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A strategic environmental impact assessment of hydrocarbon and mining activities

Scientific Report from DCE – Danish Centre for Environment and Energy No. 41 2012

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Data sheet

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Abstract: There is an increasing interest for mineral and hydrocarbon exploration in Greenland and in both regards Jameson Land is in focus. This strategic environmental impact assessment describes the status of the biological knowledge from the area and designates potential conflicts between activities and the biological environment. Furthermore biological knowledge gaps are identified. These should be filled before specific environmental impacts assessments can be carried out and relevant studies to fill these data gaps are proposed

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Preface

Jameson Land has potential for both mineral and hydrocarbon exploration, and such activities have in fact taken place in and near the area since 1952. Today it is statutory that a strategic environmental impact assessment shall be carried out and included in the background information before the Government of Greenland decides whether or not an area shall be opened for a hydrocarbon licensing round. This is not yet the case for mineral licenses, but a similar procedure is expected to be introduced soon.

Due to increasing interest for exploration activities in Jameson Land, the Bureau of Minerals and Petroleum has asked DCE to compile a strategic environmental impact assessment of both hydrocarbon and mineral activities for the area.

This report gives an overview of the environment of Jameson Land, presents important information needs in relation to future activities in the areas and provides an assessment and risk evaluation of potential environmental impacts from mineral and hydrocarbon activities in the area.

Summary and conclusions

This report describes briefly the available background knowledge on the environment of Jameson Land. It focuses on the biological environment, and identifies information needs to be addressed by future background studies.

The descriptions and the assessment are restricted to the terrestrial environment, where the activities are expected to take place. The marine environment off Jameson Land is to a large extent included in the strategic environmental impact assessment of hydrocarbon activities in the Greenland Sea (Boertmann & Mosbech 2012).

Descriptive part

Jameson Land is situated within the high arctic zone, characterised by low summer temperatures, a long dark winter with snow cover and the surrounding sea covered by ice for 6 to 8 months.

Jameson Land is in a Greenland context unusual by the large continuous lowland areas bordering the Scoresby Sound fjord system in contrast to most other parts of Greenland, which are dominated by an alpine topography. In the northern part of Jameson Land there are, however, high mountainous areas with long and wide valleys.

The lowlands (including the valleys) hold a rich fauna and flora. The most important fauna species are the muskoxen and the geese. Jameson Land holds the largest and most dense population of muskoxen in East Greenland, and large numbers of barnacle and pink-footed geese breed and moult in the area. Jameson Land is of international importance for these geese, which leave Jameson Land for the winter.

Other bird species include shorebirds and waterbirds, such as Sabines gull and king eider. On some of the islands off the mainland coast, there are colonies of breeding seabirds mainly Artic terns and common eiders.

The flora is very rich with some endemic species and some species, which in Greenland are restricted to Jameson Land.

Due to the internationally important number of geese and other birds, two large areas are designated as wetland of international importance to water birds according to the Ramsar-convention. The National Park of North and East Greenland is bordering is assssment area to the north.

The biologically most sensitive areas are found mainly in the lowlands and the wide valleys, see Figure 16.

Chemical baseline measurements are few in the Jameson Land-area. Most are from the Schuchert Elv (samples from fresh water, marine sediments and lichens), and these show elevated concentrations of a number of metals.

Assessment part

In the 1990s, hydrocarbon exploration (seismic surveys) took place in Jameson Land. The muskoxen and the geese were focused on by background studies as the most sensitive fauna. Surveys of sensitive vegetation and rare plants were also carried out.

The present assessment also designates the muskoxen and the geese as the most sensitive fauna, sensitive particularly to disturbance and habitat destruction.

Conclusions on oil activities

Exploration for hydrocarbones in Jameson Land has the potential to cause extensive physical impacts, which may be visible for decades. Such impacts can be reduced by carrying out the activities in winter. Other potential impacts from exploration include disturbance of wildlife especially geese and muskoxen, but these are temporary and would last as long as the activities takes place. A limited exploration activity will most likely not impact on population level, but activities for many years in a row or covering extensive areas require mitigating measures to avoid population effects on geese and muskoxen. These impacts can also be reduced by carrying out the activities in winter.

Exploitation last for decades and potential impacts are necessarily long lasting. Physical impacts include landscape scaring, vegetation disruption/removal, damage on terrain and permafrost (from the footprint) and disturbance and displacement of wildlife. In this respect the most sensitive ecological elements would be the muskoxen, the geese and localised vulnerable habitats, and there may be a risk of effects on population level if no mitigative measures are taken.

Cumulative effects must be expected for example in the form of landscape scaring and especially on the most sensitive elements such as muskoxen and geese. They will be excluded from habitats (increasing with expanding activities), some which could be critical with population reductions as the ultimate effect.

On a global scale, the establishment of a large producing oilfield in Jameson Land would contribute to the increasing greenhouse gas content in the atmosphere, and it has the potential to increase the total Greenland contribution manyfold. Moreover produced oil and subsequent use should also be considered in a greenhouse gas contribution context.

In case of an accidental large oil spill, impacts may in unfortunate conditions be significant. Compared to oil spills in the marine environment, the impacted area on land and in freshwater habitats would be more restricted. However, if large amounts of oil enter water courses, there will be a risk for oil reaching the marine environment where it can spread to much larger areas.

The impacts of terrestrial oil activity are summarised by the AMAP Oil and Gas Assessment (AMAP 2010): "Until now, the major impact of Arctic oil and gas activity on terrestrial systems appears to have been from changes to the environment caused by increasing infrastructure such as roads, airstrips, expanded communities, and in general increased human activity in the form of truck travel, airplanes and helicopters and shipping." A more specific analysis of oil and gas activity in Alaska (NAS 2003) concluded that the current major effects of oil and gas activity in Alaska is changes to caribou and other species distribution, physical changes to habitats and that dust, noise and impacts on permafrost and surface hydrology extend the influence of structures beyond their physical footprint. These conclusions will also apply to oil activities in Jameson Land, although muskoxen rather than caribou would be affected.

The AMAP Oil and Gas Assessment (AMAP 2010) also states that: In some areas of the Arctic, oil companies have developed new methods to reduce the impact of oil- and gas field practices. Conducting seismic and construction work in the winter, reducing the size of pads for wells, reduction or elimination of sumps, and restricting the travel of personnel have reduced the amount of changes caused by each project. Such methods shall at least be applied as a part of the Best Available Technique and Best Environmental Practice principles if oil activities are initiated in Jameson Land

Finally, the impacts of oil spills should not be neglected, just because the dispersal of oil in terrestrial environments usually will be limited. The experience from the pipeline ruptures in the Komi-republic in 1994, clearly showed that large areas may be affected, and especially if the oil hits freshwater courses.

Conclusions on mining activities

Exploration for minerals does not have the same potential to cause extensive environmental impacts like exploration for hydrocarbons (especially the seismic surveys). The wide ranging activities are short-term and when an ore body is to be studied, the activities will be restricted in space and limited to physical impacts and disturbance of wildlife.

Exploitation – mining – on the other hand will last for decades, and impacts may last much beyond the active mining phase. The physical impacts may include landscape scaring, vegetation disruption/removal and damage on permafrost and it would also disturb and displace wildlife. In this respect the most sensitive ecological elements would be the mukoxen, the geese and localised vulnerable habitats, and there may be a risk of effects at population level if no mitigative measures are taken.

Cumulative effects may be expected, especially if other mining or petroleum activities are going on in Jameson Land. They would include landscape scaring and especially disturbance of the most sensitive elements such as muskoxen and geese. These may be excluded from habitats (increasing effect with expanding activities), some of which could be critical to the populations.

Moreover, a large mine would contribute considerably to the Greenland emissions of greenhouse gasses.

However, the potentially most severe impacts may be from pollution of the adjacent environment with metals and pollutants from the mined minerals and from the chemicals used in the processes. The primary sources would be dust and drainage from tailings and waste rock. However, such environmental impacts can to a large degree be mitigated, for example by designing deposits based on detailed knowledge on chemical processes, drainage patterns, permafrost, hydrography and sedimentation and by proper monitoring.

In case of accidents, the most severe impacts would be from unplanned release of tailings and waste rock, depending on the composition of the minerals and the chemicals added during the concentration processes.

Prevention is the best way to mitigate environmental impacts form mining activities in Jameson Land. Prevention includes smart design and solutions, applying the principles of Best Environmental Practice and Best Available Techniques and by thorough planning including up-to-date background knowledge of the surrounding environment including the waste rock composition.

In the future, detailed, regional Strategic Environmental Impact Assessments (SEIAs) of mining activities would be a valuable planning tool, making the basic spatial biodiversity information as well as information on physical, geochemical and biological processes available to the industry. Such information is needed for selecting the most efficient and environmentally best solutions in a specific mining project, and will be the foundation for environmentally safe and timely regulation of mining activities. Based on these SEIAs the industry would be able to provide better project specific EIAs, resulting in less uncertainty about environmental impacts.

Sensitive areas in Jameson Land

Based on the information presented in Chapter 3, a map of the biologically most sensitive areas of Jameson Land has been prepared (Figure 16). The designated areas are almost similar to the areas designated as Ramsar-areas and the "areas important to wildlife" (Figures 14 and 15). There may very well be more sensitive areas, which will be revealed for example when new background studies are carried out.

Knowledge needs

The biological environment of Jameson Land is well studied by background studies carried out in relation to oil exploration in the area in the 1990s and to some more recent mining projects. This means that for many environmental elements the knowledge base is more or less up to date. But especially the muskoxen population needs new studies, as this population has not been surveyed since the mid-1980s, and a prelimar study in 2000 indicated that distribution patterns apparently have changed. There is also a need for better information on the muskoxens habitat preferences during the annual cycle.

Chapter 8 gives a more detailed account of knowledge needs including both area specific and needs generics also to the Arctic.

Dansk resumé

Beskrivelse af området

Jameson Land i Østgrønland er interessant både i mineral- og oliesammenhæng. Der foregik olieefterforskning i 1980erne og 1990erne og flere mineralforekomster er blevet udnyttet eller undersøgt i og nær området. Ved Mestersvig var der brydning af bly- og zinkmalm frem til 1963 og ved Malmbjerget er der en større molybdæn-forekomst, som er blevet efterforsket i flere omgange og et selskab har en udnyttelsestilladelse.

Denne rapport er en strategisk miljøvurdering (SMV, på engelsk SEIA) af både mineral- og olieaktiviteter i Jameson Land. Den indskrænker sig til landmiljøet (det terrestriske miljø), hvorfor påvirkninger i havmiljøet ikke er omtalt. Disse er til en vis grad behandlet i en anden strategisk miljøvurdering af olieaktiviteter, som dækker den grønlandske del af Grønlandshavet (Boertmann & Mosbech 2012).

Jameson Land er godt kendt i naturhistorisk sammenhæng. Det skyldes, at der i forbindelse med olieaktiviteterne i 1980- og 1990erne blev gennemført baggrundsundersøgelser af både moskusokser, gæs og vegetation. Siden blev der i 2008-2010, i forbindelse med planerne for et større mineanlæg, også udført et antal undersøgelser af gæs og andre fugle.

Jameson Land er naturmæssigt unik i Grønlandsk sammenhæng på grund af de store sammenhængende lavlandsområder. Kun mod nord er der højfjeldsområder, og her er der flere brede og lange dale. Lavlandsområderne og disse dale er rige naturområder med relativt frodig vegetation i fugtige kær og dværgbuskheder, og flere steder langs kysterne ind mod Hall Bredning er der strandenge. Disse områder har et rigt dyreliv med moskusokser, gæs og vadefugle som de vigtigste.

Moskusoksebestanden er den største og tætteste i Østgrønland og den udnyttes af befolkningen i Ittoqortoormiit. Okserne færdes mest i de frodige lavlandsområder med Ørsted Dal og nærliggende dale som et af de meget vigtige områder.

To arter af gæs – bramgås og kortnæbbet gås – forekommer i store antal i området. De både yngler og fælder (den del af bestandene som ikke yngler) i Jameson Land. De er knyttet til de frodige vådområder og især de fældende fugle optræder i tætte koncentrationer omkring søer, elve og strandenge. De er så talrige at flere af områderne i Jameson Land er af international betydning for de to arter. Det har medført at to områder er udpeget som internationalt vigtige for vandfugle (Ramsar-områder).

Andre vigtige fugle omfatter vadefuglene, som forekommer spredt ud over lavlandsområderne, og desuden nogle i Grønland mere sjældne arter som sabinemåge, lille regnspove og hjejle.

På nogle af småøerne langs kysterne er der kolonier af havfugle, som ederfugl og havterne.

Flere af de i Jameson Land forekommende dyrearter er listet som truede i Grønland (Tabel 5) og en enkelt art, nemlig isbjørnen, er desuden på den internationale liste over truede dyr (Tabel 5).

Vegetationen er artsrig med flere endemiske arter og med nogle arter, der i Grønland kun findes her.

Befolkningen i Ittoqqortoormiit udnytter primært de marine ressourcer, men enkelte terrestriske arter indgår: Særligt bestanden af moskusokser i Jameson Land og fjeldørred i og nær elvenes udløb.

I forbindelse med anlæg af miner og oliefelter er baggrundsviden om miljøets naturlige belastning af forurenede stoffer vigtig. Indtil nu foreligger der kun analyser af grundstoffer fra vand og sedimenter i Schuchert Elv-området, og de viser naturligt forhøjede værdier af en række grundstoffer.

Strategisk miljøvurdering

Olieefterforskning

De væsentligste aktiviteter under olieefterforskning er seismiske undersøgelser og prøveboringer, og miljøpåvirkningerne omfatter:

- fysiske påvirkninger fra konstruktioner og aktiviteter
- forstyrrelser af dyreliv
- udledninger til luft, vand og land.

Seismiske undersøgelser

De seismiske undersøgelser foretages fra et større optog af køretøjer med flytbare barakker og special-trucks med den seismiske lydkilde ("Vibroseis"). Dette optog kan give omfattende skader på terræn og vegetation, og kan også permafrostlaget med efterfølgende risiko for thermokarst. Da de seismiske undersøgelser foregår over store områder er der risiko for betydelige landskabsskader, og der ses stadig spor i landskabet efter de seismiske aktiviteter i Jameson Land i 1980erne.

Miljøpåvirkningerne fra seismiske undersøgelser begrænses bedst ved at udføre aktiviteterne om vinteren. Dels beskytter snelaget til en vis grad vegetation og terræn, dels er mange af de sårbare dyr væk fra Jameson Land om vinteren (gæs og andre fugle), og kun moskusokserne vil være udsatte. En yderligere mulighed kan være at anvende særligt lette køretøjer, som påvirker undergrunden meget mindre end traditionelle bulldozere.

Forstyrrelseseffekten fra selve de seismiske undersøgelser om vinteren vil blive relativt kortvarig da de seismiske undersøgelser dels bevæger sig gennem området, dels kun varer en sæson eller to. Men der vil også være en betydelig trafik af helikoptere mellem en basislejr og der, hvor der opereres, og det vil medføre en risiko for at skræmme især moskusokser. Om sommeren vil helikoptertraffik især kunne skræmme gæs bort fra vigtige levesteder. Men effekten er kortvarig og begrænset til den sæson hvor aktiviteten foregår.

Prøveboring

De fysiske påvirkninger fra prøveboring omfatter selve det sted boringen foregår og de steder hvor der placeres div. installationer og bygninger ("fodaftrykket"). Men også en kørevej mellem borestedet og et landsætningssted på kysten i nærheden indgår her, og skal den gå gennem fugtigt terræn er befæstning nødvendig. Grusudtag i nærliggende terræn vil desuden bidrage til de fysiske påvirkninger. Men de fysiske påvirkninger vil generelt blive begrænsede til de nærmeste omgivelser af et borested.

Foregår aktiviteterne i fugtigt terræn er risikoen for væsentlige terræn- og vegetationsskader større end i tørt terræn, bl.a. fordi afstrømningsmønstre kan ændres, og der for eksempel kan opstå opdæmning af vand.

Brugen af "all terrain vehicles" (ATV'er) kan være udbredt i forbindelse med prøveboringer, og har tidligere i forbindelse med mineprojekter givet anledning til mange umotiverede kørespor i terræn i Grønland.

Endelig skal der benyttes store mængder ferskvand til en prøveboring, og der kan være en risiko for at tørre mindre søer og vandløb helt ud.

De fysiske påvirkninger fra en prøveboring kan begrænses ved at bore om vinteren, når terrænet er dækket af sne. I 1996 gennemførtes en prøveboring på Nuussuaq-halvøen, og her ses stadig kørespor i terrænet, ligesom der er tydelige bulldozer-spor på den grusbanke, som boreriggen stod på.

En prøveboring i Jameson Land vil efterlade fysiske spor, primært i form af kørespor med vegetations- og terrænskader. Der vil også være en risiko for skader på permafrostlaget (thermokarst). Omfanget af sådanne skader vil afhænge af det terræn boringen foregår i og blive mest udprægede i fugtigt terræn, men her kan vegetationsskader også regenerere hurtigere end i tørt terræn, hvis de fysiske forhold (substrat og vandtilførsel) reetableres.

Prøveboringer kan virke forstyrrende på dyrelivet både ved selve borestedet og langs de færdselsruter der benyttes enten med køretøjer eller helikopter. Effekten kan være at følsomme dyrearter skræmmes bort fra levesteder nær disse anlæg. Det gælder særligt gæs og moskusokser. Formentlig har både gæs og okser alternative steder at opholde sig i en prøveboringsperiode, og der vil næppe blive tale om bestandseffekter på disse dyrearter fra en enkelt prøveboring. Men flere eller længerevarende operationer i et område vil kunne påvirke bestande af gæs og moskusokser negativt, hvis der ikke gennemføres tiltag til at begrænse påvirkningerne.

Forstyrrelser af dyrelivet forebygges bedst ved at udføre boringer om vinteren, og derudover ved nøje regulering af trafik og andre forstyrrende aktiviteter.

Udledninger

Både de seismiske undersøgelser og prøveboringer vil give anledning til udledning af udstødning fra maskineri. Især prøveboringer vil udlede store mængder af drivhusgasser, NO_x og SO_2, hvoraf de to sidstnævnte bidrager til dannelsen af "Arctic haze", sod ("black carbon") og sur nedbør.

Når en prøveboring er afsluttet skal der bortskaffes store mængder boremudder og borespåner. Disse materialer blev i Canada og Alaska tidligere efterladt i det omgivne miljø, som regel i et gravet hul (på engelsk "a sump"). Efter boringen på Nuussuaq i 1996 blev borespåner og den flydende del af boremudderet spredt ud og harvet ned i den grusbanke boreriggen stod på, og den faste del blev gravet ned og dækket til. Den faste del er siden sunket ind, og der er nu huller i terrænet, hvor der formentlig samles smeltevand med risiko for udvaskning af boremudderkomponenter om foråret.

I Alaska graver man ikke længere boremudder og borespåner ned, men genbruger så meget som muligt og deponerer resten på godkendte lossepladser. Det samme bør være praksis ved eventuelle prøveboringer i Jameson Land.

Olieudvinding

Aktiviteterne ved olieudvinding er i modsætning til efterforskningen af lang varighed, som regel årtier. De væsentligste miljøpåvirkninger vil opstå i forbindelse med:

- fysiske påvirkninger fra installationer og aktiviteter
- forstyrrelser af dyrelivet
- udledninger til vand, jord og luft
- brug af ferskvand.

Fysiske påvirkninger

Olieudvinding kan medføre omfattende fysiske påvirkninger af miljøet. Alene de mange faciliteter, der skal bygges og indrettes, dækker store landområder. Der er udover selve olieudvindingsinstallationerne for eksempel tale om bygninger, havnefaciliteter, lufthavnsfaciliteter, pipelines, affaldsdeponier, grusudtag og tanke.

Disse installationer vil også kunne påvirke permafrostlaget med risiko for udvikling af thermokarst og for indsynkning af bygninger og konstruktioner, som kan medføre forøget risiko for uheld for eksempel i form af brud på pipelines.

I Alaska har man desuden set væsentlige ændringer i vandafstrømningen med store ansamlinger af overfladevand og ændrede grundvandsforhold som resultat.

Det område (”fodaftryk”), som de mange installationer beslaglægger, medfører en risiko for ødelæggelse af værdifulde og vigtige levesteder for dyr og planter, hvilket kan være kritisk for arter med små bestande eller med meget begrænsede udbredelsesområder. Opdeling af levesteder (”habitat fragmentation”) er anden væsentlig fysisk miljøeffekt, som især vil påvirke dyr, der vandrer mellem forskellige levesteder, som for eksempel moskusokser eller fjeldørred.

Endelig er den visuelle effekt af et oliefelt også væsentlig for f.eks. turisme. I denne sammenhæng er Jameson Land særligt sårbart, da landet generelt er fladt og med vidt udsyn.

De fysiske påvirkninger forebygges bedst ved at anvende den bedst tilgængelige teknologi (BAT – ”Best Available Technology”) og de nyeste miljøtiltag (BEP – ”Best Environmental Practice”). Dette er tydeligt i Alaska, hvor nye oliefelter dækker meget mindre områder end de første, der blev anlagt.

I Jameson Land vil de fysiske påvirkninger af et oliefelt afhænge af placeringen og for eksempel af afstanden ud til kysten, hvor en havn skal anlægges. Kun i relativt begrænsede områder vil der kunne opstå de samme problemer med permafrost og ændret vandafstrømning, som det ses i Alaska, fordi Jameson Land generelt er meget mere tørt og veldrænet. De væsentligste påvirkninger må forventes at blive tab af levesteder for moskusokser og gæs og at anlæg af pipelines vil kunne spærre vandringsveje for okserne, hvis der ikke gøres noget for at forhindre eller afbøde dette.

Forstyrrelse af dyrelivet

Et oliefelt forstyrrer dyrelivet alene ved tilstedeværelsen, men også ved de mange forskellige menneskelige aktiviteter, der følger med, som for eksempel flyvning med helikopter eller trafik på veje.

Forstyrrelserne kan medføre fortrængning af dyr fra deres levesteder, og fortyrrelserne vil således forøge det område, som dyrene ikke kan benytte, på samme måde som områder der fysisk dækkes af installationer og konstruktioner.

Forstyrrelseseffekterne forebygges bedst ved at begrænse og regulere trafik og aktiviteter nøje, bl.a. for at give dyrelivet en mulighed for at vænne sig til aktiviteterne.

I Jameson Land forventes moskusokserne og gæssene at være de mest sårbare dyr i forbindelse med forstyrrelser fra et oliefelt, og der vil være en risiko for at skræmme både gæs og okser permanent væk fra vigtige levesteder og fra steder, hvor de traditionelt jages af fangere fra Ittoqqortoormiit.

Udledninger til vand, jord og luft

Den største udledning fra et oliefelt er det vand, der pumpes op sammen med den producerede olie – såkaldt produktionsvand. Dette indeholder små mængder af forurenende stoffer, som kan være akut giftige, radioaktive, m.m.

I andre arktiske lande, hvor der udvindes olie på land, udledtes produktionsvandet som regel mere eller mindre renset til floder. Udviklingen går dog i retning af at tilbagepumpe dette produktionsvand i oliebrøndene, og dette er nu praksis i Alaska. Det vil dog ikke altid være muligt at tilbagepumpe alt produtionsvand, og for at kunne udlede det, skal det underkastes en effektiv rensning. I forhold til offshore olieproduktion er det nemmere at bygge effektive rensningsfaciliteter på landbasede anlæg.

Et oliefelt udleder desuden store mængder af udstødningsgasser fra maskineri ligesom afbrænding af gas, omlastning af olie m. fl. processer giver udledninger til luften. Der er tale om store mængder af drivhusgasser (CO_2 og metan), VOC, NO_x og SO_2. Sidstnævnte bidrager til dannelsen af ”arctic haze” og sur nedbør og nedfald af sod (”black carbon”).

Boring af nye brønde fortsætter i produktionsfasen. Der bores hele tiden nye, og boremudder og -spåner skal fortsat bortskaffes. I denne fase er det muligt at deponere det i gamle brønde.

Udledninger fra olieproduktion begrænses ved at anvende bedst tilgængelige teknologi (BAT) og de nyeste miljøtiltag (BEP).

Mht. udledninger til atmosfæren vil der opstå en risiko for dannelse af ”Arctic haze”, ligesom sur nedbør vil kunne påvirke det næringsfattige miljø i et stort område omkring et oliefelt.

Brug af ferskvand

Forbruget af ferskvand i et oliefelt er meget stort, og der vil være risiko for at udtørre nærliggende søer. Mange af elvene i Jameson Land er uegnede til indvinding af vand, fordi de tørrer ud om sommeren eller bundfryser om vinteren.

Oprydning

Den sidste fase blandt olieaktiviteterne er fjernelse af et udtømt felt og efterfølgende oprydning. Aktiviteter i denne fase giver anledning til forstyrrelser og risiko for forurening med ophobede stoffer. Det er vigtigt allerede i planlægnings-og konstruktionsfasen at indtænke miljøvenlige muligheder for nedbrydning af anlæg og oprydning.

Oliespild

Et stort oliespild i forbindelse med olieaktiviteter i Jameson Land kan enten stamme fra en udblæsning (”blow out”) fra en boring eller være en følge af brud på en pipeline. Erfaringerne fra andre steder i Arktis (særligt Rusland) viser, at pipelinebrud har givet de største spild. Oliespild på land vil normalt ikke få samme store udbredelse som spild til havs. Men finder olien vej til en elv er der risiko for at olien kan spredes til større områder og evt. nå ud i det marine miljø.

Oliespild på land ødelægger især vegetationen, og olien vil opsuges i jordlagene, hvor den kan ligge i mange år, hvis ikke den graves op. Når olien ud i ferskvandsystemer, vil fisk påvirkes og forgiftes og vandfugle vil kunne rammes af olien.

Landdyr og -fugle vil undgå områder med olieforurening, og vil påvirkes ved at blive fortrængt fra levesteder. Men det vil næppe påvirke bestande, hvis det lykkes at inddæmme spildet til et begrænset landområde.

Oliespild forbygges ved at følge BAT og BEP-principperne, ligesom der skal være krav til at anvende de højeste sundheds-, sikkerheds- og miljøstandarter (HSE). Planlægning, regulering og beredskab skal tage højde for oliespild, for eksempel ved at forebygge at olie når ud i de nærliggende vandmiljøer med risiko for at nå havet.

Oliespild i Jameson Land vil primært påvirke vegetationen. Men da mange områder i Jameson Land er på klippegrund og mange elve fører direkte til havet vil der være en risiko for, at spildt olie når ud til sårbare kystområder.

Mineralaktiviteter – efterforskning

Mineralefterforskning indledes ofte med små hold af geologer i felten, og miljøpåvirkningerne fra disse er begrænsede til de fysiske påvirkninger fra lejrsteder, kørsel med ATV’er og forstyrrelse af dyreliv, hvor der arbejdes. Senere omfatter efterforskningen kerneboring for at afgrænse de interessante mineraler. Miljøpåvirkningerne fra sådanne boringer svarer til olieefterforskningsboringer (se ovenfor), bortset fra, at boreudstyret er meget lettere og forbruget af boremudder er meget mindre. Både boremudder og -spåner udledes normalt til det omgivne miljø, hvis det ikke indeholder giftige stoffer.

I Jameson Land forventes mineralefterforskning kun at føre til få og begrænsede påvirkninger, i form af fysiske påvirkninger og forstyrrelser af dyreliv. Påvirkningerne kan forebygges primært gennem Råstofdirektoratets regler for feltarbejde.

