surveys conducted by C. Shank in 1995 detected 30 Peregrine Falcon nests and four additional peregrine pairs on the escarpment bordering the lowlands. He estimated Peregrine Falcon densities of one per 80 km^2, which is similar to high-density raptor areas in mainland Northwest Territories (Shank 1995).

The only passerine that is widespread and abundant in the lowlands is the Lapland Longspur. The population status of this species is poorly defined, but Longspur densities in the lowlands are not particularly high in comparison to other sites (Table 4).

5.4 Changes in bird populations over time

Bird studies conducted in 1975 and 1976 by McLaren et al. (1977) give us a unique opportunity to assess change in bird use of the study area over a 20-year time period. Gratto-Trevor et al. (1998) undertook a detailed comparison of this study’s results and those of McLaren’s group. Methodologies between the two studies were similar, and habitat classifications and data analysis were standardised to permit valid comparisons. Gratto-Trevor et al. concluded that Red Phalaropes, Black-bellied Plovers, and American Golden-Plovers decreased significantly and sharply between the two study periods by densities per habitat type and by overall population size (Table 15, Fig. 10). Red-necked Phalaropes *Phalaropus lobatus*, which McLaren et al. (1977) considered to be a rare breeding species in the lowlands, were not seen at all in the 1990s. Other shorebird species did not exhibit significant changes in population size, though in some cases population estimates showed large decreases (e.g. White-rumped Sandpipers; Table 15). Shorebirds as a group declined in all habitat types between the two studies, as did non-shorebirds as a group and all birds.

Are shorebird populations, particularly the large plovers and the phalaropes, truly declining in the lowlands,

Table 14
Population estimates of selected large bird species in the Rasmussen Lowlands, 1975–76 and 1994–95

Species	Population estimate		Trend (%)	% of Canadian population (based on 1994–95 estimates)
	1975–76[a]	1994–95[b]		
Greater White-fronted Goose	6 941	15 374	↑(+220)	4.6 (midcontinent population)
Canada Goose	521	3 709	↑(+712)	2.2 (tall grass prairie population)
Tundra Swan	3 818	3 822	=	3.8 (eastern population)
Lesser Snow Goose	3 818	38 294	↑(+1003)	1.0 (midcontinent population)
King Eider	22 560	6 187	↓(-27)	likely >1% eastern population
Oldsquaw	8 677	1 990	↓(-23)	?
Red-throated Loon	486	4 07[c]	=	?
Pacific Loon	764	870	=	?
Sandhill Crane	764	896	=	?

[a] From McLaren et al. (1977). Adjusted for size of study area (their figures multiplied by 0.69).
[b] From Hines and Kay (unpublished data).
[c] 1994 data only.

Table 15
Population estimates of shorebird species in the Rasmussen Lowlands, 1975–76 and 1994–95[a]

	Population estimate			
Species[b]	1975	1976	1994–95	Trend (% difference)[c]
Black-bellied Plover	37 164	33 356	4 686	↓(-87)*
American Golden-Plover	33 649	23 993	5 932	↓(-75 to -82)*
Semipalmated Sandpiper	23 993	11 997	14 369	= (-40 to +16)
White-rumped Sandpiper	61 153	43 012	26 813	↓(-38 to -56)
Baird's Sandpiper	13 168	878	4 340	= (-67 to +80)
Pectoral Sandpiper	17 263	50 620	28 017	= (+38 to -44)
Dunlin	13 167	6 730	6 589	= (-2 to +50)
Buff-breasted Sandpiper	13 167	2 633	4 990	= (-42 to +47)
Red Phalarope	133 133	193 409	38 406	↓(-71 to -80)*

[a] 1975 and 1976 figures from McLaren et al. (1977); 1994–95 combined estimates from this study.
[b] Only species for which McLaren et al. reported 1975 and 1976 figures are included.
[c] *Denotes statistically significant ($p < 0.05$) differences between 1975–76 and 1994–95.

