



BIOLOGICAL BASELINE STUDY IN THE RAMSAR SITE "HEDEN" AND THE ENTIRE JAMESON LAND, EAST GREENLAND

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Christian M. Glahder
David Boertmann
Jesper Madsen
Mikkel Tamstorf
Kasper Johansen
Jannik Hansen
Alyn Walsh
Cornelia Jaspers
Morten Bjerrum



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Authors: Christian M. Glahder, David Boertmann, Jesper Madsen, Mikkel Tamstorf, Kasper Johansen, Jannik Hansen, Alyn Walsh, Cornelia Jaspers & Morten Bjerrum

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Abstract: In 2008, Quadra Mining Ltd. was granted an exploitation license that covered a large molybdenum ore body in East Greenland. Mining this ore will involve constructions inside the Ramsar site "Heden" of a port, a road and an air strip. In July 2008 NERI performed baseline studies on geese and other birds in the area. The possible impacted north-western part of the Ramsar site, Gurreholm, is lush wetland tundra. About 25% of the Pink-footed geese moulting in Jameson Land use this small part of the Ramsar site. The diversity and density of breeding birds in the area are relatively high. About 3% of the moulting Barnacle geese in Jameson Land use this area. The impact of the mining activities on the Gurreholm area is evaluated in proportion to disturbance zones of 1.5, 5 and 10 km; the most substantial impact will be that up to 4,900 moulting Pink-footed geese will avoid the area. The proposed replacement area, the extended Ørsted Dal area, holds 60-80% of the Pink-footed geese expected to avoid the Gurreholm area. The number of breeding Pink-footed geese in the affected area constitutes about one third of the Jameson Land breeding population. The replacement area will compensate for more moulting Barnacle geese than those impacted, thereby giving protection under the Ramsar Convention to an extra 7% of the flyway population. It is suggested to monitor the impact when mining starts. If the proposed replacement area can not compensate fully, yet another replacement area should be delimited.

Keywords: Ramsar site, Pink-footed goose, Barnacle goose, mining, disturbances, replacement area, Jameson Land, East Greenland.

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Summary

In 2004, Quadra Mining Ltd. was granted an exploration license that covered the Malmbjerget area in East Greenland and late 2008 the mining company was granted an exploitation licence. Early 2008 an Environmental Impact Assessment and an Interim Feasibility Study was presented by the mining company. The mining company plans to exploit a large molybdenum ore body estimated to be mined for 20-25 years. In the north western part of Jameson Land, around Gurreholm (Fig. 1), the mining company plans to construct a port with a large container terminal, a gravel road from the port and c. 75 km north to the production camp along the east side of the Schuchert River and a c. 2,000 m long air strip situated 3-4 km northeast of the port and connected to the road by a perpendicular gravel road (Figs. 45, 46). These constructions cover about 1 km². In the production phase the period July-October will be the most intensive period, with an estimated arrival of one ship every second week and a maximum of 7 trucks (c. 50 tons) per hour that will arrive or leave the port site. Every second week a Hercules plane will land and about 2 medium sized jet planes will land per week.

The port, airstrip and about 20 km road in the Gurreholm area are planned to be located inside the Ramsar site "Heden". A Ramsar site is a wetland of international importance for e.g. staging and breeding birds that holds a minimum of 1% of the total flyway population of at least one water bird species. The Ramsar site "Heden" was designated in 1988 primarily to protect internationally important populations of moulting Pink-footed geese and Barnacle geese. The area held at that time 3% of the total flyway population of Pink-footed geese and 9% of the total Barnacle geese. Of importance for the designation was also other breeding birds like Red-throated diver, Long-tailed and Arctic skua, Dunlin and Turnstone, and uncommon breeding birds like Sabine's gull, Whimbrel, Red and Red-necked phalarope. If "urgent national interests" are claimed by the national state resulting in a reduction of a Ramsar site, the Ramsar Secretariat must be informed about alternatives and a proposal for the designation of a replacement area. In a dialogue with the Ramsar secretariat the Greenland Self-Government has informed that the mining project is of "urgent national interests", meaning that the project can proceed provided that the impact of the activities are monitored and that an appropriate replacement area is found in advance.

The relatively large construction works planned inside the Ramsar site "Heden" will affect the area in two ways: Some areas will be lost due to the constructions, perhaps temporarily dependant of remediation measures, and some areas will be disturbed so that animals, especially moulting geese, will be displaced permanently or temporarily from the areas. The purpose of the present reported baseline studies performed in July 2008 in Jameson Land was to census the number and distribution of moulting and breeding geese and of other birds prior to the mine start. The studies were performed in four study areas: the possible affected Gurreholm area, the reference areas Tyskit Nunaat and Draba Sibirica River, and the planned replacement area in Ørsted Dal (Fig. 1). Also, the purpose was to map the vegetation of the entire Jameson Land.

The 2008 field studies show that the Gurreholm study area is very rich in bird species and individuals compared to the other study areas. The reason is that Gurreholm is a lush tundra wetland area rich in smaller and larger lakes and rivers, fens and coastal salt marshes. The number of breeding and moulting Pink-footed geese (more than 800 individuals in families and c. 4,000 moulting birds that constitutes more than 20% of the Jameson Land total) as well as other breeding birds (11 species with 64 successfully pairs) is high. Sabine's gull and Whimbrel, classified as "near threatened" in the Greenland Red-list are breeding in the area. Only about 3% of the total moulting population of Barnacle geese in Jameson Land use the Gurreholm area.

The possible effects of the mining activities on geese and other bird species in the northwestern part of the Ramsar site "Heden" is evaluated in relation to three disturbance scenarios, expressed by the distance at which birds are predicted to be displaced. The size of these three zones of 1.5, 5 and 10 km (Fig. 45) are based on knowledge from reactions of moulting geese to helicopter disturbances and breeding geese to airstrips and walking persons. When a large helicopter approached moulting Pink-footed geese they stayed alert at a distance of about 10 km from the plane and fled to a lake or river at distances of 7-8 km. A smaller helicopter caused the two latter reactions at distances of 4-6 km. When geese, still able to fly, are searching for suitable moulting sites they probably will avoid moulting habitats that are inside the 10 km disturbance zone. This is based on observations of Pink-footed geese that avoided a valley in Jameson Land in late June after passage of large helicopters at distances of about 5 km. No geese moulted in the valley that year. Breeding geese are more tolerant to disturbances and observations indicate little or no effects at distances of 1-2 km from the source. According to these observations we have chosen a disturbance zone of 1.5 km to breeding geese and other breeding birds. A worst case scenario is represented by the 10 km disturbance zone inside which we expect that no geese will start moulting (Fig. 45). The more moderate scenario anticipates the geese to initiate their moult in areas situated more than 5 km from the disturbances, but inside the 5 km zone no geese will moult. Breeding geese and other breeding birds are expected to avoid the area inside the 1.5 km disturbance zone.

Inside the disturbance zone of 10 km about 4,900 moulting Pink-footed geese and 530 moulting Barnacle geese were observed in 2008, while the disturbance zone of 5 km held c. 3,900 moulting Pink-footed geese and 400 moulting Barnacle geese. Inside the 1.5 km disturbance zone a minimum of 150 Pink-footed geese in family flocks (equal to c. 30 successful pairs) and a minimum of 8 breeding pairs of other breeding birds were located. It is likely that all lakes used by foraging non-breeding Sabine's gulls will be affected by the constructions. Supplementary studies on breeding birds, performed in June 2009, will be reported separately.

The size and quality of a replacement area depends on both the chosen disturbance zones and suitable areas in East Greenland. Ørsted Dal is the only relevant potential replacement area in Jameson Land. To delimit the replacement area the starting point could be to evaluate if the Ørsted Dal study area would be a sufficient replacement area. In this area we observed 400 moulting Pink-footed geese and 700 Barnacle geese, family birds of 50 Pink-footed geese and 120 Barnacle geese and 30 breeding

pairs of 5 other bird species. It is obvious that this area is not sufficient to replace especially moulting and breeding Pink-footed geese. It is doubtful if the area is sufficient to replace the diversity of other breeding species. On the other hand, Barnacle geese are fully replaced.

Therefore, it is necessary to extend the Ørsted Dal area to that depicted on Fig. 45. The replacement area shown on the figure is smaller than the proposed optimal replacement area (Fig. 51) due to two existing mineral licence areas. This area holds c. 3,000 moulting Pink-footed geese or about 60-80% of the 3,900 – 4,900 geese potentially lost inside the two disturbance zones in the Gurreholm area. In return, the extended Ørsted Dal area supports c. 4,700 moulting Barnacle geese giving protection under the Ramsar Convention to an extra 7% of the Barnacle goose flyway population. This is of importance because the population is still relatively small despite its current rapid growth. It is difficult to judge if the replacement area can fully compensate the loss of breeding Pink-footed geese and other breeding birds. The southeastern part of the area is suitable only to moulting geese and not to most breeding birds because of snow and ice coverage until late June. A preliminary spatial model indicates that the replacement area has no substantial spare habitats for the moulting geese displaced from Gurreholm.

Because of the uncertainties to assess the impact of the mining activities on the moulting and breeding birds in the northwestern part of the Ramsar site it is suggested to introduce a monitoring program when mining starts. If the proposed replacement area can not compensate for the loss of moulting and breeding birds in the Gurreholm area, yet another replacement area should be delimited elsewhere along the East Greenland coast. Studies performed in 2009 and planned in 2010 should prepare for such a situation.

Photo 1. The Gurreholm area with Scoresby Sund and Staunings Alps in background (*Alyn Walsh*).



Sammenfatning

Quadra Mining Ltd. fik i 2004 en efterforskningsstilladelse for Malmbjerget i Østgrønland og i 2008 en udnyttelsestilladelse. I den forbindelse blev der bl.a. fremlagt en vurdering af virkningen på miljøet og et midlertidigt lønsomhedsstudie. Mineselskabet planlægger indenfor de kommende år at starte en 20-25 årig udvinding af molybdæn fra forekomsten i Malmbjerget. Planerne omfatter bl.a. anlæg af en havn med tilhørende stort containerlager ved Gurreholm i det nordvestlige Jameson Land, en ca. 75 km lang vej langs den østlige bred af Schuchert Elv fra havnen mod nord til en mineby ca. 10 km syd for malmforekomsten og en stikvej til en ca. 2 km lang landingsbane til bl.a. mellemstore jettfly og Hercules transportfly beliggende ca. 1,5 km fra kysten nord for havnen (Figureerne 45 og 46). Anlæggene vil omfatte et landområde på ca. 1 km². Det skønnes, at der juli-oktober i mineperioden vil ankomme ét fragtskib hver anden uge, 2-3 fly vil lande og lette om ugen og omkring 7 lastbiler (ca. 50 tons) vil hver time ankomme eller forlade havnen.

De relativt store anlægsarbejder der planlægges ved Gurreholm ligger inde i Ramsarområdet "Heden". Et Ramsarområde er et vådområde af international betydning for bl.a. rastende og ynglende fugle og det skal rumme mindst 1% af mindst én vandfuglearts totale bestand. "Heden" blev udpeget som Ramsarområde i 1988 bl.a. på grund af de internationalt vigtige bestande af fældende kortnæbbede gæs og bramgæs, der på det tidspunkt rummede henholdsvis 3 og 9% af de totale bestande. Udpegningsgrundlaget var desuden andre ynglefugle som lommer, kjoever og vadefugle, samt relativt sjældne ynglefugle som sabinemåge, odins-hane, thorshane og lille regnspeve. Hvis et Ramsarområde vil blive påvirket eller ændret som følge af "vitale nationale interesser" skal Ramsar sekretariatet oplyses om mulige alternativer og erstatningsområder. Grønlands Selvstyre har i dialog med Ramsar sekretariatet meddelt at mineprojektet er af "vital national interesse" således at projektet fortsætter forudsat at påvirkningerne af mineaktiviteterne monitoreres og at der udpeges et passende erstatningsområde inden minestart.

De planlagte anlægsarbejder betyder dels, at der er områder som, måske midlertidigt, vil gå tabt og dels områder hvor dyrelivet, herunder især de fældende gåsebestande, vil blive forstyrret. Formålet med undersøgelserne udført i juli 2008 i Jameson Land, var dels at optælle antallet af fældende gæs i hele området inden og efter en igangsættelse af anlægsarbejderne og dels nøjere at kortlægge ynglende gæs samt andre fuglearter indenfor fire delområder: det efter planerne påvirkede Gurreholm område, to nærliggende referenceområder ved Tyskit Nunaat og Draba Sibirica elv, samt det eventuelle Ramsar erstatningsområde i Ørsted Dal (Figur 1). Desuden var formålet at udføre en vegetationskortlægning af hele Jameson Land.

Resultaterne fra undersøgelserne viser, at området ved Gurreholm er et særdeles rigt fugleområde der, i forhold til de øvrige undersøgte delområder, indeholder et meget stort antal fældende kortnæbbede gæs (ca. 4.000 eller godt 20% af hele Jameson Lands bestand), ynglende kortnæbbede gæs (over 800 familiefugle), samt et stort antal andre ynglefugle (64

par fordelt på 11 arter). Området omfatter desuden de relativt sjældne ynglefugle sabinemåge og lille regnspove, der i henhold til den grønlandske rødliste er kategoriserede som "næsten truede". Antallet af fældende bramgæs (ca. 300) er derimod lavt og udgør kun ca. 3% af den samlede bestand i Jameson Land. Baggrunden for, at Gurreholm området er så fuglerigt i forhold til de øvrige områder er, at der er et meget stort antal større og mindre søer, elve og mange kær og at denne våde lavlandshabitat er dominerende i forhold til de mere tørre dværgbuskheder.

Med den nuværende viden om hvilke aktiviteter mineselskabet planlægger indenfor det nordvestlige område af Ramsarområdet "Heden" er påvirkningen vurderet i forhold til tre forstyrrelsesscenarier. De tre scenarier er baseret på den afstand som aktiviteterne forventes at påvirke fuglelivet. Zonernes størrelser på henholdsvis 1,5, 5 og 10 km fra aktiviteterne (Figur 45) knytter sig til en viden om fældende gæs' reaktioner på helikopterforstyrrelser og ynglende gæs' reaktioner på landingsbaner og gående personer. En større helikopter der nærmer sig en flok fældende kortnæbbede gæs vil forstyrre disse på 7-10 km's afstand. På 10 km's afstand blev gæssene opmærksomme på forstyrrelsen, mens de på 7-8 km's afstand flygtede ud på søer og elve. Når en mindre helikopter nærmede sig var reaktionerne tilsvarende, men på 4-6 km's afstand. Når gæssene, der stadig kan flyve, skal vælge fældeområde, vil de være meget opmærksomme på forstyrrelser og formodentlig undgå områder indenfor en 10 km forstyrrelseszone. Dette bygger på observationer fra Jameson Land hvor kortnæbbede gæs forlod områder forstyrret af helikoptere på 5 km's afstand og gæssene vendte ikke tilbage for at fælde det år. Ynglende gæs er mere tolerante overfor forstyrrelser og observationer tyder på påvirkninger indenfor 1-2 km fra en forstyrrelse. I forbindelse med ynglende fugle har vi valgt en forstyrrelseszone på 1,5 km. Området indenfor forstyrrelseszonen på 10 km repræsenterer det værst tænkelige tilfælde, hvor ingen gæs vil påbegynde fældningen. Ved mere moderate forstyrrelser forventes det, at gæssene inden fældningen påbegyndes godt vil etablere sig i en afstand over 5 km fra forstyrrelsen, men at de bliver skræmt væk nærmere end 5 km fra forstyrrelsen. Vedrørende ynglefugle vurderes det, at alle ynglepar i den vestligste fjerdedel af Gurreholm feltområdet (området indenfor ca. 1,5 km fra anlæggene) forsvinder som følge af fysiske anlæg og forstyrrelser.

Ved optællingerne fra fly i juli 2008 registreredes ca. 4.900 fældende kortnæbbede gæs og 530 bramgæs indenfor 10 km forstyrrelseszonen og ca. 3.900 fældende kortnæbbede gæs og ca. 400 bramgæs indenfor 5 km forstyrrelseszonen. Desuden var der i 1,5 km forstyrrelseszonen mindst 150 kortnæbbede gæs i familieflokke (svarende til mindst 30 succesrige ynglepar) og mindst 8 succesfulde ynglepar af 5 andre fuglearter. Det er også sandsynligt at de søer hvor ikke ynglende sabinemåger blev set søge føde vil blive påvirket af anlæggene. Supplerende relevante ynglefugle studier blev udført i juni 2009 og vil blive rapporteret separat.

Størrelsen og kvaliteten af et erstatningsområde afhænger både af valget af forstyrrelseszoner og af hvilke passende områder der findes i Østgrønland. I Jameson Land området er Ørsted Dal området det eneste relevante område. For at afgrænse det nødvendige areal i Ørsted Dalen er det i første omgang vurderet om Ørsted Dal feltområdet er tilstrækkeligt som erstatningsområde. I dette område blev der observeret 400 fældende

kortnæbbede gæs og 700 fældende bramgæs, 50 familiefugle af kortnæbbet gås og 120 af bramgås, samt 30 ynglefugle fordelt på 5 øvrige arter. Det er åbenlyst, at Ørsted Dal feltområdet ikke er tilstrækkeligt til at kompensere for især fældende og ynglende kortnæbbede gæs. Derimod er der mere end fuld kompensation for bramgæssene.

Det er derfor nødvendigt at inddrage et større område som erstatningsområde (Figur 45). Dette område er mindre end det foreslåede optimale område (Figur 51) hvilket skyldes to områder med gældende mineraltilladelser. Hvis det udvidede Ørsted Dal område udpeges som erstatningsområde vil der her være ca. 3.000 fældende kortnæbbede gæs. Dette antal udgør stadig kun omtrent 60-80% af de 3.900 - 4.900 fældende kortnæbbede gæs der vurderes at forlade Gurreholm området indenfor forstyrrelseszonerne. Erstatningsområdet indeholder til gengæld ca. 4.700 fældende bramgæs. Derved kommer der yderligere 7% af bestanden under Ramsar Konventionens beskyttelse, hvilket er betydningsfuldt, da denne bramgåsbestand stadig er relativ lille trods den store bestandsfremgang i de sidste årtier. Det er på nuværende tidspunkt vanskeligt at vurdere om erstatningsområdet fuldt ud vil kompensere for tabet af ynglende kortnæbbede gæs og andre ynglefugle. Den sydøstlige del af erstatningsområdet er kun velegnet til fældende gæs, da sen sne og isafsmeltning ikke muliggør yngel (jf. photo 1). En foreløbig rumlig model over sammenhængen mellem fældehabitater og antallet af gæs kunne ikke påvise, at erstatningsområdet kunne rumme et forøget antal af fældende gæs.

På grund af usikkerhederne med at vurdere omfanget af påvirkningen fra mineaktiviteterne skal det foreslås, at fuglelivet i Gurreholm området årligt monitoreres. Hvis erstatningsområdet ikke kompenserer tilstrækkeligt for tabet af fældende og ynglende gæs, samt andre ynglende fugle i området, bør der udpeges endnu et erstatningsområde på Grønlands østkyst. Der er taget højde for denne situation ved i 2009 at udføre optællinger fra fly i relevante områder og ved at planlægge ynglefugleundersøgelser i 2010.

Photo 2. Non-breeding Pink-footed geese migrating north in late June to moult.



Eqikkaaneq

2004-mi Quadra Mining Ltd. Tunumi Malmbjerget-mi ujarlernissamut akuersissummik pivoq 2008-milu iluaquteqarnissamut akuersissummik pilluni. Tassunga atatillugu ilaatigut avatangiisinut sunniuteqarnissamik naliliineq aammalu utaqqiisaagallartumik imminut akilersinnaassut-simik misissuisimaneq saqqummiunneqarput. Aatsitassarsiorfik ukiuni aggersuni 20-25-ini Malmbjerget-mi molybdænimik tamaaniittumik piaanissamut pilersaaruserpooq. Pilersaarutinut ilaatigut ilaavoq Gurreholm-imi Jameson Landip avannamut kitaaniittumi containeriisivitalimmik umiarsualiviliornissaq, 75 km miss. takissusilimmik Scuchert Elv-ip sinaa kangilleq sinerlugu aqqusinniornissaq aatsitassarsiorfiup illoqarfianut aatsitassarsiorfiup kujataani 10 km miss. Ungasissusilimmiittumut aammalu aqqusinermik sanimoortumik timmisartut jetflyt akunnattumik angissusillit, timmisartut assartuutit Hercules-it mittarfissaanut umiarsualivimmiit 1,5 km miss. Avannarpasinnersumiittumut atanilerlugu (titartakkat 45 amma 46 takukkit). Sanaartorfissaq nuna 1 km² missiliorlugu angissuseqassaaq. Naatsorsuutigineqarpoq aatsitassarsiornerup nalaani juli-oktoberimi sapaatip akunnera allortarlugu umiarsuarmik assartuummik tikittoqartarumaartoq, timmisartullu 2-3 sapaatip akunnerata ingerlanera nunnillutillu aallartarumaartut aammalu lastbiilit 7 miss. (50 tons miss.) nalunaaquttap akunnerata ataatsip ingerlanerani umiarsualivimmut tikiullutillu tassannga aallartarumaartut.

Gurreholm-imi sanaartugassat annikitsuunngitsut pilersaarutigineqartut Ramsar-eqarfiup "Heden"-ip iluaniippu. Ramsareqarfik tassaavoq marsarsoqarfik nunanut assigiinngitsunut pingaarutilik, ilaatigut timmis-sanit uninngaarfiusarlunilu piaqqiorfiunermigut, aammalu taamaattoq minnerpaamik timmissap immamiittartup ataatsip nunarsuarmi 1%-ianik najorneqartuusooq. "Heden" nerlerit siggukitsut nerlernallu isarfiattut pingaarutilittut Ramsareqarfittut toqqarnerarpoq 1988-imi, taamanikkut nunarsuarmi timmissat taakkua tamarmiusut 3 aamma 9%-iinik najorneqartoq. Toqqaanermut pissutaavortaaq timmissat allat, soorlu qilannat, isunngat naloraarusillillu, kiisalu timmissat qaqutigoornerusut sabinemåge, odinshane, thorshane aamma lille regnspevenit piaqqiorfiummat. Ramsareqarfik "nunap soqutigisai pingaarutilit" pissutigalugit sunnerneqarpat allanngortinneqarpalluunniit taava Ramsarip allaffeqarfia periarfissanik taartaasinnaasunillu ilisimatinneqartussaavoq. Kalaallit Nunaanni Naalakkersuisut Ramsarip allaffeqarfia oqaloqatigalugu nalunaarutigaat aatsitassarsiorneq "nunap soqutigisarigaa pingaarutilik" taamaattumillu pilersaarut ingerlaqqissasoq piumasaraluguli aatsitassarsiornikkut ingerlatat sunniutaasa nalunaarsorneqarnissaat aammalu piukkunnartumik taatissamik toqqaasoqassasoq aatsitassarsiorneq aallartitsinnagu.

Sanaartugassat pilersaarutaasut kingunerisussaassavaat ilaatigut nunap ilaata uumasut tungaannit isigalugu annaaneqarnera imaluunniit qimanneqarnera, immaqa sivisunngitsumik, pingaartumik nerlerit isasut eqqarsaatigalugit, taakkua akornuserneqarumaarmata. Misissuinerit Jameson Land-imi julimi 2008-mi ingerlanneqartut siunertaraat nerlernik isasumik tamanna tamakkerlugu kisitsinissaq aammalu sanaartornerup

aallartinnginnerani, aallartereerneranilu aammalu nerlerit siggukitsut timmissallu allat erniortut sumiiffinni sisamani erseqqinnerusumik nalunaarsornissaat: Gurreholm-imi pilersaarutit malillugit sunnerneqartussat, eqqaaniittumi naleqqiussuussivissat marluk, Tyskit Nunaanni aamma Draba Sibirica-p kuuani, aammalu Ramareqarfimmuut anaasamut taartaasinnaasoq Ørsted Dal (Titartagaq 1). Siunertaavortaaq Jameson Land tamakkelugu naasoqarfinnik misissuinissaq.

Misissuinerit inernerisa takutippaat Gurreholm eqqaalu, immikkoortortanut misisuiiffineqartunut sanilliullugu, timmiarpassuaqartoq, nerlerit siggukitsut isasut amerlasoorujussuit (4.000 miss. imalunniit Jameson Land-imiittut tamakkerlutik 20%-ii sinnerlugit), nerlerit siggukitsut erniortut (ilaqutariit 800 sinnerlugit) aammalu timmissat allarpassuit erniortut (aappariit 64-it timmissanut assigiinngitsunut 11-nut agguataarsimasut). Tamannalu aamma timmissat qaqutigoornerusut, sabinemåget aamma lille regnspove-t ilaapput, taakkua kalaallit uumasunut navianartorsiorlutaasunut nalunaarsuiffianni "nungutitaanissamik navianartorsiorluinnangajattut" nalunaarsorsimapput. Nerlernat isasut (300 miss.) amerlanngillat tassa Jameson Land-imiittut 3%-iat missiliuinnarlugu. Gurreholm-ip taama timmiaqartigineranut pissutaavoq angeqatigiinngisitaartunik taserpassuaqarlunilu taserarpassuaqarnera, kuuit masarsuillu amerlaqisut tamannalu uumsoqarfik masarsuulluni narsaamanerusoq annertunerpaavoq panernerusortaanut orpigaqarfiusunut naleqqkiullugu.

Aatsitassarsiorfiup Ramsareqarfiup "Heden"-ip avannaa kitaani pilersaarutaanut maannamut ilisimaneqartunut tunngatillugu sunniutaajumaartutut akornusersuutit pingasunut avinneqarsimapput. Taakkunani pingasuni ingerlatat timmissanut qanoq ungasissuseqarnerat tunngavigineqarpoq. Zonit ingerlataniit 1,5, 5 aamma 10 km ungasissuseqarput (Titartagaq 45) ilisimaneqarmat nerlerit isasut helikopteriniit akornusersorneqarlutik periaasiat aammalu nerlerit ivasut mittarfeqarfinnit inunnillu pisuinnartunit akornusersorneqartarnerat. Helikopteri angisooq nerlernut siggukitsunut isasunut qaniliartortoq akornusersuilersarpoq taakkunanga 7-10 km ungasissuseqaleraangami. 10 km ungasissuseqartoq nerlerit akornusersuisoqarnera malugisarpaat, 7-8 km ungasissuseqaleraangallu tatsinut kuunnullu qimaasarlutik. Helikopteri mikinerusoq taamatut aamma qisuariarfigisarpaat, kisianni 4-6 km ungasissuseqaleraangat aatsaat. Nerlerit suli timmisinnaatillutik isaffissarsiulersut akornusersuutininut misikkarissorujussuusarput qularnanngitsumillu akornusersuiiffimmiit 10 km qaninnerusumiinniarnaviarnatik. Tamanna Jameson Land-imi helikopterit nerlerniit 5 km ungasitsigisumi akornusersuilermata tamatuminnaga qimatsisimanerannik ukiorlu taanna isajartorlutik utersimannginnerannik takusimasanik tunngaveqarpoq. Nerlerit piaqqiortut akornusersuineq naammagittarfiginerusarpaat takusimasallu malillugit akornusersuutiniit 1-2 km ungasitsigisusumiinnaallutik. Timmissanut piaqqiortunut atatillugu qinersimavarput akornusersuisumiit ungasissuseq 1,5 km. 10 km iluani nerlerit isanialissanngippata akornusersuineq ajornerpaasaaq. Akornusersuutit ajunnginnerumaartillugit ilimagineqarpoq nerlerit isalesinnatik akornusersuisumiit 5 km ungasinnerusumiinniarsinnaasasut kisiannili 5 km qaninnerugunikku pisorpalummit tatamititaassallutik. Timmissanut piaqqiortunut tunngatillugu naliliineqarpoq Gurreholm-ip sisamararterutaani kippasinnerusuaniittumit (sanaartukkaniit 1,5 km ungasitsigisumi) qimagukkumaartut sanaartukkat akornusersuutillu pissutigalugit.

Timmisartumiit 2008-mi julimi kisitsinermi nerlerit siggukitsut 4.900 miss. nerlernallu 530, 10 km akornusersuiffimmiit ungasissusillip iluani aamma nerlerit siggukitsut isasut 3.900 miss. nerlernallu 400 miss. 5 km akornusersuiffimmiit ungasissusillip iluani nalunaarsorneqarput. Kiisalu 1,5 km akornusersuiffimmiit ungasissusillip iluani minnerpaamik nerlerit siggukitsut 150 ilaqutariikkuutaartut (tassa minnerpaamik aappariit 30 iluatitsillutik piaqqisimasut) aammalu minnerpaamik aappariit piaqqisartut 8 timmiaasut assigiinngitsut 5 nalunaarsorneqarput. Ilimanarportaaq sabinemåge-t piaqqiunngitsut tatsini nerisassarsiortut takuneqartut sanaartukkanit akornuserneqarumaartut. Timmiisanik naleqquttunik piaqqiortunik ilassutaasumik misissuinerit 2009-mi junimi ingerlanneqarput kingusinnerusukkut immikkoortillugit nalunaarsuunneqarumaarput.

Taarsiutassap angissusianut pitsaassusianullu apeqqutaavoq akornusersuiffiit sumiinnerat aammalu Tunumi allami sumi naleqquttumik nasartoqarsinnaanersoq. Jameson Land-imi Ørsted Dal eqqaalu tamaani naleqquttutuaavoq. Ørsted Dal-imi nunaminertaq pisariaqartitaq kililersinnaajumallugu siullermik nallersuineqarpoq Ørsted Dal taarsiutisallugu naammassanersoq. Tamaani takuneqarput nerlerit siggukitsut isasut 400 nerlernallu isasut 700, nerlerit siggukitsut ilaqutariikkuutaat 50 aamma nerlernat 120 kiisalu timmissat assigiinngitsut tallimat kalillutik 30-iullutik piaqqisimasut. Erseqqippoq Ørsted Dal naammassanngitsoq, pingaartumik nerlerit siggukitsut isasut piaqqiortullu eqqarsaatigalugit. Akerlianilli nerlernat eqqarsaatigalugit naammattumik taartaasinnaalluni.