Mineralaktiviteter – udnyttelse

Miljøpåvirkningerne fra en mine varer længe og i mange tilfælde også ud over selve minens levetid. Påvirkningerne omfatter:

- ”fodaftrykket” fra installationer, konstruktioner og aktiviteter
- forstyrrelser af dyrelivet
- udledninger til omgivelserne herunder kemisk forurening og støv
- erosion og sedimentation.

Fysiske påvirkninger og forstyrrelser af dyrelivet

Disse svarer til de beskrevne ovenfor for olieudvinding. Dog kan det fysisk påvirkede område (”fodaftrykket”) være meget omfattende i forbindelse med et stort åbent mineanlæg med tilhørende deponier for mineaffald.

Udledninger

En hel del af udledningerne fra en aktiv mine svarer til dem fra et oliefelt (se ovenfor). Det drejer sig om udledninger til luften (udstødning fra maskineri) og affald fra beboelse og lejre. Men særligt udvinding og behandling af det kommercielle mineral kan give anledning til særlige miljøpåvirkninger af stort omfang.

Det største af miljøproblem ved minedrift relaterer til de store mængder af mineaffald, der produceres. Dette består dels af gråbjerg (den del af fjeldet, der skal fjernes for at komme ind til det mineral, man graver efter) dels af ”tailings”, som er restproduktet fra opkoncentreringen af det kommercielle mineral. Disse restprodukter deponeres sædvanligvis nær minen, og kan, ved siden af de æstetiske påvirkninger, i mange tilfælde også give anledning til forurening med miljøgifte. Sidstnævnte især hvis der er tale om sulfidmineraler, som ved kontakt med vand og ilt danner syre, som kan opløse og sprede tungmetaller, der er bundet i tailings (”acid drainage”).

Behandling af det brudte mineral kræver ofte anvendelse af kemikalier, som kan være særdeles giftige i miljøet. For eksempel bruges cyanid ved udvinding af guld.

En yderligere kilde til forurening af mineomgivelserne er det støv som dannes ved mange af aktiviteterne: brydning, transport og knusning. Det er primært tungmetaller der er problemet i denne sammenhæng.

I Jameson Land vil drænvand fra mineaffald kunne påvirke dyrelivet i både ferskvand og i havet, da der ikke er langt fra potentielle minesteder til kysten. Det vil potentielt kunne medføre forhøjede værdier af forurenende stoffer i dyr, som udnyttes af befolkningen i Ittorqqortoomiit, ligesom det er set i fjordene nær mine i Maamorilik.

Spredning af miljøgifte fra et mineanlæg skal imødegås ved allerede i planlægningsfasen at indarbejde integrerede, forebyggende tiltag i alle processer. Her er BEP og BAT-principperne vigtige at indarbejde ligesom høje HSE-standarder.

Det er for eksempel vigtigt, at forureningspotentialet i "tailings" og gråbjerg undersøges på forhånd, sådan at deponi af disse affaldsstoffer kan gøres miljømæssigt forsvarligt, og sådanne undersøgelser indgår som en væsentlig del af udarbejdelsen af miljøvurderinger og myndighedsgodkendelsen af aktiviteterne.

Uheld under minedrift

De mest alvorlige akutte miljøpåvirkninger fra miner er opstået som følge af uheld, hvor mineaffald er strømmet ud i floder eller havområder. Sådanne uheld kan i Jameson Land forebygges ved at placere mineaffald i naturlige reservoirer, som dybe søer eller i fjorde, hvor der ikke er udskiftning af bundvandet og hvor naturlig sedimentation vil dække det deponerede materiale når minderiften er afsluttet.

Kumulative påvirkninger

Der må forventes kumulative påvirkninger på særligt moskusokser og gæs som følge af flere mine- eller olieaktiviteter – både samtidigt og fortløbende – i Jameson Land.

Manglende viden

Som nævnt ovenfor er den foreliggende biologiske baggrundsviden fra Jameson Land generelt god og opdateret. Men der mangler imidlertid særligt viden omkring moskusokserne, da der ikke er udført studier af disse siden tiden omkring 1990. Der er derfor behov for både optællinger og kortlægning af deres valg af levesteder samt for mere generelle studier af deres økologi og reaktioner på forstyrrelser.

For at kunne tilrettelægge aktiviteterne så effekter af forstyrrelser bliver mindst mulige, er der behov for at foretage studier af hvordan de potentielt påvirkede dyr reagerer på forstyrrelser. Endelig vil det også være relevant at studere hvordan gæs og moskusokser eventuelt vænner sig til forstyrrelser, således at tilvænningen kan optimeres. På den måde kan det sikres at størrelsen af det areal, der ikke kan benyttes af gæs og moskusokser pga. forstyrrelser bliver mindst muligt.

Der er desuden behov for mere generel viden omkring effekter af minedrift og olieaktiviteter, særligt udvikling af miljøvenlige metoder til behandling og deponering af gråbjerg, tailings, boremudder, og produktionsvand. Da også de marine områder ud for Jameson Land vil påvirkes af kommende aktiviteter, bliver der behov for yderligere undersøgelser af vandudskiftning, sedimentation og kortlægning af vigtige habitater her.

Naalisagaq kalaallisooq

Nunap tamatuma eqqartorneqarnera

Tunumiittoq Jameson Land mineralisiornermut uuliasiornermullu tunngatillugu soqutiginartuuvoq. 1980-ikkunni 1990-ikkunnilu uuliasiortoqarpoq mineraleqarfiillu arlallit tamaani tamatumaluunniit eqqaaniittut iluaqutigineqarlutilluunniit misissorneqarput. Mestersvigimi aqerlumik zinkimillu 1963-ip tungaanut piiaasoqarpoq Malmbjergimilu annertunerusumik molybdæneqarfeqarpoq arlaleriarluni misissorneqartarsimasumik, selskabilu ataaseq iluaquteqarnissamut akuersissutaateqarpoq.

Nalunaarusiaq una Jameson Landimi mineralisiornikkut uuliasiornikkullu ingerlatanut tunngatillugu siumut sammitillugu avatangiisinik naliliineruvoq (SMV, tuluttut SEIA). Avatangiisinut nunamiittuinnarnut tunngatitaavoq (det terrestriske miljø), taamaattumik immami avatangiisinut sunniutit eqqartorneqanngillat. Tamakkuali uuliasiornikkut ingerlatanut tunngatillugu siumut sammitillugu avatangiisinik naliliinermi allami, Grønlandshavip Kalaallit Nunaannut atasortaaniittumut tunngasumi eqqartorneqangaatsiarnikuupput (se Boertmann & Mosbech 2012).

Jameson Land naturhistoriamut tunngatillugu ilisimaneqarluartuuvoq. Tamatumunnga 1980- aamma 1990-ikkunni uuliasiornermut atatillugu tunuliaqutaasumik umimmannut, nerlernut naasunullu tunngatillugu misissuisoqarnikuunera pissutaavoq. Tamatuma kingornagut, 2008-2010-mut annertuumik aatsitassanik piaaviliorniartoqarneranut atatillugu arlalinnik nerlernik timmissanillu allanik misissuisoqartarnikuuvoq.

Jameson Land nunatut isigalugu Kalaallit Nunaanni asseqanngiusartuuvoq annertoorsuarnik ataqatigiissunik pujjitsunik naqinnigaarsuaqartiterami. Taamaallaat avannamut qaqqartoortaqarpoq, arlalinnillu siluttunik takisuunillu qooruaartarsuaqarpoq. Naqinnigaat tamakkua pukitsut nunaapput taseqqat eqqaanni naggorissut pukkitsunik orpigaqarfiusut, sineriallu atuarlugu Hall Bredningip tungaanut arlalinnik sissamut atasunik narsartaqartiterpoq. Tamakkua uumasulerujussuupput, pingaartumik umimmannik, nerlernik timmissanillu naloraarusilinnik.

Tamanna Tunumi eqimanerpaanik amerlanerpaanillu umimmaqarfiuvoq Ittoqqortoormiormiunit iluaqutigineqartunik. Umimmaqarneruppput pukkitsortaa, soorlu Ørsted Dal-i qanittuanilu qooqqut naggorissut.

Nerlerit assigiinngitsut marluk – nerlernat bramgæs nerlerillu siggukitsut – tamaani amerlasoorujussuupput. Jameson Landimi nerlerit piaqqillutillu ilaat isasarput (piaqqisuunngitsortaat). eMasarsoqarfinni amerlasoorsuullutiik naggorissuniinnerusarput, pingaartumik issortaat amerlaqalutik tatsit, kuuit sissallu qanittuani narsartat najortarpaat. Imami amerlatigipput Jameson Landimi nunap ilai nunarsuarmi nerlernut taakkjununnga marlunnut pingaaruteqarluinnartuullutik. Taamaattumik nunap ilai marluk nunarsuarmi timmissanut naluusilinnut pingaarutilittut toqqagaanikuupput (Ramsareqarfiullutik).

Timmissanut pingaarutilinnut ilaapput naloraarusillit, pukkitsumi tamani tamaaniittuusut, aammalu Kalaallit Nunaanni timmissat qaqutigoornerusunik, soorlu sabinemågenik, lille regnspovenik hjejlenillu peqarpoq.

Sinerissap killinganiittut qeqertaaqqat ilaat imarmiunik timmiaqarfiupput, soorlu miternik imeqqutaallanillu.

Uumasut Jameson Landimiittut arlallit Kalaallit Nunaanni nungutitaanissamik aarlerinartorsiortutut nalunaarsugaapput (Tabel 5) ataaserlu, tassalu nanoq nunarsuarmi nungutitaanissamik aarlerinartorsiortut nalunaarsorsimaffianni ilaavoq (Tabel 5).

Naasui assigiinngisitaaqaat arlallillu tamaaniinnaq naasarput ilaqarlutillu Kalaallit Nunaanni allami naammattuugassaanngitsunik.

Ittoqqortoormiormiut pingaartumik isumalluutinik imarmiunik atuuisuupput, nunamiutalli ataasiakkaat: pingaartumik Lameson Landimi umimmaat eqaluillu kuuit akuini aamma iluaqutigineqarput.

Aatsitassarsiorfinnik uuliaqarfinnillu sanaartornermut atatillugu avatangiisini mingutitsisinnaasunut tamaaneereersunut tunngatillugu tunuliaqutaasumik ilisimasaqarnissaq pingaartuuvoq. Manna tikillugu taamaallaat imermi Schuchert Elvillu eqqaani kinnernini grundstoffit misissorneqarnikuupput, misissuinerullu takutippaa grundstoffit arlallit annertujaamik tamaaneereersut.

Siumut sammisillugu avatangiisinik nalilersuineq

Uuliamik ujarlerneq

Ulliamik ujarlernermi ingerlatat pingaaruteqarnerit tassa sajuppillatitsiarluni misissuinerit misiliillunilu qillerisarnerit, avatangiisinullu sunniutinut makkua ilaapput:

sanaartorneqartut ingerlatallu tamaani pinngortitamut sunniutaat
uumasunik akornusersuineq
silaannarmut, imermut nunamullu aniatitsinerit.

Sajuppillatitsisarluni misissuinerit

Sajuppillatitsisarluni misissuinerit ukiuunerani ingerlanneqarpata qamuterpassuit barakkillu nuunneqarsinnaasut, special-truckit sajuppillatitsissumik (”Vibroseis”) nassartut atorlugit pisinnaavoq. Toqqaannartumik sunniutit ilagissavaat naasoqarfiup aserorneqarnera nunallu ingerlaarfiusup illineqalernera. Permafrosti (nunap ilua qeriuaannartoq) ajoquserneqarsinnaavoq ajoqusiinerillu tamakkua annertuumik thermokarst-innguussinnaapput (nunap qaava ammarlugu neriorneqarlersitsineq). Sajuppillatitsisarluni misissuinerit nunami annertoorujussuarmi pisarmata nunap annertuumik innarlerneqarsinnaanera aarleqqutissaavoq, sulimi 1980-ikkunni sajuppillatitsiarluni Jameson Landimi misissuinerit erseqqilluinnartunik takussutissaqarput. Kisiannili sajuppillatitsisarluni misissuinerit aasakkut ingerlanneqarsinnaapput, taammalu atortussat tamarmik helikopterinit angallanneqarlutillu nuttarneqarsinnaallutik. Periaaseq taanna aamma 80-ikkunni atorneqarpoq. Naasoqarnermut nunamullu ajoqusersuineq annikinnerulersittarpaa, kisiannili annertuumik helikopterernermik ilaqartarluni annertuumik nerlernut umimmannullu akornusersuutaasinnaasumik.

Ukiuunerani sajuppillatitsisarluni misissuinerit akornusersuinerat sivisoorsuussanngilaq misissuinerit nikerartussaammata, aammalu sæsoni ataaseq marlullunniit taamaallaat sivisussuseqartussaagamik. Kisiannili aamma annertuumik helikopterimik qitiusumik najugaqarfiup suliffiusullu akornanni angallanneqartussaavoq, tamatumalu qimaasaarutaajumaarpoq, pingaartumik umimmannut. Aasakkut helikopterimik angallannerup pingaartumik nerlerit najortagaannit pingaarnernit nujutsissinnaavai. Sunniulli taanna sivisussanngilaq sæsonip suliffiusup nalaaniinnaq pisussaagami.

Sajuppillatitsisarluni misissuinerit avatangiisinut sunniutaat pitsaanerpaamik killilersimaarneqarsinnaapput ingerlatat ukiuunerani ingerlanneqarpata. Apummi naasunut nunamullu illerllersuutaallunilu uumasut eqqoruminarnerusut ukiuunerani Jameson Landimiinneq ajormata (nerlerit timmissallu allat), umimmaat kisimik akornusersuinermit eqqorneqarsinnaassapput. Periarfissaasinnaavortaaq qamutit spinngisamik oqitsut atorneqarpata angallavigisaminnik bulldozerinit atorneqarajunnerusunit nunamik aserorterinnginnerussammta.

Misiligummik qillerineq

Misiligummik qillerinerup takussaasumik sunniutigai qilleriviusoq namminneq aammalu sanaartukkat illullu sumut inissinneqarsimaneri. Kisianni aamma tassunga ilaavoq qamutit qilleriviusup sinerissamilu tulaassuiviusup akornanni aqqusineqartussaammat, taannalu nunakkut isugutasukkoortussaammat tunngavilersorluagaasariaqarmat. Aqqusinniap qanittuani ujaraaqqanik atortussanik piiaaneq aamma takussaasumik sunniutinut ilapittuutaasussaavoq.

Ingerlatat nunami isugutasumi ingerlanneqarpata nunami panertumiinnermit nunamik naasunillu annertuumik aseruinissaat ilimanarneruvoq, ilaatigut erngup kuuffii allanngortinneqartarmata aammalu erngup kuunnera sapusertoorlugu tasertanngorsinnaammat.

Qamutit ”all terrain vehicles” (ATV’er) misiligummik qillerinermi annertuumik atoneqarsinnaapput, tamakkualu Kalaallit Nunaanni aatsitassarsiornermik ingerlatat torinngiinnarmi illinerpassuaqarneranut pissutaapput.

Kiisalu aamma imeq annertoorujussuaq misiligummik qillerinermi atorneqartussaavoq, taamaattumik tatsinik kuunnillu minnerusunik imaarutitsisivissinnaaneq aarlerigineqarsinnaavoq.

Misiligummik qillerinerup takussaasumik sunniutai annikillilerneqarsinnaapput qillerineq ukiukkut ingerlanneqarpat, nuna aputeqartillugu. Tamannalu qilleriffiusup qanitarpiaaniitinneqarsinnaavoq. 1996-imi Nuussuarmi misiligutigalugu qillerineqarpoq, ulloq mannalu tikillugu nunami aqqutigisimasaat takuneqarsinnaapput, aammalu bulldozerit aqqutaat ujaraaqqani qilleriviusup tunngavigisaani suli erseqqivissumik takuneqarsinnaapput.

Jameson Landimi misiligummik qillerineq nunami takussaasunik qimataqarumaarpoq, pingaartumik qamutit illernisa naasoqarfinni nunamilu ajoqusiisimanerinik. Aarlerigineqarsinnaavortaaq permafrostip ajoquserneqarsinnaanera (thermokarst). Ajoqusiinerit taamaattut annertussusiannut qillerinerup nunami qanoq ittumi pinera apeqqutaavoq, nunamimi isugutasumi pisimappat ajoqusiinerit annertunerussapput, kisiannili taamaattumi naasoqarnera nunami panertumi pisumit sukkanerusumik naaqqipallassinnaaneruvoq, tassa nunap akui (substrat aamma imilersorneqarnerat) pilerseqqinneqarpata.

Misiligummik qillerinerit qilleriffiusumi qamutit helikopterillu angallaffiini uumasunik akornusersuissapput. Sunniutigisarpaa uumasut nujualasut tamatuma eqqaani sanaartukkat eqqaanni najukkaminnit nujutsinneqartarmata. Pingaartumik nerlerit umimmaallu. Ilimanarpoq nerlerit umimmaallu misiligutaasumik qillerinerup nalaani nujuffissaqartut, taamaattumik misiligummi qillerineq ataasiinnaq uumasunut taakkununnga imatut sunniuteqassangatinnanngilaq.

Uumasunik akornusersuinerit pinngitsoorneqarsinnaanerupput qillerinerit ukiukku ingerlanneqarpata, kisiannili angallanneq ingerlatallu allat akornusersuutaasut peqqissaartumik killilersornerisigut.

Aniatitsinerit
Sajuppillatitsisarluni mississuinerit misiligummillu qillerinerit tamarmik maskinaniit aniatitsinermik ilaqartussaapput. Pingaartumik misiligummik qillerinerit annertoorujussuarmik illup naatitsiviup gassiinik, NOx aamma SO_2, annertoorujussuarmik aniatitsiviusarput, taakkualu marluk taaneqartut paamik, ”Arctic haze”, (”black carbon”) sialummillu/apinermillu seernartumik pilersitsisarput.

Misiligummik qillerineq nnaammassigaangat maralluk qillerinermi atorneqartoq qillernerlukullu annertoorujussuit peerneqartussaapput. Tamakkua siusinnerusukkut Canadami Alaskamilu avatangiinut qimaannarneqartaraluarput, amerlanertigut assatamut immiullugit. Nuussuarmi 1996-imi qillerinerup kingorna maralluk qillerinermi atorneqartoq masattoq siaruarterneqarpoq manngernerusortaalu tuapaasanut qilleriveqarfiusimasumut assaalugit matoorunneqarlutik. Mangernerusortai tamatuma kingorna nilissimapput massakkullu nunami itersanngortitersimallutik qularnanngitsumik aattornerup nalaani imermik immerneqartarlutik taamalu qillerinermi maralluk atorneqarsimasoq upernaakkut kuuguttarsimassagunarlugu.

IAlaskami maralluk qillerinermi atorneqartoq qillernerlukullu massakkut assaanneqassaarput sapinngisamillu atoqqinniarneqartarlutik sinnerilu eqqaavissuarnut akuerisaasunut inissinneqartarlutik. Jameson Landimi misilugutmmik qillerinermi periaaseq taanna atorneqartariaqaraluarpoq.

Uuliamik qalluineq
Uuliamik qalluilluni ingerlatat ujarnernermi ingerlatanit sivisunerujussuusarput, amerlanertigut ukiunik qulikkuutaannik arlalinnik sivisussuseqarsinnaasarlutik. Tamatumunnga atatillugu avatangiisinut sunniutissat pingaarnerit makkuupput:

- sanaartukkat ingerlatallu takussaasumik sunniutaat
- uumasunik akornusersuineq
- imermut, nunamut silaannarmullu aniatitsineq
- imermik atuineq.

Sunniutit takussaasut
Uuliamik qalluineq annertuumik avatangiisinut takussaasumik sunniuteqartarpoq. Sanaartugarpassuimmi kisiisa eqaagaanni tamakkua nuna annertoorujussuaq qallersimasarpaat. Uuliamik qalluinermut atortuinnaat

saniatigut illut, umiarsualiviit, timmisartoqarfiit, quujorersuit, eqqaavissuit, ujaraarartarfiit tankillu sananeqartarput.

Sanaartukkat tamakkua aamma permafrost sunnersinnaavaat thermokarst-eqalersillugu taammalu illut sanaartukkaallu marrikkiartulersillugit, taamaalippallu ajutoorsinnaaneq, soorlu quujorersuarnik napisoornissaq, aarlerinarnerulersarpoq.

Tamakkua saniatigut Alaskami annertuumik erngup ingerlaarnerani allanngornerit, erngup nunap qaavani annertoorsuarmik masarsunnguulluni taseranngortiternera aammalu erngup nunap iluaniittup inissisimanerata allanngornera kingunerai.

Taamatut sanaartugarpassuit "nalunaaqutsiussaasa" uumasut najugaannik naasoqarfinnillu pingaarutilinnik aseruinissaat aarlerinarpoq, tamannalu uumasunut ikittunnguakkuutaanut imaluunniit annertunngeqisumik najugassalinnut ajortumik kinguneqarsinnaavoq. Uumaffiit agguataarneqarnerat ("habitat fragmentation") takussaasumik avatangiisinut sunniutaavoq pingaarutilik, tamannalu pingaartumik uumasunut uumaffigisamik assigiinngitsut akornanni ingerlaartartunut, soorlu umimmannut eqalunnullu sunniuteqrumaarpoq.

Kiisalu uuliasiorfik takussaasumik pingaarutilimmillu sunniuteqarpoq, assersuutigalugu takornariaqarnermut. Jameson Landimi uuliasiorfik annertoorujussuarmik nunap pissusiinut sunniuteqarsinnaavoq, nuna manissukujuuginnaammat avungarsuarlu isikkiveqarluni.

Sunniutit takussaasut teknologiip pigineqartup pitsaanerpaap (BAT – "Best Available Technology") aammalu avatangiisinut tunngatillugu iliuutsip nutaanerpaap (BEP – "Best Environmental Practice") atorneqarneratigut pinngitsoorniarneqarsinnaapput. Alaskap issittortaani misilittakkat takutippaat uuliasiorfiit nutaat, pisoqqanut naleqqiullutik, nuna annikinneerarsuaq atortaraat.

Jameson Landimi uuliasiorfiup takussaasumik qanoq sunniuteqarnissaanut sumi inississimanissaa apeqqutaassaaq, assersuutigalugu sinerissamut umiarsualiorfiusussamut qanoq ungasitsiginera. Alaskami permafrostimut erngullu kuuttarneranut tunngatillugu ajornartorsiutitut annertutigisumik nunatat annikitsuinnaat ajoquserneqarsinnaassapput, tassami Jameson landimi panertorujussuummat isugutaqarnanilu. Sunniutit pingaaruteqarnerusut tassaajumaarput umimmaat nerlerillu uumaffiisigut annaasat aammalu ruujorersualersuinikkut umimmaat ingerlaartarfiinik assiinerit tamakkua pinaveersaarlugilluunniit annikillisarneqarsinnaanngippata.

Uumasunik akornusersuineq

Uuliasiorfiup tamaaniinnerinnarmigulluunnit uumasunik akornusersuivoq, aammalu inuit tamanna pissutigalugu ingerlatarpassui, assersuutigalugu timmsiartunik helikopterinillu angallanneq aqqusernillu eqqaanniittunik akornusersuineq.

Akornusersuinerit uumasut najortagaanniit nujutsissinnaavaat, akornusersuinerillu aamma nuna uumasut iluaqutigisinnaanngisaat annertusitissavaat, taamatullu assigiinngitsunik sanaartugaqarfiit akornusersuissallutik.

Pissutsit akoirnusersuutaasinnaasut pitsaanerpaamik pinaveer-
saarneqarsinnaapput angallanneq peqqissaartumik annikillisarlugulu killi-
lersuiffigigaanni, ilaatigut taamaaliorneq uumasut ingerlatanik sungiussi-
nissaannut periarfissiissammat.

Jameson Landimi uumasut uuliasiorfeqarnertigut akornusersuinermit
eqqoruminarnerpaat tassaajumaarput umimmaat nerlerillu, aarleqqutigi-
sariaqarporlu nerlerit umimmaallu tamaannga uumaffigisaminnit pingaaru-
tilimmit, piniartunit Ittoqqortoormiormiunit piniarneqartarfiannit peersivil-
lugit nujutsinneqarsinnaanerat.

Imermut, nunamut silaannarmullu aniatitat

Uuliasiorfimmiit aniatitaq annerpaaq tassaasarpoq imeq uuliamut qalluk-
kamut ilanngullugu qallorneqartartoq – taaneqartartoq produktionsvand.
Erngup taassuma toqunartut annikitsunnguit, mingutitsissutit immaqalu
aamma stoffinik radioaktiviusunik akoqarsinnaasarluni.

Nunani allani produktuionsvand immaqa annerusumik annikinnerusu-
milluunniit salissimasoq kuunnut kuutillugu aniatinneqartarpoq, kisiannili
imaaliartorpoq imeq tamanna uuliamik qillerivimmut uterarttinneqartaleri-
artorluni, taamaaliortarnerlu massakkut Alaskami atorneqarpoq. Kisiannili
erngup produktionsvandip tamakkerlugu qillerivimmut utertinneqarnissaa
ajornanngittuaannanngilaq. Taamaakkaangat peqqissaartumik imeq sinne-
ruttoq saleqqaarlugu aatsaat aniatinneqarsinnaalissaaq. Imaannarmi uuli-
asiornermut naleqqiullugu nunami uuliasiorfinni pitsaasunik saliiviliornis-
saq ajornannginneruvoq.

Uuliasiorfittaaq maskinaniit tartaarnerup gassiinik aammalu gassimik iku-
matitsinikkut, uuliamik allamut nuutsikkut periaatsit assigiinngitsut anner-
toorujussuarmik silaannarmut naatitsiviup gassiinik aniatitsipput. Naatitsiv-
iup gassii annertoorujussuit (CO_2 aama metan), VOC, NOx aamma SO_2 tas-
sani pineqarput. Kingulleq taanna ”arctic haze” –imik pilersitsisarpoq
aammalu nakkaanermik ssernatumik aammalu paamik nakkaatitsineqartar-
poq (”black carbon”).

Nutaanik qillerineq tunisassiorneqaleraangat uninneq ajorpoq. Nutaanimmi
qillerineqartuartarpoq, tamakkunanngalu maralluk qillerinermut
atorneqartoq qillernerlukullu eqqarneqartuartussaapput. Taamaligaangat
qillikkanut atorunnaartunut tamakkua uterartinnissaat periarfissaavoq.

Uuliasiornermi aniatitat teknologiip pitsaanerpaap (BAT) avatangiisinullu
tunngatillugu iliuutsit nutaanerpaat (BEP) atorneqarnerisigut killiler-
simaarneqarsinnaapput.

Silaannarmut aniatitsineq eqqarsaatigalugu ”Arctic haze” –imik nakkaasu-
millu seernartumik peqalernissaa arlerinarsisinnaavoq avatangiisinut inu-
ussutissaqarpallaanngereersumut uuliaqarfiup eqqaaniittumut annertuumik
eqquinerlussinnaasunik.

Erngup atorneqarnera

Uuliasiorfimmi imermik (imerneqarsinnaasumik) a<tuineq annertooru-
jussuuvoq, taamaattumik aarleqqutigineqarsinnaavoq tatsit qanittumiittut
paqqertitilernissaat. Jameson Landimi kuuit ilarpassui imertarfissatut
naleqqutinngillat aasakkut paqqertaramik ukiumilu ilungerlutik qerisara-
mik.