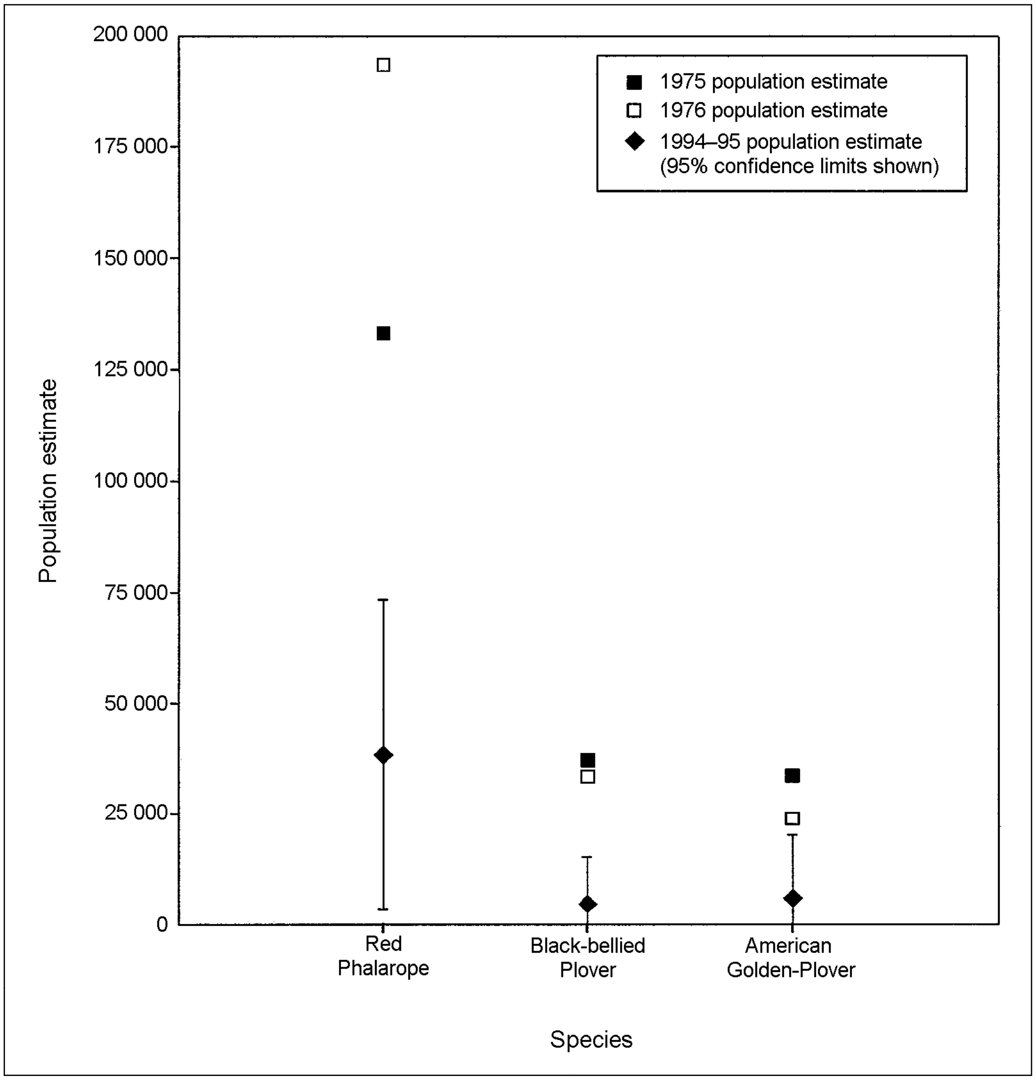
or are differences in survey methodology and year-to-year variation to account for this trend? Gratto-Trevor et al. assert that if anything, methodological differences between studies should have resulted in increased population estimates in the 1990s. McLaren's 1976 survey season was unusually cold, and nest initiation was delayed by up to two weeks. This would tend to decrease the 1970s estimates relative to ours.

The two plover species that exhibited significant population declines show strong fidelity to breeding site, among males at least (Paulson 1995; Johnson and Connors 1996). If differences between the 1970s and 1990s were due to movements between breeding areas, species exhibiting high breeding philopatry would be expected to exhibit the smallest decreases. This was not the case.

It is difficult to compare changes in shorebird populations in the lowlands with changes elsewhere in these species' ranges. Recent, long-term studies on the arctic breeding grounds are rare, particularly in the central and eastern Arctic. At Prudhoe Bay in Alaska, D. Troy monitored breeding bird and nest densities from 1981 to 1992 (TERA 1993). He found a significant downward trend in Dunlin densities. No other shorebirds exhibited significant downward trends, though significant among-year differences in nest densities were recorded for Pectoral Sandpipers and Red Phalaropes. Dunlin populations in the lowlands did not appear to change significantly between the 1970s and the 1990s (Gratto-Trevor et al. 1998). Dunlins breeding at Prudhoe Bay and Rasmussen Lowlands are thought to belong to different subspecies (Warnock and Gill 1996), so comparisons between the two may not be very useful.