Taamaattumik taartaasinnaasumik annertunerusumik ilanngussinissaq pisariaqarpoq (Titartagaq 45). Tamannami pitsaasutut siunnersuummit minneruvoq (Titartagaq 51) tamannalu pissuteqarpoq marlunnik aatsitassanut tunngatillugu akuersissuteqarfiusunik nunaminertaqarmat. Ørsted Dal annertusisaq taartissatut toqqarneqassagaluarpat tamanna 3.000 miss. siggukitsunik isasunik nerleqassaaq. Taakkuali taamaallaat nerlerit siggukitsut isassut 3.900 – 4.900-iusut Gurreholm-imi akornusersukkanik qimatsisussat 60-80%-eriinnassavaat. Taartaasussarli taarsiullugu nerlernanik isasunik 4.700 miss. peqassaaq. Taamaalillunilu 7%-mik amerlanerusut Ramsarimi isumaqatigiissutikkut llersorneqartumiilisapput, tamannalu suusupagisassaangilaq, timmiaqatigiimmi taakkua sulii amerlasoorsuunngimmata naak ukiuni qulikkeutaani kingullerni annertuumik amerlisimagaluarlutik. Massakkut tamakkiisumik oqaatigiuminaakkallarpoq taartaasusaaq nerlernik siggukitsunik piaqqiortunik timmissanillu allanik piaqqiortunik annaasanik tamakkiisumik taarsiinnaassanersoq. Taartissap kujammut kangisinnerusortaa taamaallaat nerlernut isasunut naleqquppoq, aputimmi sermillu kingusissukkut aattulersarnerat piaqqiorsinnaatitsinngimmat (tak. assilisaq 1). Utaqqiisaagallartumik isasarfiit nerlerillu amerlassusiata imminnut ataqatigiinnerannut missangersuusiap taartaasusaaq nerlernit isasunit amerlanerusunit najorneqarsinnaassanersoq takutissinnaangilaa.

Aatsitassarsiornikkut ingerlatat sunniutissaanik nalilersuiniarnermi nalorninartut pissutigalugit Gurreholm-imi timmissat ukiut tamaasa nalunaarsorneqartarnissaat siunnersuutigineqassaaq. Taartaasusaaq naammattumik nerlerit isasut piaqqiortullu, timmissallu allat tamaani piaqqisartut eqqarsaatigalugit naammattumik taartaasinnaassanngippat aamma allamik Tunumi taartaasussamik toqqaasariaqarumaarpoq. Ta-

manna naatsorsuutigineqareerpoq 2009-mi naleqquttuni timmisartumiit
kisitsinermi aammalu 2010-mi timmissat piaqqiorneranik misissuini-
samik pilersaarusernermi.

1 Introduction

In 2004, Quadra Mining Ltd. was granted an exploration license that covered the Malmbjerget area in East Greenland and late 2008 the mining company was granted an exploitation licence. The mining company plans to exploit a large molybdenum ore body estimated to be mined for 20-25 years. In the north western part of Jameson Land, around Gurreholm (Fig. 1), the mining company plans to construct a port with a large container terminal, a gravel road from the port and c. 75 km north to the production camp along the east side of the Schuchert River and a c. 2,000 m long air strip situated 3-4 km northeast of the port and connected to the road by a perpendicular gravel road (Figs. 45-51). The air strip will include northern and southern approaching corridors of unknown length, width and height. All these parts of the mining infrastructure will, according to the Environmental Impact Assessment (Cessford 2007) and the Interim Feasibility Study (Quadra 2008) presented early 2008, be placed inside the Ramsar site "Heden". The localisation of road and airstrip inside the Ramsar site was later changed so that the road was suggested to run close to the Schuchert River and the airstrip moved 1.5 km to the northeast (Quadra Mining Ltd, *in litt.* 7 October 2008).

The port will consist of wharf (100 m quay), container storage area for minimum 2,100 containers, three fuel tanks each containing 25,000 m³, a building for 10 persons and power supply. The foot-print is approximately 0.2 km². The shipping season is July-October where 3-4 cargo ships (c. 9,600 tons of cargo capacity (DWT)) and 3-4 fuel tankers are estimated to call the port each year during the mining operation. In the construction phase a total of about 24 ships will call the site per year.

The road is planned to be a single-lane gravel road about 5 m wide. Passing places will be constructed at distances of 500-1000 m. About 20 km road including a 1.5 km connecting road to the airstrip will be situated inside the Ramsar site, with a foot-print of c. 0.1 km². The dominant traffic will be trucks with trailers with a maximum weight of 48 tons. In the shipping season during July-October a maximum of 40-80 vehicles per day in both directions are expected. A year round average is expected to be 20-40 vehicles per day. The speed will in good weather conditions be 40-50 km/h.

The airstrip is based on a 1800 m runway for operating cargo aircrafts (e.g. Hercules C-130) and passenger/freight aircrafts (BAe 146-100 jet plane; 74 passengers). Included is tower, garage, staff rooms and a terminal for 160 passengers. The runway with safety areas is 2100 x 300 m. The foot-print is about 0.7 km². When the mine is operating there will be an estimated 100 flights per year (mainly DHC-8 with a minimum of 20 Hercules). During construction about 150 flights of Twin Otter and DHC-7 are expected.

The mining company's plan early 2009 is not to start construction work earlier than 2010.

Impacts on the environment

The Ramsar site "Heden" was designated primarily to protect internationally important populations of moulting Pink-footed geese and Barnacle geese (Greenland Home Rule 1990). The relatively large construction works planned inside the Ramsar site "Heden" will affect the area in two ways: Some areas will be lost, perhaps temporarily dependant of remediation measures, and some areas will be disturbed so that animals, especially moulting geese, will be displaced from the areas. Therefore, a part of the Ramsar site "Heden" does not comply with the obligations for a Ramsar site: A wetland which as an ecosystem supports a characteristic flora and fauna, especially water birds. An important purpose for the Ramsar Convention is to avoid ongoing changes and losses of wetlands today and in the future. If "urgent national interests" are claimed by the national state resulting in a reduction of a Ramsar site, the Ramsar Secretariat must be informed about possible alternatives and a proposal for the designation of a replacement area must be developed.

The Ramsar site "Heden" was designated due to the large number of moulting and breeding Pink-footed geese and Barnacle geese, other breeding birds like red-throated diver, long-tailed and Arctic skua, dunlin and turnstone, and uncommon breeding birds like Sabines gull, Red and Red-necked phalarope and Whimbrel. In the late 1980s, the numbers of moulting Pink-footed geese and Barnacle geese in the Ramsar site were 4,000 and 2-3,000, respectively (Greenland Home Rule 1990). The Greenland/Iceland Pink-footed goose flyway population held in 1990 about 190,000 birds (Mitchell 2008) and the Greenland Barnacle goose flyway population numbered c. 35,000 birds (Mitchell & Walsh 2008). The moulting Pink-footed geese in "Heden" constituted at that time 2-3% of the total flyway population and the moulting Barnacle geese 6-9%. An area qualifies to a Ramsar site if a minimum of 1% of the total flyway population of at least one water bird species is using the area.

In a dialogue with the Ramsar secretariat the Greenland Self-Government has informed that the mining project is of "urgent national interests", meaning that the project can proceed provided that the impact of the activities are monitored and that an appropriate replacement area is found in advance. The Greenland Bureau of Minerals and Petroleum (BMP) has informed the Ramsar secretariat of the mining project and the preliminary results of the biological field work performed in the area during summer 2008, where the Ørsted Dal area in Jameson Land was suggested as a replacement area (Glahder et al. 2008).

Field studies in Jameson land

The initial purposes of the biological studies to be performed in 2008 and 2009 in the Ramsar site "Heden" and in the rest of Jameson Land were to census the number and distribution of moulting geese prior to the start of any construction work and then repeat these censuses after construction work was initiated. The effect of the different constructions on the moulting geese could then be assessed both inside the Ramsar site and in Jameson Land as such, e.g. in the Ørsted Dal replacement area. Because the mining company late 2008 announced that no constructions would be initiated during 2009, BMP decided to have a first report with only the field work performed in 2008. The census of moulting geese in Jameson

Land was performed with the same methodology as used in the late 1980s in order to compare with censuses performed about 20 years ago.

Another purpose of the field work in 2008 was to census the number and distribution of moulting and breeding geese, and of other breeding bird species inside the possible affected area around Gurreholm, in the reference areas Tyskit Nunaat and Draba Sibirica River, and in the potential replacement area around Ørsted Dal. The Gurreholm area was delimited so that harbour area, airstrip and connecting roads were situated inside the study area and a land area of about 10 km from these activities was covered by the study. The reference area Tyskit Nunaat was delimited so that it was situated at least 10 km away from the mining activities in an area as similar as possible to the Gurreholm area and of approximately the same size. The reference area Draba Sibirica River was also chosen to compare grazing pressure by moulting geese in 2008 with that studied in the area in 1982-1984 (Madsen et al. 1984, Madsen & Mortensen 1987). The study area in the Ørsted Dal was chosen because the valley and its surroundings is the only possible area in Jameson Land outside the Ramsar site "Heden" that can serve as a replacement area for the affected Gurreholm area. The size of the study area is comparable to the Gurreholm area.

The studies in the above mentioned four study areas were performed in July 2008. Because these studies were performed prior to construction activities it will be possible to assess the effect of these activities on number, distribution and possibly the breeding success of geese and other bird species.

The present report describes the results of the field studies and the aerial census performed in the Jameson Land area during July and August 2008. Also, the impact of the mining activities on birds in the north western corner of the Ramsar site "Heden" is assessed. The assessment is based on the alternative localisation of the airstrip and roads as described in a letter and an attached figure from Quadra Mining Ltd. on 7 October 2008. Compared to the localisation of these constructions in the mining company's feasibility study from spring 2008, the airstrip has been moved c. 1.5 km to the northwest and the road has been moved to the coast with a perpendicular branch 1.5 km to the airstrip. According to the letter, the proposed location of the alternative airstrip was visited by the aviation authority SLV (Statens luftfartsvæsen) during summer 2008 and they indicated verbally that it was suitable.

2 The study areas

The four study areas

The Gurreholm area is a lowland area delimited to the west by Hall Bredning in the large fjord Scoresby Sund. In the north-western part of the area a huge silty delta area is formed at the mouth of the c. 10 km wide Schuchert River system. To the north and east the area gradually rises to drier areas. The entire area can be classified as a wetland with a high number of smaller and larger lakes, many marshes and smaller and larger rivers that drains the area. Mosses, cotton grasses *Eriophorum* sp, sedges *Carex* sp and different flowering plant species dominate the wet areas along lakes and rivers and in the marsh areas. On higher ground in-between the wetland areas the vegetation is dominated by dwarf scrub heath with species like Arctic blueberry *Vaccinium uliginosum*, Arctic bell-heather *Cassiope tetragona* and Arctic willow *Salix arctica*.

Photo 3. The Gurreholm study area with Staunings Alps in the back-ground.



The Tyskit Nunaat area is a lowland area delimited to the west by Scoresby Sund. To the north and the south the area is delimited by two west flowing large rivers, Fegins River and Depot River, respectively. To the east the area gradually raises to drier areas. The area is characterised by drier dwarf scrub heath with species like Arctic blueberry, Arctic bell-heather and Arctic willow. Rather few rivers drain the area, there is only one large lake, Munin lake and relatively few smaller lakes and marshes. The wet areas along these lakes, rivers and marsh areas are dominated by mosses, cotton grasses, sedges and different flowering plant species.

The Ørsted Dal area is a 4-7 km wide, u-shaped valley that runs east-west for about 50 km. To the east it borders Fleming Fjord and to the south-west it joins the Colorado Valley. Many smaller and larger rivers run into the main river and the valley floor contains scattered ponds and lakes with the largest ones found in the mouth of the Lamprenen Valley. Common mare's-tail *Hippuris vulgaris* is widespread in ponds and lakes.

The valley slopes are mostly covered by barren ground, while the low lying dry areas are dominated by Arctic bell-heather and Arctic willow. Wet areas are dominated by mosses, cotton grasses, sedges and different flowering plant species. Mossy fens are extensive along rivers and lakes where water is dammed or slow flowing. The river bed is covered by gravel and sand with only little vegetation.

The *Draba Sibirica* area is a lowland tundra heath land (0-200 m a.s.l.) with a continuous dwarf scrub with 75-100% cover with Arctic bell-heather, Arctic blueberry, Crowberry *Empetrum hermaphroditum* and Dwarf birch *Betula nana* predominating. The area is intersected with rivers and some lakes are found. Graminoid marshes are found along rivers, streams and lakes. Along the west coast, salt marshes are found (Madsen & Mortensen 1987).

Figure 1. The four study areas in the northern part of Jameson Land where intensive studies were conducted during 16 July-2 August 2008.



Climate

The climate of the Jameson Land area is arctic with the mean monthly temperature of the warmest month being below 10°C. Only three months, June, July and August, have mean temperatures above freezing. The annual mean temperature at Mestersvig lying in the northern most part of Jameson Land is -10.5°C while Ittoqqortoormiit at the south-eastern tip of Liverpool Land east of Jameson Land has an annual mean

temperature of -7.5°C . Precipitation lies in the range from 290 to 410 mm per year (Ohmura and Reeh, 1991) and decreases along the regional climatic gradients from coastal areas to inland areas and from south to north.

Climate models predict changes in the summer mean temperature of around 1°C within the period 2021-2050 compared to the period 1961-1990 and 2°C at 2051-2080 (Stendel et al. 2007). Winter temperatures will change even more with a rise of 2°C before 2050 and 8°C before 2080. With the diminishing sea ice there will also be a rise in precipitation of up to 150 mm before 2050 and 200 mm before 2080 compared to the 1961-1990 period. Hence, the area in general will experience a warmer and wetter climate similar to what is found at lower latitudes.

Weather in the area in 2008

During winter and early spring the entire Jameson Land was covered by an unusual heavy snow fall with coverage of up to 2 m on the western lowland part of Jameson Land. High temperatures in May – August in combination with very little precipitation at that time made the snow melt very rapid in May and first half of June followed by a very dry situation during July and August. In that period many smaller lakes and marshes dried out completely. Similar conditions were seen throughout north-eastern Greenland. Hence Zackenberg had a record amount of snow and one of the fastest snowmelts in the period of registration (1995-2008) and Ittoqqortoormiit also experienced record amounts of snow.

3 Methods

During the period 16 July-2 August 2008 field work was performed by three different study groups from NERI. The one group conducted an aerial survey of moulting geese in the entire Jameson Land (70°-72°N) on 17 and 18 July and the two other groups counted birds and examined vegetation plots from the ground in four selected areas in Jameson Land (Figs. 1 & 2).

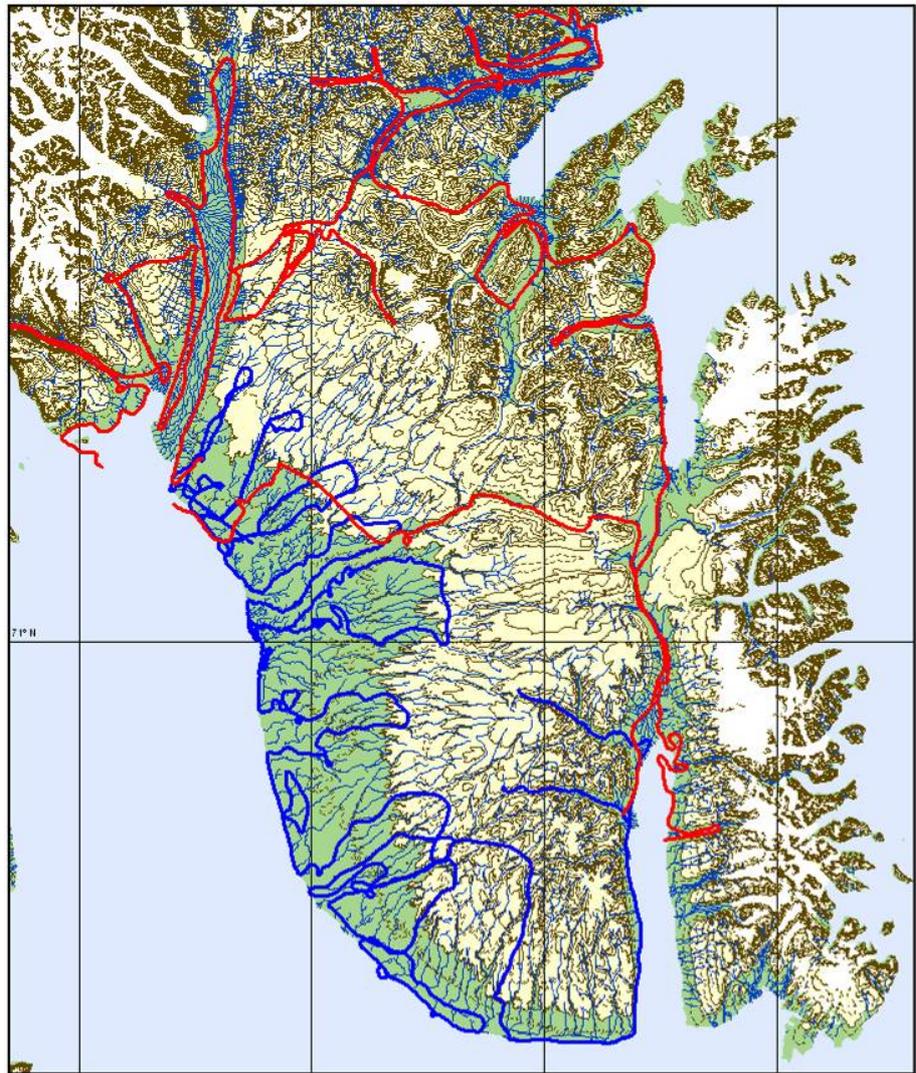
3.1 Aerial survey

The aerial goose survey was carried out on 17 and 18 July 2008, approximately one week before the first non-breeding geese attain their flying abilities. Weather conditions were optimal, with unlimited visibility, no winds and sky clear. The surveys were a replica of the surveys carried out in 1987, 1988 and 1989 (Mortensen et al. 1988, Mosbech et al. 1989, Mosbech & Glahder 1990). Aircraft and pilot were the same as in the 1980ies; a Partenavia P-68 Observer equipped with plexiglass front and bubble windows at the seats behind the pilot seats and navigated by air captain Leif Petersen. The observers were David Boertmann (participated also in 1988 and 1989) and Kent Olsen.

The flown routes were carried out as “total counts” (Laursen et al. 2008) and duplicated as far as possible from the routes in 1987-1989 (Figure 2). Navigation was visual and aided by GPS. Survey speed and altitude was the same as in 1987-1989 i.e. 90 knots (160 km/hour) and 250 feet (85 m) above ground. The two observers were placed in the co-pilot seat (watching to the right) and the seat behind the pilot (watching to the left). Observations were recorded on tape-recorders with indication of time of the day (hour, minute, second) and subsequently written into a spreadsheet. The observation file was then by the time signal merged with the position file from the GPS (observer watches and GPS time synchronised) resulting in positions of each single observation.

The airport Constable Pynt (CNP) close to Ittoqqortormiit/Scoresbysund was the base of the flights.

Figure 2. Aerial survey routes in Jameson Land 2008. Blue: 17 July, 915 km; and red: 18 July, 1004 km.



3.2 Ground survey, Gurreholm & Tyskit Nunaat

The ground survey in the Gurreholm area was performed during 17 – 25 July 2008 and in the reference area Tyskit Nunaat during 25 – 31 July. The team of two persons, Alyn Walsh and Christian M. Glahder, was flown out from Constable Pynt (CNP) by a Bell 222 helicopter to the Gurreholm camp site (71°11.958'N; 24°21.022'W), moved by helicopter to the Tyskit Nunaat camp site (71°06.237'N; 24°15.002'W) and finally flown back to CNP. Each day, trips of 10-20 km were walked and during the study period a total c. 100 km (Gurreholm) and 78 km (Tyskit Nunaat) was traversed. Routes formed radii from the camp sites to the areas' delimitations with a special focus of lakes. Thereby land areas of 68.9 km² (Gurreholm) and 48.6 km² (Tyskit Nunaat) were covered. Binoculars (Leica & Zeiss 10x magnification) and spotting scopes (Carl Zeiss Diastocope 85 TFL 20-60x) were used for observations and GPS (Garmin Etrex) for positions. All birds and mammals were registered with species, number, age, behaviour and position. Positions were either GPS positions or calculated from observations plotted in the field on false colour infrared ASTER and Landsat satellite images from 15-17 July 2004 (1:25.000). Geese were separated in non-breeding moulting geese and breeding geese in family flocks which include pulli. For other bird spe-

cies it was noted if birds were breeding or non-breeding; a breeding bird was defined as a bird connected to a nest with eggs or chicks, juvenile birds or that performed territorial behaviour (e.g. lure or chase intruders, or sing). In mammals, fox dens and cubs were registered. On selected vegetation plots of 4 m² dominating species/genera, coverage and moisture were noted. Positions and data from these plots were initially used to map fen covered areas in the entire Jameson Land (Fig. 44). In the Gurreholm area, droppings were counted in double plots each of 4 m² along transects perpendicular to shores of lakes where moulting geese were observed. The plots were placed 2, 10, 20, 40 and 60 m from the lake. These transects can in following years be used to assess the goose use of the area. All animal observations, camps, routes, observed lakes and observations points were plotted on false coloured satellite images (1:25,000) and if necessary verified by false coloured aerial photos (c. 1:22,000, 1980ies).

3.3 Ground survey, Ørsted Dal & Draba Sibirica

The ground survey in the Ørsted Dal area was performed during 17 – 25 July 2008 and in the reference area Draba Sibirica River area during 25 – 31 July. The team of two persons, Jesper Madsen and Cornelia Jaspers, was flown out from Constable Pynt (CNP) by a Bell 222 helicopter to the Ørsted Dal camp site (71°39.14'N; 23°43.52'W), moved by helicopter to the Draba Sibirica camp site (71°01.15'N; 24°00.21'W) and finally flown back to CNP. Each day, trips of 5-10 km were walked and scans with telescopes were performed from vantage points. The Ørsted Dal area covered 53.2 km² and the Draba Sibirica area 65.6 km². Binoculars (Leica & Zeiss 10x magnification) and spotting scopes (Carl Zeiss Diascope 85 TFL 20-60x) were used for observations and a GPS receiver (Trimble Recon[®]) for positions of vegetation plots and observed animals. All birds and mammals were registered with species, number, age, behaviour and position. The positions were given as estimated distance and angle from the observer to the animal; from these data the positions of the animals were calculated. Geese were separated in non-breeding moulting geese and breeding geese in family flocks which include pulli. For other bird species it was noted if birds were breeding or non-breeding; a breeding bird was defined as a bird connected to a nest with eggs or chicks, juvenile birds or that performed territorial behaviour (e.g. lure or chase intruders, or sing). For mammals, muskoxen calves, fox dens and cubs were registered. On selected vegetation plots of 4 m² dominating species/genera, coverage and moisture were noted. Positions and data from these plots were initially used to map fen covered areas in the entire Jameson Land (Chapter 6, Fig. 44).

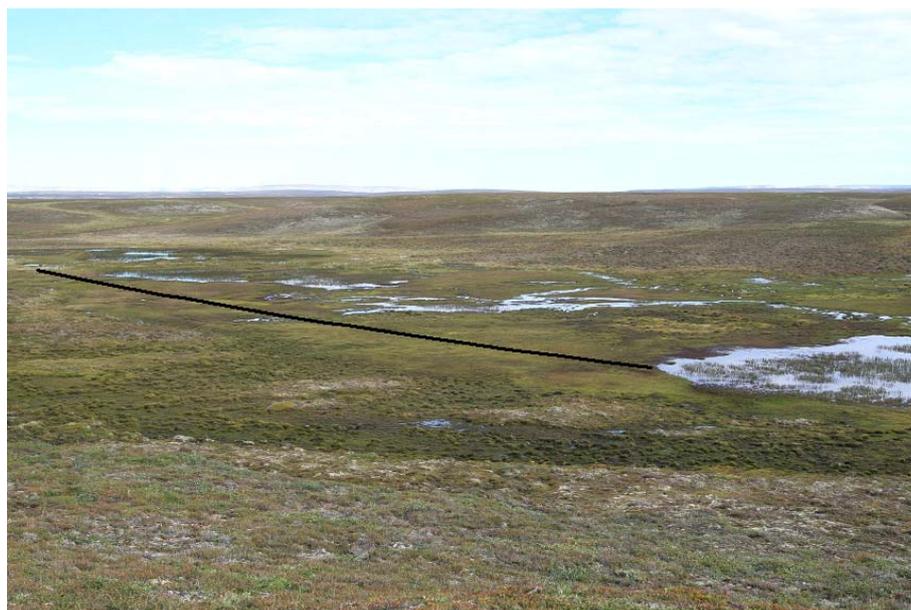
Vegetation composition and productivity in goose grazed marshes in the Draba Sibirica area

Frequency distribution

On 30 July 1984, plant species frequency was examined by use of a pinpoint method in a Hoppner's sedge *Carex subspathacea* – moss dominated sward grazed by moulting Pink-footed geese. A 165 m-long transect was laid out in the marsh perpendicular to the lake where geese were seeking refuge. At 15-m intervals a secondary transect was laid out at right angles to the main transect. Depending on the width of the marsh, the pres-

ence or absence of species was recorded in up to 180 contact points. In 2008, we repeated the analysis following the same methodology. Since we did not have exact positions of the 1984 primary and secondary transect lines, we visually judged the position of the former main transect line (see Photo 1). Due to the configuration of the marsh, we believe to have hit the 1984-primary transect line within few metres. We took GPS positions of the centre of the secondary transect lines. Due to the presence of moulting geese, breeding divers and Sabine's gulls on the nearby lake, we shortened our presence in the marsh to minimize disturbance. Therefore, instead of doing the pin-point sampling in the field, we took close up nadir digital pictures of the secondary transect lines and did the estimation of species coverage later on the basis of the pictures. For each secondary transect we took up to three pictures at two m-intervals on each side of the main transect, placing a ruler in the picture. Subsequently, the plant species presence was sampled in 32 contact points within the picture frame (which was 50 cm x 30 cm), overlaying the picture with a grid. Furthermore, for monocots grazed by the geese, we recorded whether the leaf had been grazed by geese or not. For each centre point of the secondary transects, we also took an oblique picture of the vegetation community, with a 2-m ruler as the frame. The picture thus represents an area of approximately 4 m². From each picture, we have counted the number of flowering Arctic cotton-grass *Eriophorum scheuchzeri*.

Figure 3. Transect line in goose grazed marsh in the Draba Sibirica area (Jesper Madsen).



For statistical comparison of the 1984 and 2008 transect data, we used the non-parametric version of the paired t-test, viz. a paired Wilcoxon signed rank test. For analysis of trends along the transect, we used a Mann-Kendall test for mononic trend. Non-parametric tests were used because the frequency data was not normally distributed, even after transformation.

On 31 July 2008, we made an additional transect in a *Carex subspathacea* dominated marsh along the Draba Sibirica River, using the same method and sampling protocol as described above. This marsh was primarily grazed by moulting Barnacle geese, but also some Pink-footed geese occurred according to the primary feathers found shed on the river banks.

Here, we made both the pin-point analysis in the field and the digital photo method to compare the direct field sampling with the photo-based sampling. The two methods did not yield different results.

Plant biomass and productivity of vegetation

To estimate potential food supplies available to moulting geese, the net above-ground primary production (NAPP) of marsh vegetation was studied in 1983 and 1984. In 1983, an enclosure experiment was set up in a *Carex subspathacea* dominated marsh. Biomass was estimated within and outside enclosures on 5 July and 4 August, respectively, i.e. covering the moulting period. In 1984, an enclosure experiments were set up in a Water sedge *Carex stans* - Kentucky bluegrass *Poa pratensis* dominated marsh and in a *Carex subspathacea* dominated marsh (same marsh as in 1983). We simulated goose grazing by clipping during 21 June and 30 July (see Madsen and Mortensen 1987). On 27 July 2008, we revisited the *Carex stans*-*Poa pratensis* marsh where we sampled in 1984. We were not able to set up enclosures, but we took five biomass samples at random in the previous enclosure plot. The area showed no signs of having been grazed by geese; hence, the area is regarded as comparable to the previous enclosures. In five plots of 16 cm x 16 cm (0.0256 m²) each, we clipped the above-ground vegetation to the ground and sorted the vegetation into species; only leaves which were alive were collected. If leaf tips were dead, but the lower part was still alive, the whole leaf was sampled. Samples were stored in paper bags and wind dried in the field. In the laboratory, samples were dried at 50°C for 48 hours, stored in an exicator for 24 hour and weighed.

3.4 Vegetation mapping

In the 1980s, comprehensive vegetation studies were performed in the Jameson Land area. These were based on ground truthing and either false colour infrared aerial photos or satellite imagery (Bay & Holt 1986; Mosbech & Hansen 1994). Unfortunately, we have not been able to perform quantitative analyses of the vegetation change between the 1980s and 2008, because none of the earlier studies exist on a digital form.

In the present study we used a combination of field surveys and satellite imagery processing to produce a map of the wet vegetated habitats (in the following called fens) used by geese. These areas are often located close to lakes, major river systems and coastal areas; lakes and rivers have therefore been a focus for the mapping and the following analyses.

Field surveys

Mapping of the overall coverage and composition of plant communities and registration of the moisture content in the soil surface was carried out in five areas in Jameson Land during July 2009: Ørsted Dal (n=144), Draba Sibirica River (n=86), Constable Point (n=45), Gurreholm (n=20) and Tyskit Nunaat (n=16) (Fig. 4). In plant communities which were visually judged as homogeneous within a radius of at least 15 m, a random plot was selected. Within a circle with a diameter of 2 m (area c. 3.1 m²), we estimated the following (i) the overall coverage, ranging from 0-100%, (ii) the coverage of the four most dominant plant species, including mosses (not identified to species level); hence, the sum of the coverage could exceed 100%, (iii) soil surface moisture content, categorised as

dry, moist and wet (with standing water). All plots were geo-referenced by use of a GPS. For the plots in Ørsted Dal, Draba Sibirica River and Constable Point, oblique digital photos were taken, with the picture frame covering a 2 m long ruler placed in the plot. We focussed on the habitats used by geese, but attempted to cover all major habitat types encompassed as well as gradients in coverage and soil surface moisture content. To assist in selecting habitat types subsequently identifiable from an ASTER satellite image, a handheld computer with a GPS receiver (Trimble Recon[®]) was used with downloaded ASTER satellite imagery of Jameson Land (Ørsted Dal, Draba Sibirica River and Constable Point). This enabled us to navigate and search for gradients in reflection on the image.