Uuliasiornermi ingerlassaq kingulleq tassaavoq uuliasiorfiusimasumik uuliaarussimasumik isaterilluni peersinissaq kingornatigullu saliinissaq. Taama pisoqaleraangat akornusersuinerit stoffinillu katersorneqarsimasuniit mingutitsinissaq aarlerinarsisarpoq. Pilersaarusiornerup sanaartulernerullu nalaanili atorunnaarpata avatangiisinut akornutaanngitsumik atortunik isaterillunilu qimatassamik saliinissap periaaseqarfiginissaa eqqarsaatigineqalereertariaqarpoq.

Uuliaarluerneq

Jameson Landimi uuliasiornikkut ingerlatani annertoorsuarmik uuliaarluertoqassappata tamanna puaasartoornikkut ("blow out") imaluunniit ruujorersuit uuliap aqqutaasa napineratigut piumaarpoq, Issittumilu allani misilittakkat malillugit ruujorersuarmik napisoorneq uuliaarluernermik annerpaamik pilersitsisarpoq. Nunami uuliaarluerneq immami uuliaarluernertut annertutigisumik siaruarneq ajorpoq. Uuliali kuuk iluatsillugu kuussagaluarpat annertunerujussuarmut siaruaannissaa aarleqqutigisariaqarpoq, immaqalu taamaalilluni immamut siaruaassinnaalissaaq.

Nunami uuliaarluernikkut pingaartumik naasoqarnera aserorneqartarpoq, uulialu nunap millukkumaarmagu uulia assallugu piiarneqanngikkuni ukiorpassuarni tamaaniissinnaavoq. Uuliap imeqarfiit angussagaluarpagit aalisakkat sunnerneqarlutillu toqunartoqalissapput timmissallu imarmiut uuliamit eqqorneqarsinnaassapput.

Nunap uumasuisa timmiaasalu uuliaarluerneq ingalassimaniassavaat, taammaattumillu uumaffigisaminnit nigorsimatinneqassallutip peersinneqassallutilluunniit. Kisiannili ilimananngilaq ataatsimut isigalugu uumasoqatigiinnik sunniissangatinnanngilaq, aniasoorneq assersuinikkut nunami annertunngitsuumiitinneqarsinnaappat.

Uuliaarluerneq pinngitsoorniarneqarsinnaavoq BAT BEP-lu periaatsit malinneqarpata, aammalu piumasaqaateqartariaqarpoq peqqinnissakkut, isumannaallisaankkut avatangiisinullu tunngatillugu piumasaqaatinik (HSE) peqartariaqarpoq. Pilersaarusisornerup, killilersuinerup sillimaniarnerullu uuliaarluersinnaaneq sillimaffigisariaqarpaat, assersuutigalugu uuliap imerqarfinnut qanittumiittunut anngutinnginnissaa sillimaffigissavaat, taamalu immamut anngussinnaanerata pinngitsoortinnissaa piareersimaffigalugu.

Jameson Landimi uuliaarluernikkut pingaartumik naasoqarnera sunnerneqartussaavoq. Jameson landilli ilarujussua qaarsuummat, kuuppassuillu immamut atammata uuliaarluernerup sinerissamut ajoquseruminarluinnartumut anngussinnaanera aarleqqutigisariaqarluinnarpoq.

Aatsitassarsiornikkut ingerlatat - ujarlerneq

Aatsitassarsiorneq aallartikkajuppoq geologit amerlanngitsukkuutaat tamani tamaani misissuisillugit, tamakkualu avatangiisinut sunniutigisinnaasaat taassaannaagajupput tammaarsimaarfimmik sunniisimanerit, qamutinik ATV-nik angallanneq aammalu suliffigisami uumasunik akornusersuineq. Ujarlerneq kingusinnerussukkut misissugassanik piiaalluni qillerininngortarpoq ilimanartuni aalajangersuni ingerlanneqartartoq. Qillerit taamaattut avatangiisinut sunniutaat uuliasiorluni paasiniaaluni qillerinernisut ipput (qulaaniittoq takuuk), allaassutaaginnarpoq qillerinermut atorutu oqinnerujussuunerat aammalu maralluk qillerinermi atorneqartoq annikinnerujussuummat. Maralluk qillerinermi atorneqartoq qillernerlukullu avatangiisinut aniatinneqarajupput, kisiannili tamakkua toqunartunik akoqanngillat.

Jameson Landimi aatsitassarsiorneq ikittuinnarnik sivikitsumillu takussaasumik sunniuteqartarpoq uumasunillu akornusiisarluni. Sunniutit pinngitsoortinniarneqarsinnaapput salliutillugu Aatsitassanut Ikummatissanullu Pisortaqarfiup ujarlerfimmi sulinermut maleruaqqusai aqqutigalugit.

Aatsitassarsiornikkut ingerlatat - iluaquteqarneq
Aatsitassarsiorfiup sunniutai sivisuumik atuuttarput ilaannilu aatsitassarsiorfiup atuuffia sinnerlugu atuuttarlutik. Sunniutaat makkua ilaapput:

- sunniutit takussaasut sanaartukkanit tamaaniittuneersut ingerlatitallu sunniutaat
- uumasunik akornusersuinerit
- avatangiisinut aniatitat, ilaatigut kemiskiusunik mingutitsineq pujoralallu
- nunap neriorneqarnera kinneqalernerlu.

Takussaasumik uumasunut sunniutit akornusersuinerillu
Tamakkua qulaani uuliamik qalluinermi eqqartuinermi eqqartorneqartututipput. Nunalli ilaa takussaasumik sunnerneqarsimasoq ”nalunaaqutserneqarsimasoq” annertoorujussuujumaarpoq aatsitassarsiorferujussuaq ammaannartoq aatsitassarsiornermi perlukunut eqiterivittaqartoq atorlugu tamanna ingerlanneqarpat.

Aniatitsinerit
Aatsitassarsiorfimmi ingerlasumit aniatitat uuliasiorfimmi aniatitatut ipput (qulaaniittoq takuuk). Tamakkua tassaapput silaannarmut aniatitat (mskiinat pujuliaannit) illunit inerqafiusunit tammaarsimaarfinnilu igitat. Pingaartumik iluanaarniutaasumik piiaaneqarlunilu suliarinnittoqarmat tamanna annertoorujussuarmik avatangiisinik sunniuteqarumaarpoq.

Aatsitassarsiornermi avatangiisinut tunngatillugu ajornartorsiut annerpaaq tassaavoq piiarnerlukorpassuaqalersarnera. Taamaattoq tassaasinnaavoq gråbjerg (tassa minerali angujumallugu qaarsoq piiarneqartoq) aammalu ”tailings”, tassaasoq mineralip tunisassiaasup salillugu tunisassiarinerani perlukut. Sinnikut tamakkua aatsitassarsiorfiup qanittuani katersorneqartarput, taamaattumillu, takujuminaatsunngortitsinermi saniatigut avatangiisinut toqunartunik mingutitsilersinnaallutik. Taakkua kingulliit pingaartumik tassaanerupput sulfid-mineralit, imermut iltimullu akuliukkaangamik syremik pinngortitsisartut (”acid drainage”) saffiugassanik oqimaatsunik tailingsiniittunik arrortitsinnaasumik.

Mineralit piiarneqartut amerlanertigut kemikalianik atuisariaqartitsisarput avatangiisinut toqunarluinnarsinnaasunik. Assersuutigineqarsinnaavoq guultimik piiaanermi cyanid atorneqartarmat.

Aatsitassarsiorfiup avatangiisaanut mingutitsissutaasoq alla tassaavoq pujoralak ingerlatanit arlaqartunit pilersinneqartartoq: piiaanermi, assartuinermi ujaqqanillu aserorterinermi. Tassunga atatillugu ajornartorsiutaanerpaavoq saffiugassanik qoimaatsoqarnera.

Jameson Landimi aatsitassasiornermi perlukutigut imeq aqqusaartoq imermi immamilu uumasunik sunniisinnaavoq, aatsitassaqarfiusinnaasummi sinerissamut ungasinngimmata. Tamatuma kingunerisinnaavaa mingutitsissutit uumasuni illoqqortoormiunit iluaqutigineqartuneereersut annertunerulernerat, soorlu tamanna Maarmorillip eqqaani kangerlunni takuneqarsimasoq.

Aatsitassarsiorfimmiit avatangiisinut toqunartut aniatinneqartut pilersaarusiornermili illuatungilerneqareertariaqarput pinngitsuugassaanngitsunik piumasaqaasersuinikkut ingerlatani tamani atorneqartussanik. Tassani periaatsit BEP aamma BAT, taamalu HSE-standardit sakkortuut ilanngunneqarnissaat pingaartuuvoq.

Assersuutigalugu ”tailings”-it gråbjergillu mingutitsisunngorsinnaanerata siumut misissorneqareernissaat pingaartuuvoq, taamaalilluni tamakkuninnga eqiteriffiit avatangiisinut illersorneqarsinnaasunngortillugit, misissuinerillu taamaattut avatangiisinik nalilersuinermi ingerlatassallu pisortanit akuerineqarnissaanni pingaartillugit ilaatitinneqartariaqarput .

Aatsitassarsiornermi ajutoorneq

Aatsitassarsiorfimmit tassanngaannaq avatangiisinut ajoqusiinerit pisarput aatsitassarsiornermi perlukut kuunnut immamulluunniit kuugunneqaraangata. ASjutoornerit taamaattut Jameson Landimi pinngitsoorniarneqarsinnaapput aatsitassarsiornermit perlukut itersartanut tamaaneereersunut, soorlu tasinut itisuunut imaluunniit kangerlunnut naqqani imartaat taarserartuunngitsunut aammalu kinneqareersumut aatsitassarsiorneq unippat toqqortukkanik matoorutaasinnaassulimmut.

Ataatsimut sunniutit

Ilimagisariaqarpoq Jameson Landimi pingaartumik umimmannut nerlernullu ataatsimut sunniuteqarumaartoq aatsitassarsiorluni uuliasiorluniluunniit ingerlatsisoqartillugu – nalaanni imaluunniit ingerlaqqittumik – assersuutigalugu annertuumik aatsitassanik piiaaviliortoqarlunilu peqatigitillugu annertuumik uuliasiorfik ineriartortinneqarpat.

Ilisimasanik amigaateqarneq

Soorlu qulaani taaneqareersoq Jameson Landimut tunngatillugu biologitut tunngaviusumik ilisimasat ataatsimut isigalugu pitsaasuummata nutartigaallutillu. Kisianni umimmannut tunngatillugu ilisimasat amigaatigineqarput tassami 1990-ip missaaniilli umimmannik misissuisoqaqqissimanngimmat. Taamaattumik kisitsinissaq sumiiffigisartagaannillu nalunaarsuinissaq pisariaqarpoq aammalu uumasutut misissuiffigineqarlutillu akornusersuutinut qanoq qisuariartarnerat paasiniarneqartariaqarluni.

Ingerlatassat akornusersuinikkut sunniutissaat minnerpaatinniarlugit pilersaarusiorsinnaajumalluni uumasut akornusersuutinit akornusersorneqarsinnaasut qanoq akornusersuutinit sunnerneqartarnerat misissorneqartariaqarpoq. Aammami naleqqutissaaq nerlerit umimmaallu akornusersuutinut sungiussisinnaanersut misissuisoqarpat, taamaalilluni sungiussisinnaanerat annerpaatinniarneqarsinnaassammat. Taamaalilluni nunatap akornusersuutit pissutigalugit nerlernit umimmannillu atorneqarsinnaangitsup minnerpaatinneqarnissaa qularnaarneqarsinnaavoq.

Pisariaqartinneqarportaaq aatsitassarsiornermut uuliasiorlunilu ingerlatanut tunngatillugu sukumiinerusumik ilisimasaqarnissaq, pingaartumik gråbjergit, tailings-it maralluup qillerinermni atorneqartup erngullu tunisassiornermi atorneqartup toqqortorneqarnerisa avatangiisinut qanilaarnerusumik passunneqarnissaannik periaasissanik ineriatortitsineq. Ilisimasat tamakkua ilaat aamma kangerlummut Jameson Landip avataaniittumi pissutsinut takussaasunut uumasoqarneranullu attuumassuteqarput, tamaattumillu erngup taarseraannerata, kinninngortarnerup uumasoqarfiillu pingaarnerit nalunaarsorneqarnissaat aamma pisariaqarpoq.

1 Introduction

This report is a preliminary strategic environmental impact assessment (SEIA) of mineral and petroleum activities in Jameson Land in Northeast Greenland. The area has both hydrocarbon and a mineral potential, and exploration activities for these resources are expected to increase in the coming years. The mining company Malmbjerget Molybdenum A/S has an exploration license (No. 2009/21, expiring 2013) and Quadra Mining has an exploitation license (No. 2008/40, expiring 2038). The molybdenum body is located just outside the area of this report. However, proposed infrastructure, including harbour, airstrip and roads, would be located within the Jameson Land area. There are moreover some mineral exploration licences in the northeastern part of the assessment area, e.g. Nordic Mining Ltd. at Carlsberg Fjord (No. 2007/03).

This assessment is mainly based on available information. But a new analysis of remotely sensed data on vegetation is presented.

One of the main objectives of this work has been to identify information missing for the preparation of future environmental impact assessments of specific activities.

It is stressed that an SEIA does not replace the need for site- and activity-specific Environmental Impact Assessments (EIAs). The SEIA provides an overview of the environment in the licence area as well as in adjacent areas, which can be impacted by the activities. It identifies major potential environmental effects associated with hydrocarbon and mineral exploration and exploitation activities. The SEIA will also identify knowledge and information needs, highlight issues of concern, and make recommendations for mitigation and planning.

A SEIA is included in the background information for the political decisions, when an area is opened for e.g. a license round, and it may identify general regulatory or mitigative measures and monitoring requirements that must be dealt with by the companies applying for concessions.

This is solely an assessment of impacts on the biological environment. Aspects on socioeconomics, archaeology and cultural history are not dealt with in this report.

Acknowledgements

Quadra Mining kindly gave permission to publish an overview of data collected for their impact assessment work.

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1.1 Abbreviations used

AMAP = Arctic Monitoring and Assessment Programme
ARD = Acid rock drainage
a.s.l. = above sea limit

ATV = All-terrain vehicle
BAT = Best Available Technology
BEP = Best Environmental Practice
BMP = Bureau of Minerals and Petroleum
DCE = Danish Centre for Environment and Energy, AarhusUniversity
EIA = Environmental Impact Assessment
HSE = Health, Safety and Environment
LRTAB = Convention on Long-Range Transboundary Air Pollution (UNECE)
NERI = National Environmental Research Institute, now DCE
SEIA = Strategic Environmental Impact Assessment
UNECE = United Nations Economic Commission for Europe
VOC = Volatile Organic Component.

1.2 The assessment area

This report covers Jameson Land and Scoresby Land south of the boarder to the National Park in North and East Greenland. The area is bordered by Hall Bredning and Kangetittiuaq (Scoresby Sund) to the east and south, Kangerterajiva (Hurry Inlet) to the west, and Fleming Fjord, Nathorst Fjord, Kangerterajitta Itterterrilaa (Carlsberg Fjord) and the Greenland Sea to the northeast (Figure 1). Note that Liverpool Land is not included. The marine environment is not covered by this assessment, and impacts in this habitat are described in the Strategic Environment Impact Assessment of hydrocarbon activities in the Greenland Sea (Boertmann & Mosbech 2012). This means that impacts for example from transport at sea and on narwhal hunting are not included in this SEA.

An air field is placed at Nerlerit Inaat (Constable Pynt). There are no actual settlements in the assessment area, but Ittoqqortoormiit (Scoresbysund (population: 472, Michelsen 2011) is situated just outside the area. The only settlement in Jameson Land, Ittoritseq (Kap Steward), was abandoned in 1931 (Sandell & Sandell 1991), while the two settlements in adjacent Liverpool Land, Uunarteq (Kap Tobin) and Itterajivit (Kap Hope) were abandoned in 2004 and 2005, respectively. At Suuninnguaa (Sydkap) a family settled and build a house in 1946, but left it again the following year and the site is now used as a summer hunting and fishing site (Higgins 2010). Administratively, Jameson Land is part of Sermersooq Municipality. The administrative centre of Sermersooq Municipality is Nuuk, the Greenlandic capital.

Figure 1. Map of Jameson Land with important place names mentioned in the report. The red lines delimit the assessment area.

1.3 Mineral and oil exploration in the area

1.3.1 Minerals

Mineral exploitation has taken place north of the assessment area, at Mestersvig where lead and zinc were extracted from the mine in Blyklippen in the period 1952 to 1963 (Secher 2008). At another site – Malmbjerget– also north of the assessment area, exploitation for molybdenum has taken place during several periods since the 1950s, but so far without initiation of production.

Quadra Mining obtained an exploration licence for an area at Malmbjerget in 2004, and in 2008 the company was given concession to exploit molybdenum from Malmbjerget. The plans include establishing a harbour and an air strip in northwestern Jameson Land, as well as 80 km of road along the eastern slopes of Schuchert Dal (in which the river Schuchert Elv flows).

Two other mining companies, Nordic Mining Ltd. and Tambora Mining Group Ltd., hold exploration licences in north-eastern Jameson Land. Further two companies, Avannaa Exploration Ltd. and Ironbark Zinc Ltd., have in 2011 and 2012 obtained exclusive exploration licences to areas also in northeastern Jameson Land.

1.3.2 Hydrocarbons

In December 1984 an oil exploration and exploitation licence covering Jameson Land was granted to a group of companies with ARCO (Atlantic Richfield Company) as operator. This was preceded by environmental background studies initiated in 1982 by the Greenland Environmental Research Institute (now part of Bioscience, Aarhus University). Extensive seismic surveys were carried out mainly in winter, but the licence was relinquished in 1990 before any drilling had taken place (Pulvertaft 1997). Since then some companies have shown some interests in the area, but no licences have yet been granted. The area is a favourite excursion site for hydrocarbon geologists, and several parties visit Jameson Land each summer.

1.3.3 Existing background knowledge

With respect to environmental studies Jameson Land is probably the best covered area in Northeast Greenland, with detailed studies ranging back more than 50 years.

The populations of barnacle (*Branta leucopsis*) and pink-footed goose (*Anser brachyrhynchus*) breeding and moulting in Jameson Land have been the focus of several studies since the early 1960s (e.g. Marris & Ogilvie 1962, Hall & Waddingham 1966, Marris & Webbe 1969, Meltofte 1976, Cabot et al. 1984) and especially the geese in the valley of Ørsted Dal have been studied several times.

Hall & Waddingham (1966) surveyed the breeding birds in Ørsted Dal in 1963. This was repeated in 1974 (Ferns & Mudge 1976) and in 2009 Meltofte & Dinesen (2010) mapped breeding birds in two study areas in the valley (see below).

In connection with ARCOs permission (see Section 2) to do seismic surveys in Jameson Land, a series of background studies were carried out through the 1980s (Anon. 1990). These included goose studies (ecology, behavior, abundance and distribution) (Madsen & Boertmann 1982, Madsen 1984, Madsen et al. 1984, 1985, Boertmann 1991, Mosbech & Glahder 1990); muskoxen studies (e.g. Olesen 1986, Thing et al. 1987, Aastrup 1990, Boertmann et al. 1992, Aastrup & Mosbech 1993, 2000) and vegetation studies (e.g. Bay 1990, 1997, Bay & Holt 1984, 1985, 1986).

The bird life in eastern part of Jameson Land was studied by several expeditions in 1973-1975 (Meltofte 1976, de Korte et al. 1981) and 1988 (de Korte 1988).

The most recent studies was carried out in 2008 and 2009, focusing on Heden and Ørsted Dal (Glahder et al. 2008, Boertmann et al. 2009, Glahder & Walsh 2010, Glahder et al. 2010a, 2010b, Meltofte & Dinesen 2010, Madsen et al. 2011). These studies included geese, breeding shorebirds and other important bird species.

2 The physical environment

2.1 Topography

The distance from the northern most part at the border of the national park, to the southernmost point of Jameson Land is 168 km. The distance from the westernmost part to the eastern border to Liverpool Land is 96 km.

Jameson Land to the south of 71° N, is highest to the east from where the land gradually descends towards the coasts of Kangertittivaq (Scoresby Sund) and Hall Bredning. This non-alpine area is traversed by several rivers in more or less well defined canyons. In the northern part of the lowland bordering the sea there is tundra with numerous ponds and marshes and along the coast salt marshes. The upland areas are dry with low dwarf scrub heath and extensive fell fields. Heden is the major part of the lowland, characterised by a high variation in habitat, including large areas with continous vegetation.

The upland area is a plateau with peaks reaching up to 1285 m (Rødstak).

The Scoresby Land part of the assessment area has extensive alpine areas traversed by wide glacial valleys with extensive wetlands in the riverbeds.

The coastline along the southern and western part of Jameson Land is low and dominated by sediment beaches and salt marshes especially in the central part of the west coast. The coasts towards northeast are mainly rocky, although salt marshes, deltas, lagoons, tidal flats and barrier beaches are found in the wide valleys.

2.2 Climate

The climate of Jameson Land is arctic and continental usually with long periods of stable weather, many hours of sunshine and little precipitation in summer. In average years, temperatures in mid-June to August are between 0 °C and 10 °C.

Usually, the plateau to the north and northeast has more snow and later snow melt than the lower south (Heden and the southwestern tundra), with annual precipitation ranging from 290 to 410 mm. In the north and northeast of the highest part of the plateau, there is a tendency of precipitation being lower than 300 mm pr. year (Ohmura & Reeh 1991). The sea and fjords are ice covered in winter, and some fjords, such as Carlsberg Fjord) often even in summer.

As Jameson Land is situated far north of the Arctic circle, midnight sun and winter darkness are significant features of the annual cycle.

3 The biological environment

3.1 Birds

This chapter is devoted to the birds occurring in Jameson Land, with focus on the summer situation. In winter only few species occur, with the ptarmigan (Lagopus mutus) as the most important.

The most important birds in Jameson Land are the geese. Two species, the barnacle goose (*Branta leucopsis*) and the pink-footed goose (*Anser brachyrhynchus*), are numerous and occur both as breeding birds and in large concentrations of moulting, non-breeding birds. Both species arrive from winter quarters around mid-May (Meltofte 2006, Meltofte & Dinesen 2010) and egg laying begins in early June for both species (Madsen et al. 1985).

The East Greenland populations of both species have been increasing since the 1950s, and none of them are threatened; they are listed internationally and nationally as Least Concern (LC) (IUCN 2011, Boertmann 2008). Both geese are considered as species of national responsibility due to the high proportion of the total flyway populations occurring in Greenland (Boertmann 2008).

3.1.1 Pink-footed goose

The pink-footed geese occurring in Northeast Greenland belong to a flyway population breeding in Iceland and Northeast Greenland and wintering on the British Isles. A large proportion of this population is immature, non-breeding birds, and these spend the summer moulting the plumage (becoming flightless for three weeks) in remote areas. The majority of the non-breeding birds of the entire population move to Northeast Greenland to moult (Christensen 1967).

In the 1980s it was estimated that at least 30,000 pink-footed geese moulted in Northeast Greenland and that 3.2 % of these stayed in Jameson Land (Boertmann 1991). Today the actual numbers of geese are three times higher (Glahder et al. 2011, Boertmann & Nielsen 2010) and the fraction occurring in Jameson Land in 2008 was 6.6 % and in 2009 4.1 %.

The moult migration culminates during late June (Madsen et al. 1985, Meltofte 2006). During the moult (approximately 5th June – 1st August) the geese are highly sensitive to disturbance (Madsen et al. 1985).

The moulting geese were surveyed (from aircraft) in 1982-1989 (Mosbech & Glahder 1990) and again in 2008 and 2009 (Boertmann et al. 2009, Boertmann & Nielsen 2010). The results of these surveys are listed in Table 1, along with the estimated numbers of this flyway population. Figure 2 shows the distribution of the geese during the survey in 2009.

Table 1. Results of surveys for moulting geese in 1993-1998 and 2008 (Mosbech & Glahder 1990, Boertmann et al. 2009) in Jameson Land, compared to the changes on the global flyway population. An unknown number of breeding birds and chicks are likely to be included in these numbers.

Goose species	Global flyway population		Jameson Land population	
	1990	2007/2008	1983-1989	2008
Pink-footed	190.000	290.000	6.243	19.068
Barnacle	35.000	70.500	6.071	16.603

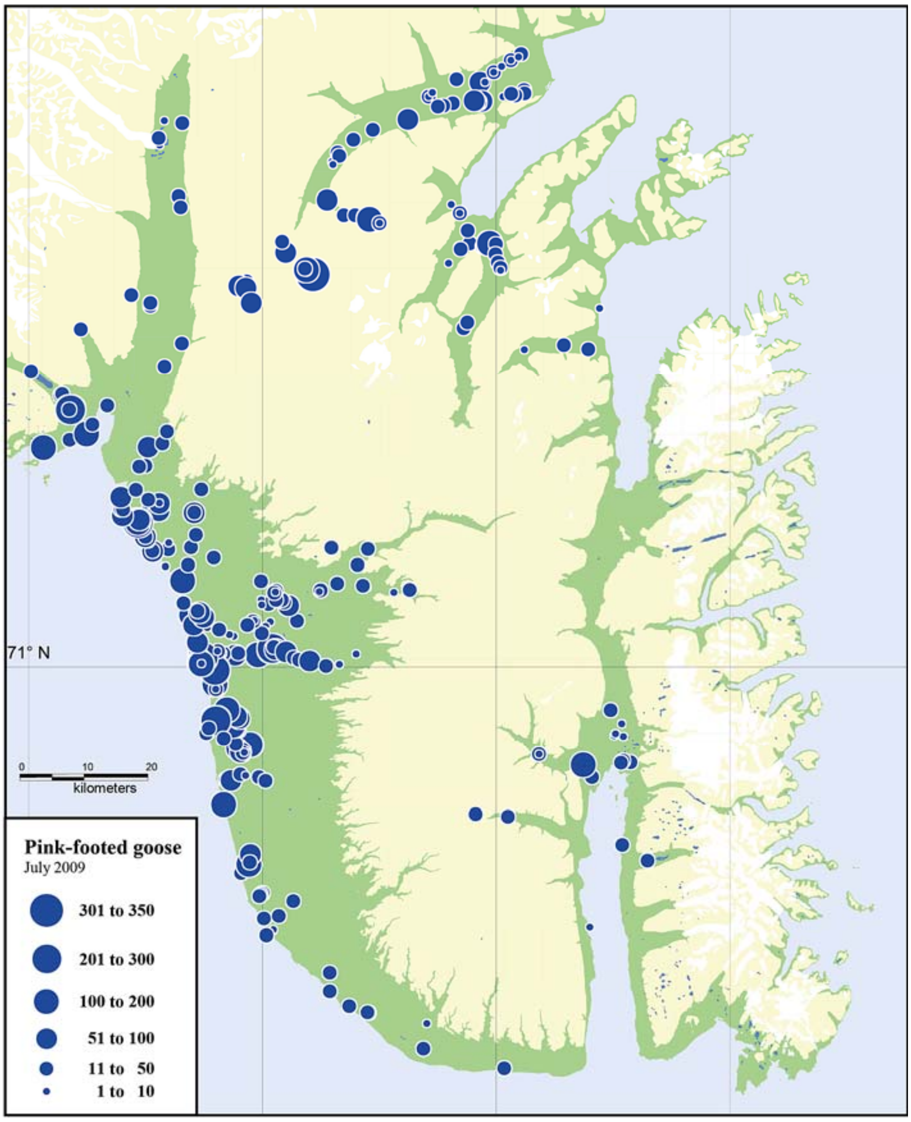


Figure 2. Distribution of pink-footed geese in Jameson Land recorded during an aerial survey 17 and 18 July 2009. In total 384 flocks and 19,068 birds were recorded (corrected for birds recorded multiple times).