Continent- or subpopulation-wide estimates of species population size are vague for most shorebird species that breed in the lowlands, and even trends in population are tentative (Morrison et al. 1994a). However, there is some evidence that shorebird populations are declining. Analysis of data from the International Shorebird Survey (Howe et al. 1989) and the Maritimes Shorebird Survey (Morrison et al. 1994b) highlighted near-significant decreases in Black-bellied Plover populations in the period 1974–83. The draft Canadian Shorebird Conservation Plan (Morrison et al. 1998) lists Black-bellied Plovers and Semipalmated Sandpipers as species with significant declines in eastern North America; a further five species (American Golden-Plover, Semipalmated Plover, Dunlin, Buff-Breasted Sandpiper, and Red Phalarope) that nest in the lowlands are reported to have declining population trends below the level of significance. So, although Gratto-Trevor et al.'s findings are not

Figure 10
Difference in estimated populations of selected shorebird species between the 1970s and the 1990s, Rasmussen Lowlands



conclusively supported by species population trends from other studies, neither are they rejected.

Gratto-Trevor et al. (1998) report that King Eiders showed a significant decline in abundance in the lowlands between the 1970s and the 1990s. The data also show that Greater White-fronted Geese increased over the same time period. These findings are supported by Hines and Kay's 1994 and 1995 aerial surveys (Table 14). They found that populations of all three goose species increased, and Oldsquaw and King Eiders decreased sharply. Numbers of other large birds remained constant. Lesser Snow Geese increased dramatically, which is consistent with the explosion of white goose populations across the Arctic (Kerbes 1996). Greater White-fronted Geese and Canada Geese are also showing population increases in many parts of their range (Ely and Dzubin 1994; Dilworth-Christie and Dickson 1997). King Eider population sizes are ill-defined; however, there is concern about declines from parts of the species' breeding range (Turner et al. 1996), and hunters in the Rasmussen area have expressed concern about decreasing King Eider numbers (McCormick, pers. commun.). Shank (1995) reported a sharp increase in the number of Peregrine Falcons nesting adjacent to the lowlands between the 1970s and the 1990s. This parallels the recovery of Peregrine Falcon populations elsewhere (RENEW 1996).

5.5 Conservation recommendations

From a biological perspective, the Rasmussen Lowlands is a suitable candidate for national wildlife area status. The major qualifying features indicated by our study are as follows:

- high shorebird species richness
- four shorebird species (Buff-breasted Sandpiper, Pectoral Sandpiper, American Golden-Plover, and White-rumped Sandpiper) present in numbers above 5% of national population estimates, and a further three (Black-bellied Plover, Baird's Sandpiper, and Red Phalarope) above 1% of national population estimates (Table 16)
- high proportions of suitable bird habitat

Table 16
Population trends and estimates of shorebird species present in the Rasmussen Lowlands[a]

Species	Trend (North American, Canadian populations)	Trend (Rasmussen)	Canadian estimate	Rasmussen estimate	Rasmussen % of population[b]
Black-bellied Plover	=?, ↓	↓	50 000	4 686	3.1
American Golden-Plover	=?	↓	100 000+	5 932	5.9
Semipalmated Plover	=?	?	50 000	858	0.6
Ruddy Turnstone	=?, =	?	235 000	958	0.4
Semipalmated Sandpiper	=, ↓?	=?	3 550 000	14 369	0.4
White-rumped Sandpiper	=?	↓?	500 000	26 813	5.4
Baird's Sandpiper	=?	=?	300 000	4 340	1.4
Pectoral Sandpiper	=?	=	250 000	28 017	11.2
Dunlin	=?, ?	=	1 000 000	6 589	0.6
Stilt Sandpiper	=?	=?	200 000	1 502	0.8
Buff-breasted Sandpiper	↓?	↓?	15 000	4 990	33.3
Red Phalarope	=?	↓	920 000	38 406	4.2