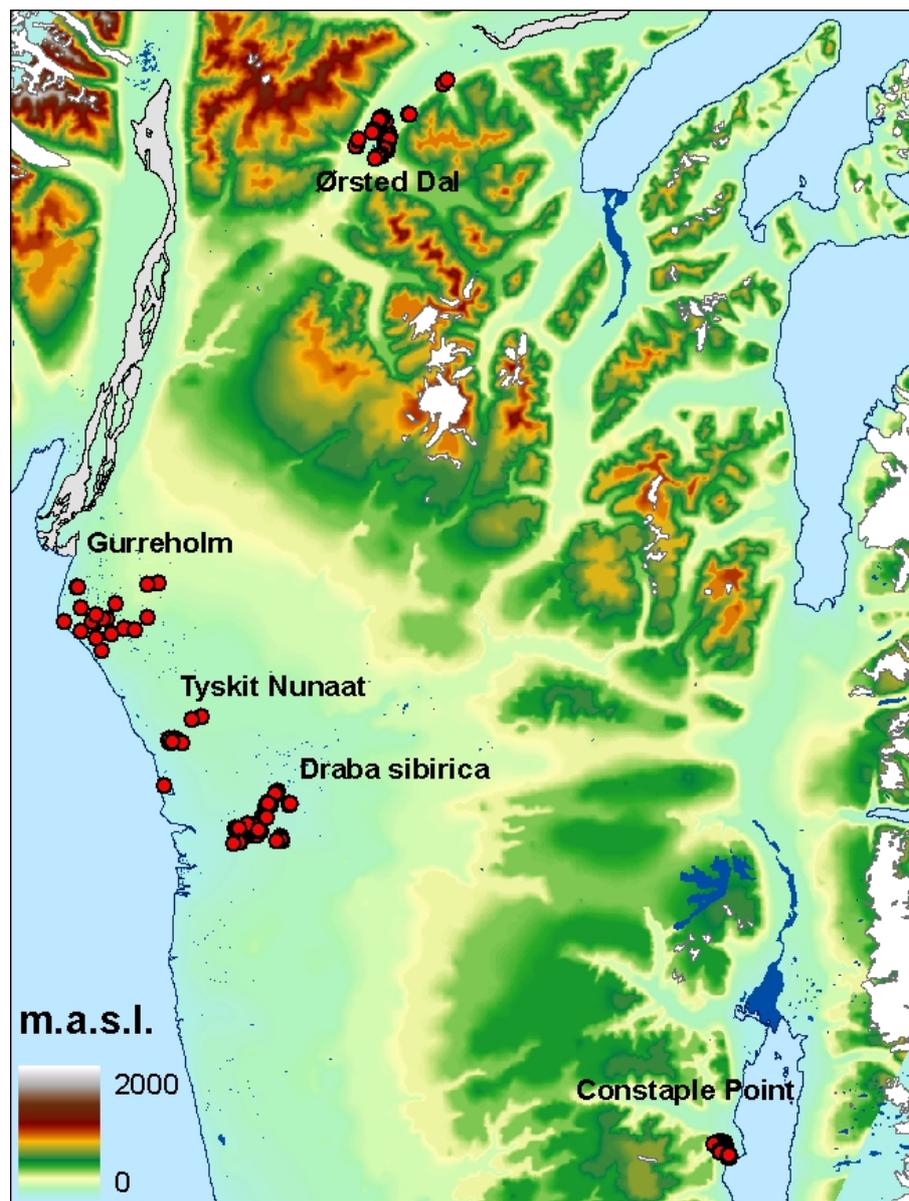
Photo 4. Vegetation ground truthing in the Ørsted Dal study area. Diameter of the 2 m plot is shown by the folding rule (*Cornelia Jaspers*).



Satellite imagery processing

A series of satellite images were used to create a mosaic that covers the entire Jameson Land area. Seven ASTER images and one Landsat ETM+ SLC-off were used. They were all acquired within the three-day period 15 – 17 July 2004 where weather and general conditions were stable. We therefore assume that vegetation development, moisture, snow cover etc. are the same during this short period. All images were georectified and resampled to 15 m using the ENVI software (<http://www.itvis.com>) and atmospherically corrected using the ATCOR3 software (Richter 1997). Due to the slightly different spectral band width and lower spatial resolution of the Landsat ETM+ sensor the edges between the coverage with the different sensor types are somewhat visible. This does not have a significant impact in the analysis of the imagery. Another problem with the Landsat ETM+ SLC-off is the missing data lines. These holes and a few clouded areas have been filled using a Delaunay triangulation based on the bordering areas. Hence, the interpolated areas will not give information on the exact pixel but a more general view of the surrounding pixels. The accuracy of the classification is therefore in these regions slightly lowered. However, as the missing lines in the regions where the Landsat ETM+ imagery has been used only covers 5 lines out of 32 the problem is small and less than 0.3 percent of the mapped area is affected.

Figure 4. Position of plant community studies at the five main field survey locations. All locations are placed in the lowland areas or valleys where vegetation is abundant.



After pre-processing, the images were used to map the areas of major importance for the geese. This includes lakes and larger rivers that function as refuge in relation to predators and wet fens that are the primary feeding ground for geese. Salt marshes are another type of major importance for geese but cannot be distinguished from fell field on the satellite imagery due to its sparse vegetation cover. Instead, salt marshes are included through the addition of a coastal region in the modelling (Refer to 3.5 Spatial analyses).

Lakes

The lakes were mapped using a standard supervised maximum likelihood classification based on visual interpretation of the final mosaic. Some problems occurred in distinguishing lakes from shadows that often are showing the same low spectral reflectance. To avoid misclassification a digital elevation model was used to filter out sloping areas and thereby shadows.

Fens

Fens were mapped using two different indices calculated from the mosaic: Normalised Difference Vegetation Index (NDVI) and Normalised Difference Infrared Index (NDII).

NDVI is widely used for monitoring vegetation characteristics and differences whereas NDII is used for vegetation and surface moisture. NDVI is calculated as the difference in reflection between the near-infrared (NIR) and the red spectral bands using the following equation (Rouse et al. 1973):

$$\frac{\sigma_{NIR} - \sigma_{RED}}{\sigma_{NIR} + \sigma_{RED}}$$

where σ_{NIR} is the reflection at the near-infrared wavelength (ASTER band 3) and σ_{RED} is the reflection at the red wavelength (ASTER band 2). The images were analysed for greenness (NDVI) and surface moisture using a moisture index, NDII (similar to NDVI but uses band 4 and 3 from the ASTER sensor to enhance areas with higher surface moisture (Yilmaz et al. 2008)). Based on the analysis with information from the field observations it was possible to distinguish wet fens with luxurious vegetation. Ranges of NDVI and NDII were based on a comparison between the field observations and the satellite data. Hence, all pixels with NDVI above 0.45 (corresponding to vegetation cover above 80%) and NDII above 0.0 (corresponding to the wet field observations) were mapped as fen. Some of the shallow lakes in the region have a relative high NDVI due to mosses and plants in the water. These areas were masked out using the lake classification.

3.5 Generalized linear model set-up

On the basis of the fen and freshwater areas extracted from the Aster satellite images and results of the ground surveys at Gurreholm and Tyskit Nunaat, we defined the potential foraging area for moulting geese in Jameson Land. Firstly, we evaluated to what extent the potential habitats of moulting geese in Jameson Land were covered by the aerial survey and thereby the credibility of this total count. Secondly, the potential foraging area served as a parameter in a model that described the relationship between the size of the foraging area and the number of geese. This model was then used to predict the number of moulting geese in the proposed replacement area around Ørsted Dal (see section 4.4).

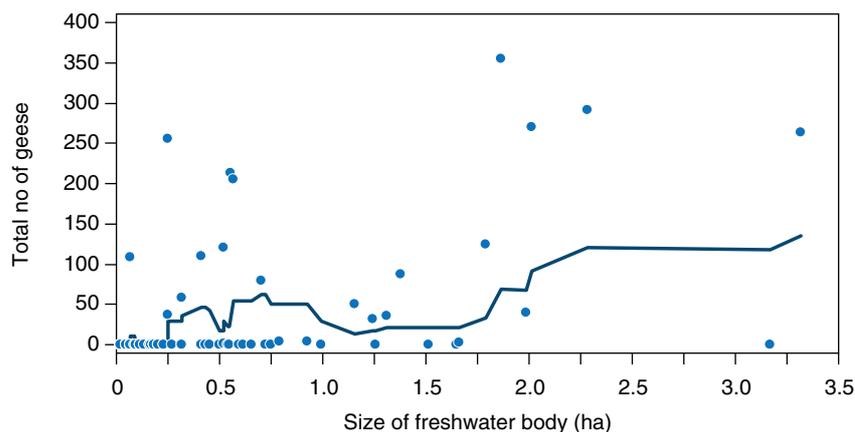
The freshwater areas which resulted from the digital image processing were not always continuous. What in reality was one discrete lake was often represented as a non-continuous cluster of freshwater cells within a limited area. This representation was considered problematic as it resulted in far too many discrete freshwater bodies.

The problem was solved by clustering freshwater bodies situated within 100 meters of each other, measured as the distance between their perimeters. The 100 meters is considered a relevant threshold value, as moulting geese are likely to move this distance and thus probably would consider different water bodies within this distance as one big refuge area (Glahder & Walsh 2006). This single-link clustering algorithm had the

fortunate consequence of chaining together the freshwater cells making up larger rivers, which in the original raster representation were severely fragmented.

The size of the freshwater bodies resulting from the clustering process were compared to the observations of moulting geese made during the field studies at Gurreholm and Tyskit Nunaat (Fig. 5). From this comparison it was evident that the freshwater bodies needed a certain minimum size to serve as a refuge area to the moulting geese. On the basis of the moving average in Fig. 5 only freshwater bodies larger than 0.25 ha were considered to be potential refuge areas.

Figure 5. Number of moulting geese in freshwater bodies of different size in the Gurreholm and Tyskit Nunaat study areas.

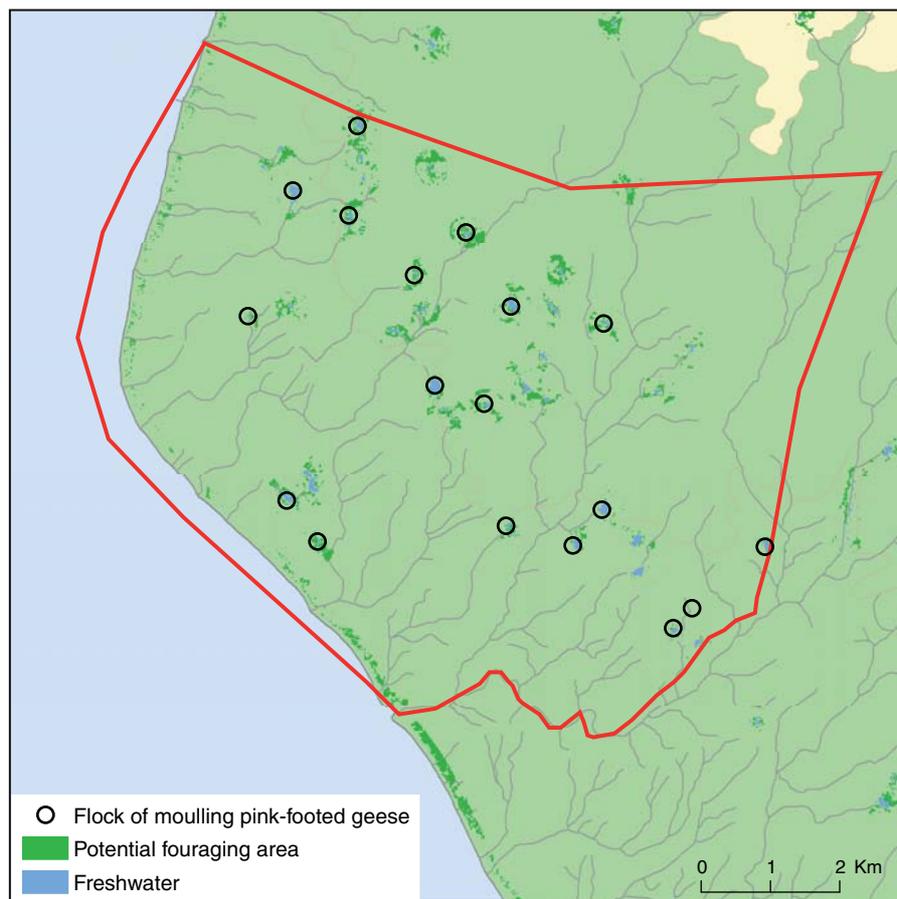


Studies of densities of goose droppings around lakes and rivers in Jameson Land have shown that the moulting geese primarily forage in the sedge-dominated fens up to 200 m away from the water bodies (Madsen & Mortensen 1987). Thus in terms of defining the potential foraging area for moulting geese in Jameson Land *the fen area within 200 m of the clustered freshwater bodies of more than 0.25 ha of size* was extracted from the raster grid of fen vegetation. However, as the moulting geese also use the coast as a refuge area, *fen areas within 200 m of the coastline* were also included.

As an example, Fig. 6 shows the distribution of potential foraging areas in the Gurreholm study area along with the field observations of flocks of moulting Pink-footed geese and all freshwater areas extracted from the satellite images.

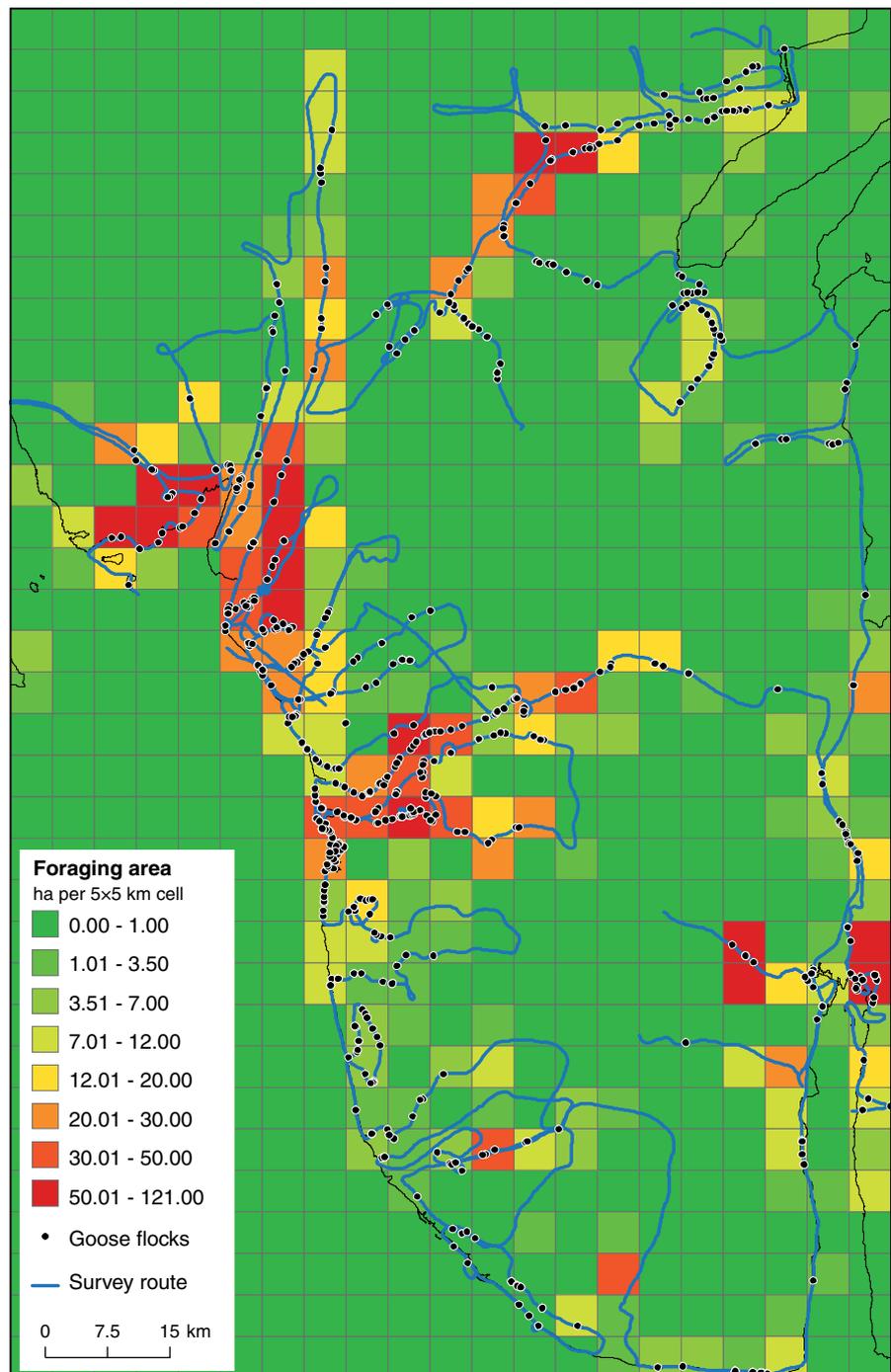
Jameson Land was then overlaid by a grid of 5x5 km cells and within each cell the size of the potential foraging area for moulting geese was calculated (Fig. 7). Aerial survey routes from July 2008 and observed flocks of moulting geese were also included on Fig. 7. Thus, the model is based on the 5x5 km grid overlaid the entire Jameson Land, but only cells intersected by the aerial survey routes and by land areas are included in the dataset. All other cells are excluded as we have no objective knowledge of the number of geese in these cells. Since the survey routes primarily cover areas with large potential foraging areas for moulting geese, we are only modelling the variation within areas where we expect to find geese. Thus, the basis of the model is not a random sample of the Jameson Land area.

Figure 6. The extracted potential foraging areas, freshwater bodies larger than 0.25 ha and observed flocks of moulting Pink-footed geese in the Gurreholm study area.



The response variable of the model is the total number of moulting geese (Barnacle and Pink-footed geese) observed in the cells during the aerial survey in 2008. Two explanatory variables were tested, the size of the potential foraging area for moulting geese within the cells and a factor called "coastal" which indicates whether or not the cells intersect the coast. The coastal areas were separated because we found that coastal salt marshes, which to a large degree constitute the foraging habitat of geese occurring there, did not consistently show up as fen habitat in the satellite imagery analysis. Hence, we expect that the number of geese in relation to salt marshes will be higher than expected from the fen habitat.

Figure 7. Jameson Land overlaid by a 5x5 km grid with calculations of the size of the potential foraging areas (red: highest coverage; dark green: lowest coverage). Aerial survey routes and observed flocks of moulting geese are shown.



A Generalized Linear Model with log-link and quasipoisson errors was applied. In this model, the interaction between potential foraging area and the factor “coastal” turned out not to be significant ($p=0.30$). Both main effects were significant and are retained in the minimal adequate model which thus contains one slope and two intercepts:

```

glm(formula = Geese ~ ForagingArea + Coastal, family = quasipoisson)
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-28.487  -12.530  -11.964   -1.382   68.285

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.270651  0.170891  24.990 < 2e-16 ***
ForagingArea  0.026626  0.003712   7.173 6.81e-12 ***
CoastalYes    0.578217  0.230274   2.511  0.0126 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 439.0666)
Null deviance: 95825 on 277 degrees of freedom
Residual deviance: 78598 on 275 degrees of freedom

```

The model explains approximately 18% of the total deviance, of which the potential foraging area and the factor “coastal” account for 85% and 15% respectively. However, too much faith should not be put in the model as the residuals show some degree of non-normality of errors. Further, there is evidence of spatial autocorrelation of residuals up to a distance of approximately 20 km and the uncertainty of the model is thus likely to be underestimated. At this stage, these issues have not been dealt with, and the model should thus be considered preliminary.

4 Results, birds

4.1 Pink-footed goose

Aerial survey

The total number of Pink-footed geese recorded in Jameson Land during the aerial survey is listed in Table 1. Almost all geese were moulting non-breeding birds. However, here and there downy young were seen in the flocks and small flocks or single pairs with goslings were also recorded. In total, 24 Pink-footed goslings were seen.

Table 1. Total number of geese recorded during the aerial survey in Jameson Land 17 and 18 July 2008.

Goose species	Number of birds	Number of flocks
Pink-footed goose	19068	384
Barnacle goose	16603	431
Canada goose	2	1

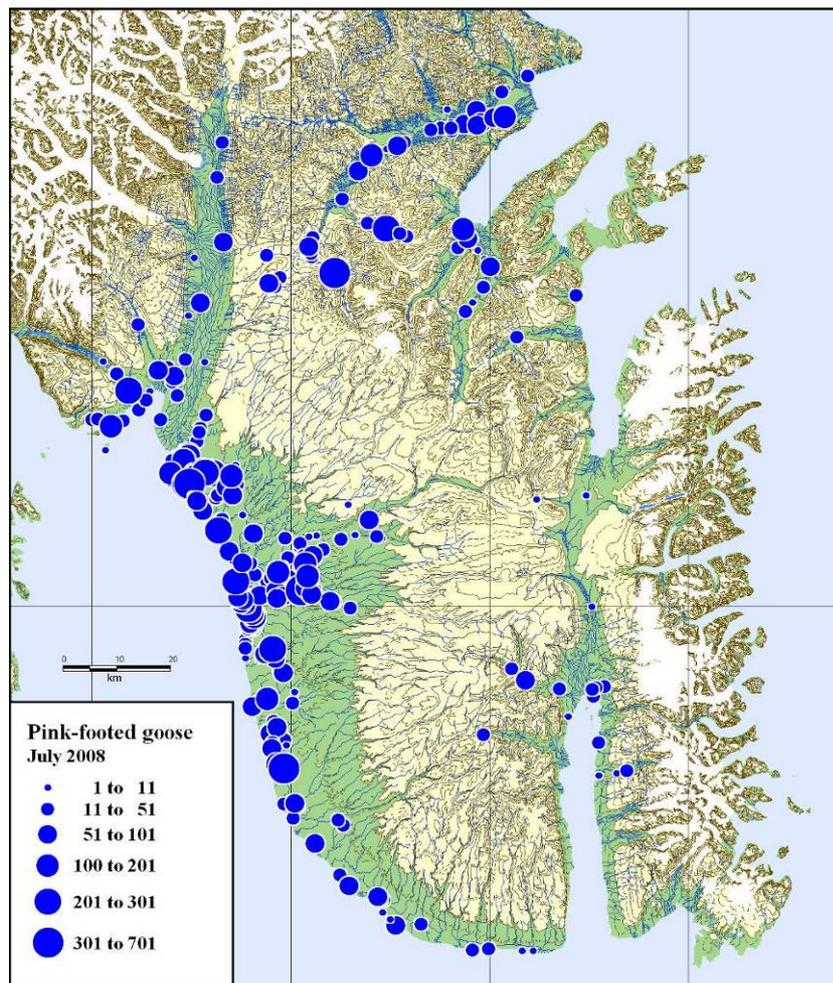
Photo 5. Flock of moulting Pink-footed geese on a lake in the Gurreholm study area (*Alyn Walsh*).



Only very few Pink-footed geese were recorded flying ($n = 21$) and the geese had usually taken refuge on water – rivers, lakes, ponds and the sea. However, a few flocks remained on river and lake shores when over flown.

The distribution of the Pink-footed geese is shown in Figure 8.

Figure 8. Distribution of flocks of Pink-footed geese in Jameson Land recorded during aerial surveys on 17 and 18 July 2008. Flock sizes are indicated by the size of the signature. In total 384 flocks with a total of 19,068 birds were recorded (corrected for birds recorded more than once).



Ground studies

From the ground it was possible to distinguish between moulting geese and family flocks. The moulting flocks were often rather large and mostly encountered on or close to larger lakes or rivers, whereas the family flocks formed smaller groups that were often feeding near ponds and streams, on marshes or on the tundra. In many instances it was possible to separate single families so that the brood size could be registered. Adult failed breeding birds could be part of the family flocks. Because of different methodology used in the aerial survey and the ground survey, it is not possible directly to compare the results, but the two studies give a fairly good idea of the total number of moulting geese in the ground study areas. Below, the results from the aerial study and the ground studies are given for each of the four ground study areas.

The Gurreholm area

A total of 2752 moulting Pink-footed geese and 834 geese in family flocks were counted from the ground (Figs. 9 and 10, Table 2). The table also show the distribution of adults and young. Young per breeding pair could be calculated from 76 families, giving an average of 2.80. From the air a total of 3971 moulting Pink-footed geese were counted, while no family groups were observed (Figure 11, Table 2).

Table 2. Pink-footed geese in the Gurreholm area counted from the air on 17 July 2008 and from the ground during 17-25 July 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
3971	0	0	0	2752	442	392	834

Figure 9. Moulting Pink-footed geese in the Gurreholm and Tyskit Nunaat areas counted from the ground. Total numbers were 2752 and 1090 birds, respectively.

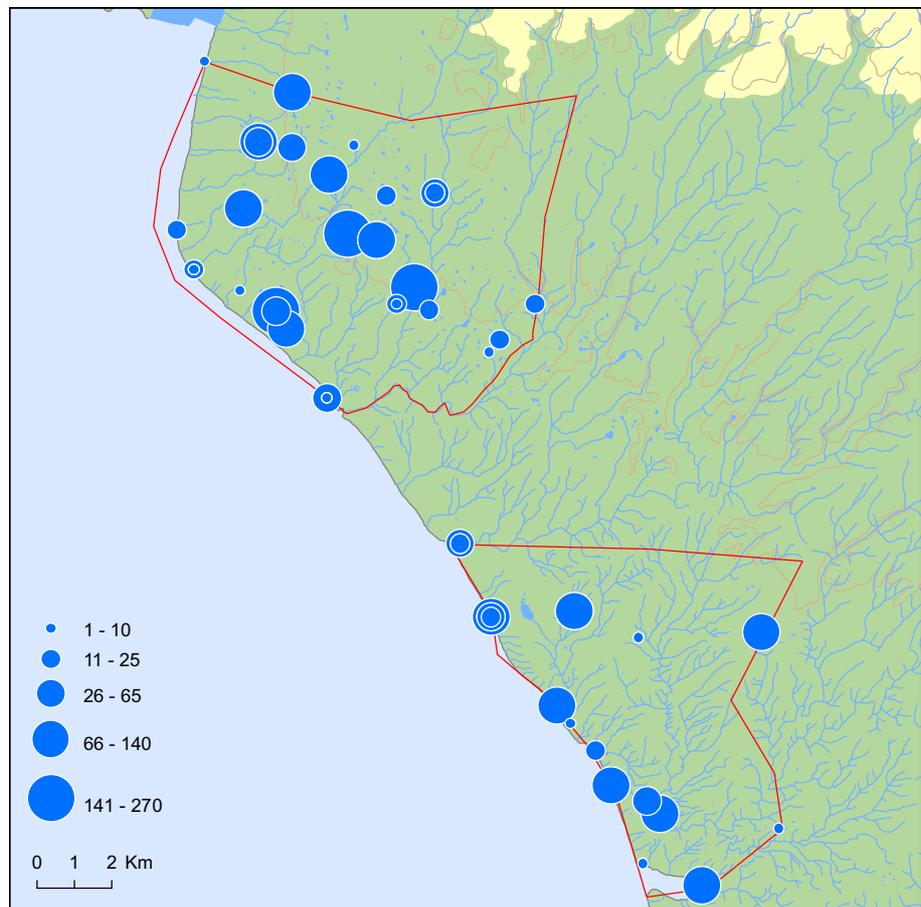


Figure 10. Family groups of Pink-footed geese in the Gurreholm and Tyskit Nunaat areas counted from the ground. Total numbers was 834 and 83 birds, respectively.

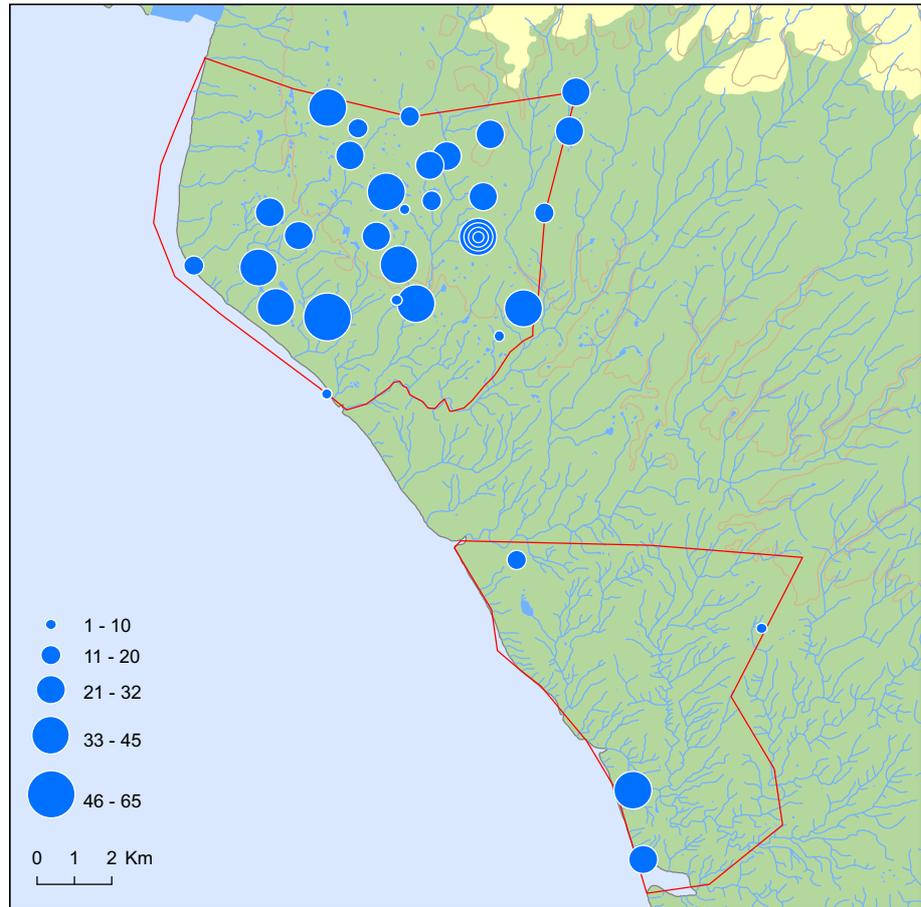
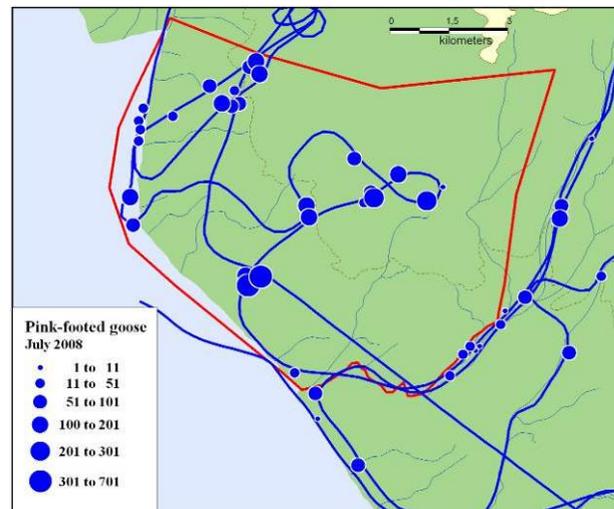


Figure 11. Pink-footed geese in the Gurreholm area counted from the air. Total number was 3971 birds.