3.1.2 Barnacle goose

The barnacle geese of Northeast Greenland also spend the winter on the British Isles, mainly in Ireland. In July 1988, Jameson Land was the by far most important moulting area for this species in Northeast Greenland. Then, about 6,000 were counted from aircraft, constituting 16.7 % of the total flyway population. The aerial surveys in 2008 and 2009 resulted in three times higher numbers (Table 2), and the fraction of birds in Jameson Land had increased to 17.5 and 23.6 % respectively (Boertmann et al. 2009, Boertmann & Nielsen 2010). Figure 3 shows the distribution of surveyed geese in 2009.

Table 2. Numbers of geese observed during aerial surveys in 1988, 2008 and 2009.

	1998		2008		2009	
Goose species	**Individuals**	**Flocks**	**Individuals**	**Flocks**	**Individuals**	**Flocks**
Pink-footed	5.560	100	19.068	384	11.860	304
Barnacle	6.035	98	16.603	431	12.349	349

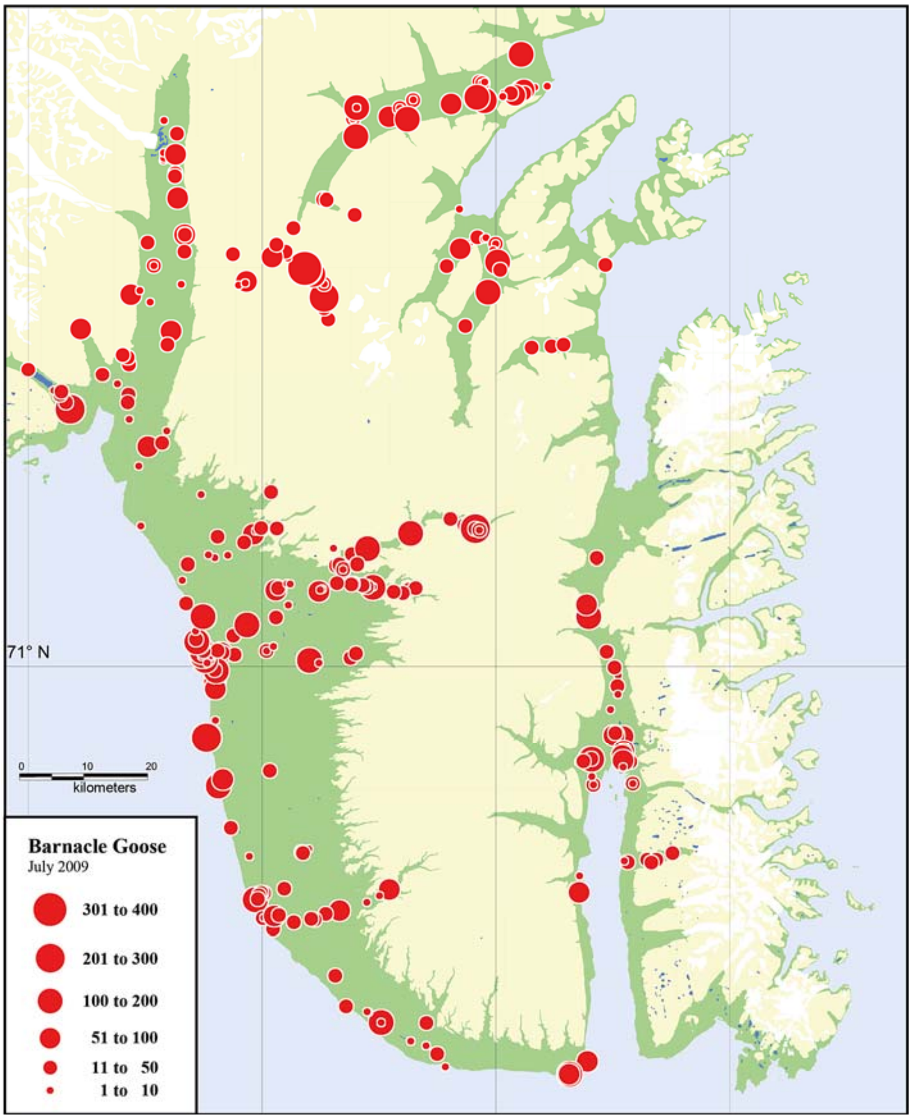


Figure 3. Distribution of barnacle geese in Jameson Land recorded during an aerial survey 17 and 18 July 2009. In total 431 flocks and 16,630 birds were recorded (corrected for birds recorded multiple times).

Barnacle geese breed in colonies on steep cliffs. Figure 4 shows the known colonies, however the data behind this map dates back to the 1980s and 1990s, and due to the population increase, several new colonies have most likely been established.

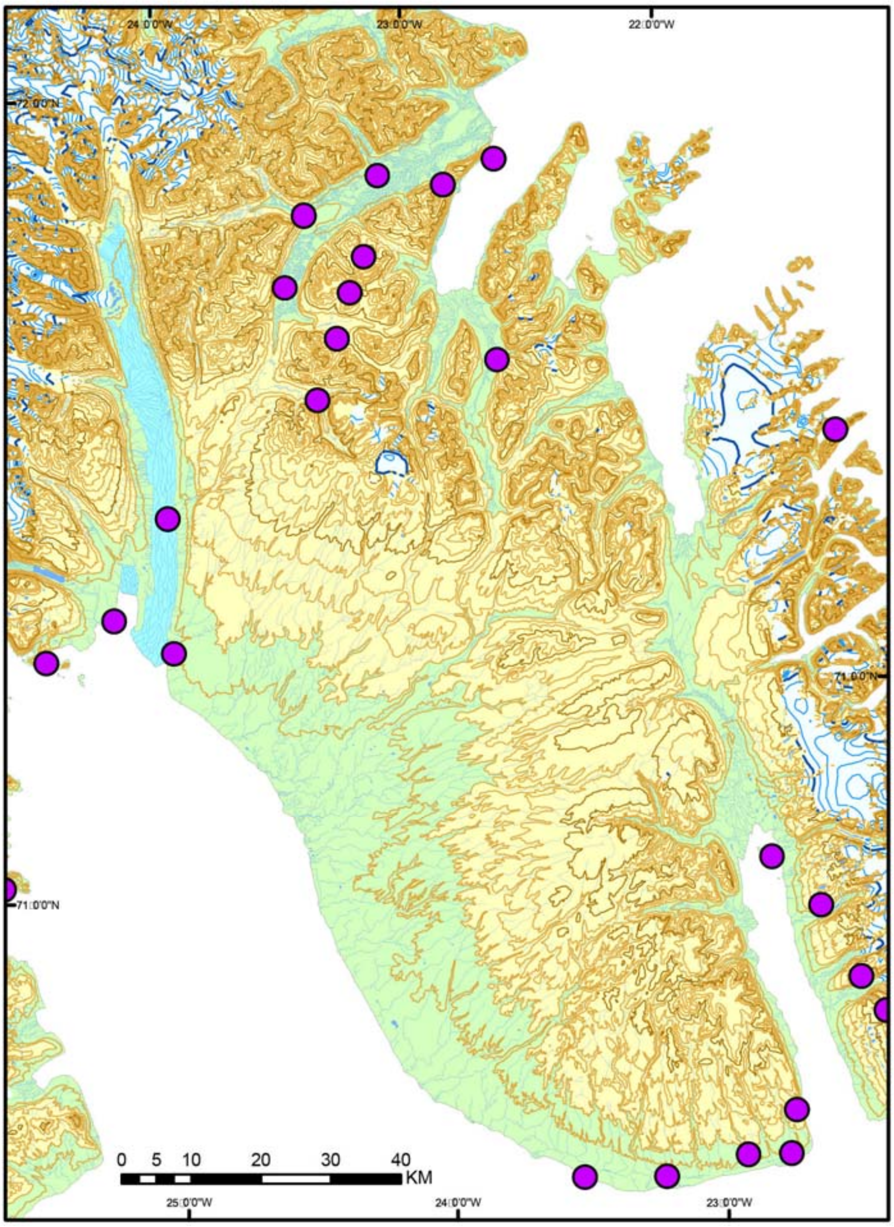


Figure 4. Known breeding colonies of barnacle geese. As the data are more than 10 years old, and the population has increased much since then, there may be many more colonies today.

3.1.3 Ducks and other waterbirds

Among the ducks, only few species breed inland. Long-tailed duck (*Clangula hyemalis*) breeds in fair numbers at ponds and lakes inland, as well as at some coastal habitats (Meltofte & Dinesen 2010). Moulting birds stay at shallow coasts especially along the south and west coast of Jameson Land (Boertmann & Nielsen 2010). The king eider (*Somateria spectabilis*) also breed in low numbers in the area at ponds and lakes (Meltofte & Dinesen 2010).

The red-throated diver (*Gavia stellata*) breeds at ponds and lakes widespread along the coasts. It is usually feeding in the marine environment making daily flights between the lake and the coastal waters. The other diver in the area is the great northern diver (common loon) (*Gavia immer*). It is very rare in Northeast Greenland, and in the region covered by this report, it has been reported from the lakes of Holger Danskes Briller and in Klitdal. The great northern diver is listed as Near Threatened (NT) on the Greenland redlist.

3.1.4 Waders

This group consists of sandpipers, plovers, curlews, turnstones and phalaropes, in total ten species. Seven species of these are common and regular breeders (Meltofte & Dinesen 2010, Mortensen 2000). Common ringed plover (*Charadrius hiaticula*), sanderling (*Calidris alba*), dunlin (*Calidris alpina*) and ruddy turnstone (*Arenaria interpres*) are widespread. While the knot (*Calidris canutus*) seems to be restricted to areas at higher altitude (Meltofte & Dinesen 2010, Mortensen 2000). The two phalarope species; red-necked (*Phalaropus lobatus*) and red (*Ph. fulicarius*) are found at lush marshes and ponds, the latter often near the coast.

Two other species occur in Greenland and only in Jameson Land: Whimbrel (*Numenius phaeopus*) and Eurasian golden plover (*Pluvualis apricaria*). They have a very restricted distribution; the whimbrel in the lowlands in the northwestern part of Heden and the golden plover in Schuchert Dal and a few other sites (Boertmann 1994, Bennike 2007, Boertmann et al.1985, Mortensen 2000).

Generally, the densities of breeding shorebirds in Jameson Land seem to be somewhat lower than the densities in central Northeast Greenland, and one factor could be that the vegetation in many areas is too dense and tall for breeding shorebirds (Mortensen 2000).

Two of the shorebirds are species of national responsibility as Greenland holds a significant (> 20 %) part of the entire flyway populations: Dunlin (endemic subspecies in Northeast Greenland) and knot. The two species with restricted distribution in Greenland; the whimbrel and the Eurasian golden plover are red-listed (and only nationally) as Near Threatned (NT) (Boertmann 2008).

At low tide, the mudflats at river mouths along the whole shore of Jameson Land are staging and foraging sites for migrating waders in August-September. Among them, the delta at Nerlerit Inaat (Olivier Gilg, pers. com.) and especially the lagoon at Kap Steward (Hans Meltofte, pers. com.) seem to be important with relatively high numbers recorded.

3.1.5 Other birds

Long-tailed skuas (*Stercorarius longicaudus*) breed commonly in suitable habitats, such as dry tundra near ponds and streams (Meltofte & Dinesen 2010).

The gyr falcon (*Falco rusticolus*) is the only bird of prey in Jameson Land, breeding with a few pairs in the area. The species is nationally red-listed as Near Threatened (NT) due to the small population in Greenland.

Snowy owl (*Bubo scandiaca*) breeds at least in Ørsted Dal in years with many lemmings, but when lemming populations are low there are no owls present in the area.

Rock ptarmigan (*Lagopus mutus*) breeds in the area, although possibly in moderate numbers (e.g. Meltofte & Dinesen 2010). This species is known to fluctuate in numbers (Hansen et al. 2008). And most, if not all leave the area for the winter (Boertmann 1994).

Among the passerine birds five species breed. However, only the snow bunting (*Plectrophenax nivalis*) is common and widespread (e.g. Meltofte & Dinesen 2010). Common raven (*Corvu scorax*) is also widespread, while redpoll (*Carduelis flammea*), Arctic redpoll (*Carduelis hornemanni*) (Meltofte & Dinesen 2010) are found only in scattered suitable habitats. Lapland bunting (*Calcaris lapponicus*) is found at few sites with relatively lush *Salix*-scrubs and common wheatear is breeding in fluctuating (low) numbers from year to year.

The only passerine of conservation concern is the Arctic redpoll as it is a species of national responsibility (Boertmann 2008).

3.1.6 Seabirds

There are Arctic tern (*Sterna paradisaea*) breeding colonies along the south coast and west coast of Jameson Land. There are also colonies on the islands to the south of Suuninnguaa/Sydkap and on Fame Øer in Kangerterajiva/Hurry Inlet (Figure 5). Apart from a few other smaller colonies, feeding birds are seen along the entire coast line, as well as several places inland, along rivers and at lakes (Glahder et al. 2010b). In some of tern colonies Sabine's gull (*Larus sabini*) also breed, for example near Gurreholm and at the mouth of Draba Sibirica Elv (Figure 5, Boertmann et al. 1985, Glahder & Walsh 2010).

Glaucous gulls (*Larus hyperboreus*) breed in scattered pairs along the coasts or on small colonies on steep cliffs near the sea (Figure 5).

Common eiders (*Somateria mollissima*) (Figure 6) and red-breasted mergansers (*Mergus serrator*) breed on some of the islands close to or just inside the assessment area.

Figure 5. Distribution of breeding colonies for Arctic tern, sabine's gull and glaucous gull in Jameson Land.

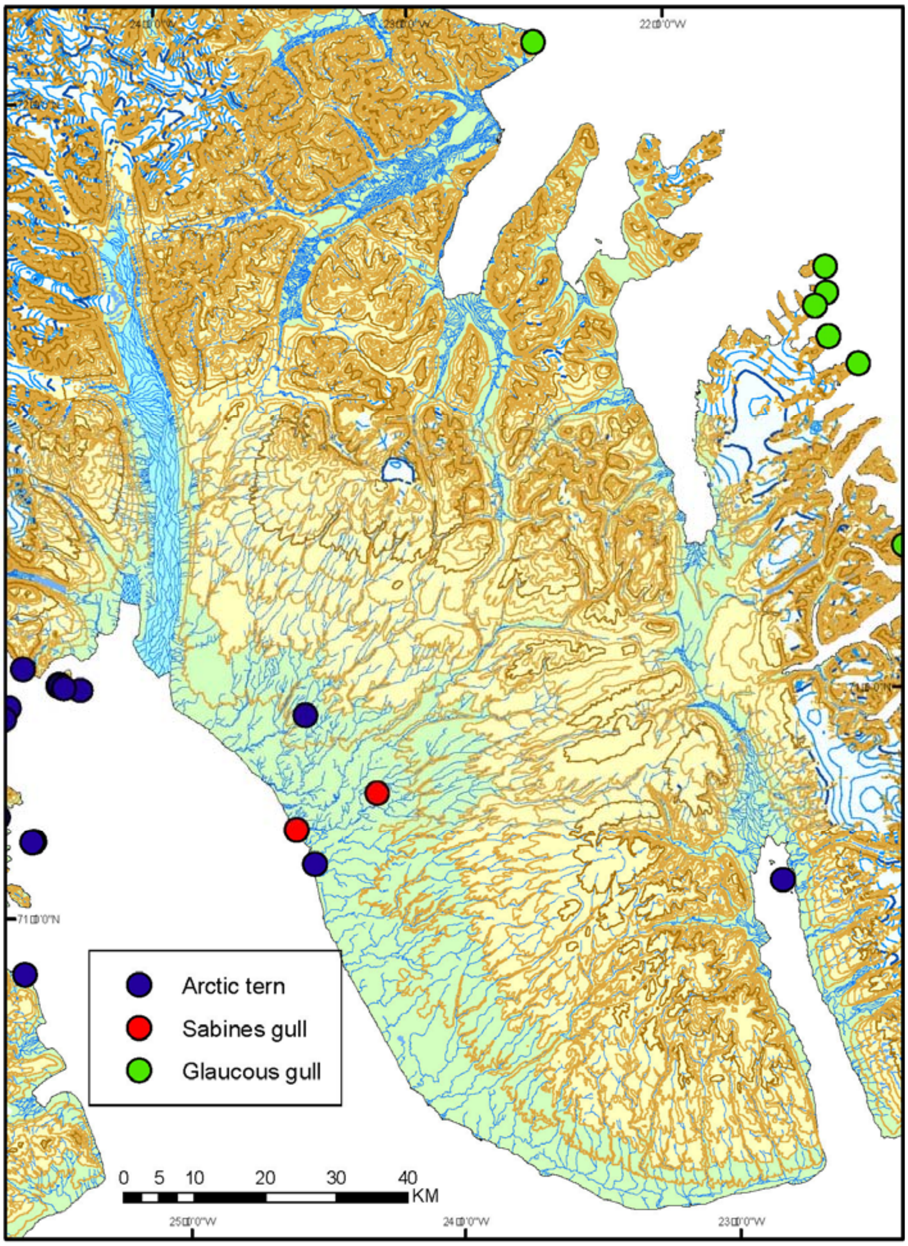
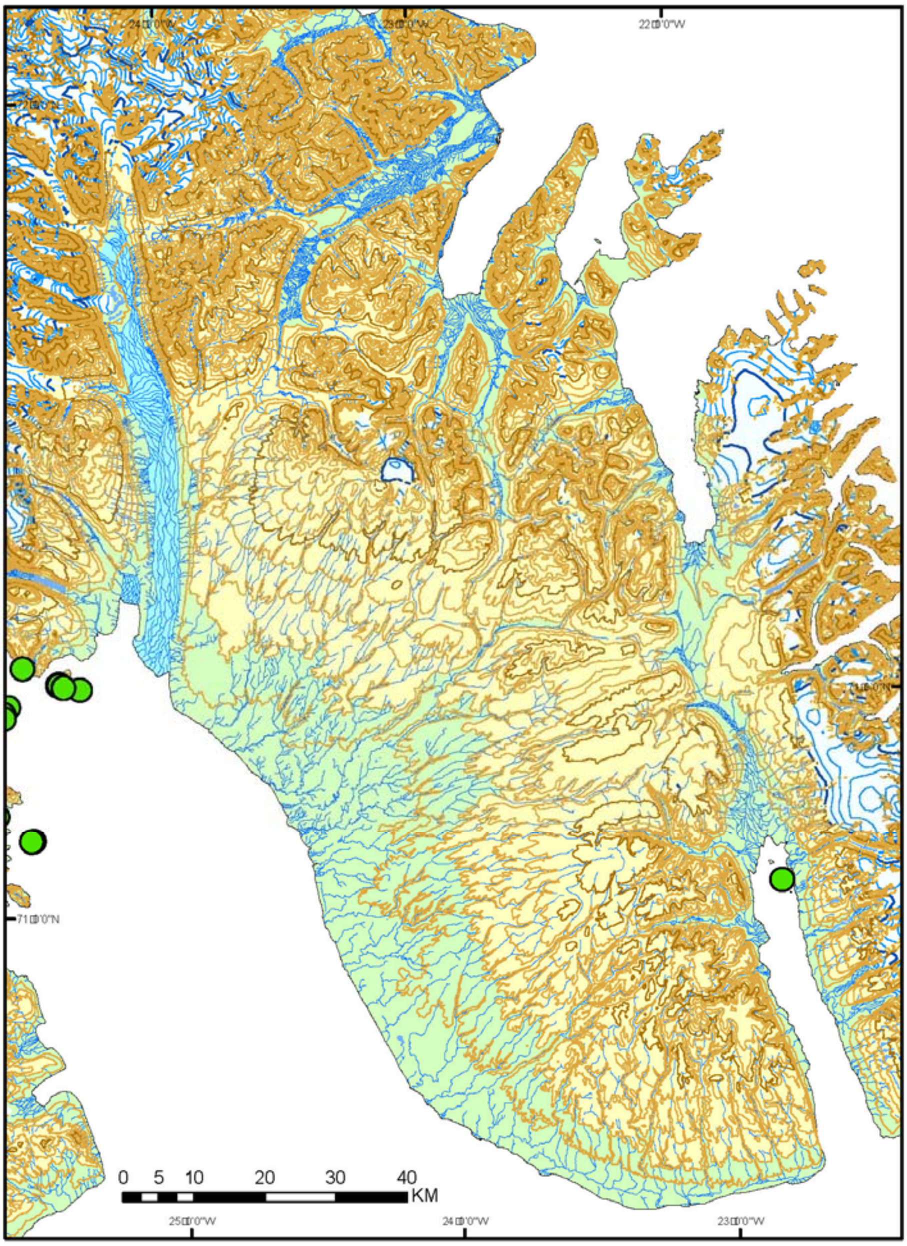


Figure 6. Distribution of common eider breeding colonies in Jameson Land.



3.1.7 Important bird areas in Jameson Land

The most important goose moulting areas are the lowlands of Heden particularly the northern part, the Ørsted Dal and the two valleys of Pingel Dal and Enhjørningen Dal.

Important areas for breeding birds are the lush lowlands around Gurreholm, the lowland tundra to the south of outlet of Draba Sibirica Elv and the Ørsted Dal, corresponding to the census areas shown in Figure 7.

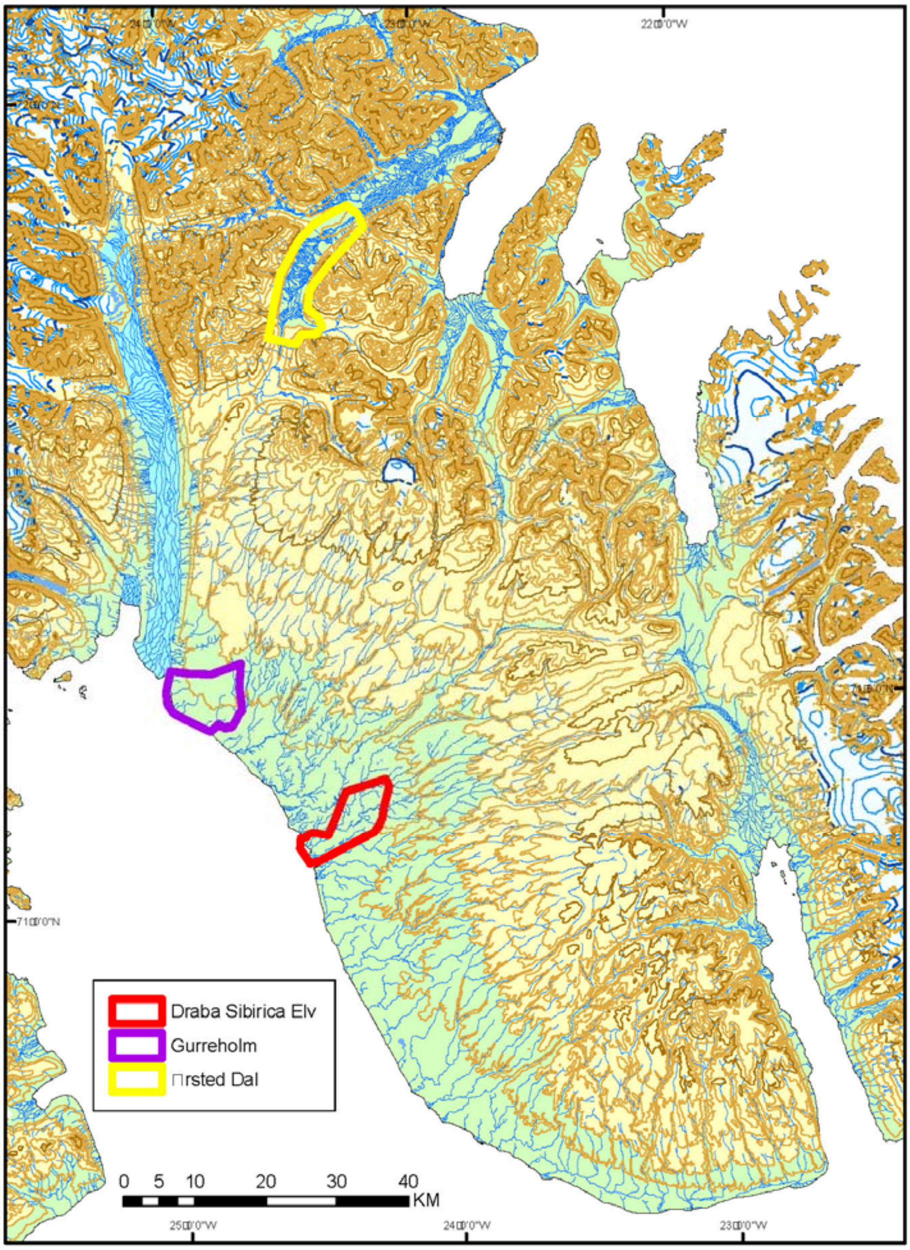


Figure 7. Areas where breeding birds have been surveyed in recent years.

3.2 Mammals

As in most of the Arctic, there are few species of terrestrial mammals in Jameson Land. Caribou (*Rangifer tarandus*) died out in East Greenland a century ago, so the herbivores today comprise muskoxen (*Ovibos moschatus*), Arctic hares (*Lepus arcticus*) and collared lemmings (*Dicrostonyx groenlandicus*). Among carnivores, Arctic wolves (*Canis lupus arctos*) are rare, stoats (*Mustela erminea*) more common and Arctic foxes (*Vulpes lagopus*) are widespread. Polar bear (*Ursus maritimus*) also occurs, but it is mainly a marine species and will not be dealt with here, but see the Strategic Environmental Impact Assessment of hydrocarbon activities in the Greenland Sea (Boertmann & Mosbech 2012).

3.3 Muskoxen

Jameson Land holds the largest population of muskoxen in Northeast Greenland (Boertmann et al. 1992). Intensive studies were carried out on this population in the 1980s as a part of the back ground studies (e.g.Olesen 1986, Thing et al. 1987, Aastrup & Mosbech 2000).

In the 1980s, the population was estimated at 3,000 to 4,500 individuals (Aastrup & Mosbech 2000, Boertmann et al. 1992). In 2000, the Greenland Institute of Natural Resources attempted to survey the population again (Ingerslev 2000), but the survey results were never published. The available data indicate a decline in the numbers since the 1980s (Table 3).

The Greenland Red List (Boertmann 2008) categorizes muskoxen as 'least concern' (LC), globally it is also considered as 'least concern' (LC) (IUCN 2011).

Table 3. Numbers of muskoxen recorded during aerial surveys in Jameson Land. The subareas refer to Figure 8. Data from 1982 to 1990 are from Aastrup & Mosbech (2000); data from 2000 are from Ingerslev (2000). Note that the survey results from Karstryggen, Coloradodal, Ørsted Dal and Fleming Fjord are pooled in 2000.