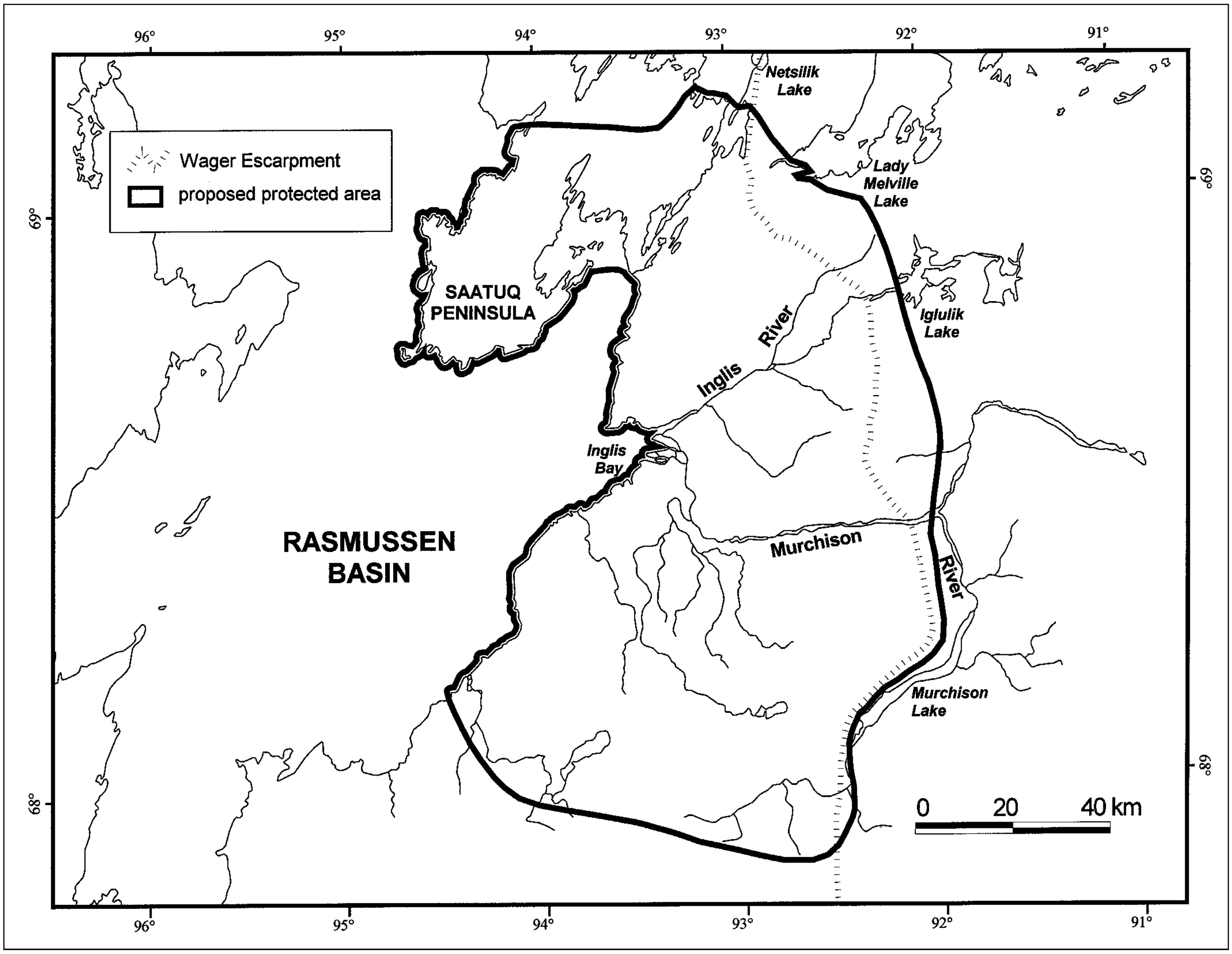
[a] North American and Canadian trends and estimates from Morrison et al. (1998) and Morrison et al. (1999); Rasmussen trends and estimates from this study.
[b] Percentage of Canadian population accounted for by Rasmussen population.

- area of transition between low- and mid-arctic climatic and ecological zones
- at or near 5% of national populations of Greater White-fronted Goose (midcontinent population) and Tundra Swan (eastern population)
- over 1% of national populations of Canada Goose (tall grass prairie population), Lesser Snow Goose (midcontinent population), and likely King Eider (eastern population)
- high-density nesting area for Peregrine Falcon

A proposed national wildlife area should include all of the features listed above. The highest proportions of "good" shorebird habitat occur in regions 2, 3, and 4, but the highest diversity of shorebird species is found in region 1. Regions 2 and 3 contained the highest densities of waterfowl. For all birds except raptors and passerines, nesting densities decrease as one moves inland from the coast toward the bordering escarpments. However, nesting peregrines attain their highest densities on the escarpments. Though outside of the area of the present study, aerial surveys showed that the adjacent Saattuq Peninsula contained high numbers of King Eiders and Canada Geese (Hines and Kay, pers. commun.).