Goose droppings counts in the Gurreholm area

In the Gurreholm area the relative activity of moulting geese was registered by counting goose droppings along transect lines at selected lakes shores. At 13 lakes droppings were counted at a total of 16 transects (figure 12, Table 3).

Figure 12. Transect with goose droppings counts in Gurreholm (green dots).

Included also are observations of exploration activities: blue dots show Quadra Mining Ltd. activities (port site to the west and airstrip length indicated by the two dots further north); in 1960's the mining company Nordisk Mineselskab explored the area (brown dot indicates a smaller harbour) and in 1980's the oil company ARCO explored intensively the area (lilac dots indicate seismic vehicle tracks).

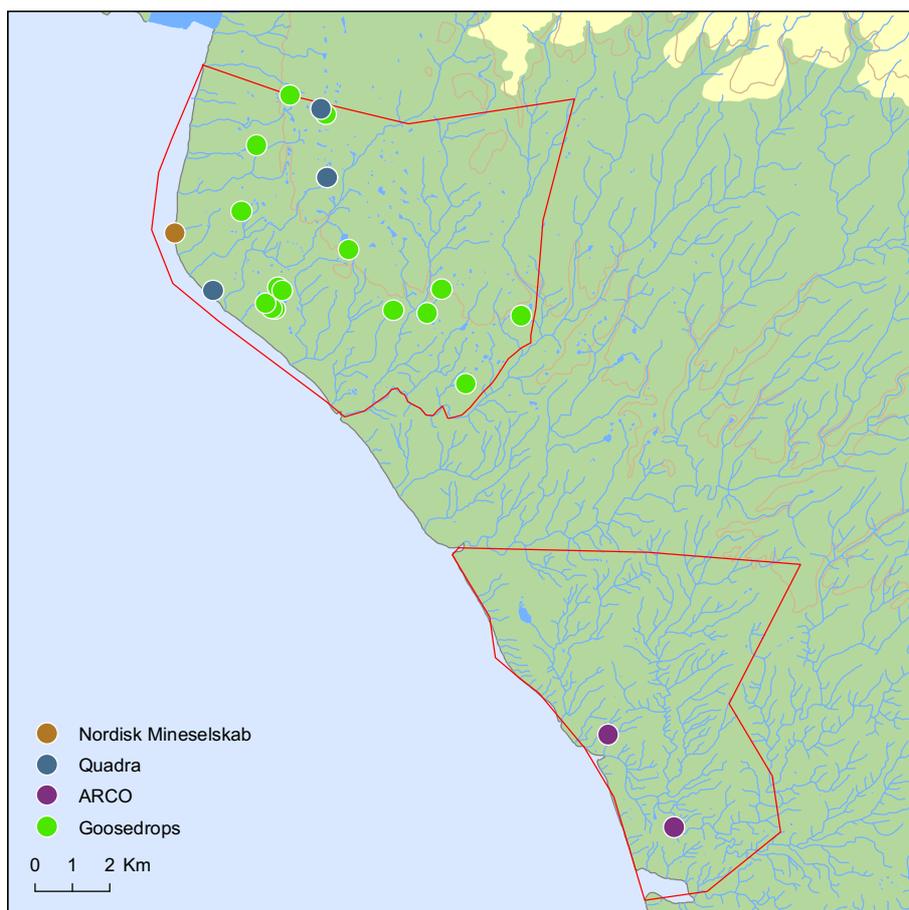


Table 3. The relative number (in % of highest number) of Pink-footed goose droppings from 15 transects in moulting habitats in the Gurreholm area. *): The transect JT12 was in a family group habitat. Droppings were counted in distances of 2, 10, 20, 40 and 60 m from the lake shore (Dist. (m)).

Dist. (m)	JT01	JT02	JT03	JT04	JT05	JT06	JT07	JT08	JT09	JT10	JT11	JT12*)	JT13	JT14	JT15	JT16
2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	45.0	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0
10	30.2	76.5	58.8	52.9	44.8	56.1	31.9	60.0	20.0	52.4	52.0	100.0	71.4	93.6	46.2	21.8
20	13.8	17.6	32.4	70.6	6.9	63.4	16.7	60.0	0.0	4.8	16.0	0.0	14.3	36.2	57.7	12.7
40	9.4	11.8	5.9	17.6	3.4	24.4	0.0	95.0	0.0	23.8	4.0	100.0	19.0	12.8	23.1	1.8
60	0.0	0.0	23.5	5.9	6.9	43.9	0.0	100.0	6.7	0.0	0.0	75.0	4.8	8.5	7.7	5.5

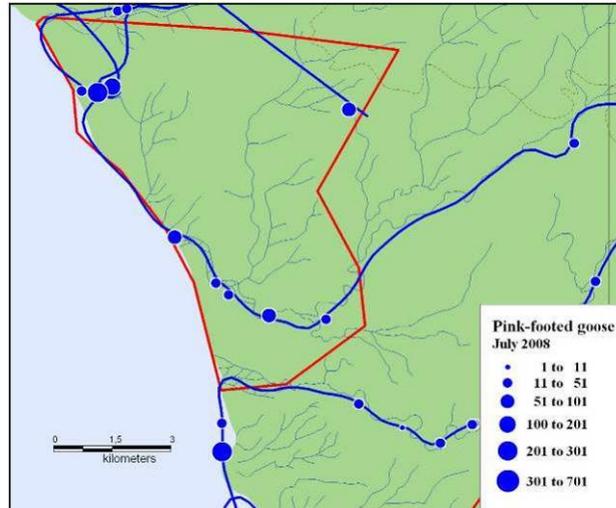
The Tyskit Nunaat area

From the ground, a total of 969 moulting Pink-footed geese and 83 geese in family flocks were counted (Figs. 9 and 10, Table 4). The table also show the distribution of adults and young. Young per breeding pair could be calculated from only 4 families, giving an average of 3.50. The aerial survey observed a total of 969 moulting Pink-footed geese, nearly the same amount counted from the ground. No family groups were observed from the air (Figure 13, Table 4).

Table 4. Pink-footed geese in the Tyskit Nunaat area counted from the air on 17 July 2008 and from the ground during 25 July and 1 August 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
969	0	0	0	1090	57	26	83

Figure 13. Pink-footed geese in the Tyskit Nunaat area counted from the air. A total of 969 birds were observed.



The Ørsted Dal area

A total of 166 moulting Pink-footed geese and 54 geese in family flocks were counted from the ground (Figure 14, Table 5). The table also shows the distribution of adults and young. Young per breeding pair could be calculated from 10 families, giving an average of 2.70. From the air a total of 408 moulting Pink-footed geese were counted, while no family groups were observed (Figure 15, Table 5).

Table 5. Pink-footed geese in the Ørsted Dal area counted from the air on 18 July 2008 and from the ground during 17-25 July 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
408	0	0	0	166	27	27	54

Figure 14. Moulting Pink-footed geese and family flocks in the Ørsted Dal area counted from the ground. Total numbers were 166 and 54 birds, respectively.

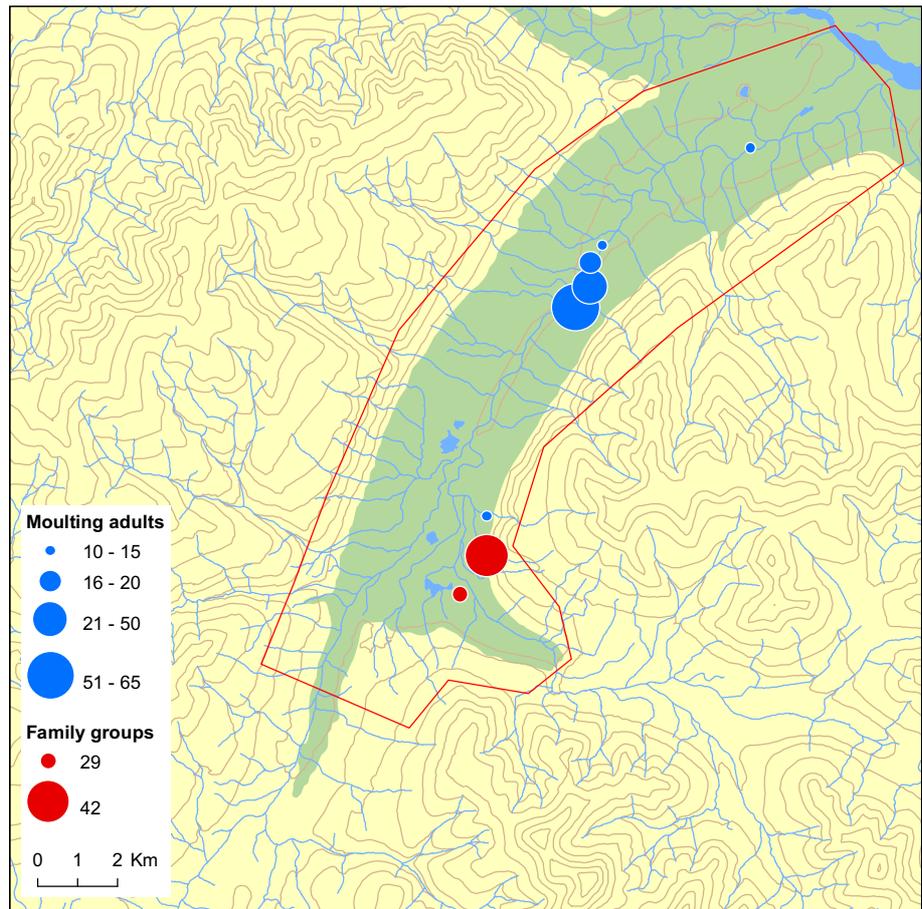
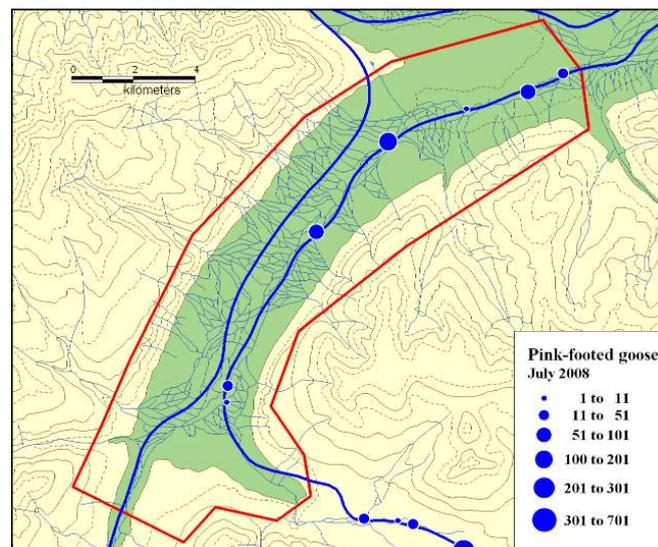


Figure 15. Pink-footed geese in the Ørsted Dal area counted from the air. A total of 408 moulting birds were observed.



The Draba Sibirica area

A total of 2756 moulting Pink-footed geese and 770 geese in family flocks were counted from the ground (Figure 16, Table 6). The table also shows the distribution of adults and young. Brood sizes could not be counted accurately. From the air a total of 2483 moulting Pink-footed geese were counted, while no family groups were observed (Figure 17, Table 6).

Table 6. Pink-footed geese in the Draba Sibirica area counted from the air on 17 July 2008 and from the ground during 17-25 July 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
2483	0	0	0	2756	338	432	770

Figure 16. Moulting Pink-footed geese and family flocks in the Draba Sibirica area counted from the ground. Total number was 2756 and 770 birds, respectively.

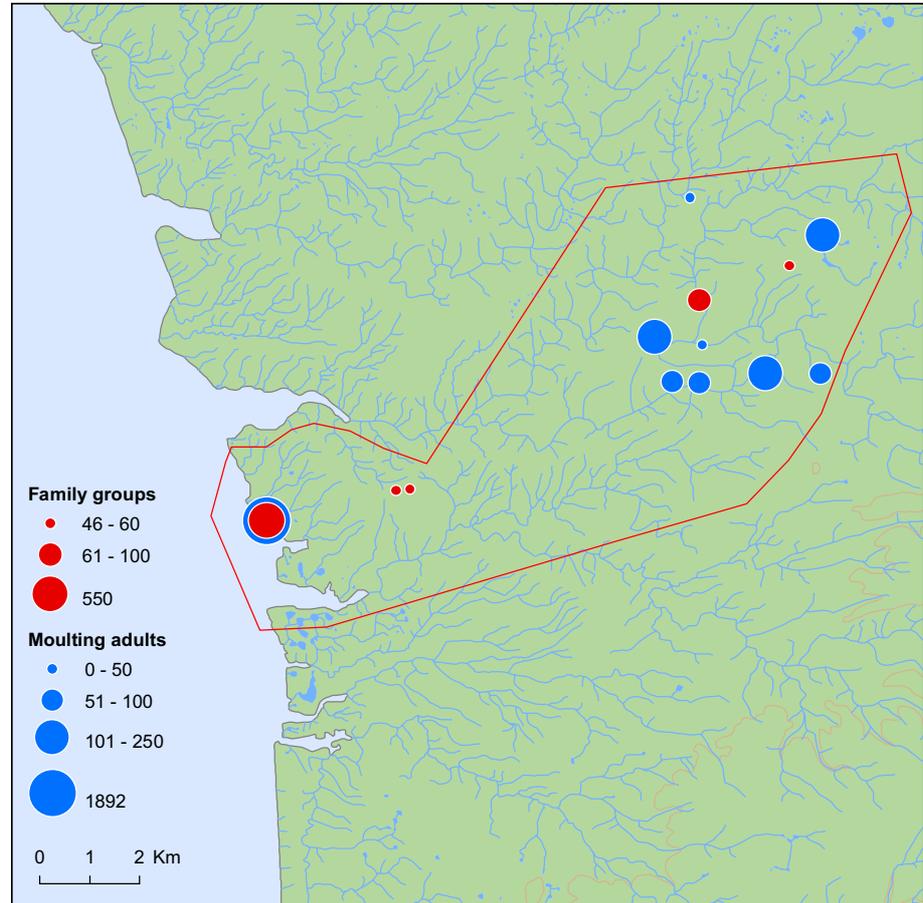
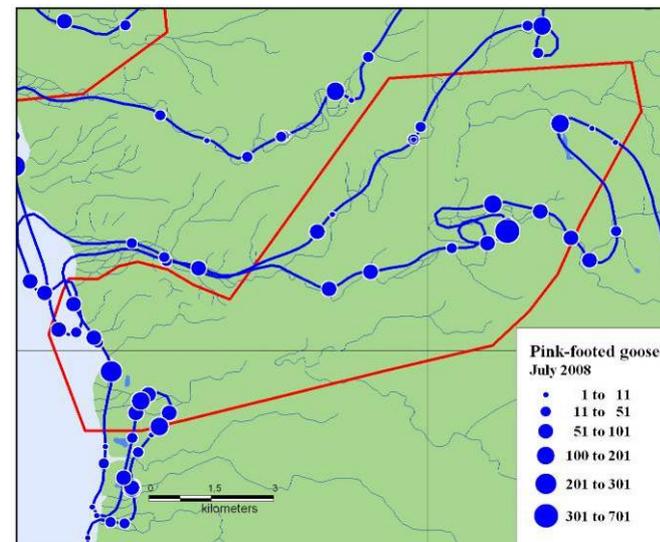


Figure 17. Pink-footed geese in the Draba Sibirica area counted from the air. A total of 2483 birds were observed.



4.2 Barnacle goose

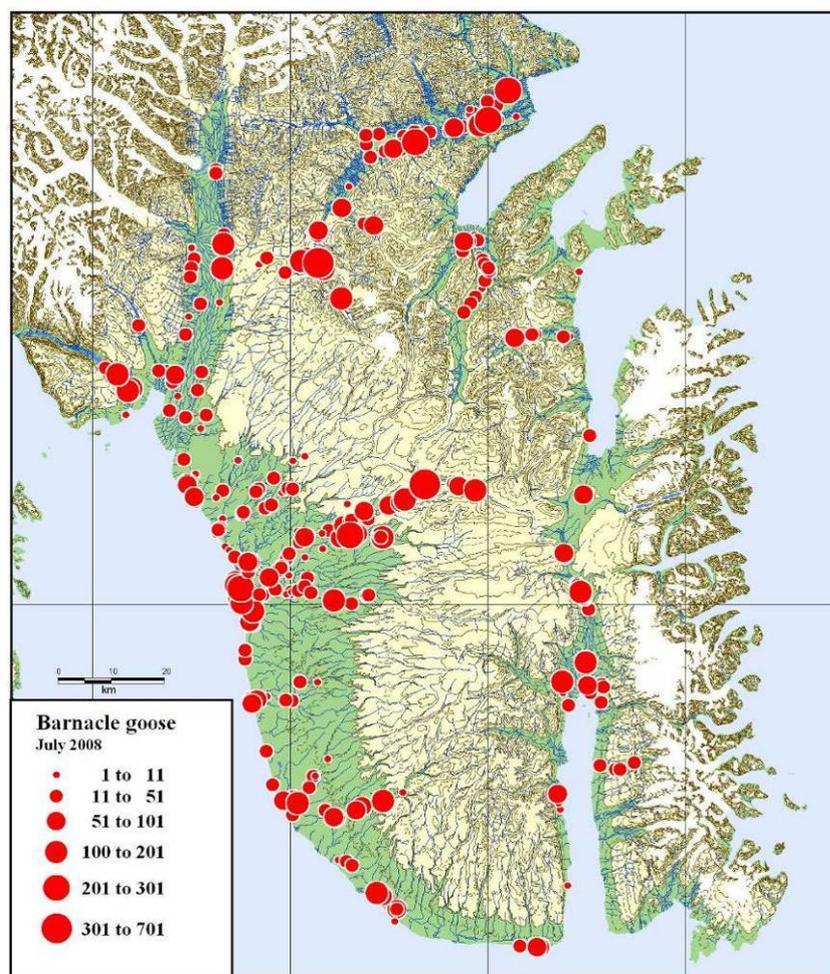
Aerial survey

The total number of Barnacle geese recorded in Jameson Land during the aerial survey is listed in Table 1. Almost all were moulting non-breeding birds. However, here and there downy young were seen in the flocks and small flocks or single pairs with goslings were also recorded. In total, 45 Barnacle goslings were seen.

Only very few Barnacle geese were recorded flying ($n = 8$) and the geese had usually taken refuge on water – rivers, lakes, ponds and the sea.

The distribution of the Barnacle geese is shown in Figure 18.

Figure 18. Distribution of flocks of Barnacle geese in Jameson Land recorded during aerial surveys on 17 and 18 July 2008. Flock sizes are indicated by the size of the signature. In total 431 flocks with a total of 16,630 birds were recorded (corrected for birds recorded more than once).



Ground studies

From the ground it was possible to distinguish between moulting geese and family flocks. The moulting flocks were often rather large and mostly encountered on or close to larger lakes or rivers, whereas the family flocks formed smaller groups that often were feeding near ponds and streams. In many instances it was possible to separate single families so that the brood size could be calculated. Because of different methodology used in the aerial survey and the ground survey, it is not possible directly to compare the results, but the two studies give a fairly good idea

of the total number of moulting geese in the ground study areas. Below, the results from the aerial study and the ground studies are given for each of the four ground study areas.

Photo 6. Barnacle geese still able to fly.



The Gurreholm area

A total of 167 moulting Barnacle geese and one family flock of 8 individuals were counted from the ground (Figs. 19, Table 7). From the air a total of 284 moulting Barnacle geese were counted, while no family groups were observed (Figure 20, Table 7).

Figure 19. Moulting (blue) Barnacle geese and family flocks (red) in the Gurreholm and Tyskit Nunaat areas counted from the ground. Total numbers in Gurreholm were 167 moulting geese and 8 family birds and in Tyskit Nunaat 201 moulting geese.

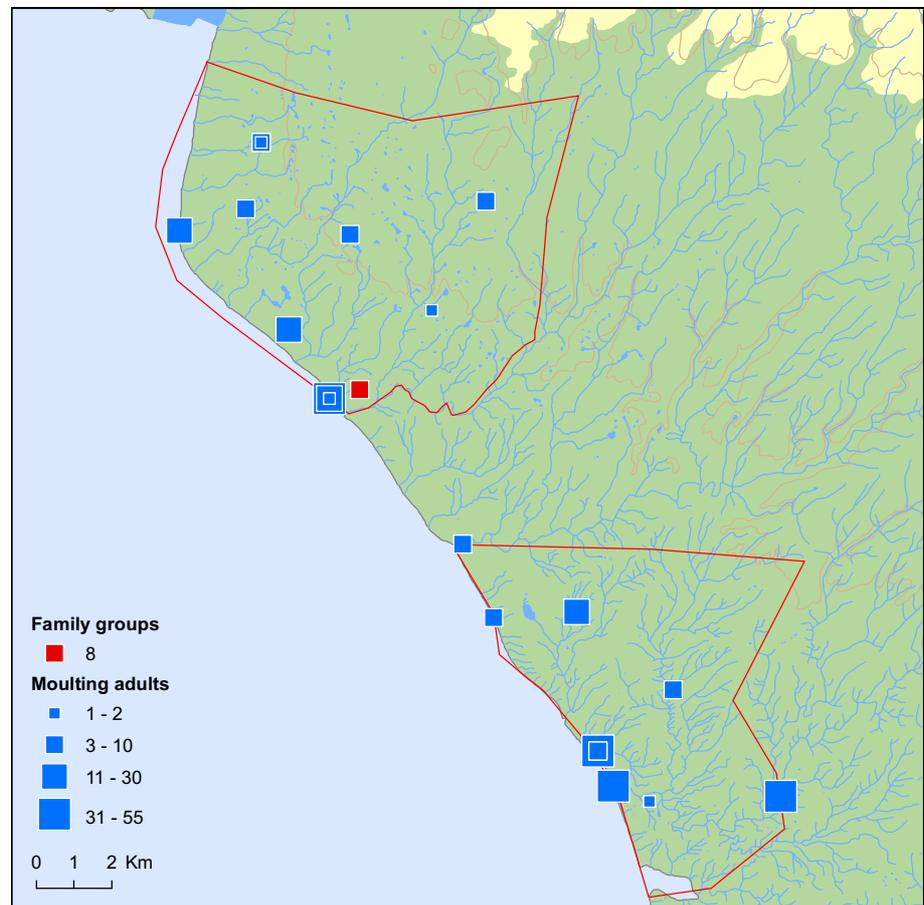
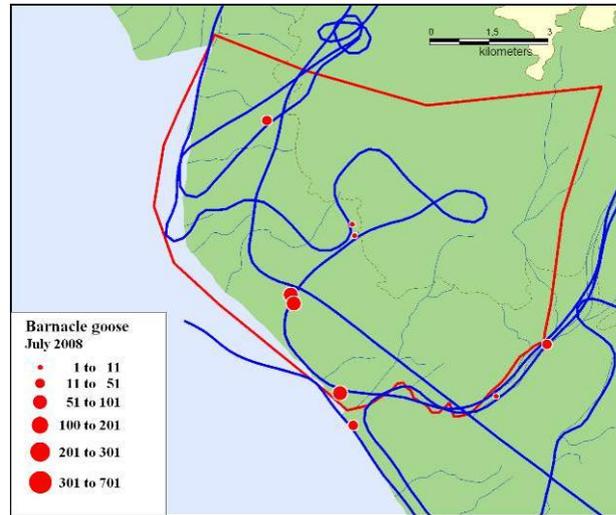


Table 7. Barnacle geese in the Gurreholm area counted from the air on 17 July 2008 and from the ground during 17-25 July 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
284	0	0	0	167	6	2	8

Figure 20. A total of 284 moulting Barnacle geese were counted from the air in the Gurreholm area.



The Tyskit Nunaat area

From the ground, a total of 201 moulting Barnacle geese and no family flocks were counted (Figs. 19, Table 8). The aerial survey observed a total of 269 moulting Barnacle geese, not very different from the number counted from the ground. No family groups were observed from the air (Figure 21, Table 8).

Figure 21. A total of 269 moulting Barnacle geese were counted from the air in the Tyskit Nunaat area.

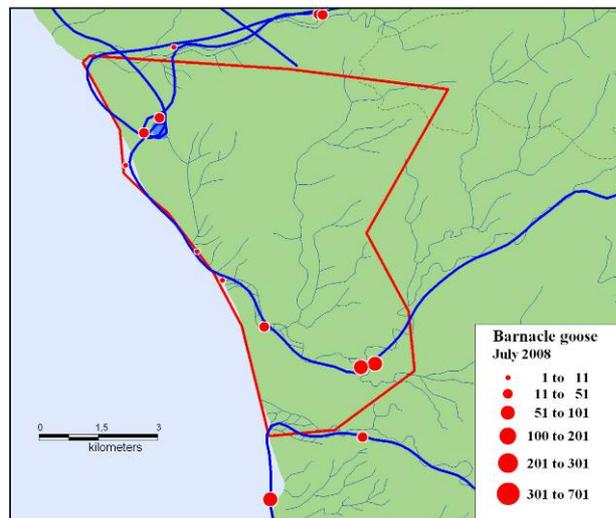


Table 8. Barnacle geese in the Tyskit Nunaat area counted from the air on 17 July 2008 and from the ground during 25 July and 1 August 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
269	0	0	0	201	0	0	0

The Ørsted Dal area

A total of 696 moulting Barnacle geese and 123 geese in family flocks were counted from the ground (Figure 22, Table 9). The table also shows the distribution of adults and young. Young per breeding pair could be calculated from 17 families, giving an average of 1.71. From the air a total of 542 moulting Barnacle geese were counted and probably only one family group with 2 young were observed (Figure 23, Table 9).

Figure 22. Moulting Barnacle geese and family flocks in the Ørsted Dal area counted from the ground. Total numbers were 696 and 123 birds, respectively.

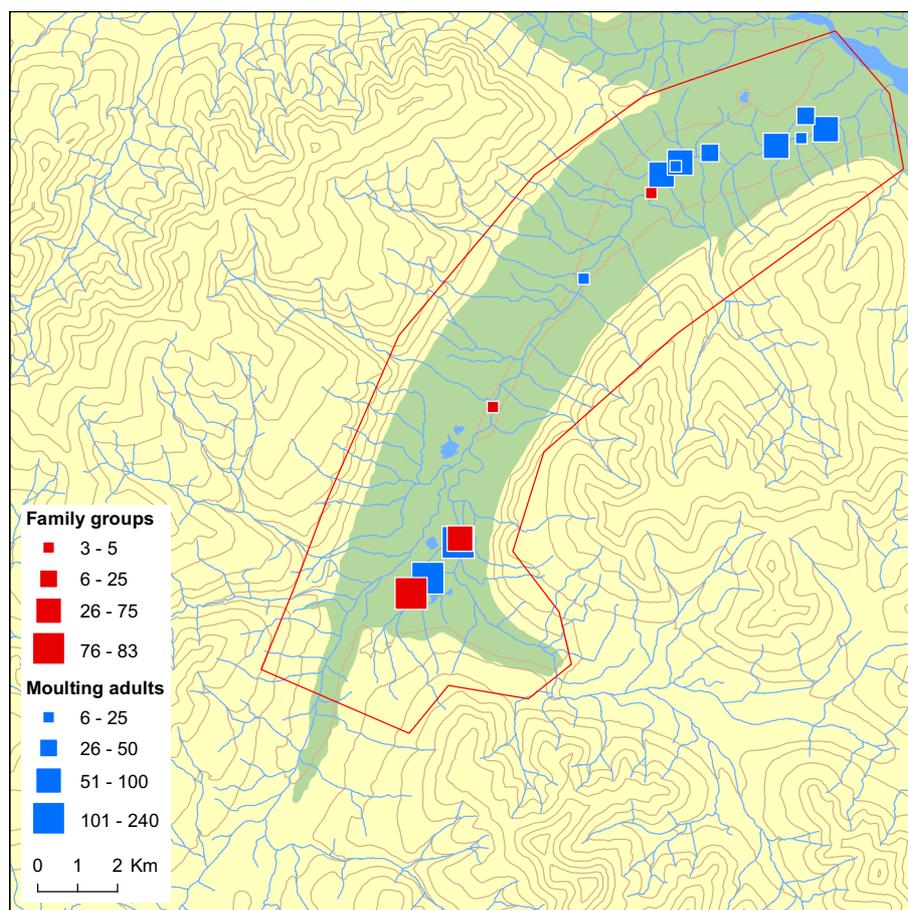
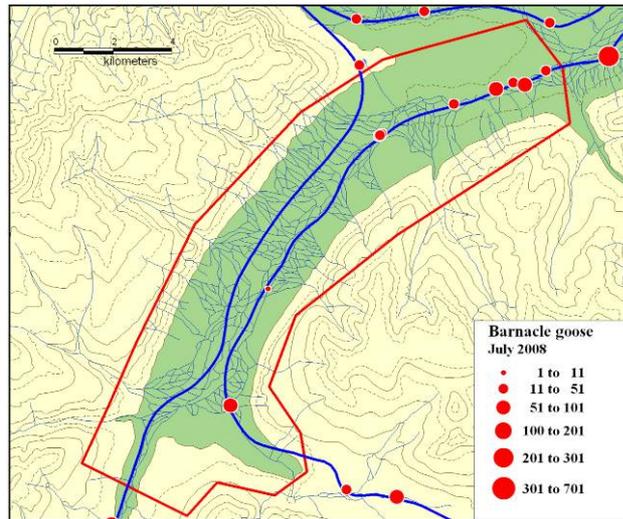


Table 9. Barnacle geese in the Ørsted Dal area counted from the air on 18 July 2008 and from the ground during 17-25 July 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
542	0	2	2	696	82	41	123

Figure 23. Barnacle geese in the Ørsted Dal area counted from the air. A total of 544 birds were observed.