Year	Heden 1 – east of Schuchert Dal	Heden 2 – central Jameson Land	Heden 3 – southern Jameson Land	*Karstryggen – west of Schuchert Dal*	Colorado Dal	Ørsted Dal	Fleming Fjord	Total
1982	2.121	278	253	*306*	938	193	148	4.237
1983	2.286	65	0	*253*	661	246	0	3.511
1984	.	.	.	.	.	.	.	.
1985	2.841	158	115	*401*	863	301	0	4.679
1986	2.087	373	323	*277*	472	120	0	3.652
1987	1.764	249	190	*145*	461	62	0	2.871
1988	1.296	431	246	*601*	630	64	15	3.283
1989	2.011	288	15	*503*	871	240	0	3.928
1990	1.699	179	156	*542*	77	349	0	3.002
2000	735	60	111		*799*			1.705

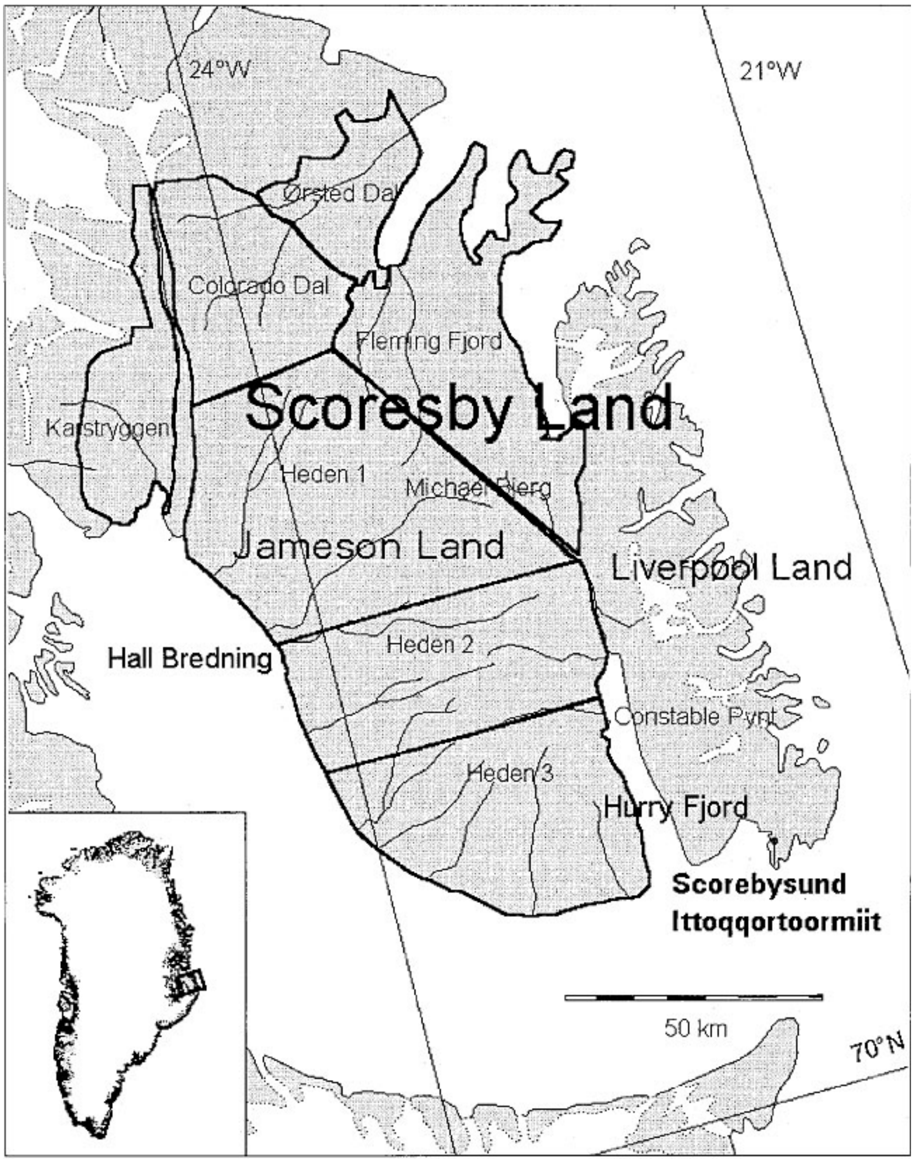
3.3.1 Distribution in Jameson Land

The surveys in 1980s gave a good view of the distribution of muskoxen, especially in late winter, when the surveys were carried out (Figure 8, Table 3). Summer surveys were also carried out (Aastrup 2000).

Thing et al. (1987) found that muskoxen prefer wet fens and snow bed vegetation during summer, while windblown dry dwarf-shrub heath was the preferred vegetation type in winter because the snow depth here is only moderate (Hansen & Mosbech 1994). Graminoids dominate the winter diet, while Arctic Willow (*Salix arctica*) dominated during summer. The deposition of fat during summer is important for winter survival and calf production; hence, good summer forage and no disturbance when feeding is very important to survive the winter.

The muskox concentrations are generally high in summer in the Ørsted Dal/Colorado Dal area, and in winter also around Gurreholm. These ranges can be regarded as core ranges for the muskoxen in Jameson Land.

Figure 8. The Jameson Land muskox census areas used in the 1982-1990 surveys. From Aastrup & Mosbech 2000.



Around Michael Bjerg, Nerlerit Inaat and in southern Jameson Land concentrations were not as high as could have been expected from the vegetation greenness. This may relate to hunting in these areas – in summer along the coast and in winter along the sledge trail across Jameson Land.

Muskoxen in Jameson Land move over long distances. Tagged muskoxen were observed at least 120 km from the tagging location, and movements between Colorado Dal and Mestersvig 75 km away were also documented (Aastrup 2003). Hence, it seems likely that areas depleted for muskoxen by hunting or because of temporary disturbances can be filled up again, as long as the population is thriving in the undisturbed core ranges. Figure 9 shows the most important area for muskoxen in Jameson Land.

3.3.2 Sensitive periods

Muskoxen are most sensitive to disturbances during March-May (late winter) when they are calving and when the body condition generally is poor due to the sparse availablity of food during the preceding winter. As muskoxen do not concentrate in specific calving areas, the winter concentrations areas can be regarded as the sensitive areas also during the calving time.

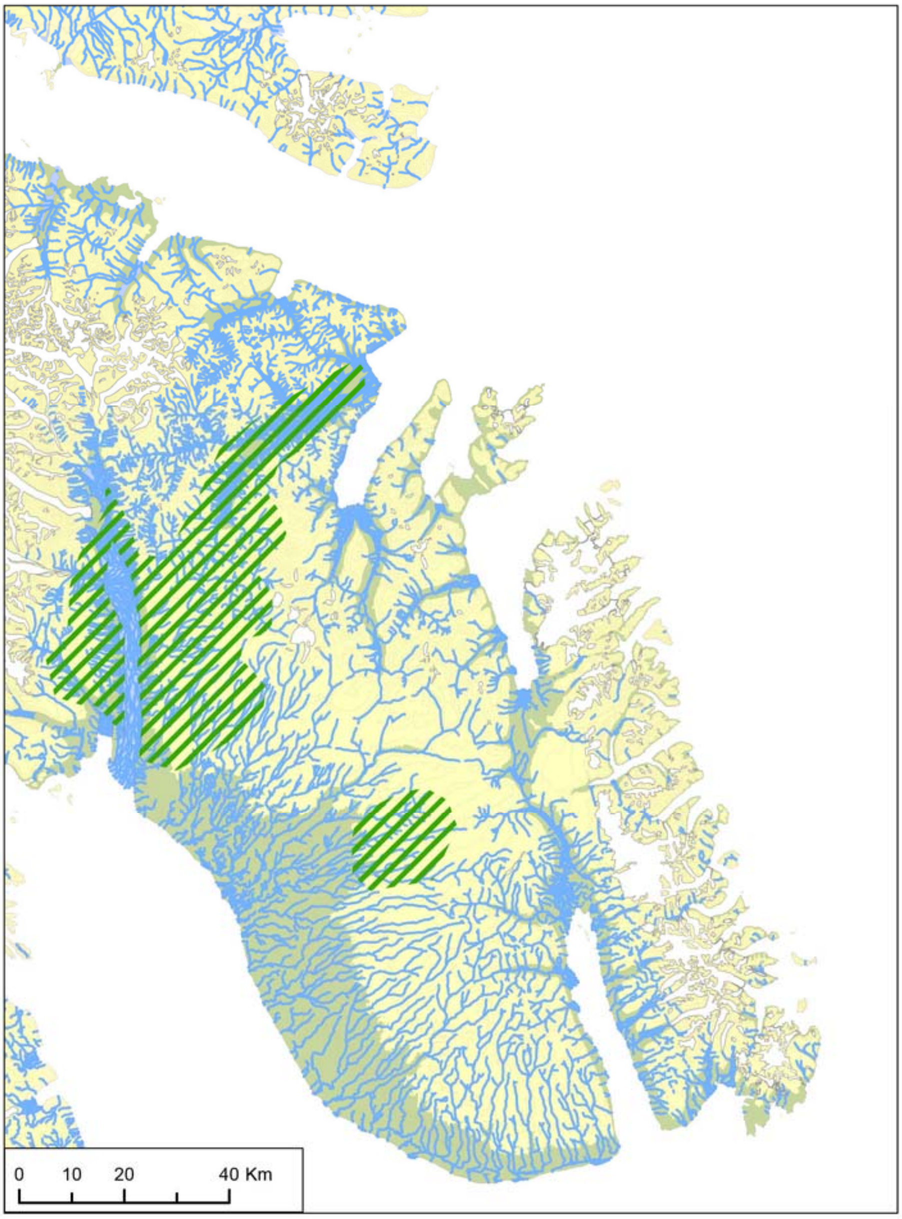


Figure 9.The most important muskox areas in Jameson Land, based on Aastrup & Boertmann (2009).

3.4 Freshwater fish

Arctic char (*Salvelinus alpinus*) is the only freshwater fish in Jameson Land. The only rivers where they spawn within the assessment area are found Suuninnguaa/Sydkap and Schuchert Elv. All other rivers dry up in summer and/or freese to the bottom in winter, why they are not suitable to Arctic char. This was also confirmed by as survey in 1985 (Nygaard & Skriver 1986). Three-spined stickleback (*Gasterosteus aculeatus*) also occur in coastal lagoons.

3.5 Invertebrates

The invertebrate fauna of most of Greenland is poorly studied (J. Böcher, pers. comm.). It is known, however, that Jameson Land has a low diversity of beetle species (Bennike & Böcher 1994; Böcher & Bennike 1996) and that four of the five true butterflies (Papilionoidea) in Greenland, occur in Jameson Land (Böcher 2001).

3.6 Vegetation

In this account the flora and vegetation types of Jameson Land are described. First, the flora is described in detail, followed by a description of the dominating plant communities.

3.6.1 Flora

The knowledge of the flora and vegetation of Jameson Land was limited before the botanical investigations took place as a part of the background studies mentioned in Section 1.3 (Bay & Holt 1986). These studies included intensive studies on twenty localities (Table 4, Figure 10), mainly in the inland.

Jameson Land is situated in the northernmost part of low arctic East Greenland and constitutes one of the largest lowlands in East Greenland. The large variation in physical conditions has resulted in a diverse flora with elements from both the low and the high arctic flora. A total of 196 species of vascular plants have been found in Jameson Land. The number of species at the investigated localities varied from 104 to 161 among the well investigated localities i.e. localities investigated during at least a week (Bay & Holt 1984, 1986). The difference in number of species is due to local differences in climate, topography and edaphic conditions.

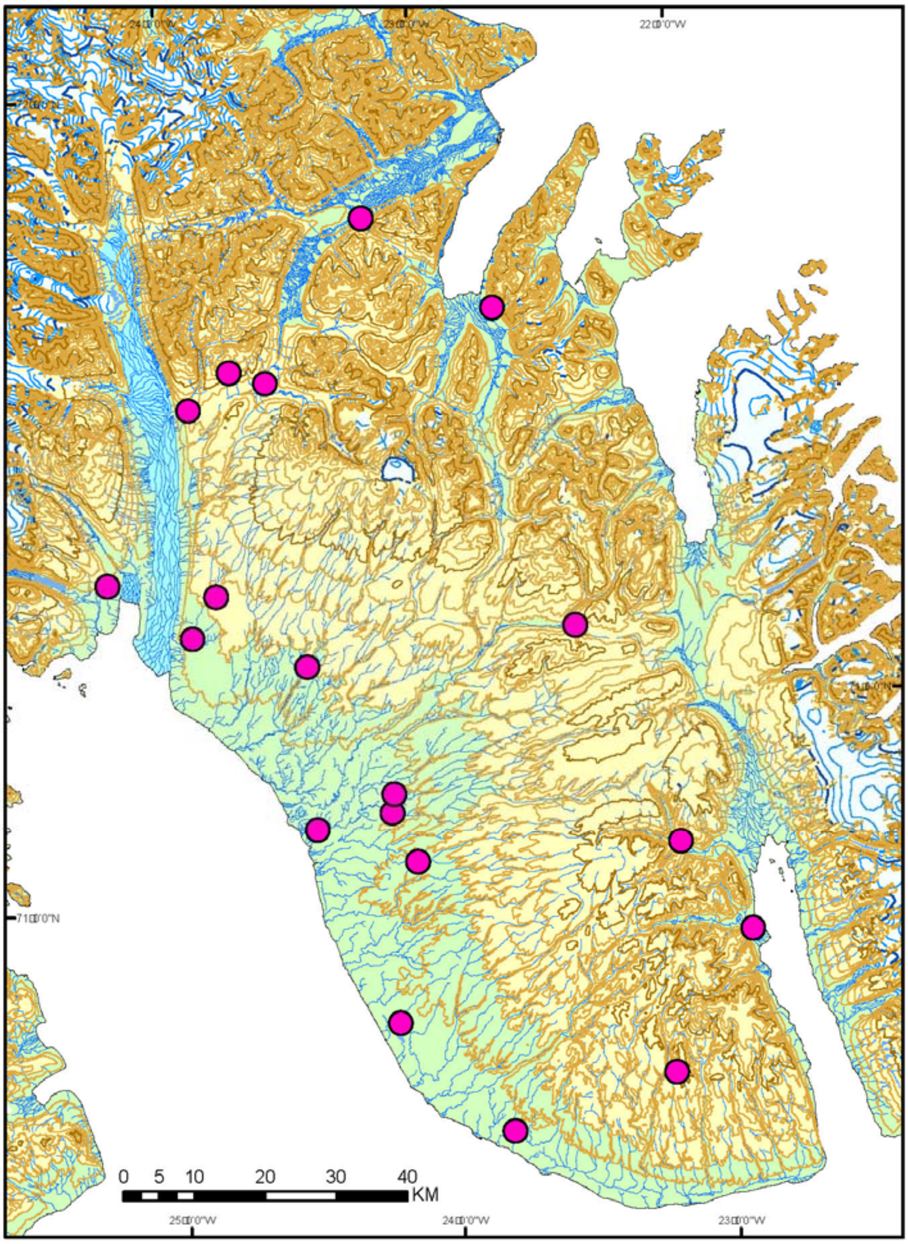
Some high arctic species have their southern distribution limit in Jameson Land (e.g. *Braya purpurascens*, *Poa abbreviata*, *Elymus hyperarcticus*) and several low arctic species have their northern limit in the area (e.g. *Epilobium anagallidifolium*, *Sparganium hyperboreum*, *Loiseleuria procumbens*, *Phleum commutatum*). Some extremely rare species have been found: The record of *Menyanthes trifoliata* was the first in East Greenland and there are extremely few previous records of *Potentilla stipularis*, *Utricularis minor*, *Ranunculus affinis* and *R. auricomus*in East Greenland.

Potentilla rubella, Saxifraga nathorstii, Draba sibirica ssp. *arctica* and *Potentilla stipularis* var. *groenlandica* are endemic to Greenland with a very limited distribution restricted to the northern part of Jameson Land (Bay 1992).

Table 4. Endemic (to Greenland) vascular plants found in Jameson Land.

Taxon	No. of known sites in Jameson Land
Species	
Potentilla rubella Th. Sør.	30
Saxifraga nathorstii (Dusén) Hayek	125
Subspecies	
Drabs sibirica (Pall.) Thell. ssp. *Arctica* Böch.	28
Variety	
Potentilla stipularis L. var. *groenlandica* Th. Sør.	12

Figure 10. Localities, where the flora has been studied intensively.



3.6.2 Vegetation

The vegetation of Jameson Land was classified and mapped by use of false colour infrared aerial photos (Bay & Holt 1986) and compared with a vegetation map based on satellite data (Mosbech & Hansen 1994). The vegetation has been divided into 14 classes of plant communities.

To the north and east, uplands (600-1100 m. a.s.l.) dominate and from here the terrain is sloping to the west. The area called 'Heden' is a biologically very important area because of continuous diverse vegetation, which contributes significantly to the food resources for the wildlife. The dominant vegetation type up to 200 m a.s.l. is dry dwarf shrub heath dominated by *Cassiope tetragona*, *Salix arctica* and *Betula nana* with a cover of vascular plants of 25-75%. In some areas on the west side of Jameson Land a more moist type dominated by *Vaccinium uliginosum* and *Salix arctica* dominates. The areas in question are the interior of Draba Sibirica Elv east of Tyskit Nunaat and the area east of Regneelv along Lodins Elv. The vegetation cover of vascular plants exceeds 75% in this type and is rich in mosses. Further to the east the dwarf shrub heath becomes more open and fell-field and solifluction soils dominate in the uplands. The heath vegetation in the coastal areas between Jyllandselv and Tyskit Nunaat is mixed with snowbed vegetation dominated by *Salix arctica*, *Carex bigelowii* and *Polygonum viviparum*.

In the coastal region along the west coast fens dominated by *Eriophorum scheuchzeri*, *Carex saxatilis* and *C. rariflora* occur on silty, level ground in connection with rivers, lakes and below snowbeds on sloping terrain. A hummocky fen type occurs in depressions in heaths and on sloping terrain dominated by *Eriophorum triste*, *Rannuculus sulphureus* and *Arctagrostis latifolia*. Fens occur also in the northern part of Jameson Land often in connection with grassland.

In the large valleys on the east side facing Kangerterajiva/Hurry Inlet and on south facing slopes along the large east-west going rivers in the western Jameson Land, a lush complex vegetation mosaic of moist dwarf shrub heath, copse, herb slope, snowbed and grassland vegetation occur. The herb slopes are found on south facing slopes and have a high species diversity and several low arctic species have their northernmost occurrences in this type (e.g. *Phleum commutatum*, *Epilobium anagalidifolium* and *Alchemilla glomerulans*). Salt marshes characterised by the species *Carex subspathacea*, *Puccinellia phryganodes* and *Stellaria humifusa* are recorded along the west coast of Jameson Land and at Nerlerit Inaat/Constable Pynt.

3.6.3 NDVI

Vegetation maps (Figure 11, 12) have been produced for this assessment from satellite images from 15 July and 17 July 2004. The images were obtained within a 5-day period and have therefore been treated as one, after geo-registration and atmospheric correction. Atmospheric and topographic correction was made using the ATCOR3 software (Richter 1997). Figure 11 shows the distribution of vegetation expressed as "greenness". A normalised difference vegetation index (NDVI) is an index developed as an indicator of the level of greenness of the vegetation and is widely used for monitoring vegetation characteristics and differences. The NDVI is calculated as the difference in reflection between the near-infrared 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 (Landsat band 4) and σ_{RED} is the reflection at the red wavelength (Landsat band 3).

The areas with highest levels of greenness (NDVI) are the inner part of central Heden, as well as the areas around Suuninnguaa/Sydkap and northwest of Gurreholm and Ørsted Dal/Colorado Dal. Most of Heden has NDVI values higher than 0.25 (Figure 11).

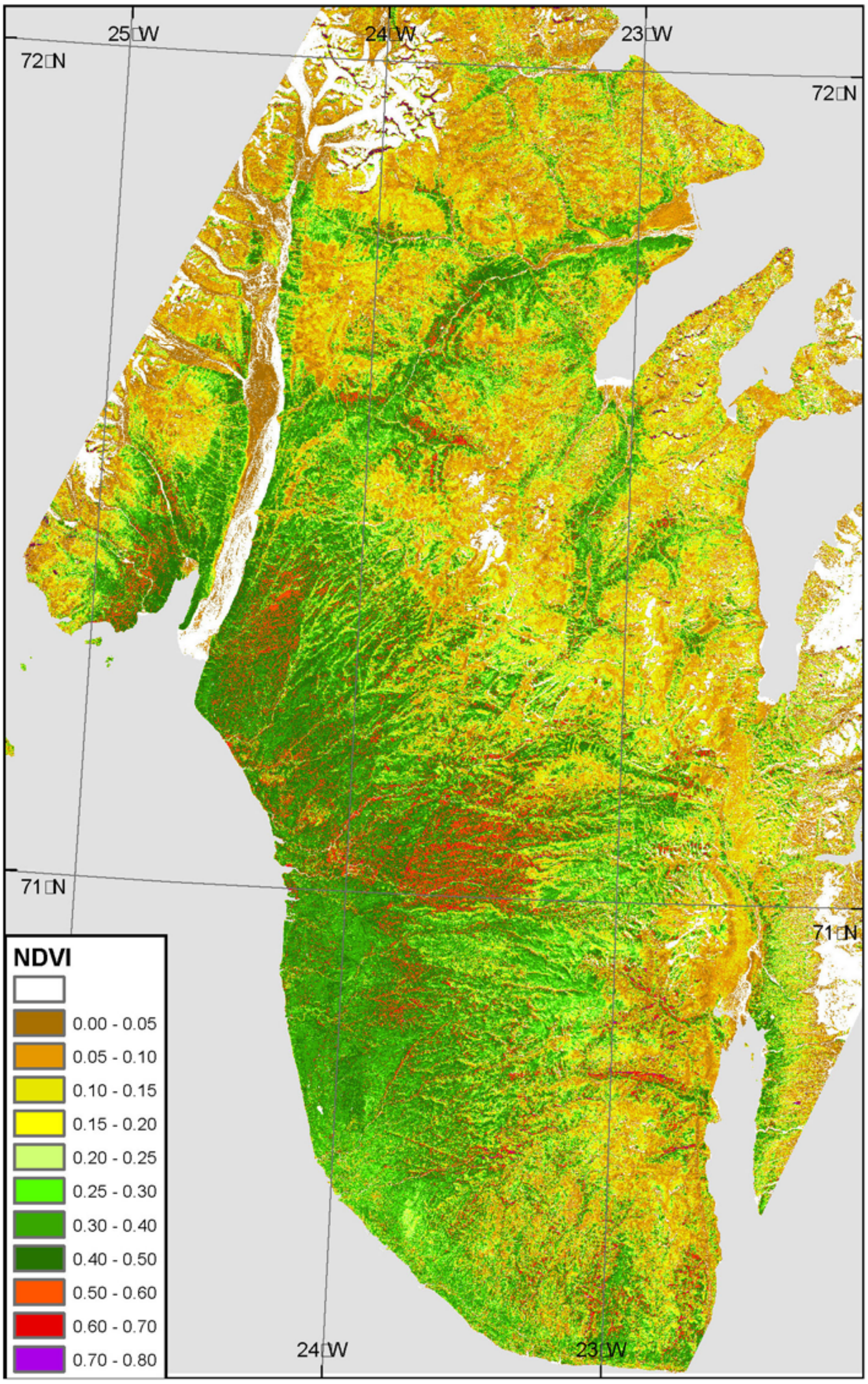
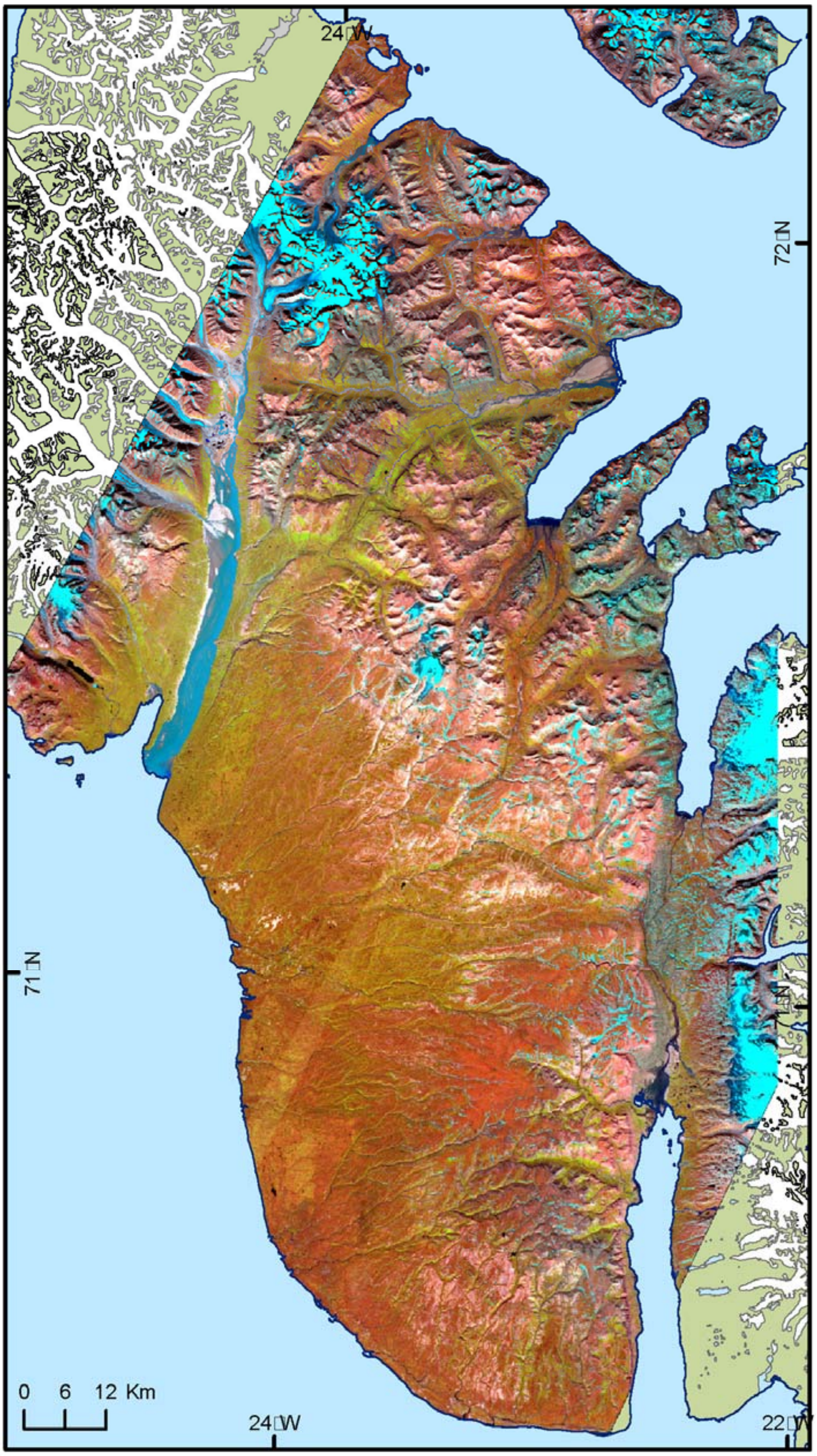


Figure 11. This vegetation map has been produced from Landsat ETM+ mosaic satellite images from 15 July and 17 July 2004. Light brown indicates no vegetation. NDVI scaled with yellow indicating sparse, low vegetation, green for intermediate growth and red/purple for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

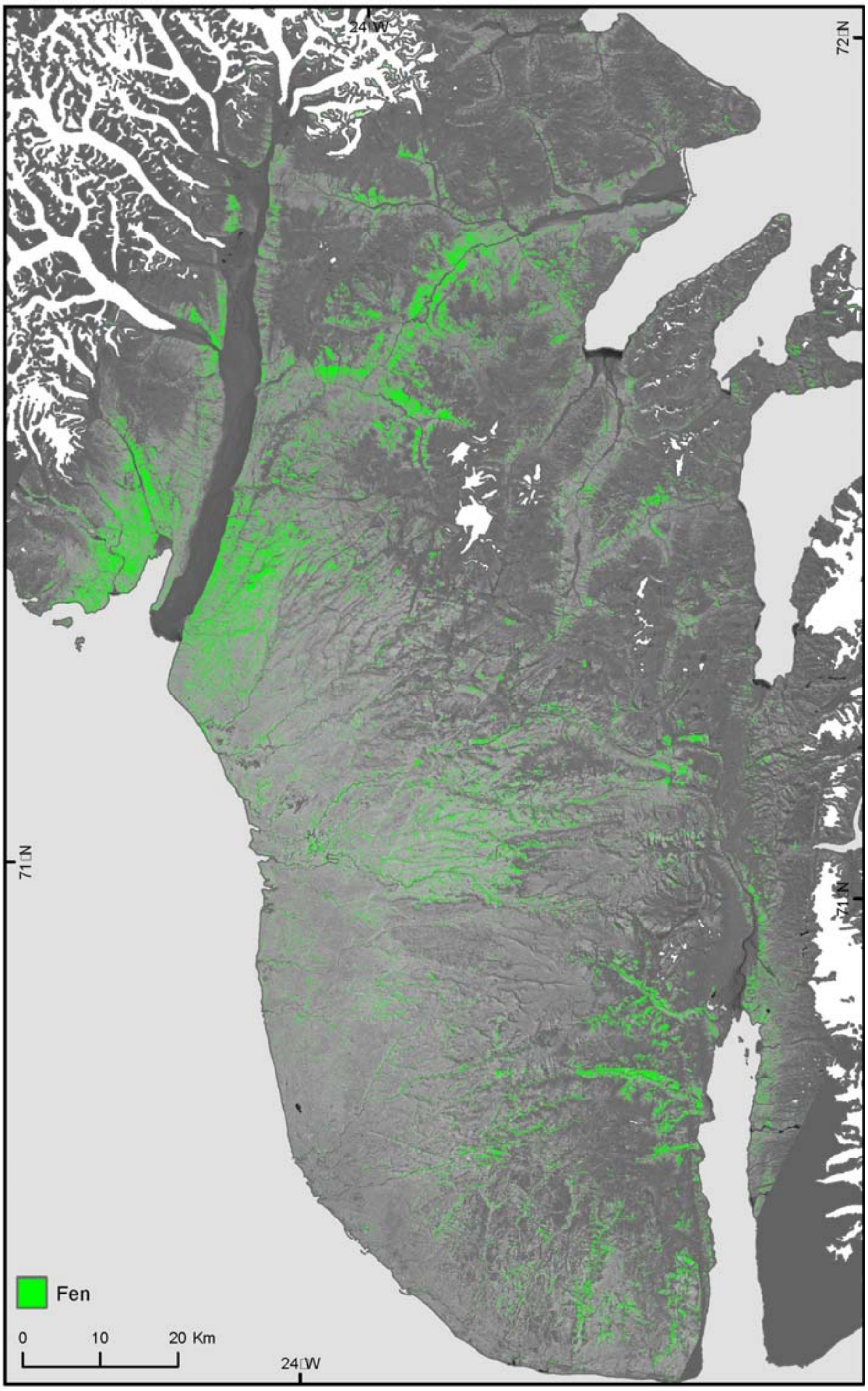
Figure 12 shows the distribution of vegeation in Jameson Land with an ASTER satellite image (combined from 15 and 17 July 2004) draped on the map. Jameson Land is dominated by the high mountain ranges north and east of the large west-sloping drainage area along Hall Bredning. The vegetation is primarily located in the areas below 300 m a.s.l.