A boundary that includes all of these important areas is outlined in Figure 11. We recommend this boundary as a starting point when discussions regarding conservation area status for the lowlands commence.

Figure 11
Recommended National Wildlife Area boundary, Rasmussen Lowlands



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Appendices

Appendix 1
Plants identified from the Rasmussen Lowlands, 1994 and 1995

Equisetaceae — Horsetail family	
Equisetum arvense	horsetail
Lycopodiaceae — Club Moss family	
Lycopodium selago	Mountain club moss
Gramineae — Grass family	
Alopecurus alpinus	foxtail
Arctagrostis latifolia	grass
Calamagrostis stricta	reed-bentgrass
Deschampsia brevifolia	hairgrass
Dupontia Fisheri	grass
Dupontia sp.	grass
Elymus arenarius	lyme grass
Festuca baffinensis	fescue
Festuca brachyphylla	fescue
Festuca sp.	fescue
Hierochloe alpina	holy grass
Hierochloe pauciflora	holy grass
Poa arctica	bluegrass
Cyperaceae — Sedge family	
Carex aquatilis	sedge
Carex atrofusca	sedge
Carex Bigelowii	sedge
Carex membranacea	sedge
Carex misandra	sedge
Carex rariflora	sedge
Carex saxatilis	sedge
Carex scirpoidea	sedge
Carex subspathacea	sedge
Eriophorum angustifolium	cotton grass
Eriophorum Scheuchzeri	cotton grass
Eriophorum vaginatum	cotton grass
Kobresia myosuroides	sedge
Juncaceae — Rush family	
Juncus arcticus	rush
Luzula confusa	wood rush
Luzula nivalis	wood rush
Luzula Wahlenbergii	wood rush
Salicaceae — Willow family	
Salix arctica	willow
Salix herbacaea	least willow
Salix reticulata	net-veined willow
Betulaceae — Birch family	
Betula glandulosa	dwarf birch
Polygonaceae — Buckwheat family	
Oxyria digynia	mountain sorrel
Polygonum viviparum	alpine bistort
Caryophyllaceae — Pink family	
Cerastium regelii	mouse-ear chickweed
Silene acaulis	moss campion
Silene involucrata	bladder campion
Silene uralensis	bladder campion
Stellaria crassipes	chickweed
Ranunculaceae — Crowfoot family	
Caltha palustris	marsh marigold
Ranunculus gmelinii	buttercup
Ranunculus nivalis	snow buttercup
Ranunculus Pallasii	Pallas' buttercup
Ranunculus Sabenei	buttercup
Ranunculus sulphureus	buttercup
Papaveraceae — Poppy family	
Papaver radicatum	arctic poppy
Cruciferae — Mustard family	
Cardamine pratensis	bitter cress
Cardamine bellidifolia	bitter cress
Cochlearia officinalis	scurvy grass
Draba alpina	whitlow grass
Draba corymbosa	whitlow grass
Draba lactea	whitlow grass
Eutrema Edwardsii	mustard
Lesquerella arctica	bladderpod
Parrya arctica	mustard
Saxifragaceae — Saxifrage family	
Chrysosplenium tetrandum	watercarpet
Saxifraga aizoides	yellow mountain saxifrage
Saxifraga caespitosa	tufted saxifraga
Saxifraga cernua	nodding saxifrage
Saxifraga foliolosa	saxifrage
Saxifraga hieracifolia	saxifrage
Saxifraga hirculus	yellow marsh saxifrage
Saxifraga oppositofolia	purple saxifrage
Saxifraga tricuspidata	prickly saxifrage
Rosacaea — Rose family	
Dryas integrifolia	mountain avens
Potentilla hyparctica	cinquefoil
Potentilla vahliana	cinquefoil
Leguminosae — Pea family	
Astragalus alpinus	alpine milk vetch
Oxytropis arctobia	oxytrope
Oxytropis Maydelliana	oxytrope
Pyrolaceae — Wintergreen family	
Pyrola grandiflora	large-flowered wintergreen
Ericaceae — Heath family	
Ledum decumbens	labrador tea
Cassiope tetragona	arctic heather
Vaccinium uglinosum	bilberry
Vaccinium vitis-idaea	mountain cranberry
Diapensiaceae — Diapensia family	
Diapensia lapponica	diapensia
Scrophulariaceae — Figwort family	
Pedicularis capitata	capitate lousewort
Pedicularis hirsuta	hairy lousewort
Pedicularis lanata	wooly lousewort
Pedicularis sudetica	lousewort
Compositae — Composite family	
Matricaria ambigua	seashore chamomile
Non-vascular plants	
Marchantia sp.	liverwort
Sphagnum	lichen
Discomycetes	fungus