The Draba Sibirica area

A total of 240 moulting Barnacle geese and 37 geese in family flocks were counted from the ground (Figure 24, Table 10). The table also show the distribution of adults and young. Young per breeding pair could be calculated from 6 families, giving an average of 3.83. From the air a total of 1122 moulting Barnacle geese were counted, while no family groups were observed (Figure 25, Table 10).

Figure 24. Moulting Barnacle geese and family flocks in the Draba Sibirica area counted from the ground. Total numbers were 240 and 37 birds, respectively.

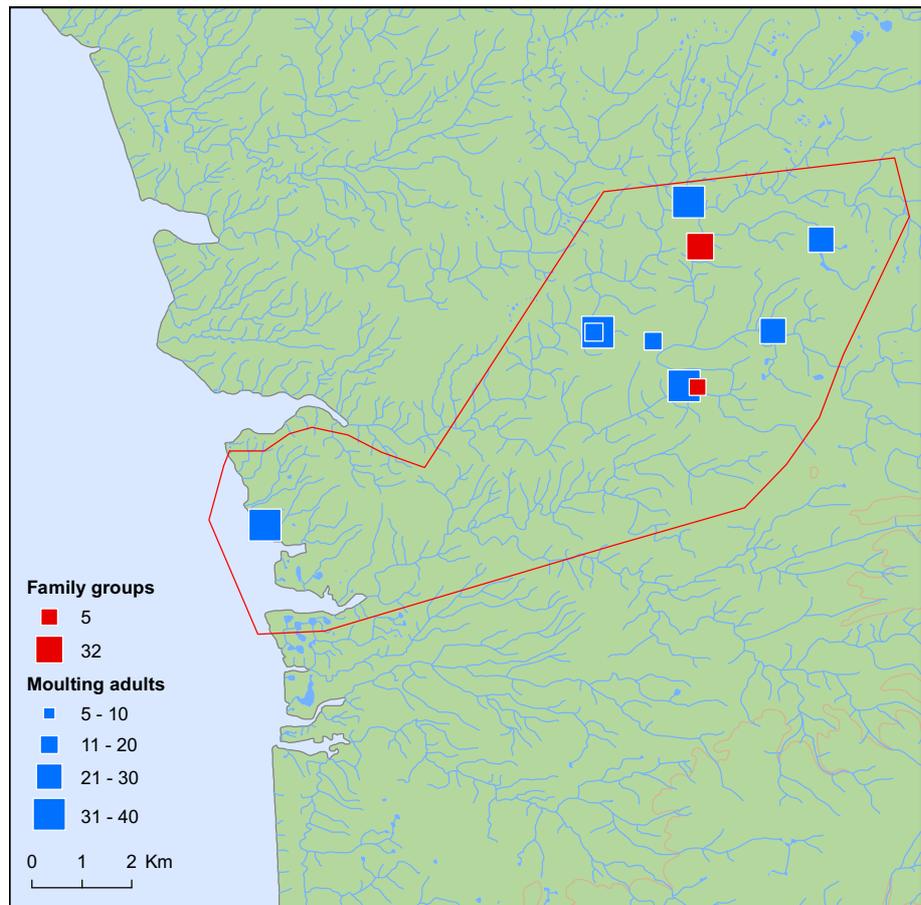
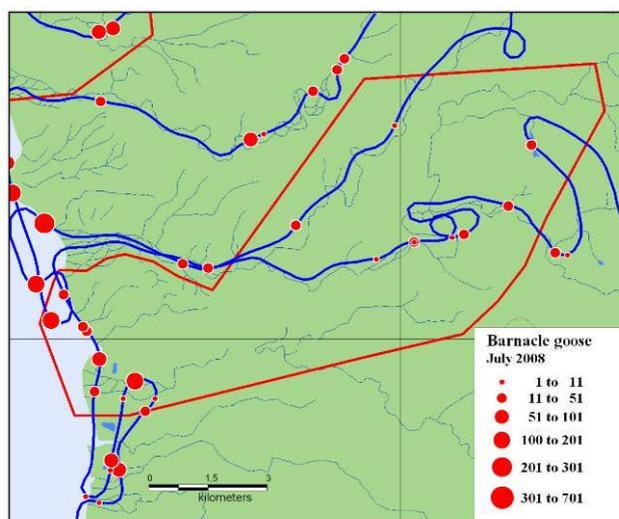


Table 10. Barnacle geese in the Draba Sibirica area counted from the air on 17 July 2008 and from the ground during 25-31 July 2008.

Aerial survey				Ground count			
Moulting	Breeding			Moulting	Breeding		
	Adult	Young	Total		Adult	Young	Total
1122	0	0	0	240	14	23	37

Figure 25. Barnacle geese in the Draba Sibirica area counted from the air. A total of 1122 birds were observed.



4.3 Goose grazed marshes

In 1983 and 1984, studies of the plant frequency distribution and productivity of vegetation used by moulting geese were carried out in the Draba Sibirica area (Madsen et al. 1984, Madsen & Mortensen 1987). To see if major changes had taken place from 1983-84 to 2008, i.e., as a long-term effect of possible intensified goose grazing due to increasing goose populations over the 25 year period or as an effect of climate change, we returned to the same areas to repeat the studies. This information is important for the assessment of the habitat carrying capacity of Jameson Land for moulting geese.

Marsh vegetation composition

The overall composition of the vegetation of the goose grazed marsh in the Draba Sibirica area in 1984 and 2008 is comparable (Fig. 26). Less frequent species (less than 1% in overall frequency) are not shown, such as Herb-like willow *Salix herbacea*, *Saxifraga foliosa*, Viviparous knotweed *Bistorta viviparum*, *Juncus* spp., *Carex stans* and Horsetail spp. *Equisetum* spp. At a distance of up to approximately 120 m from the lake shore, *Carex subspathacea*, protruding the moss carpet, was dominating. Further away from the lake, Loose-flowered Alpine sedge *Carex rariflora* became dominant. However, between years, there were significant differences.

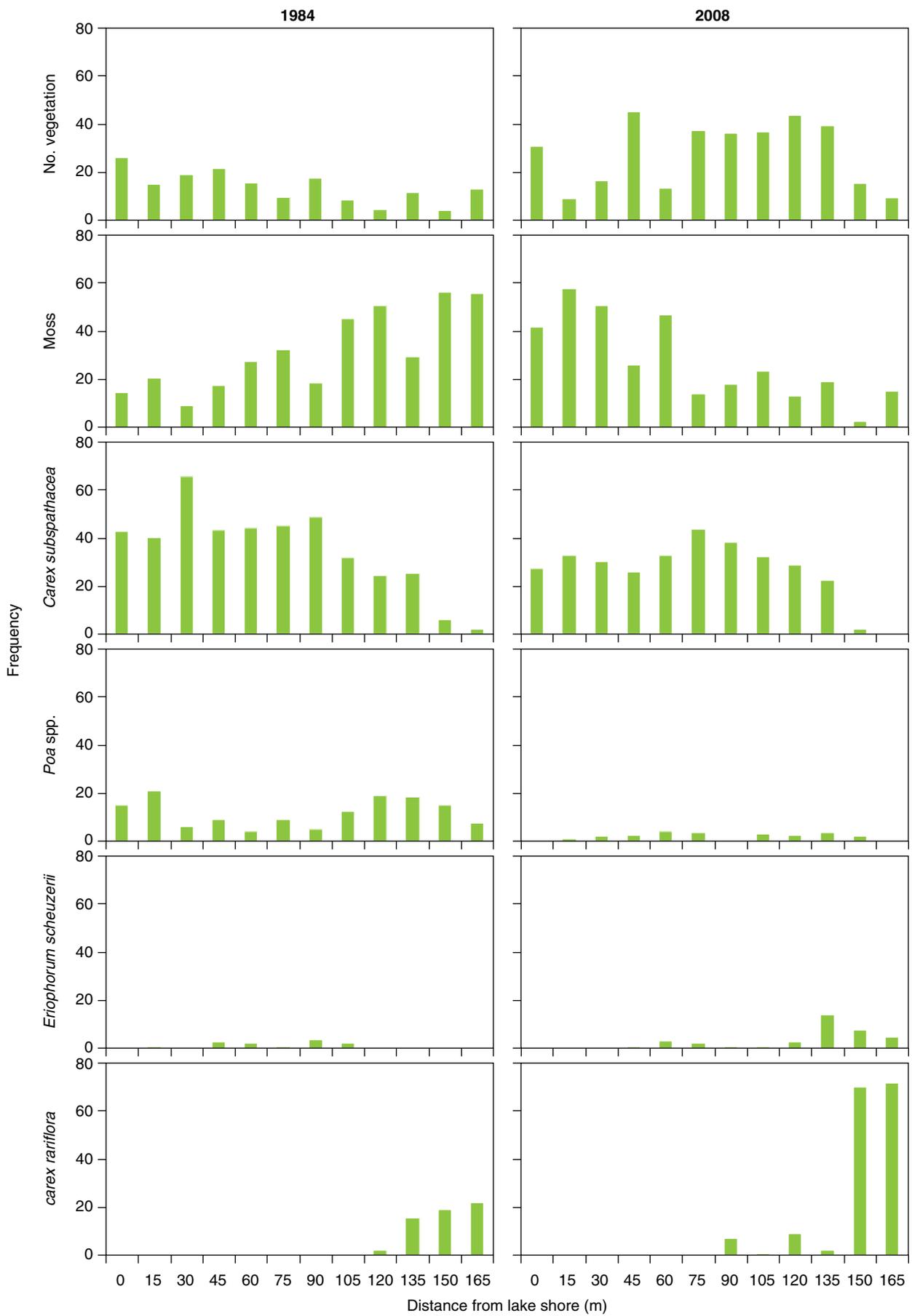


Figure 26. Frequency distribution in 1984 and 2008 of plants and unvegetated points in a goose grazed sedge and moss dominated marsh in the Draba Sibirica area in relation to the distance to the lake shore.

First, the frequency of points with no vegetation increased from 1984 to 2008 (Table 11); in 1984, the frequency decreased with distance from the lake shore, whereas there was no trend in 2008. Second, in 1984, the frequency of moss increased with distance from lake shore, whereas the opposite was the case in 2008. Third, the frequency of *Carex subspathacea* was higher in 1984 compared to 2008. Fourth, *Poa* spp. was more frequent in 1984 compared to 2008. *Eriophorum scheuchzeri* increased in frequency with distance to lake in 2008, but showed no trend in 1984.

Table 11. Statistical comparison of coverage of vegetation along transect in goose grazed marsh in the Draba Sibirica area, 1984 vs. 2008, and trends in coverage from the lake shore and 165 m inland. Difference in coverage between 1984 and 2008 is expressed by a Paired Wilcoxon signed rank test (V-value) (non-parametric equivalent of a paired t-test), trends by a Mann-Kendall test for mononic trend (Tau-value).

	Difference 1984-2008 V	Trend 1984 Tau	Trend 2008 Tau
No vegetation	11 *	-0.576 *	0.06 ^{n.s.}
Moss	42 ^{n.s.}	0.758 **	-0.606 **
<i>Carex subspathacea</i>	72 **	-0.485 *	-0.382 ^{n.s.}
<i>Poa</i> spp.	78 **	0.091 ^{n.s.}	0.095 ^{n.s.}
<i>Eriophorum scheuchzerii</i>	16 ^{n.s.}	-0.224 ^{n.s.}	0.688 **
<i>Carex rariflora</i>	4 ^{n.s.}	0.759 **	0.776 **

*significant at 5% level (2-sided); ** significant at 1% level (2-sided); ^{n.s.} not significant.

The geese grazed the vegetation intensively. Hence, within 100 m from the lake shore, approximately 80% of all leaves of *Carex*, *Poa* and *Eriophorum* were grazed. Beyond that distance, grazing pressure decreased, and at distance of 165 m from the lake, none of the leaves were grazed (Fig. 27). Furthermore, until 130 m from the lake shore, no *Eriophorum scheuchzeri* was recorded flowering in the central photo plots; beyond that distance, flowering plants occurred frequently (with 4-9 flowers per 4 m²).

Figure 27. The proportion of leaves of monocot vegetation grazed by moulting geese in relation to the distance to the lake shore. Data are from the same marsh shown in Fig. 26 in the Draba Sibirica area in 2008.

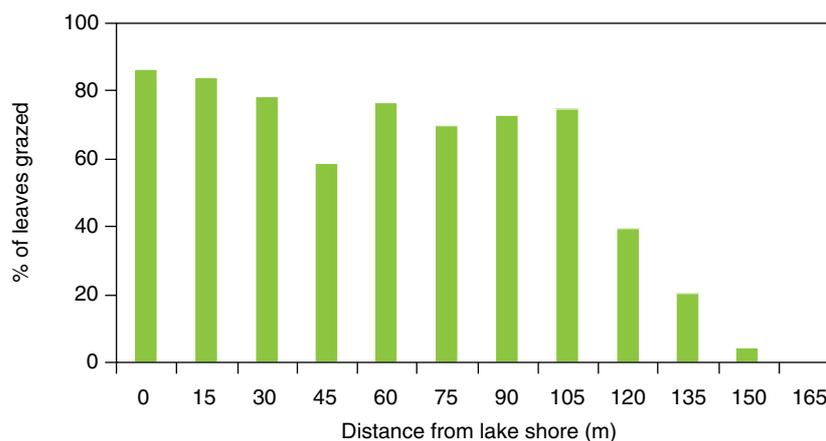
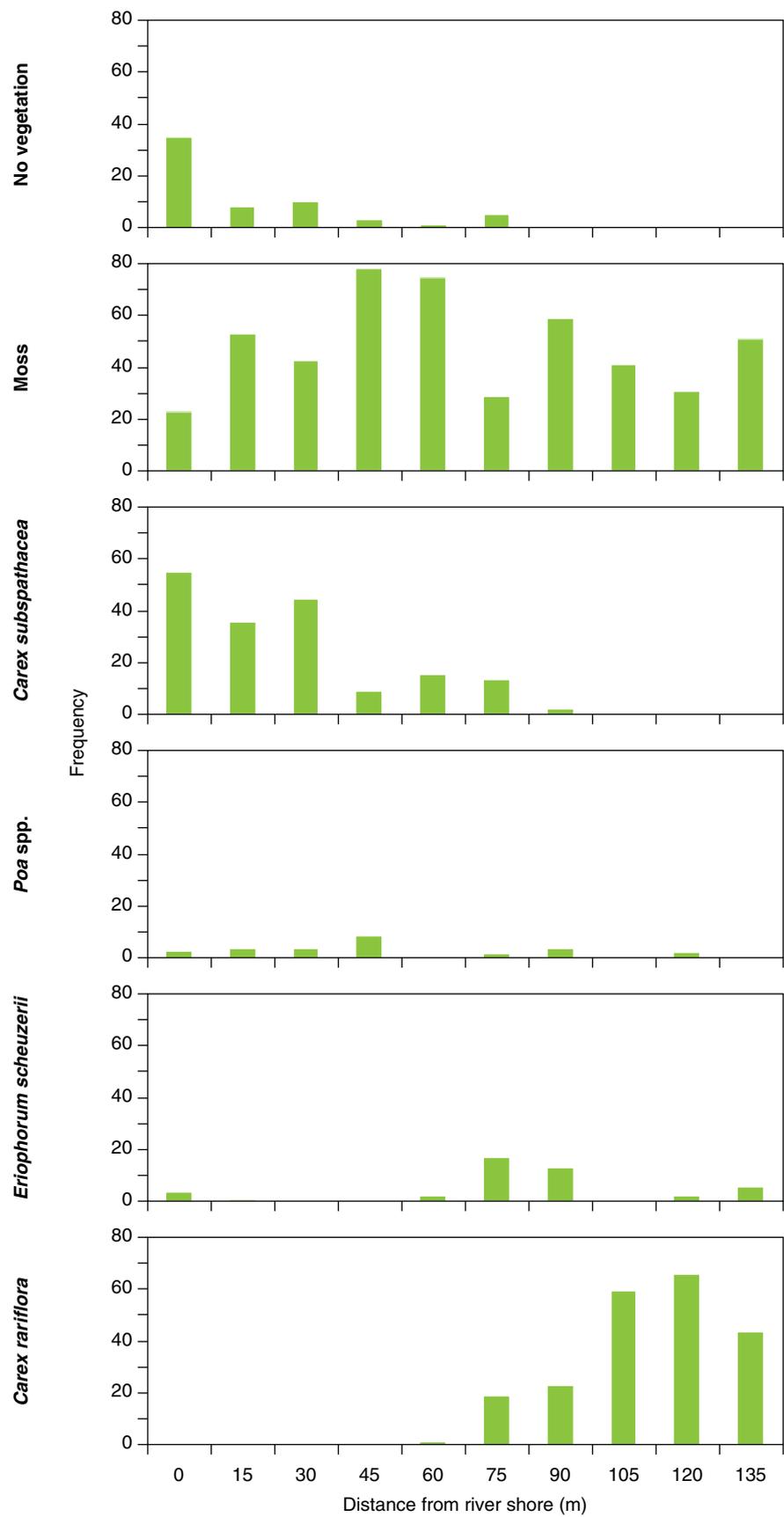
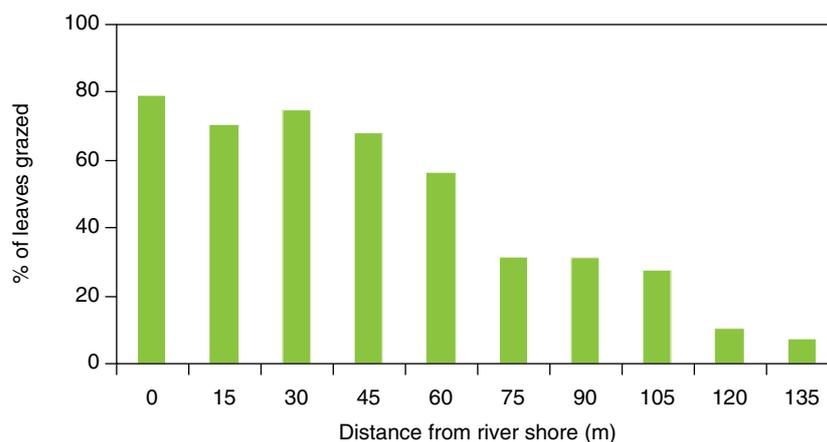


Figure 28. Frequency distribution in 2008 of plants and unvegetated points in a goose grazed sedge and moss dominated marsh at the Draba Sibirica river in relation to the distance to the lake shore.



In the marsh adjacent to the Draba Sibirica River, the overall vegetation composition and spatial trends were similar to the lake marsh (Fig. 28). However, frequency of moss was higher and *Carex subspathacea* decreased at a shorter distance from the river bank and was replaced by *Carex rariflora* at a distance of 75 m from the river. *Poa* spp. and *Eriophorum scheuchzeri* were infrequent; *Eriophorum* started to flower at a distance of 90 m from the river (with 1-13 flowers per 4 m² picture frame). The grazing pressure, expressed by the proportion of leaves grazed, was high close to the river, but decreased at a distance of 60 m from the river (Fig. 29).

Figure 29. The proportion of leaves of monocot vegetation grazed by moulting geese in relation to the distance to the river bank. Data are from the same marsh as shown in Fig. 28 in the Draba Sibirica area in 2008.



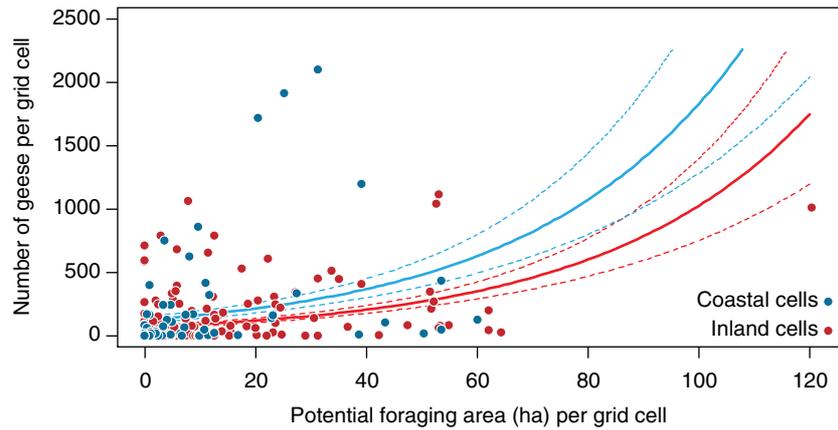
Biomass and productivity

The biomass clipping in five marsh plots in late July 2008 showed a standing crop of on average 98 g d.w. m⁻² (s.d. = 36.0), comprised of 88.8% *Carex stans* and 11.2% *Poa* spp. This compares to a cumulative above-ground biomass of on average 42 g d.w. m⁻², measured in the same plot late July 1984 (Fig. 9B in Madsen and Mortensen 1987). Because we only based our 2008 biomass estimate on live plant material, the biomass samples taken late July represent a conservative estimate of the cumulative above-ground biomass as estimated in 1984.

4.4 Modelling the number of moulting geese in the extended Ørsted Dal area

The number of moulting geese in the whole Ørsted Dal replacement area was estimated using a Generalized Linear Model. The model is based on data from the entire Jameson Land, i.e. the number of moulting geese observed from the air and the potential foraging areas (chapter 3.5). The original data on which the model is based and a prediction made from the model with confidence bands of ± 1 standard error is shown on Fig. 30. As expected, the number of moulting geese observed in the 5x5 km cells during the aerial survey is positively correlated with the size of the potential foraging area within the cells, although much variation is left unexplained by the model. The coastal cells have a higher intercept than the inland cells which is certainly due to the presence of the coastal salt marshes.

Figure 30. The number of moulting geese observed from the air in each 5x5 km cell as a function of the potential foraging area inside the cell. Cells including coastline were separated from inland cells.



The predicted number of geese in the extended Ørsted Dal area is shown in Fig. 31. These 76 cells cover an area of 1900 km², and the predicted total number of geese is 7043 with a 95% confidence interval of 6752 – 7347. Given the problems of spatial autocorrelation and the tendency towards non-normality of errors in the model residuals, this confidence interval may be a bit too optimistic. Consequently, a very conservative confidence interval was calculated as the sum of the upper and lower limits of the 95% confidence interval of the individual grid cell estimates. This results in a lower limit of 5060 and an upper limit of 9807.

Figure 31. The predicted number of moulting geese in each 5x5 km cell of the extended Ørsted Dal area.

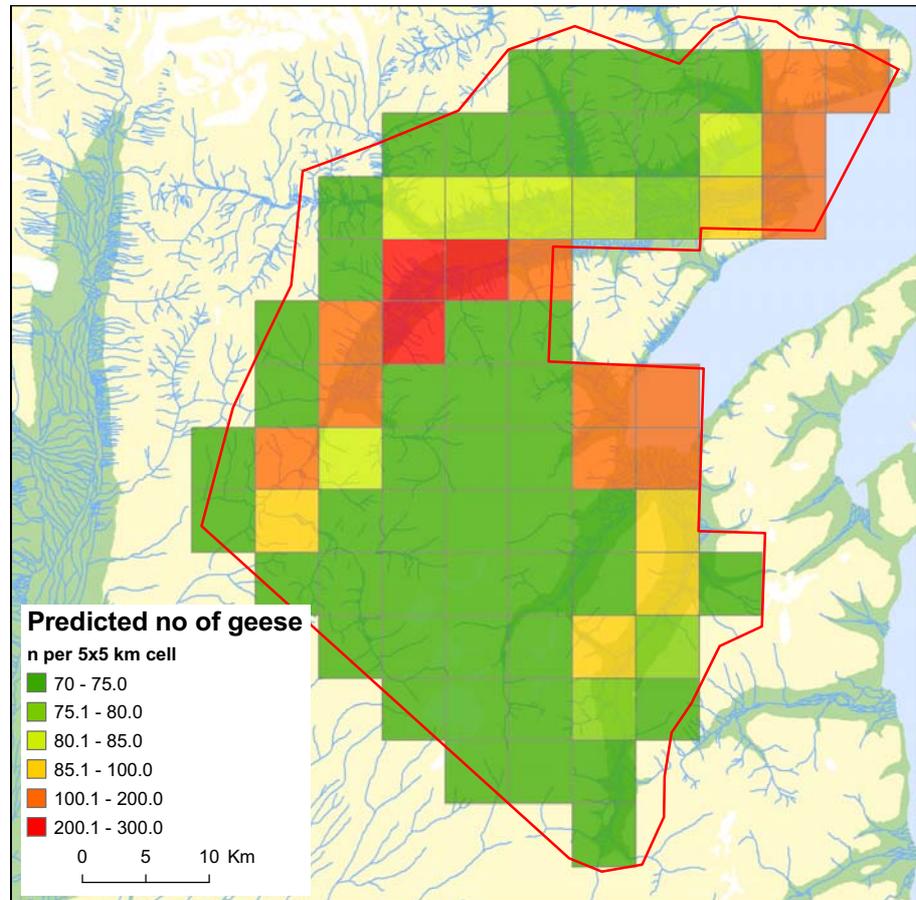


Photo 7. Large flock of moulting Pink-footed geese on a lake in Gurreholm. One family of Pink-footed goose is seen in front of the flock to the right (*Alyn Walsh*).



4.5 Other bird species

During the field work the three groups observed other bird species than the two most common goose species, the Pink-footed goose (chapter 4.1) and the Barnacle goose (chapter 4.2). In this chapter we give a brief description of most of the other species observed (excluding passerines): divers, swans, geese, ducks, waders, skuas, gulls and terns. Species like waders, King eider and rock ptarmigan were observed too scant from the air, so these bird species are described only from the four study areas where ground surveys were performed. For each species we start with observations from the air with reference to Figs. 32 and 33. This description is followed by observations from the ground in the four study areas (Figs. 34-38).

Red-throated diver (*Gavia stellata*) is a common breeding bird in the area. They nest in small ponds and lakes and feed often in nearby coastal waters. During the aerial survey 17 were observed, mainly in coastal waters (Fig. 32). Three were seen at the coast of the Gurreholm area indicating breeding pairs at ponds inland.

In the Gurreholm area 6 breeding pairs and 8 individuals were observed (Fig. 34). The individual birds were often seen flying over or at the coast and could be registered or unregistered breeding birds. In the Tyskit Nunaat 2 breeding pairs were observed together with 11 individuals (Fig. 34). In Ørsted Dal no divers were observed; in the Draba Sibirica area, one nesting pair and a single individual were found (Fig. 37).

Whooper swan (*Cygnus cygnus*) is a relatively rare visitor to the area. Breeding has not been recorded, but may be expected as swans seem to have occurred more frequently in recent years. Seven birds were observed from the air (Fig. 32).

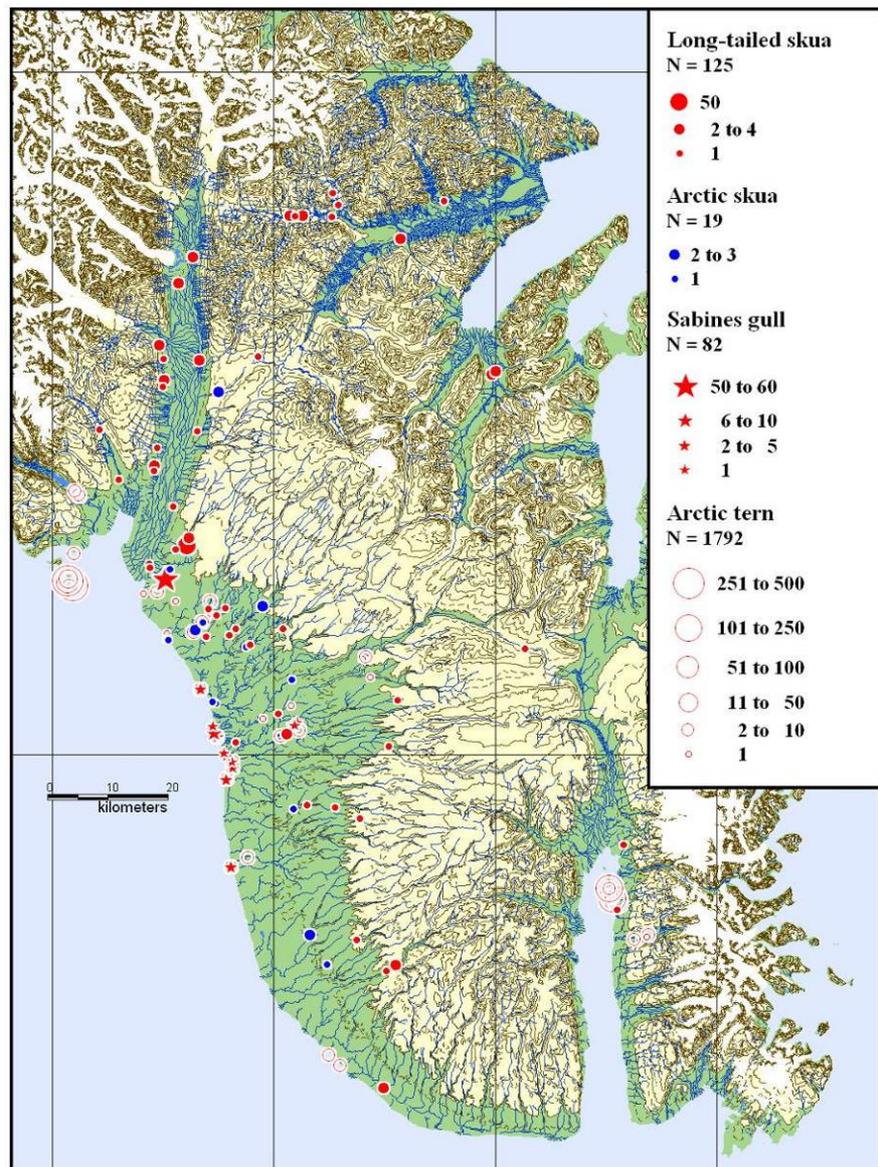
Figure 32. Divers, ducks, swans observed on the aerial surveys in Jameson Land 17 and 18 July 2008.



In Ørsted Dal a group of seven plus two birds were observed during 17-25 July. The swans, which were all able to fly, were feeding in wet marshes, often without connection to open water, and they were roosting on the central lake (Fig. 36).

Lesser snow goose (*Anser caerulescens caerulescens*). A blue-phased individual was observed in a flock of Barnacle geese at the Draba Sibirica River on 25 July.