Figure 12. False-colour image of Jameson Land from 15 to 17 June 2004. The image is a composite of ASTER and Landsat ETM+ images, band 7, 4 and 2 in the red, green and blue channels, respectively. This combination enhances vegetation in green colours, bare areas in brown and red, snow in light blue and fresh water in darker blue colours (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).



The distribution of fens in Jameson Land is shown in Figure 13. This 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 Elv, the eastern and southern part of Suuninnguaa/Sydkap and the Ørsted Dal have a high abundance of this type of vegetation. Other areas with fens are the central part of Heden, especially along the rivers.

Figure 13. Distribution of fen vegetation in Jameson Land. Fens are shown in green with a NDVI grey scale image as background. Image is based on seven ASTER scenes from 15 and 17 July 2004 using one Landsat ETM+ SLC-off scene from 15 July 2004 for a missing stripe and few clouds.



3.7 Protected areas and threatened species

3.7.1 International conventions

Two areas in the region described by this report have been designated as ‘Wetlands of International Importance’ (Ramsar-sites) (Figure 14). These are “Heden”, the lowland along the western side of Jameson Land from Gurreholm and southwards to Sjællandselv (Egevang & Boertmann 2001) and Ørsted Dal in the northeastern part of the assessment area. The development activities in connection with the mining site Malmbjerget, covered part of Heden, why a compensation area – Ørsted Dal – was designated to replace the impacted part. However, the plans to mine the Malmbjerget deposit were postponed, and an official reduction in size of the Ramsar area awaits the re-initiation of the activities.

3.7.2 NGO designations

The international bird conservation society BirdLife International has designated Important Bird Areas (IBA) in Greenland (Figure 14). Two of these IBAs are situated in the assessment area, and they are "Heden"and "Ørsted Dal and Coloradodal" almost identical to the Ramsar-sites (Heath & Evans 2011, BirdLife International 2011a, b).

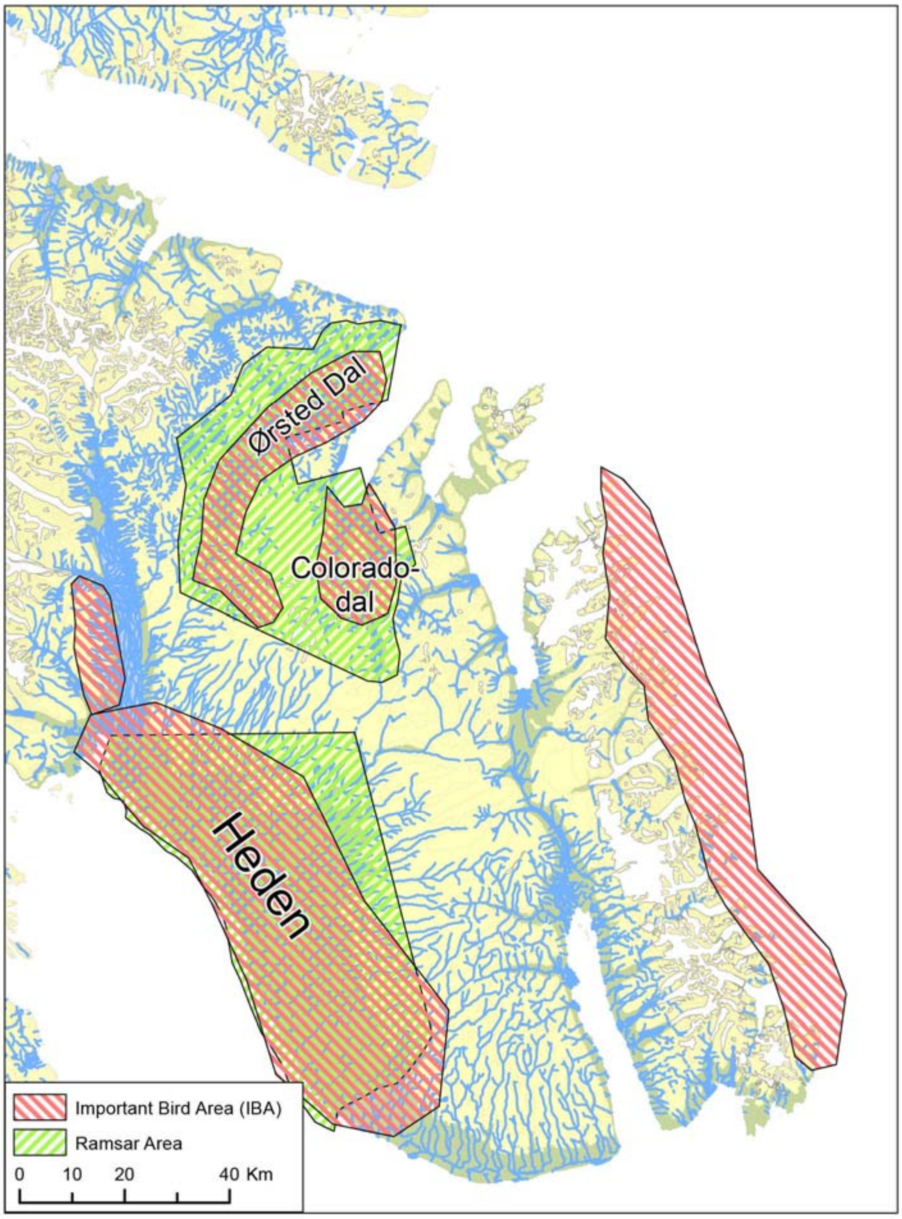


Figure 14. The Ramsar-areas in Jameson Land and the Important Bird Areas (IBAs) appointed by BirdLife International.

3.7.3 Threatened species

The Greenland list of threatened species (the Red list) includes an number of species occurring in the Assessment area (Table 5). From the global list of threatened species a few species also occur in Jameson Land (Table 5).

Table 5. Nationally threatened (Boertmann 2007) and globally red-listed (IUCN 2011) species occurring in Jameson Land. * applies to the entire Greenland population, and red-listed because the population in West Greenland is decreasing, a trend not apparent in East Greenland.

Species	Greenland Red List status	International Red List status
Wolf	Vulnerable (VU)	Least Concern (LC)
Polar bear	Vulnerable (VU)	Vulnerable (VU)
Great northern diver	Near Threatened (NT)	Least Concern (LC)
Gyr falcon	Near Threatened (NT)	Least Concern (LC)
European golden plover	Near Threatened (NT)	Least Concern (LC)
Whimbrel	Near Threatened (NT)	Least Concern (LC)
Sabines gull	Near Threatened (NT)	Least Concern (LC)
Arctic tern*	Near Threatened (NT)	Least Concern (LC)

Greenland has a special responsibility for species for which a significant part (> 20 %) of the global population occurs within the territory, implying that their global survival depends on a favourable conservation status in Greenland. National responsibility species occurring in the assessment area include one mammal and five birds (Table 6).

Table 6. National responsibility species occurring in Jameson Land

Species
Polar bear
Pink-footed goose
Barnacle goose
Knot
Black guillemot

3.7.4 Areas important to wildlife

The Bureau of Minerals and Petroleum (Greenland Government) has issued a set of rules for carrying out field work in relation to mineral and petroleum exploration. Among these rules, 'important areas for wildlife' are designated, where field activities (helicopter flying, driving, prospecting etc.) are regulated in order to minimise the disturbance of wildlife. The map in Figure 15 shows areas important to wildlife within the assessment area.

3.7.5 Sensitive areas in Jameson Land

Based on the information presented in Chapter 3, a map of the biologically most sensitive areas of Jameson Land has been prepared (Figure 16). The designated areas are almost similar to the areas designated as Ramsar-areas and the "areas important to wildlife". There may very well be more sensitive areas, which will be revealed by studies for example when new background studies are carried out.

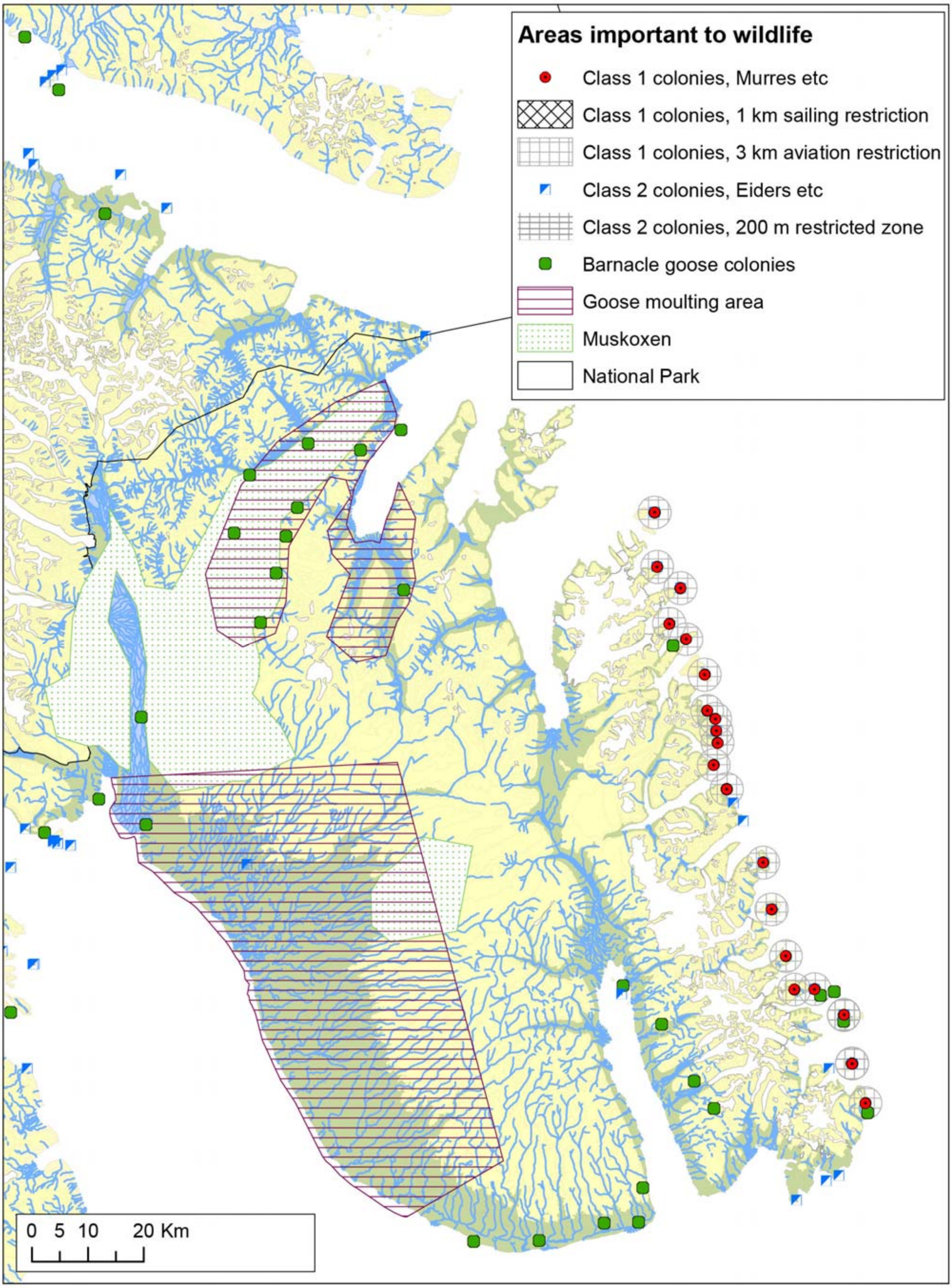


Figure 15. The "areas important to wildlife" as stated in the field rules issued by Bureau of Minerals and Petroleum. Class 1 colonies include seabird species such as murres, little auk and kittiwake, while class 2 include species like common eider and arctic tern. Within the designated areas, there are regulations in exploitation activities in the sensitive periods in order not to disturb wildlife

3.7.1 Flora and fauna protection areas

As a part of a discussion of "no-go" (for mineral and petroleum activities) areas in the National Park and adjacent areas, NERI (today DCE) proposed a number of "Fauna and flora protection areas" (Aastrup & Boertmann 2009). One of these protection areas cover a large part of northwestern Jameson Land and include many of the biological most sensitive areas (Figure 16). Another cover the southeastern part. These protection areas hold a number of "Species specific core areas" or "hot-spots", which are particularly sensitive to activities, they contain most of the habitat and species diversity found in Northeast Greenland and they were proposed as a basis for designating "no-go" areas in the National Park and adjacent areas.

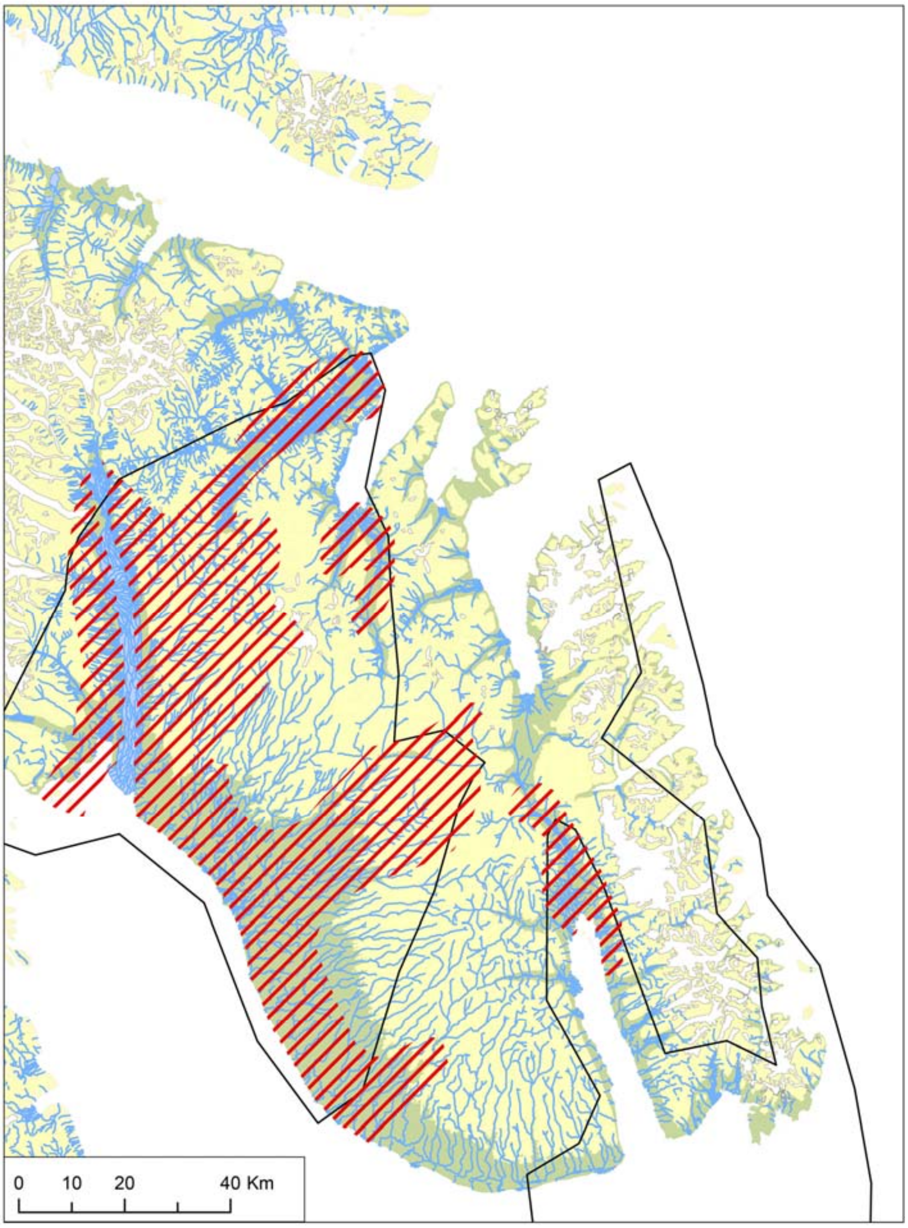


Figure 16. The biologically most important areas in Jameson Land indicated with red hatching and the "Fauna and flora protection areas" framed with black lines.

3.8 Local use of the biological environment

3.8.1 Fisheries

Arctic char (*Salvelinus alpinus*) is the only species of importance to fisheries in the area. Fishing is for private consumption. Sports angling for Arctic char by tourists play a minor role, but could potentially grow. The inhabitants of Ittoqqortoormiit use gill nets for char fishing. Within the assessment, fisheries mainly take place near the Suuninnguaa/Sydkap and in Kangerterajiva/Hurry Inlet (Figure 1).

3.8.2 Hunting

Each year the Government of Greenland stipulates quotas for muskox hunting in the area. The latest muskox hunting quota (2010/11) for Jameson Land/Liverpool Land was 81 muskoxen to be taken during the period November 10 to March 31 (60 by registered hunters and 21 by sport hunters). Traditionally, the winter hunt takes place in central Jameson Land around Michael Bjerg, with hunters using dog sledges for transport. The local hunts are organized by the local authorities, while tour operators (in accordance with local authorities) arrange trophy hunts for tourists. In years of difficult ice conditions, the authorities have sometimes opened for 2-3 weeks of hunting in March (Aastrup et al. 2005).

Arctic hares and Arctic foxes are also hunted in Jameson Land, but only to a limited degree and only for local use.

Birds especially geese and common eiders are hunted also for local use. This hunt primarily takes place in the vicinity of the town and only occasionally in Jameson Land.

The hunt for seals, narwhals, polar bear and other marine mammals is the most important occupation for the inhabitants of Ittoqoortormiit. As this hunt takes place in the marine environment it is not dealt with here, but is described in the Strategic Environmental Impact Assessment of hydrocarbon activities in the Greenland Sea (Boertmann & Mosbech 2012).

3.9 Tourism

Tourism is developing in Ittoqqortoormiit, and areas of Jameson Land and adjacent waters are destinations for day trips, cruises and sports expeditions.

Interior Jameson Land is largely inaccessible to tourists, although some venture there on moskoxen trophy hunt. The area at Suuninnguaa (Sydkap) is important for recreational purposes, and tourists also visit this site.

3.10 Archaeology

Thule culture winter dwellings, graves and tent rings have been found in several sites in this region. At Ittoritseq (near Kap Stewart) and at Suuninnguaa/Sydkap several winter dwellings, tent rings and graves have been found, indicating the largest winter settlements in the region (Sandell & Sandell 1991).

Along the Jameson Land coast, further winter dwellings and tent rings have been found at fifteen sites. Small settlements have also been located at Kap

Biot and Kap Wardlaw (Sandell & Sandell 1991) in the northeastern part of the assessment area.

3.11 Summary of sensitive areas and species

3.11.1 Species and their habitats

The most important bird species in the assessment area seen from a disturbance point of view are the geese. They are very numerous and the proportions of the flyway populations occurring in the assessment area are very high. Both species' populations are increasing. The geese prefer wetlands in the lowland areas, where Ørsted Dal/Colorado Dal, Heden and the large valleys Pingel and Enhjørningen are the most important.

Shorebirds breed mainly in the lowlands. They occur dispersed, and usually with the highest densities in wet areas with fens and marshes.

Rare and threatened bird species (red-listed) occurring in Jameson Land include great northern diver, gyrfalcon, Eurasian golden plover, whimbrel and Arctic tern (Table 5).

Several of these species are species of national responsibility (Boertmann 2008). The list of this category, however, also includes some species, which are not included in the Red list (Table 6).

Estuaries and lagoons along the shore of Jameson Land have an importance for migrating waders during southward migration.

Among the mammals, the muskoxen is the most sensitive to disturbance, and they are most sensitive during March-May (late winter and at calving time), when their body condition most often is poor. Within the assessment area the most important area for muskoxen is northern Jameson Land around Ørsted Dal/Colorado Dal/Major Paars Dal.

3.11.2 Flora

Several rare plants have been found in Jameson Land (cf. Section 4.4). However, the information on their distribution and occurrence is limited.

3.11.3 Vegetation and terrain

In general all vegetation types in Jameson Land are sensitive to driving and construction activities. Activities in moist habitats can create substantial damages, but these may also regenerate relatively fast, while damages in dry vegetation seems less conspicuous, but are very slow to regenerate (Figure 17).

Among the moist habitats, the salt marshes along west coast of Heden will be very sensitive. The fen vegetation shown in Figure 13 is likewise sensitive.

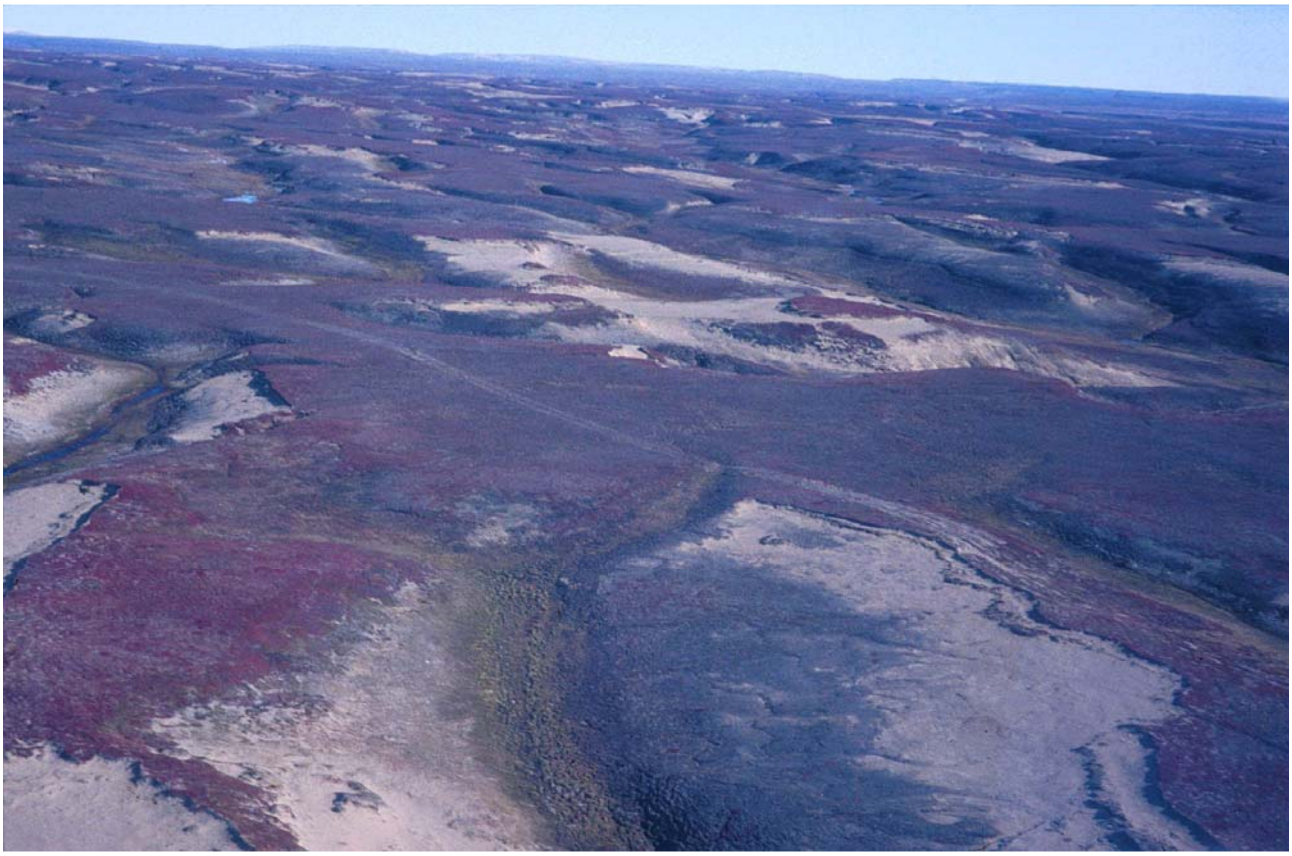


Figure 17. Track from a trailer camp made in relation to winter seismic surveys in a *Cassiope* heath in Jameson Land and still visible approximately 10 years later. Photo: P. Aastrup.

4 Background levels of contaminants

4.1 Chemistry of water, lichens and sediments

Several samples of sediments, lichens and water have been collected around Schuchert Elv in relation to the Malmbjerget molybdenum project. Analysis results of those samples are compared with results from other areas in Greenland in the following.