Appendix 2
Range extensions of plants encountered in the Rasmussen Lowlands, June–July, 1994[a]

Deschampsia brevifolia
- first record for mainland Keewatin[b]
- closest previous record is on the Boothia Peninsula 100 km to the northeast

Dupontia Fisheri ssp. *psilosantha*
- closest previous record is 500 km southeast near Rankin Inlet

Juncus arcticus
- closest previous record in 300 km south on mainland Keewatin[b]

Luzula Wahlenbergii
- northernmost record to date in the Keewatin[b]
- intermediate between records at Queen Maud Gulf and on the Melville Peninsula

Betula glandulosum ssp. *exilis*
- closest previous record is 300 km to the southeast

Caltha palustris
- the most northeastern record to date
- previous records 150 km to the southwest, and west on King William Island

Ranunculus gmelinii
- 500 km extension northward from previous record in central Keewatin[b]

Ranunculus Pallasii
- previous closest records were 650 km southeast at Chesterfield Inlet and 800 km west near Coronation Gulf

[a] From Cody (1996).
[b] As Keewatin existed prior to the creation of Nunavut in 1999.

Appendix 3
Bird species and numbers recorded, Rasmussen Lowlands, 1994 and 1995

Species	Scientific name	Confirmed breeding	No. in plots[a]		No. outside plots		Total		
			1994	1995	1994	1995	1994	1995	Both years
Red-throated Loon (RTLO)	*Gavia stellata*	yes	2	0	7	4	9	4	13
Pacific Loon (PALO)	*Gavia pacifica*	yes	10	0	8	11	18	11	29
Tundra Swan (TUSW)	*Cygnus columbianus*	yes	1	1	29	57	30	58	88
Greater White-fronted Goose (GWFG)	*Anser albifrons*	yes	21	43	132	323	153	366	519
Snow Goose (SNGO)	*Anser caerulescens*	yes	0	1	163	339	163	340	503
Canada Goose (CAGO)	*Branta canadensis*	yes	12	6	29	67	41	73	114
Northern Pintail (NOPI)	*Anas acuta*	no	0	0	0	22	0	22	22
King Eider (KIEI)	*Somateria spectabilis*	yes	7	5	41	86	48	91	139
Oldsquaw (OLDS)	*Clangula hyemalis*	yes	5	0	1	5	6	5	11
Red-breasted Merganser (RBME)	*Mergus serrator*	no	0	0	0	13	0	13	13
Rough-legged Hawk (RLHA)	*Buteo lagopus*	yes	0	0	1	3	1	3	4
Peregrine Falcon (PEFA)	*Falco peregrinus*	yes	0	0	3	7	3	7	10
Rock Ptarmigan (ROPT)	*Lagopus mutus*	yes	2	1	2	2	4	3	7
Sandhill Crane (SACR)	*Grus canadensis*	yes	1	3	14	15	15	18	33
Black-bellied Plover (BBPL)	*Pluvialis squatarola*	yes	9(5)	4(3)	7	3	16	7	22
American Golden-Plover (AMGP)	*Pluvialis dominica*	yes	7(5)	8(7)	5	27	12	35	37
Semipalmated Plover (SEPL)	*Charadrius semipalmatus*	yes	2(2)	0(0)	0	0	2	2	4
Ruddy Turnstone (RUTU)	*Arenaria interpres*	no	1(1)	0(0)	0	2	1	2	3
Semipalmated Sandpiper (SESA)	*Calidris pusilla*	yes	21(16)	22(17)	1	11	22	33	55
White-rumped Sandpiper (WRSA)	*Calidris fuscicollis*	yes	31(19)	54(34)	5	55	36	109	145
Pectoral Sandpiper (PESA)	*Calidris melanotos*	yes	43(39)	34(24)	1	27	44	61	105
Dunlin (DUNL)	*Calidris alpina*	yes	12(12)	10(10)	4	3	16	13	29
Stilt Sandpiper (STSA)	*Micropalama himantopus*	yes	2(1)	1(1)	2	0	4	1	5
Buff-breasted Sandpiper (BBSA)	*Tryngites subruficollis*	no	10(6)	5(1)	0	0	10	5	15
Baird's Sandpiper (BASA)	*Calidris bairdii*	yes	3(3)	8(7)	0	2	3	10	13
Red Phalarope (REPH)	*Phalaropus fulicaria*	yes	56(38)	72(45)	38	133	94	205	299
Parasitic Jaeger (PAJA)	*Stercorarius parasiticus*	yes	7	3	7	12	14	15	29
Long-tailed Jaeger (LTJA)	*Stercorarius longicaudus*	no	2	2	19	63	21	65	86
Jaeger sp.	*Stercorarius sp.*		?	?	40	0	40	0	40
Thayer's Gull (THGU)	*Larus glaucoides thayeri*	no	0	0	2	16	2	16	18
Glaucous Gull (GLGU)	*Larus hyperboreus*	no	7	0	20	49	27	49	76
Sabine's Gull (SAGU)	*Xema sabini*	no	0	0	1	8	1	8	9
Gull sp.	*Larus* sp.		?	?	3	0	3	0	3
Arctic Tern (ARTE)	*Sterna paradisaea*	no	0	0	1	1	1	1	2
Snowy Owl (SNOW)	*Nyctea scandiaca*	no	2	0	1	1	3	1	4
Horned Lark (HOLA)	*Eremophila alpestris*	no	10	7	1	4	11	11	22
Common Raven (CORA)	*Corvus corax*	no	0	0	7	9	7	9	16
Lapland Lonspur (LALO)	*Calcarius lapponicus*	yes	241	228	63	115	304	343	647
Snow Bunting (SNBU)	*Plectrophenax nivalis*	no	2	4	1	12	3	16	19
Totals			529(147)	522(149)	659	1507	1188	2031	3219