Figure 33. Skuas, gulls and terns observed on the aerial surveys in Jameson Land 17 and 18 July 2008.



Canada goose (*Branta canadensis*) is another relatively rare visitor not breeding in the area. The aerial survey on 17 July observed two birds among moulting Pink-footed geese (Fig. 32).

Northern pintail (*Anas acuta*). An adult female was observed in the Gurreholm area (Fig. 34).

Greater scaup (*Aythya marila*) was seen off Gurreholm on 20 July 2008. It was an adult male in eclipse plumage. The bird was alone when observed, but joined later with a group of 6 long-tailed ducks. The species is a rare vagrant to East Greenland (Boertmann 1994).

Common eider (*Somateria mollissima*) was seen in groups of 19 and 2 along the Gurreholm coast, and one group of 2 off Tyskit Nunaat. In Tyskit Nunaat one female with 6 ducklings were observed on 31 July (Fig. 34).

Figure 34. Breeding divers, ducks and skuas and non-breeding Sabine's gulls in the Gurreholm and Tyskit Nunaat areas. A small dot represents a breeding pair, a larger dot 2 or 3 breeding pairs. A blue square represents a flock of 6-25 Sabine's gulls.

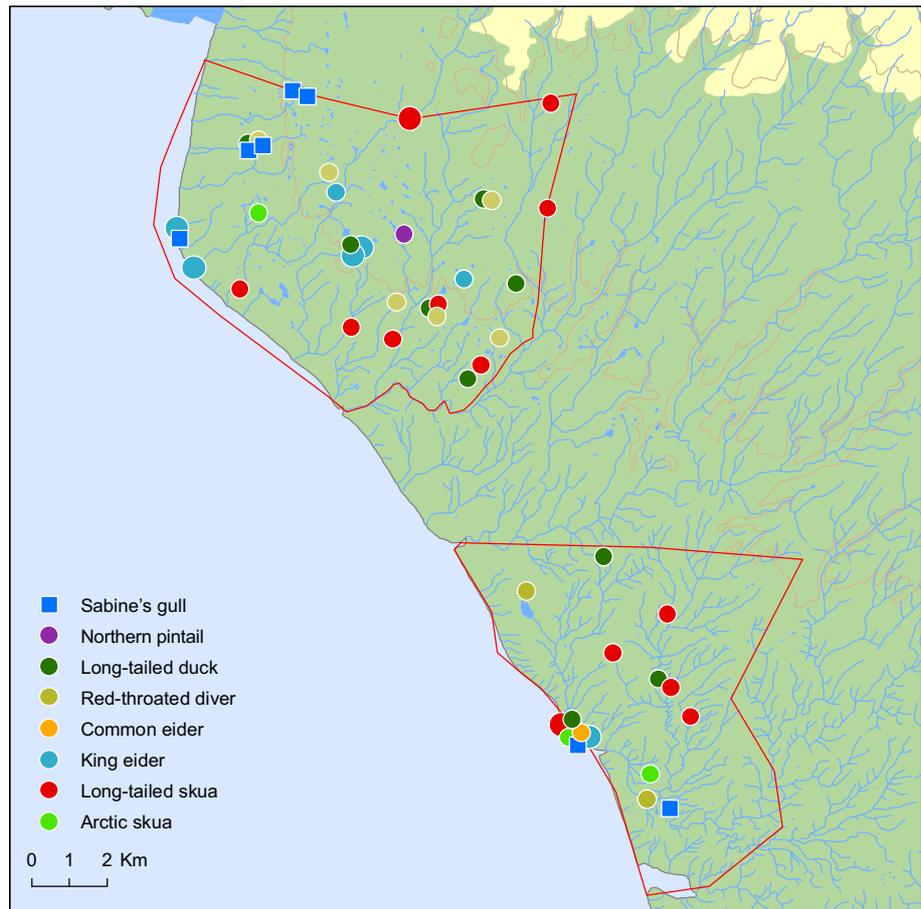
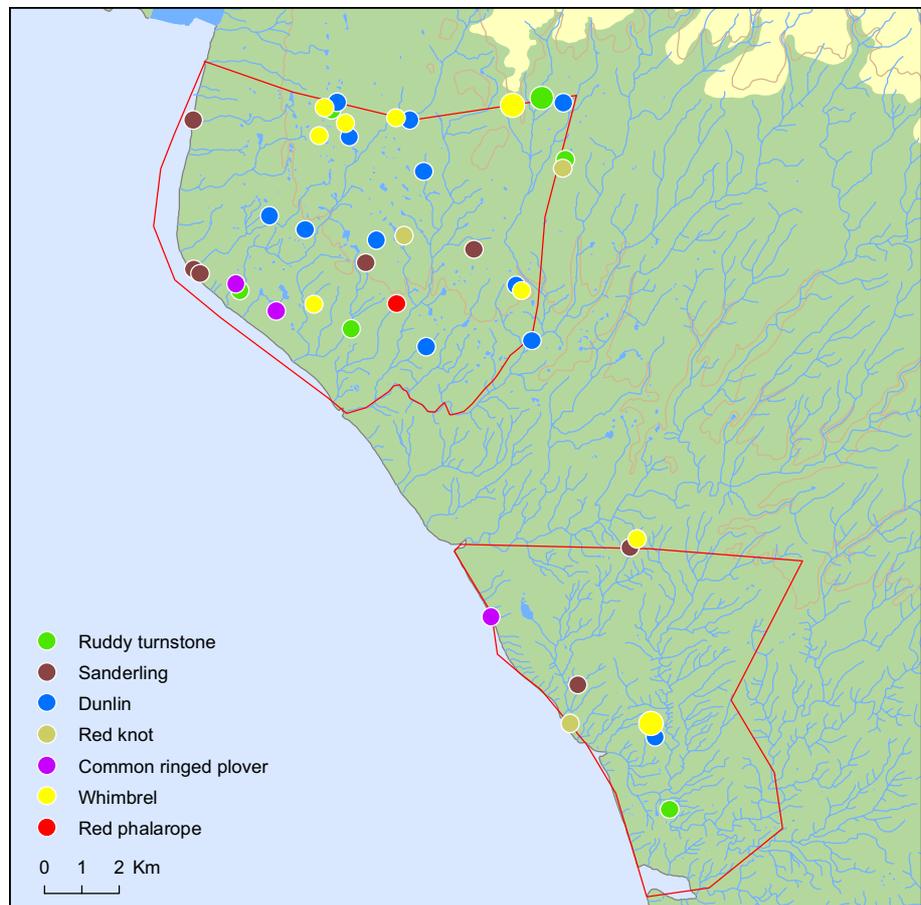


Figure 35. Breeding waders observed in the Gurreholm and Tyskit Nunaat areas. A small dot represents one breeding pair, a larger dot 2 or 3 breeding pairs.



King eider (*Somateria spectabilis*). In the Gurreholm area 11 breeding females were observed, including 2 females together with 3 ducklings. In the Tyskit Nunaat area 2 breeding birds were seen and 4 individuals along the coast (Fig. 34).

Long-tailed duck (*Clangula hyemalis*) was rather numerous during the aerial surveys, both inland and along the coasts (Fig. 32). The flock seen in coastal habitats probably represent post-breeding males, while the birds seen in ponds and lakes inland most likely were breeding birds. The density of inland birds was relatively high in the Gurreholm area, which also was surveyed more thorough than other inland areas.

In the Gurreholm area a minimum of 6 possibly breeding females were seen in inland lakes and a minimum of 3 breeding females in the Tyskit Nunaat area (Fig. 34). Along the coast of both areas a total of 823 birds were seen in flocks up to 250 birds. In the Ørsted Dal area, a flock of up to 30 was observed on the central lake. In the Draba Sibirica area, one pair was observed.

Rock ptarmigan (*Lagopus muta*). In the Tyskit Nunaat area 2-3 males were seen. In the Ørsted Dal area a female with 5 chicks were observed.

Common ringed plover (*Charadrius hiaticula*) were observed with 2 breeding pairs in the Gurreholm area and 1 pair in the Tyskit Nunaat area (Fig. 35). In the Ørsted Dal, ringed plovers are common, and territorial birds were observed (Fig. 36).

Eurasian golden plover (*Pluvialis apricaria*). A single adult bird was observed feeding in a marsh along a lake in the Draba Sibirica area on 26 July (Fig. 38).

Red knot (*Calidris canutus*). Two breeding birds were seen in the Gurreholm area including one adult bird with 3 pulli. One breeding bird was observed in the Tyskit Nunaat area and 15 non-breeders, including a flock of 10 birds on 28 July (Fig. 35). Three birds were observed in display flight in the Draba Sibirica area on 27 July (Fig. 38).

Sanderling (*Calidris alba*). Five breeding birds, including one with a flying juvenile, were observed in the Gurreholm area, while 2 breeding birds were seen in the Tyskit Nunaat area (Fig. 35). A total of 66 non-breeding birds were seen in the two areas, including one flock of 17 on 17 July and one flock of 25 on 31 July. An adult with a nearly fledged young was observed in the Draba Sibirica area on 29 July (Fig. 38).

Dunlin (*Calidris alpina*). In the Gurreholm area 11 breeding birds were seen, including one nest with 3 eggs and one pulli. One breeding bird was observed in the Tyskit Nunaat area (Fig. 35). A total of 39 non-breeders were seen in the two areas, mainly in small groups; one flock of 10 birds was seen on 25 July. Dunlin is a common breeding bird in Ørsted Dal, and territorial birds were observed in marshes and along streams (Fig. 36). In the Draba Sibirica area few pairs were observed (Fig. 38).

Figure 36. Breeding Rock ptarmigan, waders and Long-tailed skua and non-breeding Whooper swans observed in the Ørsted Dal area. A dot represents one breeding pair. Blue squares represent a flock of 2 and 7 Whooper swans, respectively.

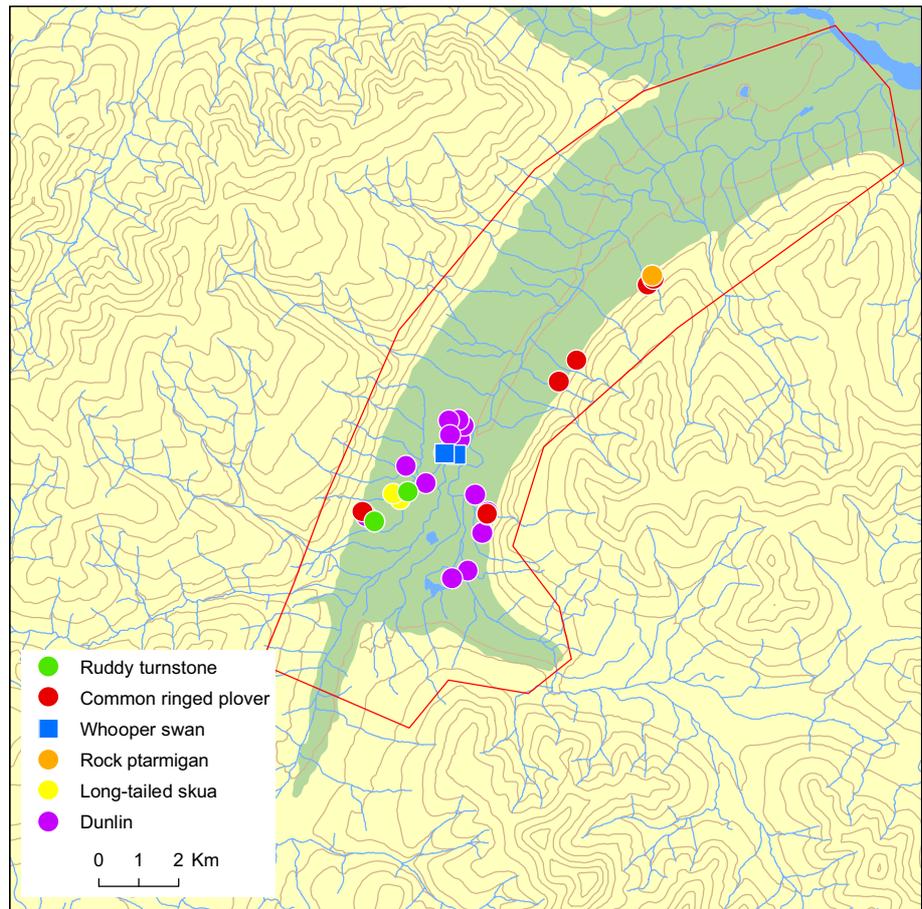
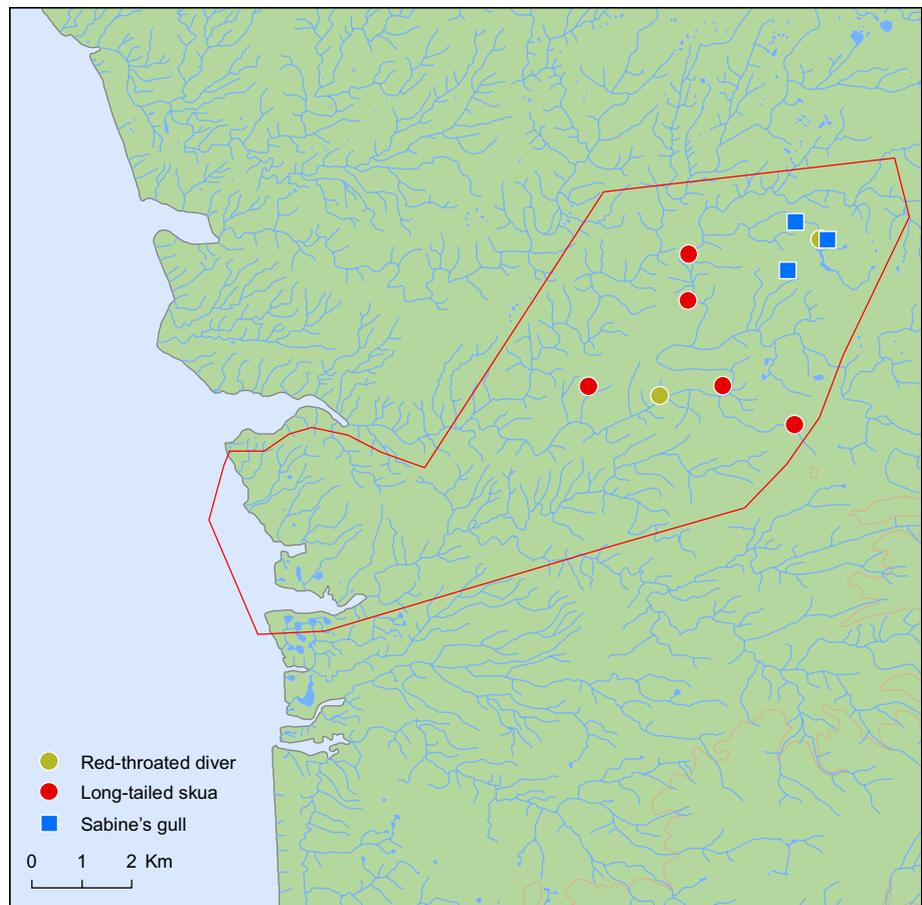


Figure 37. Breeding Red-throated diver, Sabine's gull and Long-tailed skua observed in the Draba Sibirica area. A dot represents one breeding pair.



Ruddy turnstone (*Arenaria interpres*). A total of 8 breeding pairs were observed in the Gurreholm area, including 2 pairs each with 2 pulli. In the Tyskit Nunaat area one breeding pair was seen (Fig. 35). In the Tyskit Nunnat area 22 non-breeding birds were observed, including 10 juvenile birds. Two territorial birds were observed in Ørsted Dal (Fig. 36), and one young bird was observed in the Draba Sibirica area (Fig. 38).

Whimbrel (*Numenius phaeopus*) is breeding only in Jameson Land in Greenland with 50-100 pairs. According to the Greenland Red-list it is classified as “near threatened” (Boertmann 2007). Eight breeding pairs were observed in the Gurreholm area and 3 pairs in the Tyskit nunaat area (Fig. 35). A total of 16 overflying birds in groups of 4-6 birds were seen in the two areas during 21-29 July. In late July 2007 13 observations were made of Whimbrel in the Gurreholm area, but there was no information on number of individuals and possible pairs (Skov & Hansen 2007). Three territorial pairs were recorded in the Draba Sibirica area (Fig. 38).

Red phalarope (*Phalaropus fulicaria*). One male held a territory in the Gurreholm area, where he was seen during the entire study period 17-25 July (Fig. 35). In late July 2007 two single birds were observed in the Gurreholm area (Skov & Hansen 2007).

Photo 8. Female Red phalarope.



Red-necked phalarope (*Phalaropus lobatus*). One male was observed in a small pond not suitable for breeding in the Gurreholm area. A total of 6 individuals were observed on ponds in the Ørsted area; a single bird was observed in the Draba Sibirica area.

Long-tailed skua (*Stercorarius longicaudus*) was observed frequently on the aerial survey (Fig. 33). A single large flock (50 birds) indicates that breeding birds had begun to assemble in flocks, due to scarcity of food (lemmings). Many of the observation of single birds or pairs in inland areas probably represent birds still in their breeding territories.

Photo 9. Long-tailed skua defending the chick.



Nine breeding pairs, including 2 pairs each with 2 pulli and one pair with one juvenile, were observed in the Gurreholm area. In the Tyskit Nunaat area 6 pairs were seen (Fig. 34). In Gurreholm the largest flock of non-breeding birds held 23 birds and in the Tyskit Nunaat area the largest flock had 9 birds. In Ørsted Dal, at least 4 territorial pairs were observed, including one young, and up to 20 birds were observed flocking (Fig. 36). In Draba Sibirica, at least 3 territorial pairs were active (Fig. 37).

Arctic skuas (*Stercorarius parasiticus*) were seen in small numbers on Heden during the aerial survey (Fig. 33).

In both Gurreholm and Tyskit Nunaat areas 2 pairs were seen (Fig. 34). Few single arctic skuas were seen in the two areas. In the Draba Sibirica area, a total of 7 individuals were observed, with no signs of breeding activity.

Sabine's gull (*Larus sabini*) is breeding in small colonies in the area. It is classified as "near threatened" in the Greenland Red-list (Boertmann 2007). Several were seen on Heden during the aerial survey (Fig. 33).

In the Gurreholm area a flock of non-breeding birds were seen, and in the well known breeding site at the mouth of Draba Sibirica Elv many birds were also seen. A few birds were also seen at a lake in inland parts of the Draba Sibirica Elv water shed. These were also breeding birds, confirmed by the field team working here. Flocks of 20 and 25 birds were seen in the Gurreholm area on 20 and 21 July, respectively (Fig. 34). These flocks included probably the same birds. In Gurreholm flocks of 5 and 10 were observed in July 2007, but no breeding birds were found (Skov & Hansen 2007). In the Tyskit Nunaat area flocks of up to 8 birds were seen (Fig. 34). There was no sign of breeding. Ground survey in the Draba Sibirica area revealed 3 breeding pairs, including a young, on a lake in the interior (Fig. 37).

Photo 10. Sabine's gull.



Arctic tern (*Sterna paradisaea*) is a common bird along the coasts. During the aerial survey the breeding colonies at Fame Øer in Hurry Fjord and on the island off Sydkap were confirmed (the large numbers shown in Fig. 33). Small numbers were seen here and there representing feeding birds, small colonies or single breeding pairs.

Figure 38. Breeding waders observed in the Draba Sibirica area. A dot represents one breeding pair.

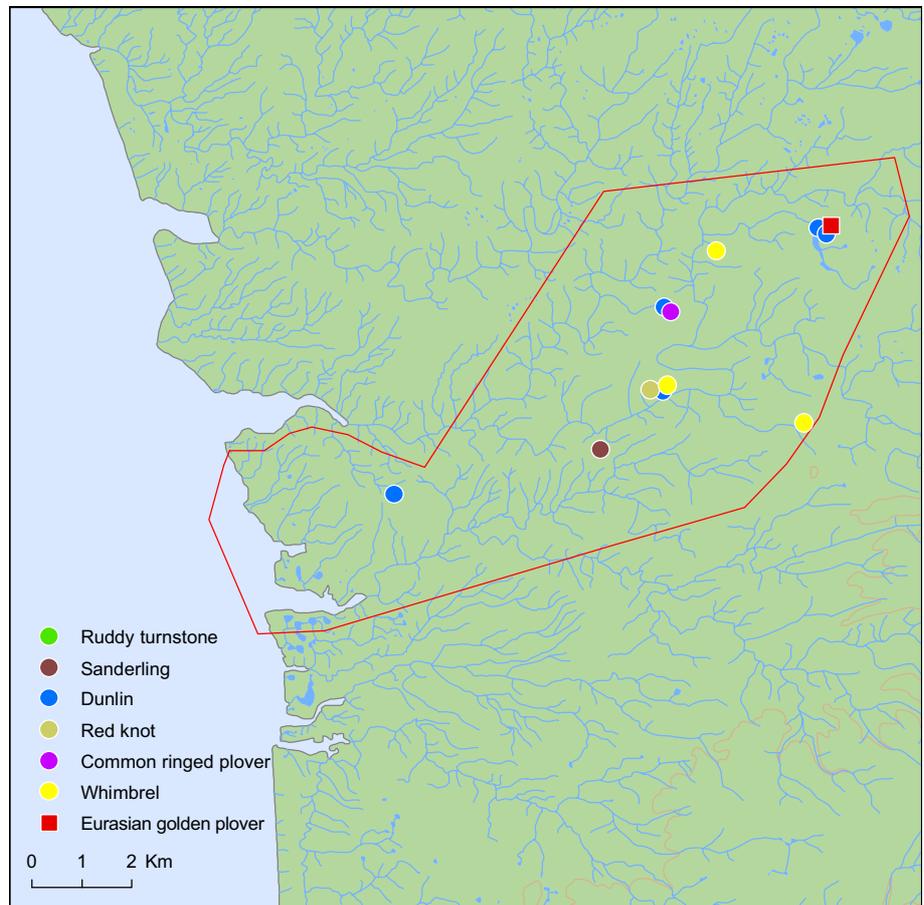


Photo 11. Red knot.

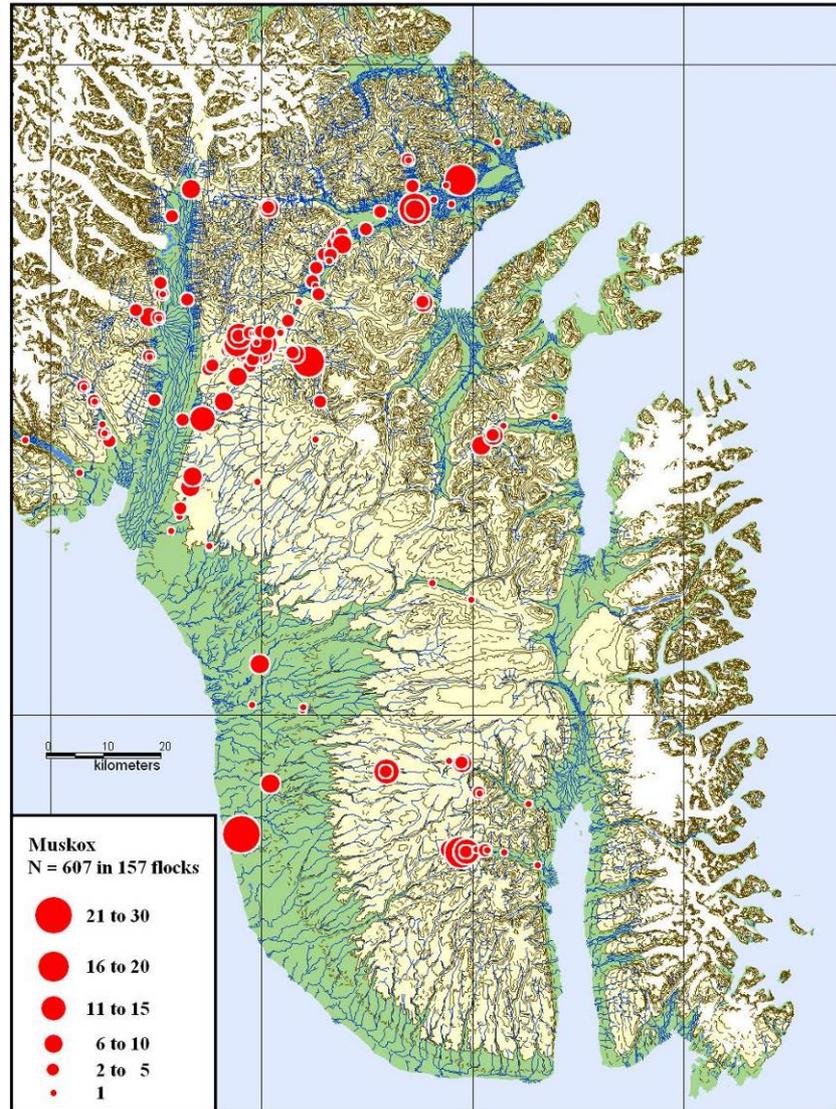


A total of 71 Arctic terns were seen in the Gurreholm area with 17 birds in the largest flock. In Tyskit Nunaat a total of 35 Arctic terns were seen with the largest flock holding 10 birds. There were no signs of breeding performance in the two areas. In the Draba Sibirica area a single bird was observed.

5 Results, mammals

During the field work the three groups observed Muskox, Arctic fox and Arctic hare. Muskox observations cover both the entire Jameson Land (aerial surveys, Fig. 39) and the four study areas, while observations of fox and hare are given only for the study areas (Figs. 40-42).

Figure 39. The distribution of Muskoxen in Jameson Land recorded on the aerial survey 17 and 18 July 2008.



Muskox (*Ovibos moscatus*). During the aerial survey 607 Muskoxen were recorded. Their distribution is shown in Figure 39.

In the Gurreholm area only two bulls were seen and in the Tyskit Nunaat area a distant flock of six animals was observed (Fig. 40). Such few animals agree with the observations during the aerial survey. In Ørsted Dal, several groups of Muskoxen passed through the valley. Up to 78 individuals could be observed from one vantage point on the hill side in the central valley (Fig. 41). In the Draba Sibirica area, Muskoxen were infrequent (3 groups observed of 2-5 individuals, Fig. 42).

Figure 40. The distribution of Muskox, Arctic fox and their dens in the Gurreholm and Tyskit Nunaat areas. Two Muskoxen were observed in the Gurreholm area and six in Tyskit Nunaat. One Arctic fox dot represents one animal except for the den in southwest Gurreholm where one adult and 3 juvenile were seen.

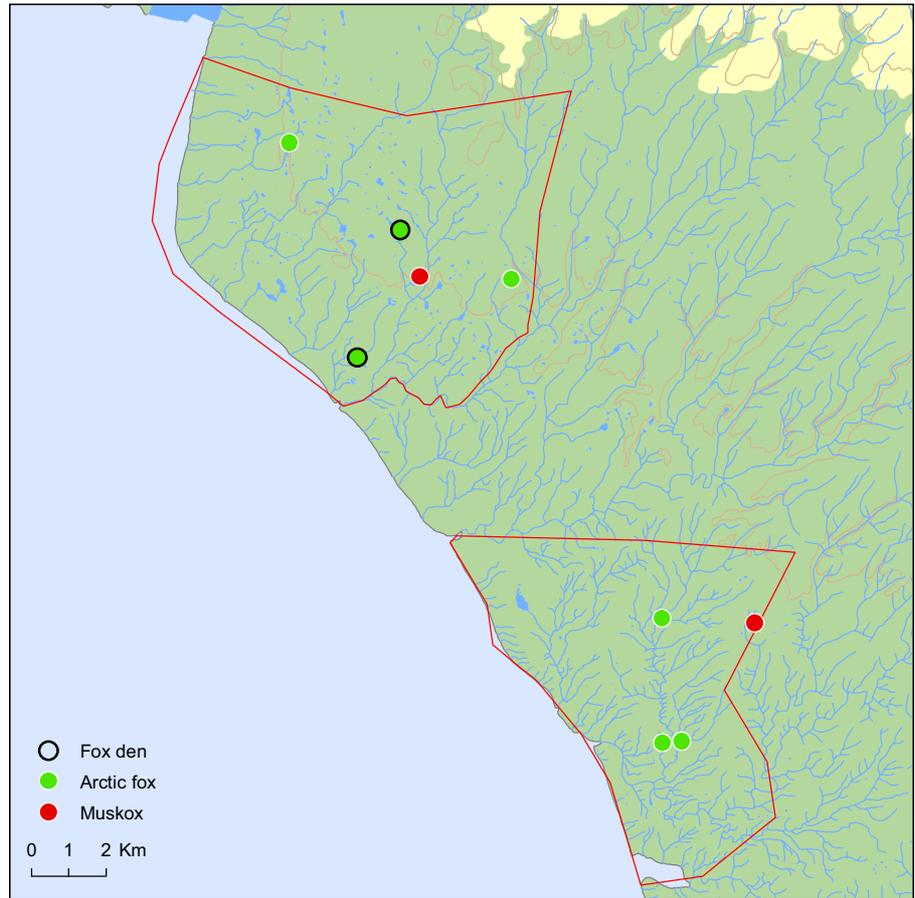


Figure 41. The distribution of Muskox, Arctic fox and Arctic hare in the Ørsted Dal area.

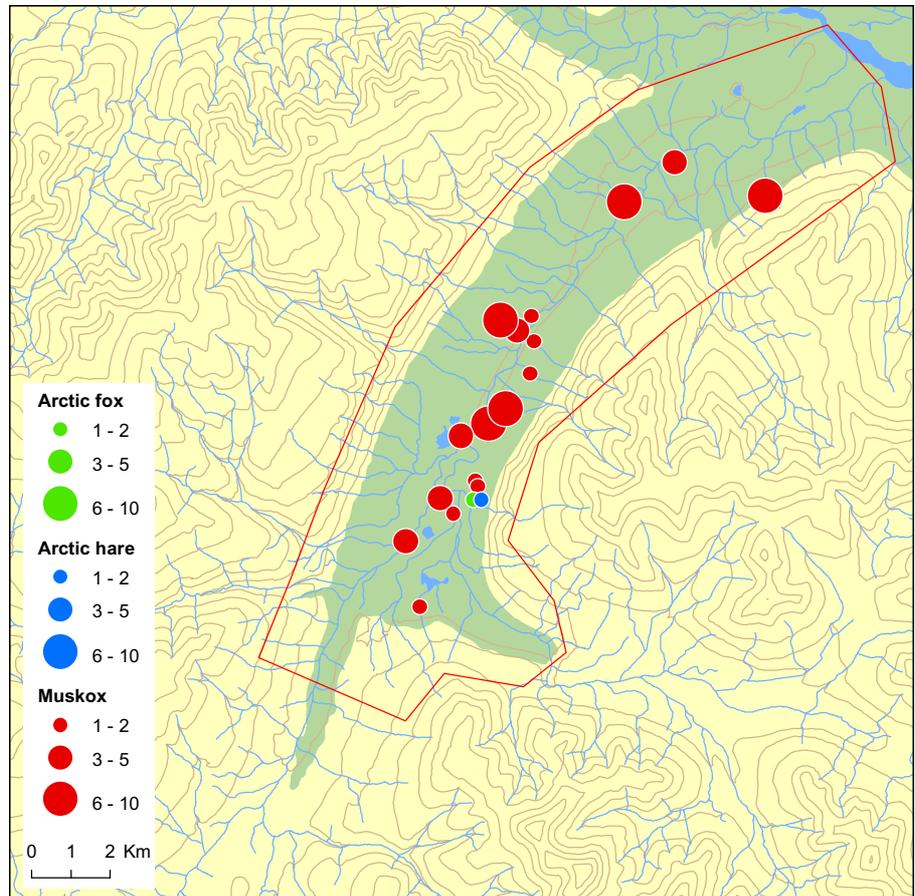


Figure 42. The distribution of Muskoxen and Arctic fox in the Draba Sibirica area.