4.1.1 Water

Water from Schuchert Elv have been sampled and analysed at several locations and at several dates (Table 7).

Concentrations of Sn, Ba, U are more than 10 times higher in the Schuchert Elv system than in other Greenland river systems. This is probably a local property of the Schuchert Elv system and not necessarily typical for other Jameson Land fresh water systems.

4.1.2 Air

Pollution from dust can be measured in lichens, and usually in the species *Flavocetraria nivalis* (formerly: *Cetraria nivali*s). Lichen samples have been collected and analysed at stations near Schuchert Elv. The chemical composition is a result of precipitation and dust dispersal. In Table 8 analysis results of lichen samples are compared with results from other parts of Greenland. The Schuchert Elv area shows elevated values of Li, Be, Se, Sr, La, Ce, Nd, Th and U. These elements can all be found in concentrations that are 4 or more times higher in the Schuchert Elv area compared to the areas mentioned in the table. Other elements are in general slightly higher in the Schuchert Elv area compared to the other areas in Greenland.

4.1.3 River sediments

Several sediment samples from Schuchert Elv have been collected and analysed. A direct comparison with other river sediments from Greenland is not possible because of lack of data on multi-element analyses. The analysis of river sediments collected for the mining project at Citronen Fjord, are the only relevant data available for comparing with the samples from Schuchert Elv. The Citronen Fjord samples were analysed after dissolution in hydrofluoric acid followed by aqua regia. The Schuchert Elv sediments were analysed after dissolution in aqua regia without hydrofluoric acid. The aqua regia method does, however, not dissolve all elements completely. Nonetheless, the elements P, S, La, Ce, Nd are considerably higher in the river sediments of the Schuchert Elv. Also, Mn, Zn, U and Th are higher in the here. (Table 9).

There are several outlying high concentrations in the data. Therefore, the median values are compared. For a good evaluation of river sediment chemistry in Jameson Land, analyses of sediments from other areas including sediments from other locations in Jameson Land are needed.

Table 7. Concentrations of 49 elements found in water of the Schuchert Elv river system. Median, standard deviation µg/L. Some unusually high concentrations that could be related to small creeks draining mineral outcrops (selected by purpose), have been removed from the table in order to present only typical unpolluted streams. These concentrations are all well below the Greenland water quality guidelines.

		Schuchert Elv system (n=150)		**Rest of Greenland (n=98)**	
	Detektion limit	**Median**	**Std.dev.**	**Median**	**Std.dev.**
Li	0,31	1,61	1,05	0,11	0,96
Be	0,051	<0.05		0,004	0,047
Na	82	3,064	14,384	1,322	2,06
Mg	7	3,755	2,374	232	186
Al	1	35	55	29	41
Si	1	17	24		
P	10	<10		0	4
S	4.432	6.149	11.576	390	509
K	162	1.678	1.022	356	303
Ca	44	23.122	11.467	1.916	988
Sc	0,53	<0.5		0,014	0,106
Ti	0,31	0,57	1,4	0,15	0,44
V	0,32	<0.3		0,05	0,05
Cr	0,11	<0.11		0,04	0,13
Mn	0,293	1,06	16,609	0,276	0,653
Fe	6	8	32	6	17
Ni	0,31	<0.3		0,31	0,65
Co	0,035	<0.35		0,015	0,032
Cu	0,3	0,34	0,5	0,47	0,46
Zn	0,25	1,08	2,44	0,72	19,54
Ga	1.088	<1		0,024	0,121
As	0,686	<0.6		0,096	0,427
Se	0,39	<0.39		0,07	0,32
Rb	0,037	1,148	0,634	1,301	0,85
Sr	0,9	316,9	309,7	6,6	5
Y	0,005	0,03	0,054	0,065	0,208
Zr	0,025	0,076	0,179	0,015	0,123
Mo	0,174	0,732	1,526	0,16	1,346
Rh	0,005	0,0076	0,0105		
Ag	0,044	<0.04			
Cd	0,0427	<0.04		0,0054	0,0146
Sn	0,02	0,023	0,015	0,001	0,099
Sb	0,059	<0.06			
Te	0,108	<0.1		0	0,013
Cs	0,047	<0.047		0,017	0,016
Ba	0,067	28,393	19,281	2,611	3,092
La	0,004	0,033	0,118	0,225	0,512
Ce	0,003	0,047	0,206	0,172	0,587
Nd	0,011	0,03	0,096	0,152	0,334
Ta	0,039	<0.039			
W	0,069	<0.069		0,017	0,147
Au	0,067	<0.07			
Pt		0,0083	0,0113	0,0012	0,0029
Hg	0,034	<0.034		<0.005	0,02
Tl	0,038	<0.068		0,028	0,047
Pb	0,038	0,046	0,122	0,028	0,45
Bi	0,004	<0.004			
Th	0,003	0,011	0,03	0,009	0,036
U	0,039	2,014	1,815	0,123	0,449

Table 8. Composition of elements in the lichen *Flavocetraria nivalis* in the Schuchert Elv area compared to three other areas in Greenland, where background studies have been carried out in relation to initiation of mineral exploration.

	Seqi 2004		**Nalunaq 2004**		**Mestersvig 2005**		**Schuchert Elv area 2006**		**Schuchert Elv area relative to mean of rest**	
No. of samples	**24**		**20**		**58**		**22**			
	median	mean	**median**	mean	**median**	mean	**median**	mean	**median**	mean
Li	**0,04**	0,04			**0,09**	0,14	**0,41**	0,41	**6,56**	4,54
Be	**0**	0			**0,02**	0,02	**0,05**	0,05	**4,19**	4,15
Na	**1928**	2074,69			**353**	427	**457**	527	**0,4**	0,42
Mg	**1898**	1935,81			**498**	545	**849**	1033	**0,71**	0,83
Al	**174**	183,67			**410**	419	**906**	981	**3,1**	3,25
P	**579**	594,2			**610**	593	**789**	783	**1,33**	1,32
S	**427**	476,92			**601**	579	**808**	834	**1,57**	1,58
K	**2303**	2293,69			**2004**	1977	**2153**	2178	**1**	1,02
Ca	**2855**	4094,15			**9594**	13056	**15814**	15877	**2,54**	1,85
Sc	**0,44**	0,47			**0,26**	0,27	**0,46**	0,5	**1,32**	1,36
Ti	**16,58**	15,57			**25,66**	26,93	**65,1**	69	**3,08**	3,28
V	**0,2**	0,23			**0,58**	0,69	**1,36**	1,5	**3,49**	3,26
Cr	**0,25**	0,37	**1,6**	1,61	**0,6**	0,72	**0,98**	1,01	**1,2**	1,12
Mn	**42,54**	49,63			**36,34**	38,59	**42,51**	48,51	**1,08**	1,1
Fe	**98**	107			**296**	326,87	**664**	668	**3,37**	3,07
Co	**0,1**	0,17	**0,52**	0,53	**0,23**	0,25	**0,32**	0,37	**1,14**	1,17
Ni	**0,41**	1,05	**1,65**	1,59	**0,5**	0,57	**0,67**	0,73	**0,78**	0,68
Cu	**0,62**	0,79	**2,84**	2,86	**0,79**	0,83	**0,99**	1,04	**0,7**	0,7
Zn	**16,52**	18,71	**13,3**	12,99	**15,26**	16,39	**13,87**	14,36	**0,92**	0,9
Ga	**0,06**	0,16			**0,13**	0,14	**0,34**	0,38	**3,6**	2,59
As	**0,14**	0,21	**0,34**	1,02	**0,12**	0,11	**0,17**	0,2	**0,87**	0,44
Se	**0,05**	0,05	**0,07**	0,08	**0,2**	0,18	**0,58**	0,64	**5,48**	6,06
Rb	**1,84**	2,23			**3,1**	2,99	**3,93**	4,36	**1,59**	1,67
Sr	**18,6**	20,07			**16,9**	28,26	**76,37**	102,53	**4,3**	4,24
Zr	**0,12**	0,13			**0,23**	0,23	**0,53**	0,65	**3**	3,63
Mo	**0,01**	0,01			**0,02**	0,03	**0,04**	0,06	**2,41**	3,37
Ag	**0,01**	0,01			**0,02**	0,02	**0,02**	0,03	**1,85**	1,89
Cd	**0,06**	0,07	**0,07**	0,07	**0,11**	0,2	**0,1**	0,11	**1,21**	0,94
Sn	**0**	0,01			**0,04**	0,04	**0,03**	0,02	**1,37**	1,09
Cs	**0,03**	0,04			**0,11**	0,11	**0,13**	0,14	**1,83**	1,88
Ba	**6,92**	9,57			**33,39**	33,92	**34,51**	34,37	**1,71**	1,58
La	**0,15**	0,19			**1,33**	1,35	**4,45**	5,92	**6,03**	7,67
Ce	**0,31**	0,39			**2,78**	2,86	**8,95**	11,57	**5,79**	7,12
Nd	**0,15**	0,17			**1,38**	1,36	**3,79**	5,04	**4,96**	6,58
W	**0**	0			**0,01**	0,01	**0**	0,01	**1,1**	1,44
Hg	**0,03**	0,03	**0,03**	0,03	**0,02**	0,02	**0,04**	0,04	**1,56**	1,51
Tl	**0**	0			**0,01**	0,01	**0,01**	0,03	**1,85**	3,58
Pb	**0,44**	0,47	**1,03**	1,12	**1,72**	1,68	**1,96**	2,58	**1,85**	2,37
Bi	**0**	0			**0,01**	0,01	**0,01**	0,01	**2,67**	3,71
Th	**0,01**	0,02			**0,14**	0,15	**0,75**	0,97	**9,99**	11,78
U	**0,01**	0,01			**0,04**	0,05	**0,15**	0,18	**5,54**	6,3

Table 9. Chemical composition of river sediments in Schuchert Elv in mg/kg, compared to similar sediments from the Citronen Fjord area. Elements that are known for not being completely dissolved in aqua regia are printed in grey. There are several out-lying high concentrations in the data. Therefore, the median values are compared.

Project	**Citronen Fjord**	**Schuchert Elv**	**Schuchert Elv/ Citronen Fjord**
No. of Samples	**39**	**40**	
Dissolution method	**Complete**	**Aqua regia**	
	Median	**Median**	**Ratio**
Li	28,4	9,2	0,32
Be	1,25	1.006	0,8
Na	5405	807	0,15
Mg	12422	3337	0,27
Al	39671	16275	0,41
P	500	1870	3,74
S	377	1216	3,22
K	11711	3281	0,28
Ca	65703	7142	0,11
Sc	8	4	0,52
Ti	2270	648	0,29
V	61	32	0,51
Cr	58	18	0,31
Mn	290	362	1,25
Fe	25457	19675	0,77
Co	8,6	6,1	0,7
Ni	34,1	18,9	0,55
Cu	16	8,8	0,55
Zn	60,5	71	1,17
Ga	10,3	8,9	0,86
As	5,4	1,4	0,26
Rb	68,9	28,8	0,42
Sr	120,2	52,9	0,44
Y	16,6	14,3	0,86
Zr	97,7	0,9	0,01
Mo	0,475	0,436	0,92
Ag	0,06	0,003	0,05
Cd	0,153	0,08	0,52
Sn	1,57	0,863	0,55
Sb	0,615	0,134	0,22
Te	0,025	0,012	0,48
Cs	2.405	1.453	0,6
Ba	258	92	0,36
La	19	51	2,73
Ce	39	105	2,69
Nd	18	44	2,42
W	1.195	0,03	0,03
Hg	0,048	-0,003	-0,06
Tl	0,45	0,151	0,34
Pb	13,8	13,9	1,01
Th	5,73	10,4	1,82
U	1,72	2,26	1,32

4.1.4 Marine sediments

Among the background studies related to the Malmbjerget project, marine sediments were collected in Kangertittivaq (Scoresby Sund) near the mouth of Schuchert Elv. The analysis results of these samples are compared to similar sediment analysis results from Kong Oscars Fjord and Citronen Fjord (Table 10).

Loring & Asmund (1996) have described marine sediments along the Greenland coast. A general result was that the chemical composition depends on the overall geology of the area.

The Kangertittivaq marine sediments belong to the Caledonian fold belt province and therefore have the composition shown in the Table 10 under "Caledonian fold belt".

The marine sediments of Kangertittivaq have in general lower element concentrations than similar sediments from other parts of Greenland and compered to the Caledonian fold belt in general (Loring & Asmund 1996) (Table 10).

Extreme care should be taken in the use of those results as they are based on few samples collected in very restricted areas. All the sediments that have been analysed are fine grained silt.

4.1.5 Analysis of fish

Shorthorn sculpins (*Myoxocephalus scorpius*) from Kangertittivaq near Schuchert Elv have been sampled for the Malmbjerget project (Table 11).

These have yet to be analysed.

4.1.6 Conclusions on contaminants and trace elements

Fresh water

Li, Mg, S, Ca, Sr, Sn, Ba, U are found in concentrations more than ten times higher in the water of the Schuchert Elv system than in the rest of Greenland (98 samples). This is probably a property of the base rock in the Schuchert Elv system and not necessarily typical for other Jameson Land fresh water systems. However, the concentrations are all well below the Greenland water quality guidelines, and will not create special problems for mining activities.

Lichens

The Schuchert Elv area has natural high values of Li, Be, Se, Sr, La, Ce, Nd, Th and U. All these elements can be found in concentrations at least four times higher in the Schuchert Elv area compared to the areas mentioned in Table 8.

River sediments

Concentrations of P, S, La, Ce and Nd are considerably higher in the Schuchert Elv area than in similar sediments from the Citronen Fjord area, Peary Land, Greenland. Also, Mn, Zn, U and Th concentrations are higher in the Schuchert Elv area. This is probably due to local mineralisations.

Table 10. A comparison of trace element in seabed sediments in Kangertittivaq (near the outlet of Schuchert Elv) and in Citronen Fjord and Kong Oscars Fjord in mg/kg. Most elements have a ratio lower than 1 and no elements are particular high in the Kangertittivaq sediment.

No. of samples	Kong Oscars Fjord 5	Citronen Fjord 14	Kangertittivaq near Schuchert river 26	Caledonian fold belt 4	Kangertittivaq/ Kong Oscar and Citronen Ratio	Kangertittivaq / Caledonian Ratio
Li	57,77	39,42	39,19	48	0,81	0,82
Be	4,42	1,76	3,25		1,05	
Na	51435	11604	16073		0,51	
Mg	12907	18375	8741	15600	0,56	0,56
Al	121912	58217	51491	79800	0,57	0,65
P	875	676	1003		1,29	
S	3025	804	338		0,18	
K	38662	15922	20535		0,75	
Ca	16439	43906	9840	15200	0,33	0,65
Sc	34,68	11,71	9,28		0,4	
Ti	4371	3259	4930	4700	1,29	1,05
V	110,83	86,11	95,47	145	0,97	0,66
Cr	83,17	75,09	59,57	96	0,75	0,62
Mn	596,58	364,19	536,84	1410	1,12	0,38
Fe	32192	35752	38436	45200	1,13	0,85
Co	12,86	12,52	12,82		1,01	
Ni	40,07	44,58	24,57	47	0,58	0,52
Cu	24,4	22,03	14,49	32	0,62	0,45
Zn	138	87,5	123	92	1,09	1,34
Ga	27,58	14,82	20,91		0,99	
As	13,78	7,76	5,26		0,49	
Se	1,19	0,37	0,58		0,74	
Rb	184	103	58		0,41	
Sr	199	83	172		1,22	
Y		19,84	9,36		0,94	
Zr	69	132	94		0,94	
Mo	1,52	0,81	1,63		1,4	
Ag	0,12	0,09	<0.1			
Cd	0,15	0,11	0,05	0,08	0,39	0,63
Cs	12,28	4,37	4,41		0,53	
Ba	763	351	491		0,88	
La	39,4	26	15		0,46	
Ce	81,17	53,86	34,9		0,52	
Nd	36,37	23,69	17,08		0,57	
W	1,68	1,49	1,49		0,94	
Hg	0,49	0,04	<0.2	0,06		
Tl	1,37	0,51	1,58		1,68	
Pb	55,09	23,27	30,91	24	0,79	1,29
Bi	0,49	0,21	0,12		0,33	
Th	17,66	8	9,02		0,7	
U	4,92	2,12	3,08		0,87	

Marine sediments

Most elements in the analysed samples were, in fact, lower than in samples from Kong Oscar Fjord and what could be expected for sediments from the Caledonian Fold Belt sediments.

4.2 Samples in the DCE sample bank

Table 11 shows the samples of plant, animals and sediment from Jameson Land that are kept in the DCE sample bank.

Table 11. Number of sediment, plant and animal samples from Jameson Land in the DCE-sample bank. These samples are available for chemical analyses.

Sample type	No of samples
Marine sediment	33
Shorthorn sculpin	14
Snow lichen, *Flavocetraria nivalis*	5
Blue mussel	5
Other mussels	6
Crustaceans	9
Bladder wrack, *Fucus vesiculosus*	10
Laminaria (kelp)	4
Fucus (kelp)	4

5 Impact assessment

5.1 Methodology and scope

The following assessment is based on the available information from the Jameson Land area reviewed in the previous sections (2 to 7). This include the background information collected in relation to the oil exploration in the 1980s and the reports compiled in relation to the management of the National Park and adjacent areas (Aastrup *et al*. 2005, Aastrup & Boertmann 2009).

5.2 Boundaries

The assessment area is the area described in the introduction (Figure 1).

The assessment includes, as far as possible, all activities associated with an oil field or the development of a mine, from exploration to decommissioning.

5.3 Impact assessment procedures

The first step of an assessment is to identify potential interactions (overlap/contact) between the activities and the ecosystem components in the area both in time and space. If interactions may cause impacts these are evaluated regarding their temporal and spatial extent and mitigating actions are discussed.

Quantification of the potential impacts on ecosystem components is very difficult, and generally the available data are not adequate for this task. Moreover, the spatial overlap of the expected activities cannot be assessed, as it is not known where the activities will take place. There is also lack of knowledge concerning important ecosystem components and how they interact. In addition, climate change also impacts the ecosystems, complicating assessment of impacts from oil and mineral activities.

Many sources have been drawn upon to assess impacts from oil activities. Especially important in this respect are the Arctic Council Oil and Gas Assessment (AMAP 2010) and the assessment of cumulative environmental effects of oil and gas activities on Alaska's North Slope (NAS 2003).

5.4 Summary of petroleum activities

Utilisation of an oil/gas field develops through several phases, which to some degree overlap. These include exploration, appraisal, field development and production and finally decommissioning. The main activities during exploration are seismic surveys, exploration drilling and well testing. The appraisal phase is also a part of the exploration. During field development, drilling continues (production wells, injection wells, delineation wells) and production facilities, pipelines and shipment facilities, etc. are constructed. Production requires maintenance of equipment and during decommissioning, structures and facilities are dismantled and removed. The exploration activities are usually of short-term (in total a few years), appraisal may also take a couple of years, while the development and exploitation phases are of long-term and may last for decades.

5.5 Summary of mineral activities

Mineral activities include three major activities differing in their nature. The first activity of a mining project is exploration often starting with field sampling or airborne geophysics over larger areas and later concentrating on delineating mineral occurrences in smaller areas through drilling. The second major activity is the exploitation phase, which most often includes the production of a mineral concentrate and waste such as mine tailings and waste rock. Construction of production plants and most often also infrastructure like roads, harbours and airstrips are associated with this phase in which also exploratory drilling for more ore continues. The final phase is the closure of the mining project including environmental restoration. Environmental monitoring is conducted during all phases. The exploration phase lasts several years, typically 5-10 years. The exploitation phase may last from a few years to more than 100 years, but is typically around 20 years for many projects. The closure phase is short, lasting a few years.

6 Impacts from petroleum activities

6.1 Routine exploration activities

In general all activities related to exploration are temporary and will be terminated after a few years if no commercial discoveries are made. The exploration activities include primarily seismic surveys and drilling, and the major conflicts with environment relates to:

- physical impacts from facilities and activities
- disturbance of wildlife
- discharges to air and land/water.

If discoveries are made, an appraisal phase will follow. This can last for several years and include seismic surveys, drilling and well testing. If the appraisal shows a commercial discovery, development may follow.

Aerial surveys of gravimetry and magnetism can be carried our in large areas where low level flying takes place in a densely spaced network. The major risk of impact from such activities are disturbance of wildlife, most severe if helicoptes are used. The impact will, however be short-term.

During exploration drilling there is a risk for blow-outs and subsequent oil spills. The impacts from such events are described in a separate section below.

6.1.1 Physical impacts

The footprint is the area physically covered by the constructions and activities, such as placement of infrastructure and tracks and trails in the terrain.

Seismic surveys

Seismic surveys on land are usually carried out as vibrating seismics, where the sound source is a large vibrating devise ('Vibroseis'), replacing previous times' dynamite. The vibrator is usually carried by a large truck, while other equipment and accommodation (trailer camp) can be hauled by bulldozers. Besides this activity support vehicles may commute to a permanent facility to bring fuel, supplies and staff.

Impacts

The most significant impact of seismic surveys are the physical footprints on the terrain and vegetation in the form of trails, ruts, disrupted or removed vegetation and compressed soil. Seismic surveys are an off-road activity, which takes place over very long stretches. In case of 2D-seismics, the parallel lines are spaced with up to 10 kilometres, and in case of 3D seismics the lines are spaced with a 100 to 200 meters. Therefore large land areas can be physically impacted by seismic activities, which for example is the case in many areas of Arctic Russia and on the North Slope of Alaska.

The magnitude of the impacts also depend on the activity level, and for example 3D-seismics can cause greater impacts in soil and vegetation than 2D-seismics, because of higher density of trails, heavier equipment and tighter turns at end of the lines.

Experience from other Arctic areas shows that especially terrain damages have the potential to be enlarged by wind and/or water erosion and in many sites also the permafrost layer has also been impacted with thermokarst as the ultimate impact (Figure 18).

These physical impacts on the terrain and vegetation also contribute to very obvious visual impacts, which can cover extensive areas.

Figure 18. Thermokarst near Constable Pynt in Jameson Land.

Mitigation

The AMAP oil and gas assessment conclude that seismics 'can be conducted in the winter with virtually no permanent footprint on the Arctic tundra' (AMAP 2010). This is, however, a conclusion with modifications, as especially in areas with steep altitudinal gradients, damages on terrain and vegetation may occur even after winter seismic surveys (NAS 2003).

However, the most efficient way to mitigate the physical and visual impacts from seismic surveys is to survey in winter when soil is frozen and terrain and vegetation is snow covered. This reduces physical impacts considerably and facilitates moving over moist and wet habitats. Impacts can be further reduced by using light weight vehicles with low pressure tires. In Canada a 'Low Impacts Seismic' (LIS) approach is now applied, including the use of such light weight vehicles.

Winter seismics were carried out in Jameson Land in the late 1980s. Especially in dry habitats where snow cover was slight or in areas where the snow was removed by the driving (e.g. on steep hill sides and river banks), vegetation and terrain was impacted (ruts and trails) and some of these damages are still visible (Figure 7).

Drilling

Exploration drilling on land can result in physical impacts from placement of structures at the drill site (lease area), at the camp site and at a mobilization area, which in Jameson Land probably will be at the coast. Physical impacts may also occur along access roads and trails. In wet areas, as for example on the North Slope in Alaska, gravel pads are constructed for drill and camp sites. Such pads are probably not necessary in most parts of Jameson Land, where rocks and dry gravel dominate the surface. For example the drill rig, during the so far only terrestrial oil-drilling in Greenland in 1996, was placed on a natural gravel bank (Boertmann 1998).

Access roads and trails connect a mobilization area at the coast and drill sites inland. In 2006, drilling equipment was brought in by ship and landed on the beach of Nuussuaq and afterwards by an extensive transport activity with large trucks and bulldozers brought to the drill site. No road was constructed, but a trail was laid out and afterwards remediated. This is still visible and will remain visible for many decades (Boertmann 1998). In moist areas roads have to be constructed on gravel embarkments.

Impacts

The footprint from exploration drilling includes the drill and camp area, the mobilization area and the roads and trails. From a single drilling this impact would probably be relatively limited in extend and consist mainly of vegetation and terrain damages as for example seen at the drill site in West Greenland in 1996. However, long access roads would increase the impacted area.

In dry terrain the demand of gravel would be small, but drilling in wet tundra requires huge amounts of gravel for the construction of pads for rig and camps and embankments for roads. The gravel would have to be taken from pits or mines, which would increase both the physical and the visual impacts.

The construction of embankments in wet habitats would also alter the drainage pattern, with potential large impacts on the surrounding terrain and on the permafrost layer (see Section 6.2.1).

Finally, dust contamination from roads and gravel pads can also be considered as a physical impact (see below 6.2.1).

The physical impact on terrain and vegetation may also result in visual impacts, which in the unspoilt Arctic landscapes can be extensive.

The physical impacts may moreover include damages on vegetation and terrain, habitat loss, dust from roads and tracks, impacts on local water drainage (impoundment, diversion, increased sediment runoff, etc.) and ruts, which may develop to thermokarst (destruction and erosion of the permafrost layer).

In summer, leisure off-road driving with light vehicles (ATVs) can create a dense network of trails and ruts in the surrounding terrain, a phenomenon seen at some communities and old exploration sites in Greenland. For example on Nuussuaq Peninsula, where both mineral and hydrocarbon exploration have taken place (Boertmann 2007). First of all, such tracks contribute to the visual impact, but ruts may also facilitate thermokarst.

Exploration drilling activities can consume large amounts of fresh water. The drilling itself requires the largest part, for example 5.7 million litres for a well (NAS 2003), but the camp facilities are dependent also of a large freshwater supply (e.g. 1.4 million litres during a single season, NAS 2003). This would have to be taken from nearby lakes or rivers, and may in case of a restricted supply, dry out these sources and destroy them as habitat for freshwater fauna and waterbirds. During the 1996-drilling on Nuusuuaq in West Greenland, fresh water was taken from an artificial lake created by damming a small watercourse.

In case of winter activities the construction of ice roads and pads also requires the use of large amounts of fresh water. According to NAS (2003) construction of one mile ice road would consume 3.8-5.7 million litres of water.

Large parts of Jameson Land are dry with very few lakes or ponds and with rivers which dry out during the summer. Especially the lakes in these areas may be impacted significantly by an exploration drilling and the construction of ice roads and ice pads would be difficult, due to lack of available water in large part of the area in winter.

Mitigation

The physical impacts from exploration drilling can to a high degree be mitigated, first of all by carrying out the activities in winter when terrain and vegetation is frozen and covered by snow. Careful planning and regulation (BAT and BEP principles applied), including new and up-to-date techniques are other important measures, which are especially important to apply to summer activities. Remediation can also contribute to mitigate both physical and visual impacts.

Winter drilling in wet habitats does not require the construction of gravel pads and embarkments, as these can be constructed of ice; a technique widely used in Canada and Alaska. Such icepads and -roads leave much lesser physical damages on terrain and vegetation when they melt away.

The footprint of the 1996-drilling in West Greenland is today dominated by the remains of the access trail and some terrain damages caused by bulldozers, which stuck in moist areas in the melting period in late spring. Tracks from off road driving with ATVs are also visible today. At close range, bulldozer trails from the remediation are still visible at the lease and camp areas (Boertmann 2007).

Physical impacts in Jameson Land

If seismics are carried out in winter, relatively slight footprint impacts are expected in Jameson Land. These may occur in form of vegetation and terrain damages at mobilization areas and along the seismic lines especially in areas with light snow cover and on steep hill sides.