[a] Numbers in parentheses = number of indicated breeding pairs.

Appendix 4
Morphometric measurements of Stilt Sandpipers and eggs from the Rasmussen Lowlands, 1994

	Wing length (mm)[a]	Culmen length (mm)[b]	Tarsus length (mm)	Weight (g)	Egg length (mm)	Egg width (mm)
Adult 1	136	38.2	39.9	54.0		
Adult 2	137	43.1	45.6	54.5		
Adult 3	139	42.1	43.7	54.5		
Egg 1					36.5	25.8
Egg 2					38.1	25.9
Egg 3					37.9	25.8

[a] Max. chord measured.
[b] Exposed culmen (feathering to tip).

Appendix 5
Criteria for selecting candidate national wildlife areas[a]

An area is considered to meet the minimum requirements of a national wildlife area (NWA) if it meets at least one of the following criteria:

1. Migratory birds

a) the area supports a population of a species or subspecies or a group of species which is concentrated, for any portion of the year.

OR

b) where data on populations are available, the area supports at least 1% of the Canadian population of a species or subspecies or a group of species, for any portion of the year. **Variant — Northern Conservation Division (NCD) of CWS uses 5% of population as minimum measure for candidate NWA status.**

OR

the area possesses a high research potential for restoration or enhancement, such that migratory bird populations could be increased to meet national population targets.

2. Wild flora and fauna

a) the area supports an appreciable assemblage of rare, vulnerable, threatened, or endangered species or subspecies of plants or animals, or an appreciable number of individuals of any one or more of these species or subspecies (e.g. COSEWIC list).

OR

the area has special value for maintaining the genetic and ecological diversity of a region because of the quality and uniqueness of its flora and fauna.

3. Unique wildlife habitats

The area is a rare or unusual wildlife habitat, of a specific type in a biogeographic region.

Additional NCD criteria used to assess sites for candidate NWA status[b]:

- is the site identified in the *Nunavut Land Claims Agreement?*
- are there indications of community support for a conservation area at the site?

[a] From Canadian Wildlife Service (1994).
[b] From Canadian Wildlife Service (1993).

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