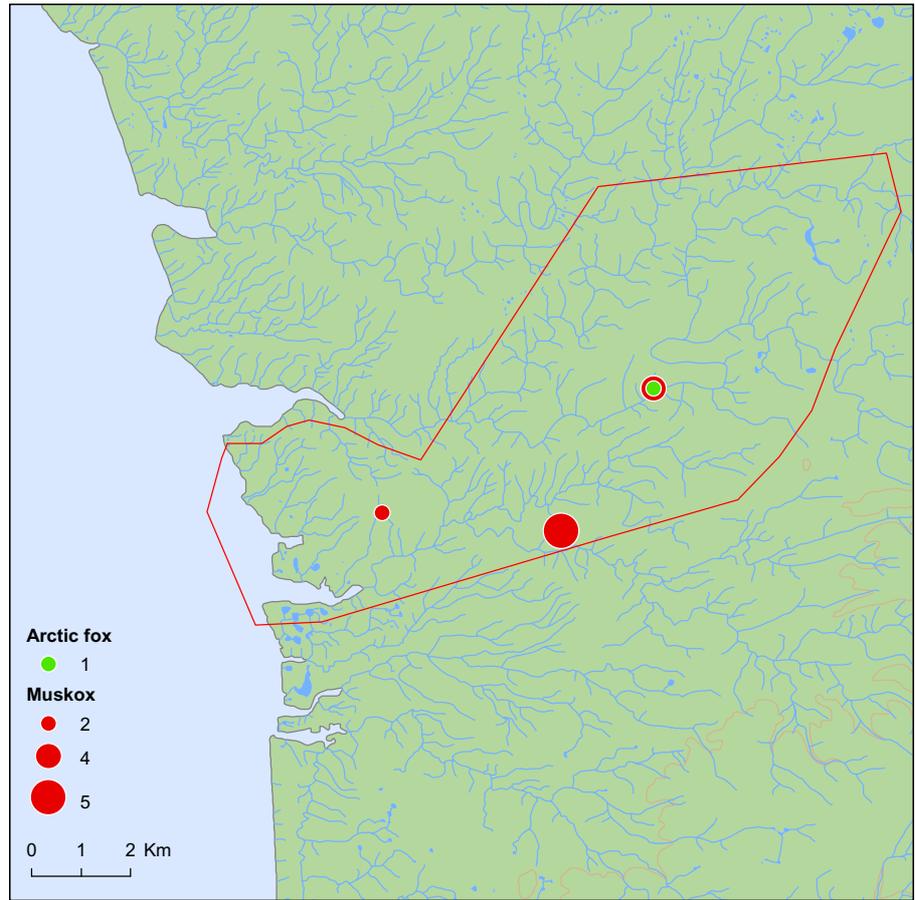


Photo 12. Muskox bull (*Cornelia Jaspers*).



Arctic fox (*Alopex lagopus*). In the Gurreholm area a total of 7 foxes were seen, including a family of 1 adult and 3 juvenile in a fox den. Another fox den was seen in the centre of the study area. In the Tyskit Nunaat area 3 foxes were observed and no dens (Fig. 40). In Ørsted Dal, one pair of foxes was active in the central part of the valley, but no den was found (Fig. 41). In the Draba Sibirica River, a single individual was observed (Fig. 42).

Photo 13. Arctic fox at the den
(Alyn Walsh).



Arctic hare (*Lepus arcticus*). Arctic hare was recorded only in the Ørsted Dal area (Fig. 41) where one individual was observed.

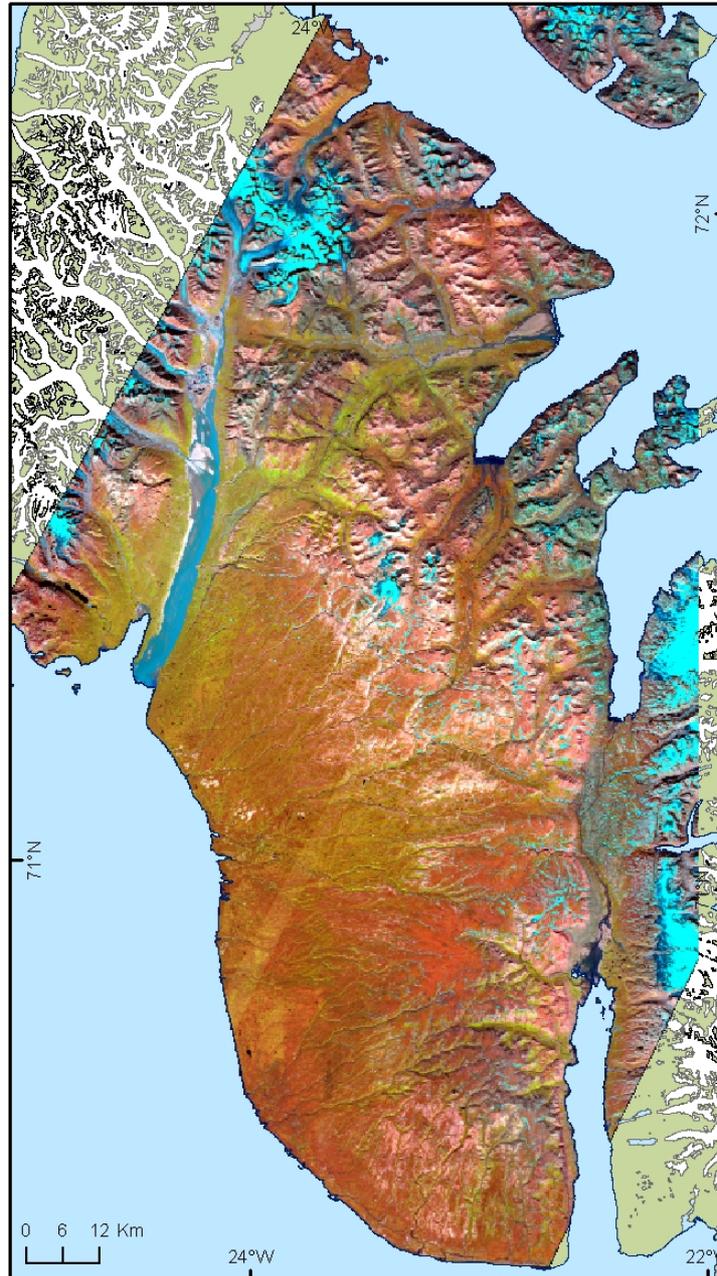
Photo 14. Arctic hare.



6 Results, vegetation

Figure 43 shows an overview of Jameson Land with the ASTER and Landsat-7 ETM+ satellite mosaic (combined from 15 and 17 July 2004) draped on the map.

Figure 43. Coverage of satellite images over Jameson Land. Mosaic is composed of ASTER and Landsat ETM+ images from 15 to 17 June 2004. The shown image has band 7, 4 and 3 in R, G, B, respectively.



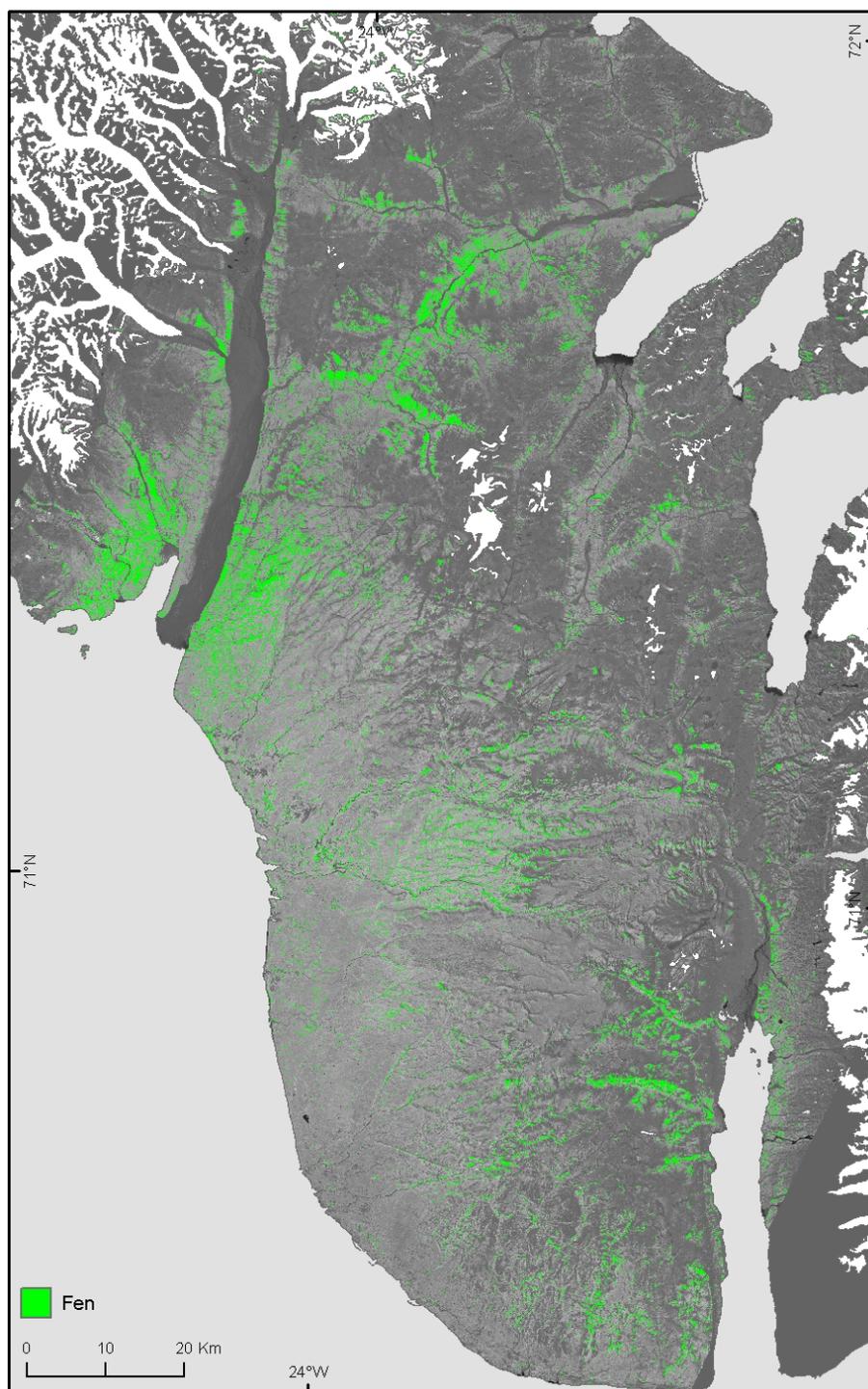
The image is a false colour composite of the shortwave infrared, the infrared and the green band (7, 4 and 3) in the red, green and blue colour channel, respectively. This enhances the contrast between vegetated and bare surfaces shown in green and red colours, respectively. Jameson Land is dominated by the high mountain ranges north and east of the

large west-sloping drainage area along the Hall Bredning. The main part of the vegetation is located in the lower parts below 300 m.a.s.l.

The fen cover distribution in Jameson Land is shown in figure 44. The vegetation type is clearly located in the lowland or in valleys and valley slopes where melting snow can supply adequate water throughout the growing season.

Especially the areas around the outlet of the Schuchert River and the Ørsted Dal have a high abundance of this type of vegetation.

Figure 44. Fen covered areas on Jameson Land. Fens are shown in green with a NDVI greyscale image as background.



7 Discussion

7.1 Mining activities

The mining activities can be separated in a construction phase of 2-3 years, a production phase of 20-25 years and a closure period of 1-2 years.

The construction phase is planned not to start before mid 2010 at the earliest. During this phase the port, access road and a temporary runway will be constructed inside the Ramsar site. It is expected that air traffic, calling ships and truck driving are more intensive during this phase than during production, but aircrafts are smaller due to shorter runway. Therefore, the disturbance of the environment can be expected to be somewhat higher during construction than during the production phase.

In the production phase the period July-October will be the most intensive period because ships can only enter the Scoresby Sund during this open water window. It is estimated that one ship will arrive at the port site every second week and that a maximum of 7 trucks per hour will arrive or leave the port site. Every second week a Hercules plane will land and about 2 medium sized jet planes will land per week. The foot-print of the roads, airstrip and port site including the container storage area is about 1 km².

The closure period is not dealt with in this report, but it will probably be a very active and intense period with more disturbances during July-October than that during the production phase.

Photo 15. A bulk carrier is ready to be loaded with ore. The photo is from the Nalunaq gold mine in South Greenland.



7.2 Methods employed

Aerial goose census

Because the methodology used in July 2008 was as identical as possible to that performed in the 1980s we believe that the results from the present survey and the past surveys are comparable. The aircraft, pilot, air-speed and altitude above ground, the one observer and the route were the same during the two periods. The route in the 1980s was not fixed by GPS coordinates but drawn on a map; therefore an exact repetition of the route has not been possible, but the divergence is small due to the pilot and the one observer being the same. In 1988 and 1989 photographic verification was added to the aerial surveys (Mosbech et al. 1989; Mosbech & Glahder 1990). The numbers of observed Pink-footed geese and Barnacle geese were adjusted according to photographed flocks to give true numbers. In general, flocks below 75 geese were overestimated by 13.6% while flocks above 75 geese were underestimated by 3.2%. In 2008, no photographs were taken, but if we use the above results on our flocks, the total count of Pink-footed geese and Barnacle geese should be reduced by 2 and 3%, respectively. Due to this small difference we have kept the observed numbers in this report.

Ground surveys

Ground surveys in the four study areas were performed in the same way with special focus on moulting and breeding geese. The aim was to obtain full coverage of moulting geese and family flocks inside the study areas. This was done by daily walking trips and observations from vantage points covering all major water bodies and wetland areas. Moulting geese counted from the air and the ground in the four study areas differed, but not systematically. In Pink-footed geese the ground counted geese differed from the aerial count in most cases between 70 and 113% and with only 41% found in Ørsted Dal. In Barnacle geese the differences varied in most cases between 60 and 128% with only 21% found in the Draba Sibirica area. The big difference in Ørsted Dal could be due both to the different census periods and to the possibility of the geese to move along the main river and thereby out of the study area. In Draba Sibirica many of the moulting Barnacle geese counted from the air were observed along the coastline and these flocks could have moved out of the study area when the ground team arrived about one week later.

The most marked difference between the two methods were that the ground counts observed a total of 1741 Pink-footed family geese and 168 Barnacle goose family birds, while only 2 Barnacle goose family birds were observed from the air. Family birds are not observed from the air either because they blend into the moulting geese or they are invisible while feeding on the tundra or in marsh areas.

The ground observations of other birds than geese from the four study areas were focusing on breeding birds. In July, birds are either incubating or attending young birds, so what we observe at this time of the breeding season is the successful breeding birds. Failed breeders constitute a major part of the breeding population and these birds have at this time of the year gathered in flocks. The numbers of breeding birds in this

report represent therefore a minimum. A more comprehensive method of counting breeding birds is given by Meltofte (2001).

7.3 Geese in Gurreholm and Jameson Land

The present study has especially focused on the populations of Pink-footed and Barnacle goose that breed and moult in Jameson Land, because the Ramsar site “Heden” was designated mainly due to these populations. In the four study areas moulting geese and geese in family flocks were counted on the ground, while moulting geese in the whole of Jameson Land was censused from the air. In one of the study areas the productivity in goose grazed marshes was assessed.

Goose populations in Jameson Land

During 1983-1989 the moulting geese from the two populations were censused from the air in 1983, 1984, 1987-89 (Mosbech & Glahder 1990). On average 6,071 (SD=634, n=5) Barnacle geese and 6,243 (SD=1012, n=5) Pink-footed geese were counted. The global flyway populations of the two species were in 1990 estimated to 35,000 Barnacle geese and 190,000 Pink-footed geese and in 2007 and 2008 to 70,500 Barnacle geese and 290,000 Pink-footed geese (Table 12, Mitchell 2008, Mitchell & Walsh 2008).

Table 12. Changes in the global flyway populations of Barnacle geese and Pink-footed geese and in the number moulting geese in Jameson Land during 1983-2008 (Mitchell 2008, Mitchell & Walsh 2008, Mosbech & Glahder 1990, the present study in 2008).

Species	Global flyway population		Jameson Land number	
	1990	2007/2008	1983-89	2008
Barnacle goose	35,000	70,500	6,071	16,603
Pink-footed goose	190,000	290,000	6,243	19,068

It appears from Table 12 that that the global populations during the 20 years period have increased 1.5-2 times while the moulting geese from the two populations in Jameson Land have tripled their numbers. The proportion of Barnacle geese in Jameson Land of the total population has increased over the period from 17 to 24% and for Pink-footed geese from 3 to 7%.

The increase of the two species in Jameson Land over the 20 years period is not evenly distributed. In the extended Ørsted Dal (the replacement area proposal, Fig. 45) both species have more or less doubled their number (Barnacle goose from 2377 (average 1983-89) to 4106, and Pink-footed goose from 960 to 1952). In the Gurreholm area, on the other hand, the number of Barnacle geese has decreased to nearly the half (from 430 to 284), while Pink-footed geese have increased their number six fold (from an average of 634 to 3,971). In the Draba Sibirica area numbers of the two species have not changed much in the 20 year period (Barnacle goose 1980s-average of 1114 compared to 1122 in 2008, and Pink-footed goose numbers have increased slightly from 2030 to 2483).

Especially in the Gurreholm area the expanding Pink-footed goose population has been able to find unexploited habitats. Consequently, about

25% of the entire Jameson Land population of moulting Pink-footed geese are today using the Gurreholm area as a moulting ground.

Productivity in goose grazed marshes

Based on field studies during 1982-1984, it was concluded that habitat carrying capacity of Jameson Land for moulting geese was close to being reached (Madsen & Mortensen 1987). Over the subsequent 25 years the moulting populations of the two goose species have tripled in Jameson Land (Table 12). What are the possible explanations for this increase in goose exploitation of Jameson Land?

The conclusion drawn in Madsen & Mortensen (1987) was based on: (1) All suitable sites (a combination of a certain minimum width and surrounding marsh habitat) along coastlines, rivers and lakes were occupied. A linear correlation between the size of available habitat and the number of geese, suggested that the geese had filled up the area (habitat matching). (2) In the *Carex subspathacea* dominated marsh, the most common moulting foraging habitat, the geese removed a significant part of the net above-ground primary production. (3) By the end of the moulting period, the vegetation was grazed below 0.5 cm height, and the geese abandoned the sites immediately after they regained flight

Two possible explanations are discussed here. The one is the effects of climate change on the production of vegetation biomass, the other is the ability of the geese to exploit habitats to a higher degree than anticipated.

The climate in East Greenland has been warming during recent decades. In Zackenberg further north, the average July air temperature has increased by 0.28 °C per year during 1996-2005 (Forchhammer et al. 2008). This may have had a positive influence on the productivity of the marsh vegetation, possibly explaining the estimated more than doubling in biomass of the *Carex stans* - *Poa* spp. plots from 1984 to 2008. If this is generally the case, the habitat carrying capacity of Jameson Land for moulting geese will have increased, resulting in higher densities of geese. On the other hand, our ground truthing of the vegetation cover carried out in the Draba Sibirica and in the Ørsted Dal areas reveal that in marshes grazed by moulting geese, *Carex subspathacea* dominates, whereas in marshes without grazing, *Carex rariflora* or *Carex stans* dominate, including flowering *Eriophorum scheuchzeri*. Therefore, we need biomass estimations from goose grazed marshes to be more confident before we put forward general conclusions about an increase in primary productivity.

Even though it is likely that biomass production has increased in Jameson Land, intensive goose grazing might reduce biomass production. Our results from the repeated vegetation transect in the Draba Sibirica area showed a significant increase in dead vegetation, and decrease in moss cover and cover of *Carex subspathacea* and *Poa* spp. This may suggest that moulting geese have a long-term effect on the vegetation composition and cover in the marshes subject to intensive grazing.

The increase in the two global flyway goose populations over the last decades has inevitably lead to an increased pressure on existing and new moulting areas in East Greenland. On existing areas like in Jameson Land the geese might exploit other plant species than the preferred *Carex*

subspathacea in order to overcome the moulting period. On the wintering grounds, both species have, during a few decades, changed their feeding habitats from natural wetlands like salt marshes to farmlands (Mitchell et al. 1999; Ogilvie et al. 1999). It is likely that a change to other feeding habitats can also happen on the summering grounds in the Arctic, even though relevant data is lacking. We know that Pink-footed geese have exploited new areas in East and North Greenland (Boertmann & Glahter 1999, own observations 2008, 2009) where large moulting flocks have been observed on apparently very poor feeding habitats.

Breeding geese in Jameson Land

In the four ground study areas we have counted 1741 family group individuals of Pink-footed geese and 160 family individuals of Barnacle goose. This gives an approximate number of 430 successfully breeding pairs of Pink-footed geese and 50 pairs of Barnacle geese in the four study areas. We do not have total numbers of breeding pairs of the two goose species for the entire Jameson Land despite the aerial survey performed in 2008. The reason is that from the air (1) gosling can be difficult to differentiate from older geese in dense flocks and (2) family flocks in general segregate spatially from non-breeding moulting geese on habitats (small rivers and ponds, marshes without connection to open water, tundra) where they are difficult to detect. During the 1980s the total Jameson Land breeding population of the Pink-footed goose was estimated to 300-500 pairs in 1982-84 (Madsen et al. 1985) and 600 in 1988 (Mosbech et al. 1989).

Photo 16. Breeding Pink-footed goose on a mound in the Gurreholm area June 2009.



The breeding population of the Barnacle goose was in 1982-84 estimated to 300-400 pairs. In the Ørsted Dal the breeding population was, on the basis of juveniles, estimated at about 60 pairs in 1963 and 1974 (Hall & Waddingham 1966; Ferns & Mudge 1976) and 201 nest in 9 colonies in June 1984 (Cabot et al. 1984). In a breeding bird study in June 2009 in Gurreholm and Ørsted Dal a total of c. 400 nests of Pink-footed goose and c. 50 nests of Barnacle goose were counted (Glahter & Meltofte, *in prep.*).

The possible moulting goose capacity in the extended Ørsted Dal area

The extended Ørsted Dal area has been suggested as a replacement area to the possible loss of area in the Ramsar site "Heden". Besides the number of moulting geese in this replacement area we were interested in knowing if the area had extra potential capacity to absorb some or all of the geese from the disturbed Gurreholm area. On the basis of modelling we predicted 7043 (limits: 5060-9807) moulting geese in the extended Ørsted Dal area, which is not very different from the actually counted number of 7814. This may indicate that there is little spare habitat for the expelled geese here, although it is important to stress that too much confidence should not be placed on the model prediction. The model is based on the observed distribution and density of geese in Ørsted Dal. However, if in the future the geese occupy new habitats in Ørsted Dal (of lower quality as has been observed in other areas) or occur in higher density on the existing moulting areas in Ørsted Dal, this potential for increase in number is not included in the model.

7.4 Birds in the Gurreholm area

The Gurreholm study area is an area very rich in bird species and individuals compared to the other study areas. The number of breeding and moulting Pink-footed geese (more than 800 individuals in families and c. 4,000 moulting birds) as well as other breeding birds (11 species with 64 successfully pairs) is high (Table 13). The area is not very important for Barnacle geese where the highest number of breeding birds (123 individuals) was observed in Ørsted Dal and the highest number of moulting birds (c. 1100) was counted in the Draba Sibirica area.

The reason for this relative high biodiversity is the high number of different habitats such as many larger and smaller lakes and rivers, fens and salt marshes. This mosaic of wet areas are dominating over the dryer dwarf scrub heath. The Tyskit Nunaat area is dominated by dwarf scrub heath with only few lakes, rivers and fens. The Ørsted Dal and Draba Sibirica areas are intermediate between the two areas described above.

Table 13. Breeding birds and moulting geese in the four study areas in Jameson Land. Breeding birds are successfully pairs only. Figures in bold show the highest count in the four areas.

Study area	Gurreholm	Tyskit Nunaat	Ørsted Dal	Draba Sibirica
Area (km ²)	68.9	48.6	53.2	65.6
Pink-footed goose (moult)	3971	1090	408	2756
Pink-footed goose (family)	834	83	54	770
Barnacle goose (moult)	284	269	696	1122
Barnacle goose (family)	8	0	123	37
Other breeding birds (pair)	64	22	30	20
Other breeding birds (species)	11	10	5	9

Observations of specific interest in the Gurreholm area were 8 pairs of Whimbrel, 1 pair of Red phalarope, 11 pairs of King eiders and 9 pairs of Long-tailed skua; a total of 34 foraging Sabine's gulls were also observed. In the Tyskit Nunaat area we observed 3 pairs of Whimbrel, 1 pair of King eider and 6 pairs of Long-tailed skua, plus a total of 15 non-

breeding Sabine's gulls. In Ørsted Dal we registered 3 pairs of Long-tailed skuas and 9 non-breeding Whooper swans. In the Draba Sibirica area 3 pairs of Whimbrel, 3 pairs of Sabine's gulls and 1 Eurasian golden plover were observed.

Whimbrel and Sabine's gull are in the Greenland Red-list classified as "near threatened" (Boertmann 2007). Whimbrel breeds in Greenland only in the dwarf scrub heath north of Ittoqqortoormiit with the majority of the 50-100 pairs breeding in the Ramsar site "Heden". The Sabine's gull has in Greenland a population below 1000 adult birds breeding only on about 20 sites. Probably the Greenland population is increasing.

It should be noted that July is not the optimal period to register breeding birds. Therefore, only successfully breeding pairs are registered, while breeding attempts are not included. The given figures of breeding pairs therefore represent a minimum. In June 2009 breeding birds were registered in two areas in the Gurreholm area and two in the Ørsted Dal area (Glahder & Meltofte, in prep.). In the Gurreholm area, numbers of breeding geese were not much higher in June 2009 than observed in July 2008, whereas numbers of other breeding birds like waders, ducks and skuas were about 5-7 times higher in June 2009. These results will be reported in a separate report.

7.5 Possible effects of mining activities

The possible effects of the mining activities on geese and other bird species in the northwestern part of the Ramsar site "Heden" is evaluated in proportion to two disturbance zones. It must be emphasized that our knowledge of the mining activities is based on the EIA and feasibility study from early 2008 with some additional material on airstrip and roads from the mining company from late 2008. The most constant disturbance is thought to come from noise emitted by trucks and from activities in the harbour area. Due to the open and relatively flat terrain and to the often strong fjord wind blowing eastward from around mid day, it is expected that noise from these activities easily can propagate 3-5 km. Noise from fixed wing aircrafts using the south-north directed runway about twice a week will propagate even further due to their elevation above ground. No helicopter traffic has been described; this type of aircraft will have the strongest disturbance effect on the geese in the area.

We have chosen two disturbance zones of 5 and 10 km from the mining activities to discuss the effects of the activities on geese and other birds in the area. These two zones are based on knowledge from reactions of moulting geese to helicopter disturbances (Mosbech et al. 1989; Mosbech & Glahder 1991). Two helicopter types were studied, a larger (Bell 212) and a smaller (Bell 206) model. When a large helicopter approached moulting Pink-footed geese they stayed alert at a distance of about 10 km, fled to water bodies at 7.5-9 km and formed a dense group on the water at 7-8 km. A smaller helicopter caused the two latter reactions at distances of 4-6 km.

During late June and early July the geese, still able to fly, are searching for suitable moulting sites. If the geese are disturbed during this period

they will probably avoid moulting habitats that are inside the 10 km disturbance zone. Flocks of Pink-footed geese avoided a valley in Jameson Land in late June after passage of large helicopters at distances of about 5 km. No geese moulted in the valley that year; the previous year 75 Pink-footed geese had moulted here (Mosbech et al. 1989; Mosbech & Glahder 1991).

Regarding disturbance distances to breeding Pink-footed geese we have few observations from a river valley and delta near the airstrip and camp area Constable Pynt, Jameson Land (Mosbech et al. 1989; Mosbech & Glahder 1990; de Korte 1988). The nearest nests were 1-2 km from Constable Pynt and this was also the case in 1975, 10 years before the airstrip and camp were established. There was a slight but not significant increase in clutch size over a c. 15 km distance from Constable Pynt (de Korte 1988). A similar disturbance effect was found in breeding Pink-footed geese in Iceland (Sigurdsson 1974). Shortly after hatching the families gather in family flocks and these can be disturbed at minimum distances of 600 m and perhaps up to several km (Mosbech & Glahder 1990). In Svalbard, Pink-footed goose families showed an escape response at a distance of almost 2 km from approaching humans (Madsen et al. 2009). According to these observations we have chosen a disturbance zone of 1.5 km to breeding geese and other breeding birds.

Photo 17. Moulting Pink-footed geese fleeing from one walking person in the Gurreholm area (Alyn Walsh).



Worst case scenario is represented by the 10 km disturbance zone inside which we expect that no geese will start moulting (Fig. 45). The more moderate scenario anticipate the geese to initiate their moult in areas situated more than 5 km from the disturbances, but inside the 5 km zone no geese will moult. Breeding geese and other breeding birds are less sensitive to disturbances, so we expect breeding birds only to avoid areas closer than about 1.5 km from harbour, roads and runway. Appendix 1 shows in detail the affected birds in the Gurreholm area.

Disturbance zone of 10 km

Based on the aerial survey, c. 4,900 moulting Pink-footed geese and 530 moulting Barnacle geese will avoid the area. Moreover, about 150 Pink-

footed geese in family flocks and a minimum of 8 breeding pairs of 5 bird species will abandon the Gurreholm study area. New figures for breeding birds will be available from the June 2009 field study in a larger Gurreholm area (Glahder & Meltofte *in prep.*). It is likely that all lakes used by foraging non-breeding Sabine's gulls will be affected by the constructions.

Disturbance zone of 5 km

About 3,900 moulting Pink-footed geese and c. 400 moulting Barnacle geese will abandon the area. The breeding birds will be affected as described above: Moreover, about 150 Pink-footed geese in family flocks and a minimum of 8 breeding pairs of 5 bird species will abandon the Gurreholm study area. New figures for breeding birds will be available from the June 2009 field study in a larger Gurreholm area (Glahder *in prep.*). It is likely that all lakes used by foraging non-breeding Sabine's gulls will be affected by the constructions.

7.6 The proposed replacement area in Ørsted Dal

The size and quality of a replacement area depends of both the chosen disturbance zones and suitable areas in East Greenland. If the disturbance zone of 10 km is chosen then the replacement area should include about 4,900 moulting Pink-footed geese, 530 moulting barnacle geese, min. 150 Pink-footed geese in family flocks (equal to ca. 30 successfully pairs; in Gurreholm we found 2.8 gosling/pair, n=76) and a minimum of 8 breeding pairs of other breeding birds. If the disturbance zone of 5 km is chosen the replacement area should hold c. 3,900 moulting Pink-footed geese, 400 moulting Barnacle geese and the same number of breeding pairs as described for the 10 km disturbance zone.

Photo 18. The western part of the proposed replacement area Ørsted Dal late June 2009.

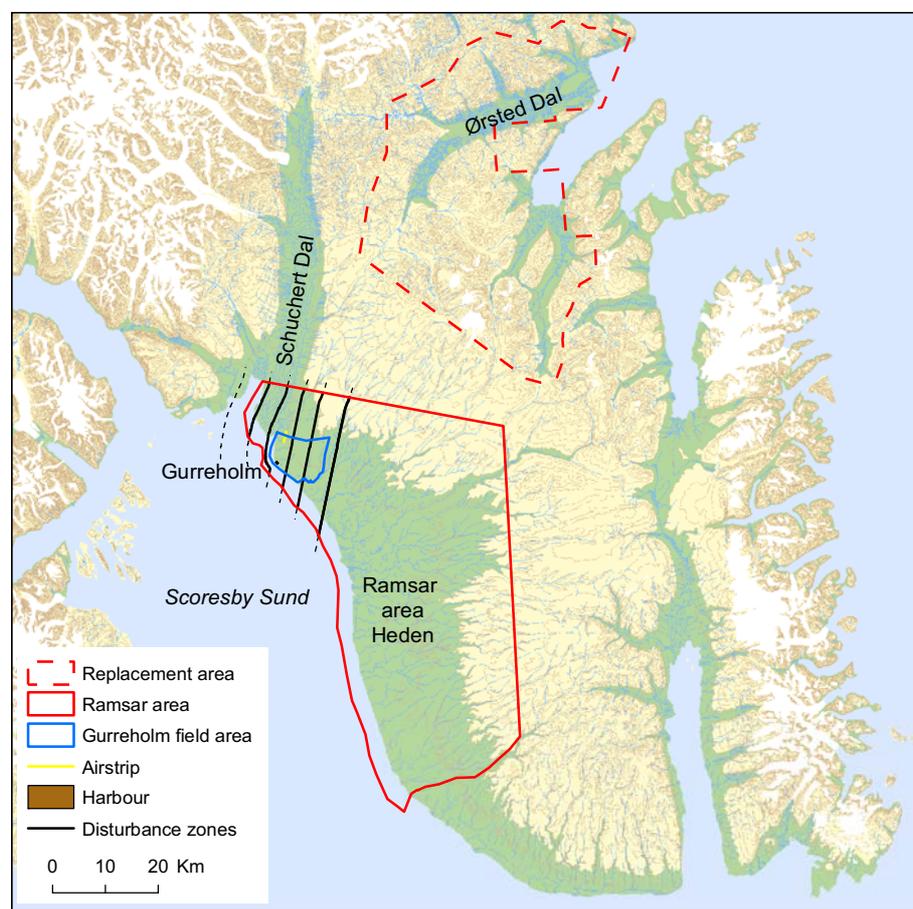


In the Jameson Land area the only suitable habitat outside the Ramsar site "Heden" would be the Ørsted Dal, Karstryggen (west of Schuchert Dal) and a few valleys in the southeastern Jameson Land. Karstryggen is close to the mining activities, partly included in the 10 km disturbance

zone and supports too few moulting Pink-footed geese. The southeastern valleys are too small to support that many moulting geese and different breeding bird species. That leaves Ørsted Dal as a possible Ramsar replacement area in this part of East Greenland.

To delimit the replacement area the starting point could be to evaluate if the Ørsted Dal study area would be a sufficient replacement area. In the Ørsted Dal study area (Table 13) we observed 400 moulting Pink-footed geese and 700 Barnacle geese, family birds of 50 Pink-footed geese and 120 Barnacle geese and 30 breeding pairs of 5 other bird species. It is obvious that this area is not sufficient to replace especially moulting and breeding Pink-footed geese. It is doubtful if the area is sufficient to replace the diversity of other breeding species. On the other hand, Barnacle geese are fully replaced. It should be noted that more relevant data on breeding bird species and densities in the Gurreholm and Ørsted Dal areas was provided June 2009 and the findings will be published in a separate rapport.

Figure 45. The Ramsar site Heden inside which the field area Gurreholm is shown as well as the air strip (A) and the port area (H). The three disturbance zones of 1.5, 5 and 10 km from the mining activities are shown in black lines. The replacement area, the extended Ørsted Dal area, shown here is smaller than the proposed optimal replacement area (refer to Appendix 2, Fig. 51) due to two existing mineral licence areas.



Therefore, it is necessary to extend the Ørsted Dal area to that depicted on Fig. 45. The replacement area shown on the figure is smaller than the proposed optimal replacement area (refer to Appendix 2, Fig. 51) due to two existing mineral licence areas. This area holds c. 3,000 moulting Pink-footed geese which still is less than the about 4,000 Pink-footed geese expected to avoid the area inside the 5 km disturbance zone. In return, the extended Ørsted Dal area supports c. 4,700 moulting Barnacle geese giving protection under the Ramsar Convention to an extra 7% of the Barnacle goose flyway population. This is of importance because the po-

pulation is still relatively small despite its rapid expansion. It is difficult to judge if the replacement area can fully compensate the loss of breeding Pink-footed geese and other breeding birds. The southeastern part of the area, Pingel Dal and Enhjørningens Dal, is suitable only to moulting geese and not to most breeding birds because of snow and ice coverage until late June (Photo 19). We tried to evaluate if the replacement area had extra potential capacity to absorb some or all of the moulting geese from the disturbed Gurreholm area. By model prediction we reached a figure (between 5,060 and 9,807) close to what was observed during the aerial survey (c. 7,700) and this may suggest that there is little spare habitat for the expelled geese.

At present, it is difficult to judge the impact of the mining activities on the moulting and breeding birds in the northwestern part of the Ramsar site "Heden". Geese might not initiate moulting inside the 10 km disturbance zone, moulting and breeding birds might seep out of the area over some years or the birds will habituate to the activities, especially if these are predictable to the birds, so that the outskirts of the area will be reoccupied. It is possible, to a certain degree, to plan for and regulate activities in a way that will facilitate habituation e.g. by planning a fixed aircraft corridor and prevent traffic outside main facilities.

Photo 19. Southeastern part of the extended Ørsted Dal replacement area on 26 June 2009. The mouth of Pingel Dal is in the center and that of Enhjørningen Dal to the right.



Because of the uncertainties of impacts from mining activities, a monitoring program should be introduced when the mining activities are initiated. If the proposed replacement area can not compensate for the loss of moulting and breeding birds in the Gurreholm area, yet another replacement area should be delimited. This must be elsewhere along the East Greenland coast; our knowledge of such areas has been prepared by extending the Jameson Land aerial survey in July 2009 to cover Hold With Hope and Wollaston Forland situated 200-300 km north of Jameson Land. Also, we plan to study breeding birds in the Hold With Hope area in June 2010 similar to the breeding studies performed in Jameson Land in June 2009.

8 Conclusions

In 2008, Quadra Mining Ltd. was granted an exploitation license that covered a large molybdenum ore body in East Greenland. Mining this ore for a period of 20-25 years will involve constructions inside the Ramsar site "Heden" of a port with a large container terminal, a gravel road north along the coast and the Schuchert River and a c. 2,000 m long air strip.

The possible impacted northwestern part of the Ramsar site, Gurreholm, is a lush wetland area of the tundra rich in smaller and larger lakes and rivers, fens and coastal salt marshes. About 25% of the Pink-footed geese moulting in Jameson Land use this area that constitutes 5% of the Ramsar site (2524 km²). The diversity and density of breeding birds in the area are relatively high; breeding Whimbrel and Sabine's gull are classified as "near threatened" in the Greenland Red-list. Only about 3% of the total moulting population of Barnacle geese in Jameson Land uses the Gurreholm area.

The impact of the mining activities on the Gurreholm area is evaluated in proportion to three disturbance zones of 1.5, 5 and 10 km; the most substantial impact will be that 3,900 to 4,900 moulting Pink-footed geese will avoid the area. The proposed replacement area, the extended Ørsted Dal area (Fig. 45), holds about 3,000 moulting Pink-footed geese corresponding to about 60-80% of geese expected to avoid the Gurreholm area. Modelling indicates that the replacement area has no substantial spare habitats for the expelled geese. The number of breeding Pink-footed geese in the affected Gurreholm area is high and constitutes, to our present knowledge, about one third of the Jameson Land breeding population, perhaps even half of that. Also, the number of other breeding bird species is relatively high in the area. We estimate that less than one fifth of the breeding birds will avoid the area.

The replacement area will not fully compensate for the impacted number of moulting Pink-footed geese, but more so for the moulting Barnacle geese; we expect about 500 moulting Barnacle geese to avoid the Gurreholm area compared to the 4,700 moulting Barnacle geese counted in the replacement area. Thereby, an extra 7% of the Barnacle goose flyway population is giving protection under the Ramsar Convention. This is of importance because the population is relatively small despite its rapid expansion.

Because of the uncertainties to assess the impact of the mining activities on the moulting and breeding birds in the northwestern part of the Ramsar site it is suggested to introduce a monitoring program when mining starts. If the proposed replacement area can not compensate for the loss of moulting and breeding birds in the Gurreholm area, yet another replacement area should be delimited elsewhere along the East Greenland coast. The studies performed in 2009 and planned for in 2010 should prepare for such a situation.

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Appendix 1. The Gurreholm area in detail

Figure 46. The Ramsar site Heden and the Gurreholm field area, together with the airstrip (A), the port site (H) and the two disturbance zones of 5 and 10 km.

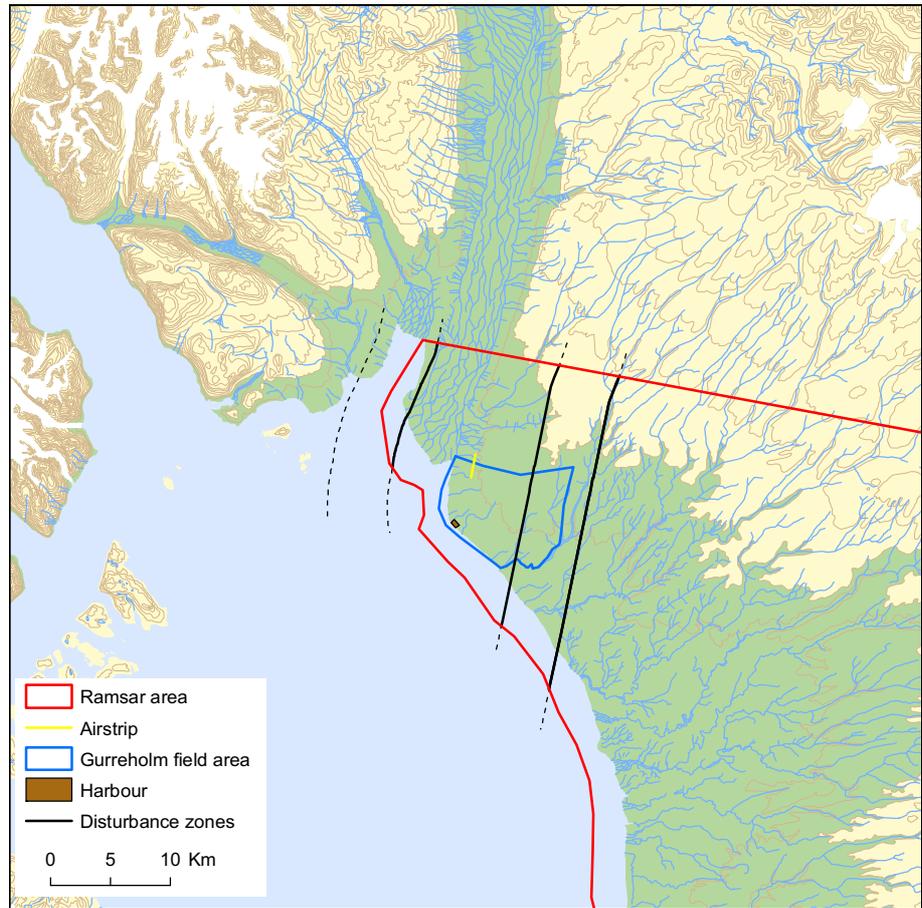


Figure 47. The distribution of moulting Pink-footed geese inside the two field areas Gurreholm and Tyskit Nunaat (delineated by red line). The two disturbance zones of 5 and 10 km are shown as well as the port site (brown), the road along the coast and the airstrip (yellow).

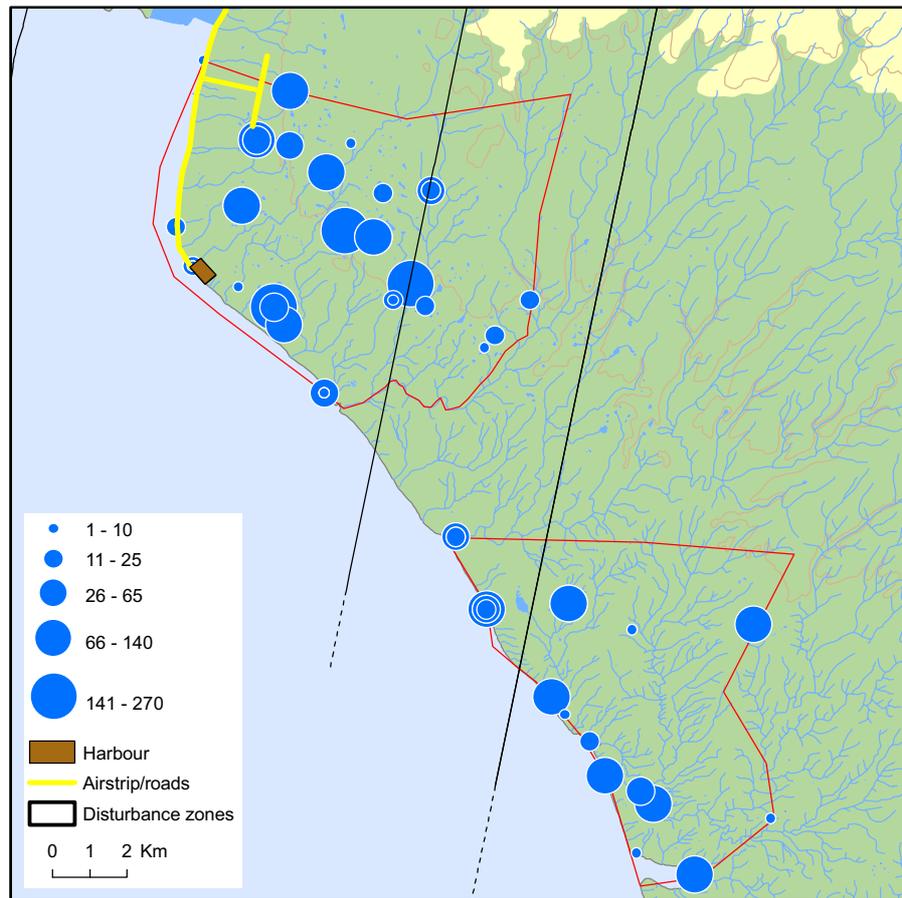


Figure 48. The distribution of family flocks of the Pink-footed goose inside the two field areas Gurreholm and Tyskit Nunaat (delineated by red line). The disturbance zone of 1.5 km is shown as well as the port site (brown), the road along the site and the airstrip (yellow).

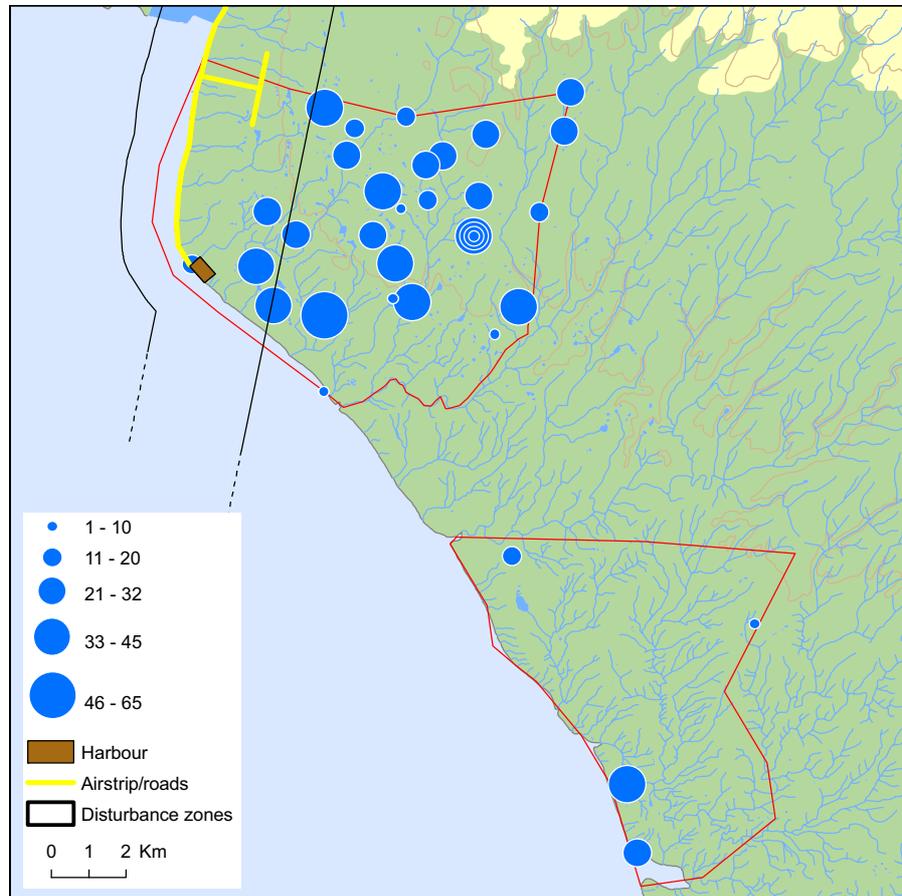


Figure 49. The distribution of breeding waders inside the two field areas Gurreholm and Tyskit Nunaat (delineated by red line). One dot represents a breeding pair. The disturbance zone of 1.5 km is shown as well as the port site (brown), the road along the coast and the airstrip (yellow).

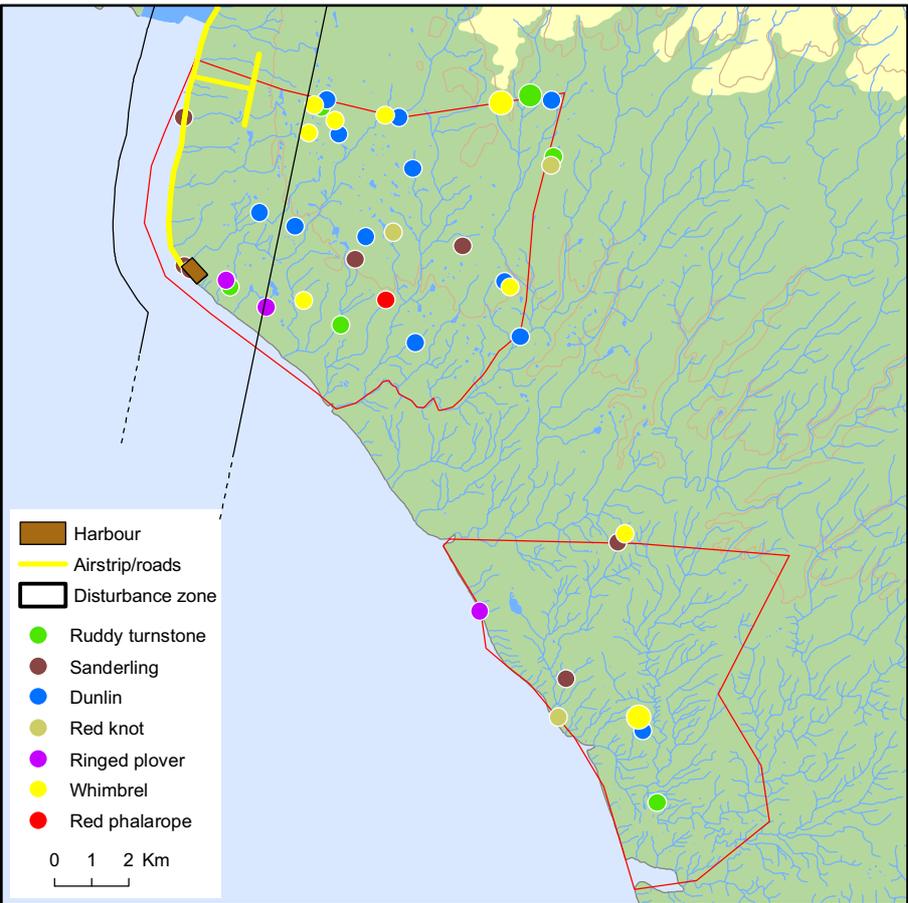
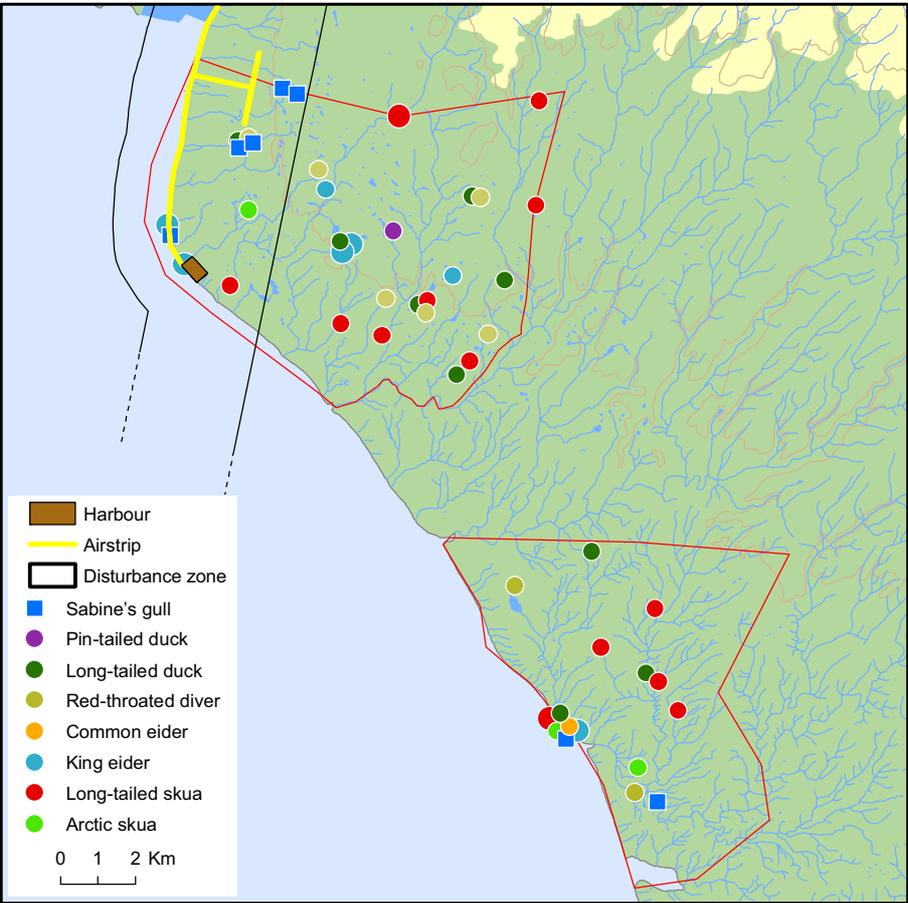
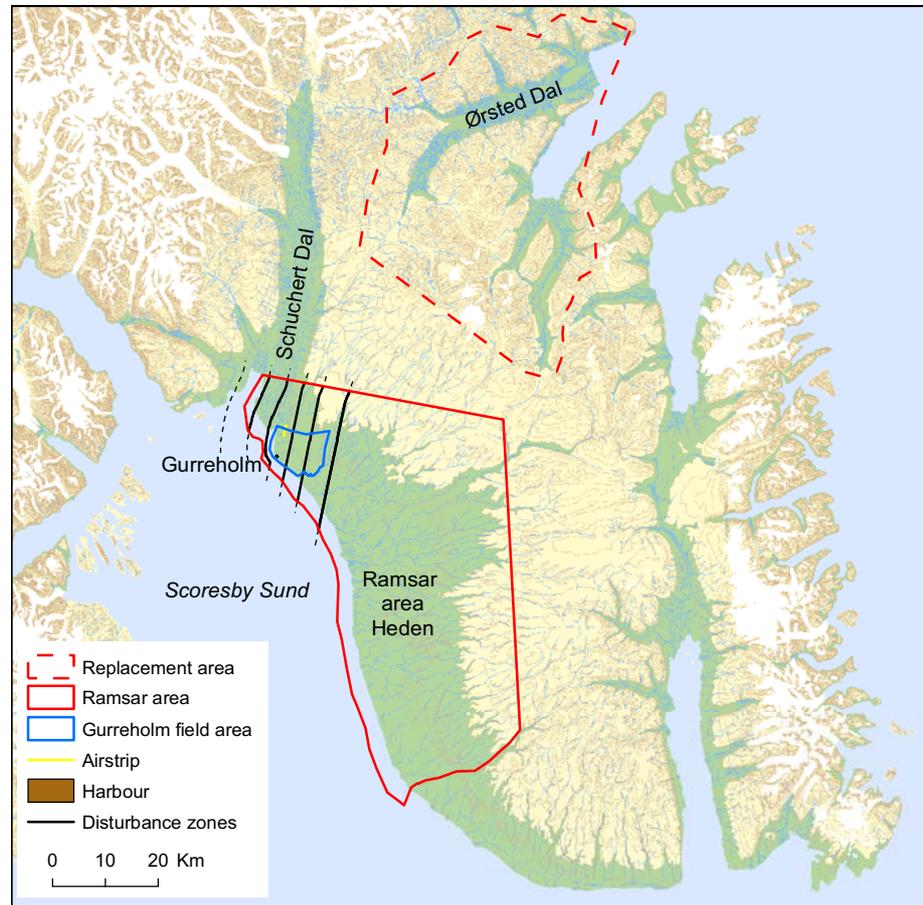


Figure 50. The distribution of breeding species of divers, ducks and skuas inside the two field areas Gurreholm and Tyskit Nunaat (delineated by red line). One dot represents a breeding pair. Sabine's gulls were non-breeding birds in flocks of 6-25 birds. The disturbance zone of 1.5 km is shown as well as the port site (brown), the road along the coast and the airstrip (yellow).



Appendix 2. The possible replacement area in Ørsted Dal

Figure 51. The Ramsar site Heden inside which the field area Gurreholm is shown as well as the air strip (A) and the port area (H). The three disturbance zones of 1.5, 5 and 10 km from the mining activities are also shown (black lines) and the replacement area, the extended Ørsted Dal area.



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National Environmental Research Institute
Frederiksborgvej 399
PO Box 358
DK-4000 Roskilde
Denmark
Tel: +45 4630 1200
Fax: +45 4630 1114

Management
Department of Arctic Environment
Department of Atmospheric Environment (main address)
Department of Environmental Chemistry and Microbiology
Department of Marine Ecology (main address)
Department of Policy Analysis

National Environmental Research Institute
Vejlsovej 25
PO Box 314
DK-8600 Silkeborg
Denmark
Tel: +45 8920 1400
Fax: +45 8920 1414

Department of Freshwater Ecology
Department of Marine Ecology
Department of Terrestrial Ecology

National Environmental Research Institute
Grenåvej 14, Kalø
DK-8410 Rønne
Denmark
Tel: +45 8920 1700
Fax: +45 8920 1514

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BIOLOGICAL BASELINE STUDY IN THE RAMSAR SITE "HEDEN" AND THE ENTIRE JAMESON LAND, EAST GREENLAND

In 2008, Quadra Mining Ltd. was granted an exploitation license that covered a large molybdenum ore body in East Greenland. Mining this ore will involve constructions inside the Ramsar site "Heden" of a port, a road and an air strip. In July 2008 NERI performed baseline studies on geese and other birds in the area. The possible impacted north-western part of the Ramsar site, Gurreholm, is lush wetland tundra. About 25% of the Pink-footed geese moulting in Jameson Land use this small part of the Ramsar site. The diversity and density of breeding birds in the area are relatively high. About 3% of the moulting Barnacle geese in Jameson Land use this area. The impact of the mining activities on the Gurreholm area is evaluated in proportion to disturbance zones of 1.5, 5 and 10 km; the most substantial impact will be that up to 4,900 moulting Pink-footed geese will avoid the area. The proposed replacement area, the extended Ørsted Dal area, holds 60-80% of the Pink-footed geese expected to avoid the Gurreholm area. The number of breeding Pink-footed geese in the affected area constitutes about one third of the Jameson Land breeding population. The replacement area will compensate for more moulting Barnacle geese than those impacted, thereby giving protection under the Ramsar Convention to an extra 7% of the flyway population. It is suggested to monitor the impact when mining starts. If the proposed replacement area can not compensate fully, yet another replacement area should be delimited.