Physical impacts from exploration drilling in Jameson Land would depend on the actual drill site and the season in which the drilling is carried out. The least physical and visual impacts would be expected from winter drilling. Summer activities would cause more widespread terrain and vegetation damages, which can be very pronounced in moist habitats if gravel pads and embankments are required. In summer there would also be a pronounced risk of off-road driving with ATVs if this activity is not regulated.

6.1.2 Disturbance of wildlife

Petroleum exploration disturbs terrestrial wildlife. Disturbance includes displacement (scaring away) and behavioural changes. Seismic surveys which slowly move trough the terrain, may impact wildlife briefly in a large region. However, shuttle traffic to a permanent facility has the potential to impact wildlife more continuously throughout the season.

Exploration drilling would impact wildlife for a season in a localised area. Helicopter commuting between the drill site and nearest airport would have the potential to disturb wildlife over larger regions.

Impacts and mitigation of disturbance of wildlife in Jameson Land

The most disturbance sensitive wildlife in Jameson Land is the muskoxen and the geese. The muskoxen are most sensitive during winter, because their winter strategy is to move as little around as possible to save energy, primarily relying on fat reserves build up during summer foraging. Repeated disturbance during winter may force them to spend more energy and repeated disturbance during summer may hamper foraging and the build-up of fat reserves, thereby increasing mortality. The geese are only present in the summer and both the large flocks of moulting geese and the breeding birds are vulnerable to disturbance.

Winter activities therefore will have the potential only to disturb muskoxen. In winter 1985/86 it was shown that helicopters and snow scooters had stronger impacts on muskoxen behavior than the seismic “train” in Jameson Land (Olesen 1986). Due to the local and temporal characteristics of the disturbance from exploration activities, only small impacts on muskoxen can be expected from a single seismic survey or a single drill site in most parts of Jameson Land, and there is ways to mitigate impacts by careful planning, for example by avoiding activities and traffic (helicopters and snowscooters) in especially sensitive areas and periods. The BMP ‘field rules’ designate muskoxen areas especially sensitive to disturbance and here activities are regulated in order to reduce disturbance.

Summer activities may impact the goose populations moulting and breeding in Jameson Land. These occur especially in the relatively lush wetlands in the lowland areas. A single activity has the potential to displace geese from a large area, but they would probably re-occupy such areas the following season if activities are terminated. The impacts can be reduced by careful planning and avoidance of the sensitive areas in the sensitive periods. The BMP ‘field rules’ designate goose areas in Jameson Land especially sensitive to disturbance and here activities are regulated in order to reduce disturbance.

There will however, be a risk for effects on population level on geese and muskoxen, if exploration activities are more extensive and especially if they last for many years without proper mitigation.

6.1.3 Discharges

Both seismic surveys and exploration drilling emit greenhouse gasses and other air pollutants from combustion of fuel in machinery and for heating. Especially drilling requires combustion of large amounts of fuel, and the drilling of a well may produce 5 million m3 exhausts per day (LGL 2005). The off-shore drillings carried out in West Greenland in recent years have increased the Greenland greenhouse gas budget significantly. The emissions also include NO_x and SO_2, which contribute to formation of Arctic haze, black carbon and which may impact local vegetation by acidic precipitation, especially if the buffer capacity of the soil is low.

Drilling also creates large amounts of drilling mud and drill cuttings to be disposed of at the end of activities. A common way to dispose these substances after an exploration drilling in the Arctic (Russia, Alaska, Canada), is to leave them in the environment, usually in a sump near the drill site. The intention is that the sump shall freeze into the permafrost. This is however, often problematic and especially now, with increasing temperatures and a general reduction in the permafrost layer. There are also examples of drill mud containing so much salt, that it cannot freeze, and in many cases sumps have leaked their contents to the surroundings. Sumps often subside, and this may increase the risk of leaching of mud chemicals and hydrocarbons to the environment.

After the drilling on Nussuaq in 1996, the flare pit was used as sump for the solid fraction of the remaining drilling mud (a part of it was left in the well-bore). The fluid fraction was sprayed over the lease area and cleaned cuttings were spread over a part of the lease area and grated. The site was inspected in 1998 (Boertmann 1998) and the area with the cuttings looked indistinguishable from the other parts of the lease area, which was also grated. However, the sump had subsided and this subsiding had developed further when inspected again in 2007 (Figure 19) (Boertmann 2007).

Mitigation

In Alaska sumps are not used anymore and mud and cuttings are reused, recycled, reinjected or transported to approved deposition facilities. Moreover, old sumps are remediated. In other Arctic areas in Russia and Canada, deposition in sumps is still used (AMAP 2010).

Figure 19. The subsided sump at the Gro#3 drill site on Nuussuaq Peninsula in 2007. The sump was established in 1996 in the flare pit close to the well and was used for the solid fraction of the drilling mud. The drill site is a natural gravel bank.

6.2 Impacts from petroleum activities – routine exploitation activities

Exploitation of hydrocarbons is, compared to exploration long lasting, and oil fields may produce for decades, why impacts from exploitation will be of long-term. The major conflicts with environment derive from:

- physical impacts from facilities and activities
- disturbance of wildlife
- discharges to air and land/water
- fresh water consumption.

However, extensive environmental impacts may derive from a large oil spill, which could occur as a result of an accident. Impacts of oil spills will be described in a separate section below.

6.2.1 Physical impacts

The physical impacts from oil extraction are extensive. The infrastructure of a producing oil field include camps, airstrip, pipelines, processing facilities, access roads, multiple well sites, gravel mines, shipment facilities, waste disposal facilities and tank farms creating a extensive physical footprint.

The infrastructure may also impact the permafrost layer by heating from facilities or by altering the insulation properties of the surface layers, e.g. by removal of vegetation or by piling of snow.

Moreover the drainage patterns of surface and subsurface waters may be altered by the infrastructure. This is most significant in wet habitats such as the North Slope tundra in Alaska (AMAP 2010).

The footprint may cause habitat loss where habitats simply are physically destroyed. This impact can be especially critical to species with very restricted distributions or with very small populations.

Habitat fragmentation is another impact, which can be significant especially where animal movements are obstructed e.g. by gravel embankments or pipelines. Rivers can be obstructed for migrating fish such as Arctic char and there are examples of obstruction of migration pathways for terrestrial species, such the migrating caribou stocks in Alaska and Canada.

Thawing of permafrost is related to heating from buildings and pipelines and also from drill pipes penetrating the frozen layer (AMAP 2010). The major problem, seen from an environmental point of view, is formation of thermokarst, creating large and deep wounds in the terrain (Figure 8). Thermokarst may for example occur in connection with roads and trails. During a driving operation in the Nuussuaq Peninsula in 2008, a 22 km long road was constructed. In some areas, where the upper layer of gravel was scraped off in order to level the terrain, continuous thawing of the permafrost layer made the road un-drivable and new trails transposed a few meters to the side had to be established. These also became un-drivable after some time and further parallel trails was constructed.

Buildings and constructions may sink into thawing permafrost, and this may increase the risk of accidental oil spills, especially from ruptured pipelines.

Freshwater drainage patterns may be impacted by the infrastructure. On the surface, impoundment of water may occur in the melting season and especially where gravel roads cross wetlands. The impounded water may destroy habitats for terrestrial animals, but may also improve the conditions for animals associated with open waters. Impoundments also have the potential to cause thermokarst. On the North Slope tundra in Alaska such impoundment problems have been significant (Walker et al. 1986, Noel et al. 1996, NAS 2003).

Dust formation is also characterized as as a physical impact. This may occur on gravel roads with extensive traffic, and the dust may settle as far as 1 km from the road and impact snow melt and vegetation (Myers-Smith et al. 2006).

Finally, all the infrastructure of oil extraction can contribute with visual impacts, which may impact local tourist industries, using the unspoilt Arctic environment as their primary asset.

Mitigation

The technical development has in recent decades reduced the footprint from production sites, e.g. by the use of directional drilling, where several wells are drilled from the same drill site. Other ways to mitigate these impacts are by careful planning including in-depth background studies of the potentially impacted environment and applying strict regulation incl. the BMP field rules.

In Alaska, on the North Slope, permafrost damages were prominent in the early period of the development. Such effects are less evident now, where heated structures and pipelines are elevated. Especially the elevated pipelines may cause additional impacts in the form of visual impacts on landscapes and they may be much more difficult to cross for migrating terrestrial mammals.

In many areas of Jameson Land activities and constructions can be established on rock and other stable ground, but there are areas where impacts on permafrost would be evident, if no actions are taken to counteract thawing. This may especially be the case in the lowlands of Heden.

In this context climate change would tend to aggravate the problems with impacts on the permafrost layer.

Potential physical impacts in Jameson Land

Before oil is found and the location of facilities is selected it is difficult to assess specific environmental impacts, but a more general assessment can be made. The physical environmental impacts of oil extraction in Jameson Land would naturally depend on the size of the oil field and on the actual location. For example, the distance to a shipment facility on the coast would be decisive for the length and routing of a pipeline.

The extensive physical impacts of oil fields seen on the North Slope and in Artic Russia, especially on water regime and permafrost, can probably be avoided in Jameson Land, because the terrain is much drier and facilities can be established on rocky or other stable and dry subsurface.

There may be a high risk of habitat loss especially for muskoxen and geese, but also for species with a restricted distribution or species that are rare. Such species include the shorebirds whimbrel and golden plover, which have their only Greenland breeding sites in Jameson Land.

There may also be a high risk of habitat fragmentation particularly for muskoxen, if pipelines cross migration pathways. In case pipelines would be established in Jameson Land, it should be secured that muskoxen can cross them without any difficulties.

The visual impacts from a production facility can be significant in an area like Jameson Land, which is dominated by extensive areas of more or less level lowland. Unobtrusive and landscape adapted facilities would be difficult to design and establish.

6.2.2 Disturbance of wildlife

Disturbance derives from the presence of infrastructure and from the human activity related to them, such as traffic on roads, helicopter flying and just people walking around in the surroundings.

Disturbance may displace animals from critical habitats, and may in special cases be a serious threat to small populations with a limited distribution.

Ground nesting birds are sensitive to disturbance from traffic and humans moving around in their habitat, and it has been shown that shorebirds avoid nesting at distances between 50 m and 220 m from roads (Glahder et al. 2011). This may, together with the habitat loss created by the footprint, reduce the populations in close vicinity to oil installations. Some species would probably show habituation, and re-enter the affected areas after some years.

A special case of this issue is attraction of predatory animals, mainly Arctic foxes and ravens, which can feed on discards from the kitchen (subsidized predators). These predators may increase the predation pressure on birds (especially on nests) and small mammals living in nearby environment, and moreover their population may increase due to reduced natural mortality during the winter.

Mitigation

Disturbance can be reduced by strict regulation (incl. the BMP field rules) of traffic and human activities, for example based on studies on of how to optimize habituation among the sensitive species.

Subsidized predators shall be mitigated by making all kind of edible waste unavailable and intended feeding of the wildlife must be prevented.

Potential impacts in Jameson Land

In Jameson Land the most disturbance sensitive species are the geese and the muskoxen. Especially the moulting geese are very sensitive to disturbance, because they are not able to fly and need undisturbed marshes and lakes (Mosbech & Glahder 1991, Madsen et al. 2009). Exploitation activities may displace moulting geese from the surroundings, and if a larger oil field is established in an important moulting site, as for example Heden on the west coast of Jameson Land, the entire population from that site would most likely be displaced. This area holds internationally important numbers of pink-footed geese (13,620 in 2008 4.8 % of the E Greenland/Iceland/UK flyway population) and barnacle geese (6,760 indvs. in 2008, which is 9.5 % of E Greenland/ Scotland/ Ireland flyway population).

The rare shorebird species mentioned above are also sensitive to disturbance and may be displaced from the very restricted breeding sites.

6.2.3 Discharges from production activities

Discharges to land and water

The by volume largest discharge from a production well to land and water is produced water. The overall ratio of water to oil is in Alaska 2.9 (Clark & Veil 2009), but the production of water shows a considerable variation through the life time of a production well. Produced water contains besides the water small amounts of oil, substances from the reservoir and chemicals added during the production process. Some of the substances are acute toxic, radioactive, contain heavy metals, have hormone disruptive effects or act as nutrients. Some are persistent and have the potential to bioaccumulate.

Produced water is often discharged to rivers (Russia) after cleaning for oil residues. However in Alaska this practice is now abandoned and all produced water is re-injected into the wells (AMAP 2010).

Emissions to atmosphere

Emissions to air are mainly combustion gases from the energy producing machinery (for drilling, production, pumping, transport, etc.). But also flaring of gas, trans-loading of produced oil and de-pressurerizing of produced water contribute to emissions. The emissions consist mainly of greenhouse gases (CO_2, CH_4), NO_x, VOC and SO_2.

The emissions of CO_2 from a large Alaska field (Prudhoe Bay) were estimated by Jaffe et al. (1995) to more than 7.3 million tonnes in 1990, a figure raised by a factor 4-6 by another study (Brooks et al. 1997). This is more than ten times present day total contribution from Greenland.

Methane (CH_4) is a very active greenhouse gas, which is released in small amounts together with other VOCs from produced oil when loading oil between tanks.

SO_2 contributes to acidic precipitation and the deposition of black carbon and NO_2 to formation of Arctic haze.

Drilling waste

As drilling continues during the production phase, drilling mud and cuttings will be produced and have to be disposed of. As described above in the exploration section (6.1.3), disposal in sumps is problematic seen from an environmental point of view. However, reinjection in old wells is an option in the production phase.

Waste

The amount of waste from a production site can be considerable and discharge of sewage water into freshwater systems has the potential to pollute and destroy the natural ecology. This is especially significant in the arctic, where lakes and rivers usually are nutrient poor. There is technology available to clean sewage water and impacts can be reduced to acceptable levels.

Mitigation

The impact from discharges are mitigated by reducing discharges applying the principles of BAT and BEP. They encompass for example re-injecting produced water, disposal of drilling waste at controlled sites and exclusively use of ultra low sulfur diesel (ULSD, < 15 ppm sulphur) in all vehicles and machinery.

Potential impacts in Jameson Land

The produced water probably presents the most important discharge problem to solve before eventual oil production is initiated. It has the potential to cause significant pollution problems if discharged into rivers, lakes or to the sea (via pipeline), why the only recommendable solution will be to re-inject it into the wells.

The atmospheric emissions have the potential to impact vegetation on nutrient poor soil, which is widespread in Jameson Land and also to contribute to the formation of Artic haze. Finally the CO_2 emission from a large-scale activities will increase the total Greenland greenhouse gas contribution many fold.

6.2.4 Fresh water consumption

This issue is described above in Section 6.1.1. The consumed amounts of fresh water will increase during production, and the risk of negatively impacting especially lakes in Jameson Land is apparent. The rivers in most of Jameson Land are less sensitive because they either dry up in summer or have an extremely high water discharge due to melt water from glaciers.

6.2.5 Impacts on use of local recourses

Muskoxen are the most important terrestrial species hunted by the inhabitants of Ittoqqortormiit. The hunt is limited by an annual quota of 170 animals.

Many of the activities of oil exploitation have the potential to impact the availability of muskoxen for the hunters in Ittoqortoormiit.

6.2.6 Miscellaneous impacts

The establishment of an oil field in an otherwise almost inaccessible area, will open for other human activities with potential environmental impacts.

6.3 Impacts from petroleum activities – decommisioning

Decommissioning include removal of all constructions and infrastructure and remediation of terrain and vegetation damages. The most significant impact on the environment is remobilization and spreading of accumulated contaminants, which can be spread by wind (dust) and watercourses.

Decommissioning activities also include intensive transport with the risk of disturbing wildlife along transport corridors and at shipment facilities.

The impacts shall be mitigated by careful planning, applying the BEP and BAT principles. It is moreover important to construct the different constructions in a way facilitating future removal.

6.4 Accidental oil spills

A serious threat to the environment from oil activities in Jameson Land will be a large oil spill. During exploration and development large oil spills could be the result of a blow-out of a well, while another source – pipeline rupture – adds to the risk during exploitation/transport. Accidents with barges transporting oil on rivers is another potential source to oil spills in the inland (freshwater), but this is not relevant to deal with in a Greenland context, as no rivers are navigable.

In contrast to marine oil spills, which have the potential to impact very large areas e.g. coastlines for many hundreds of kilometres, terrestrial oil spill usually would be confined to a limited area close to the source, unless the spill makes its way to wetlands and watercourses, which facilitates the spreading of the oil. Oil trapped in snow in winter time would also be able to spread with the melting snow in spring.

The hitherto largest terrestrial oil spill occurred in the Komi Republic (Russia) in 1994, when a pipeline ruptured at several sites along 18 km and leaked more than 100,000 tons of crude oil to tundra, wetlands and rivers. Estimates of impacted land areas vary between different sources from 21 km^2 to 70 km^2 (NAS 2003, AMAP 2010). There is no information on ecological effects; recovery and toxicity available from the spill, but at least concern for the fish resources and the fishery in the affected rivers was expressed. Poorly maintained pipelines seem to be a significant source to terrestrial oil spills in Arctic Russia. Terrestrial oil spills have also occurred in Alaska, but of much smaller scale than the Komi-spill.

Impacts

Oil spilled on land may destroy vegetation (Box 1) and accumulate in soils, where it can be preserved for many years due to low temperatures. There are examples of oil penetrating the permafrost layer. If oil reaches watercourses, fish resources will be impacted over long sections. If concentrations are high, fish and other limnic fauna may be killed (Giessing et al. 2002; Mosbech 2002), but low concentrations would cause tainting, making fish useless for consumption. Since rivers and streams tend to melt upstream first, frozen areas downstream might work as blocks, forcing oil contaminated water out of the river and onto the land causing impact on vegetation (e.g. Collins et al. 1994). Birds living on and near oil contaminated water may also be fouled with oil, usually with detrimental effect (Mosbech 2002).

Larger mammals would probably avoid oil contaminated areas (Boertmann & Aastrup 2002), while small mammals probably would die in heavily contaminated areas.

Mitigation

Accidental oil spills are mitigated by keeping the highest HSE and technical standards (BEP, BAT), and by strict regulation and careful planning, for example avoiding unstable areas for pipeline construction and by constructing berms around well sites and tanks in order to control spilled oil and preventing it from moving into watercourses and wetlands. In an area like Jameson Land, with many rivers and few lakes, it will be essential to keep spilled oil away from the rivers, because the distance to the sea is short. Snow can also absorb and contain spilled oil. If removed before spring thaw, such spills would tend to give less environmental impacts compared with spills in snow free areas.

Impacts in Jameson Land

An oil spill restricted to land areas may destroy the vegetation in the areas affected by the oil and revegetation may take decades. If berms and dikes can restrict the dispersion, the impacted area can be limited to the drill site and the immediate surroundings. If oil moves further, a larger area may be impacted. An oil spill would most likely not impact the muskox population, and in most cases only few water birds would be harmed if oil assembles in nearby lakes, and population effects on waterbird populations would not be expected even from a large oil spill, especially if the spill is contained by dikes and berms. In many areas of Jameson Land, drilling would have to take place on cliff ground and gravel banks where oil would run off and assemble in depressions and potentially also make its way to water courses. If this happens, there would be a high risk of oil reaching the marine environment, where impacts can spread over a much larger areas and hit much more sensitive ecological elements, such as seabirds and coastal habitats. Oil spill impacts in the marine environment are described in the Strategic Environmental Impact Assessment of oil activities in the Greenland Sea (Boertmann & Mosbech 2012).

Experiments with spilled oil have been carried out in Jameson Land (see Box 1).

6.5 Other accidental events which may impact environment

Accidental spills may also include chemicals from the various processes related to oil exploration and exploitation.

Accidental and uncontrolled fires originating from an oil activity may cause environmental impacts, primarily on vegetation. Especially in dry areas, such fires can cover extensive areas.

Accidents of this kind shall be mitigated by strict HSE-regulation and by applying the BAT and BEP principles.

6.6 Cumulative impacts

Cumulative impacts must be expected for example in the form of landscape scaring and especially on the most sensitive elements such as muskoxen and geese. They will be excluded from habitats (increasing with expanding activities), some which could be critical with population reductions as the ultimate effect.

Box 1

Oil spill experiments in Jameson Land

As part of the background studies carried out in the 1980s an oil spill experiment was set up near Mestersvig in 1982 (Holt 1987). Crude and diesel oil was spilled on five different plant communities, with 10 L/m^2. Vegetation communities included wet marsh, grassland, and three different dwarf shrub heaths. The effects were monitored over the subsequent three seasons.

Shortly after the experiment was initiated, plants in the study sites started to loose chlorophyll, both those treated with crude oil and those treated with diesel. Already the first year, the number of vascular plants decreased significantly and the total plant cover decreased to less than 5 % of the original cover (Bay 1997).

The status after the third and eleventh year are described below

Crude oil spills

<u>After three years</u>
Shrubs showed moderate recovery. *Salix arctica* showed best recovery, while *Dryas octopetala* and *Vaccinium uliginosum* hardly showed any recovery. In wetter areas, graminoids recovered moderately, but very little or not at all in dry sites. In the third year forbs had a few seedlings, but otherwise showed no recovery. Mosses showed moderate to good recovery in the wetter plots, but almost no recovery in the drier plots. Generally, wet and moist plant communities showed the best recovery (Holt 1987).

<u>After eleven years</u>
Woody species, herbs and graminoids had recovered less than 1 %, in crude oil sites. Mosses growing in soils with high water content recovered to 70 % in fens, and approximately to 30 % in grasslands (slightly higher than in crude oil spills). In dry sites, recovery was less than 1 %.

Diesel oil spills

<u>After three years</u>
Shrubs showed no recovery. Among graminoids, only *Carex bigelowii* had moderate recovery, while the others had next to none. Forbs did not recover, except for very few seedlings. In dry plots, there was a moderate recovery of mosses, while they recovered excellently in wetter sites.

For mosses, recovery was higher in diesel spills compared to crude oil spills.

<u>After eleven years</u>
For woody species, herbs and graminoids, less than 1 % recovered.
Mosses in wet habitats had a recovery of 53 %, close to 30 % in grassland and less than 1 % in dry habitats.

7 Impacts from mining activities

7.1 Routine exploration activities

7.1.1 Routine exploration activities - prospecting

When prospecting for minerals, large areas are searched by small field teams walking or driving in the terrain with ATVs. The potential environmental impacts from these activities are limited to physical impacts from campsites and vehicles used and to disturbance of wildlife. These impacts are restricted in time and space and much smaller compared with the impacts from seismic surveys during exploration for hydrocarbons (cf. Section 6.1).

Passive geophysical measuring of gravimetry and magnetism may also take place during this phase of the mineral exploration. This is carried out by means of aircraft or helicopter, and includes low level flying covering large areas and along a densely spaced network of survey lines. The major environmental impact would be disturbance of wildlife.

In Jameson Land, particularly muskoxen and moulting geese will be sensitive to prospecting activities, and impacts can be mitigated by surveying in periods and areas when wildlife is less sensitive as stipulated in the "Rules for field work" (LINK) issued by BMP.

7.1.2 Routine exploration activities – drilling

When the exploration becomes more focused, the related activities become more intensive. Most of the potential environmental impacts from this phase are comparable to the impacts from exploration drilling for hydrocarbons, described in Section 6.1. The impacts may include:

- physical impacts from infrastructure
- disturbance of wildlife at the exploration site and along transport corridors between the site and a mobilisation site
- discharges to water, air and soil.

For description of physical impacts and disturbance of wildlife, please refer to the sections on these issues in the hydrocarbon section (6.1), as the potential impacts are identical.

Many of the discharges from mineral drilling are also similar to those from hydrocarbon drilling, e.g. those to the atmosphere or from campsites. These are described in detail in Sections 6.1.3 and 6.2.3. However, mineral drilling differs substantially from hydrocarbon drilling. The equipment is much lighter, the drilled holes are of much smaller dimensions and cores are retrieved. The use of drilling fluid (incl. chemicals) is much less and the amount of produced drill cuttings is limited. On the other hand many more holes are usually drilled during the search for and delimitation of an ore body. The cuttings are usually left at the drill sites, and the drilling mud is discharged to the surroundings if it is non-toxic.

Impacts in Jameson Land

Mineral drilling is expected to result only in very limited impacts in Jameson Land, mainly as temporary disturbance of wildlife.

Mitigation

Mineral exploration activities in Greenland are regulated by BMP "Rules for field work" (LINK) in order to mitigate environmental impacts. These rules set up guidelines for driving in terrain, drilling, waste management etc. They include a.o. approvement of the drilling mud additives, securing that only environmentally friendly substances are used. The cuttings are usually smoothed out at the drill site.

Disturbance of wildlife are also mitigated by the BMP "field rules", which regulate activities in the field in order to avoid operating in sensitive areas in sensitive periods.

7.2 Impacts from mineral activities – mining

When a mine has been established the environmental impacts will be long lasting, and exists at least as long as extraction takes place and in many cases also for a long time after the closure of the mine. There are many abandoned mining sites worldwide, incl. in Greenland, which continue to impact the environment adversely, because of inadequate planning and waste management. It is important to keep the "lessons learned" from these sites in mind when planning new mineral activities.

The major conflicts with environment derive from:

- physical impacts from facilities and activities
- disturbance of wildlife
- discharges to air and land/water, drainage, chemical pollution, dust
- erosion and sedimentation.

7.2.1 Physical impacts and disturbance of wildlife

The physical impacts and disturbance of wildlife are similar to those from hydrocarbon exploitation and for potential impacts and mitigation in Jameson Land, please refer to Sections 6.2.1 and 6.2.2. However, the physical footprint can be of a much wider extension in case of a large open pit site, where, besides the pit, also extensive areas can be covered by disposed waste rock and tailing deposition sites.

7.2.2 Discharges from mining activities

The discharges from a mining site in Jameson Land would be almost the same as from an oil production facility. This applies to emissions to the atmosphere, especially from machinery and waste from camp sites and accommodation facilities. See Section 6.2.3.

But handling and treatment of ore may give rise to discharges, which may challenge the environment in a very different way.

Mining waste

The major problem related to mining is the generation of large amounts of mining waste: waste rock or overburden (the material to be removed to get access to the ore) and tailings (the uneconomic fraction of the ore). These wastes have to be disposed of near the mine. Besides the aesthetical impacts, mining waste has the potential to chemically pollute the surrounding environment, especially if the waste contains sulphide-minerals. In contact with water and oxygen these sulfid's generate sulphuric acid, which again mobilize heavy metals in the minerals with the risk of spreading to the surrounding environment (acid drainage).

The minerals from the ore can be concentrated in different ways, and toxic chemicals used in such processes pose another risk of pollution. Cyanide is for example used when extracting gold. Toxic chemicals are often discharged to a tailings pond or a retention basin, from where they can escape to the environment if not neutralized or contained properly.

Smelting is another process to extract valuable metals from the ore. This may impact environment by large emissions of greenhouse gasses to the atmosphere and by release of heavy metals also to the atmosphere. It is however not likely that a smelter will be established in Jameson Land because of limited access to energy resources.

Discharge of dust can be another severe source to pollution form mining. Extraction, crushing, transport and treatment of ore or concentrate can generate dust, which potentially may pollute the surroundings with contaminants from the ore – primarily heavy metals.

Impacts of waste rock and tailings in Jameson Land

If not mitigated, contaminants from waste rock or tailings can leach to waterways and eventually to the marine environment, where biota may be impacted, and if severe, be unsuitable for human consumption as seen from the lead contamination of the fjord adjacent to the Maamorilik-mine in West Greenland. Such pollution is long-term especially if the source cannot be removed. For example, the levels of lead and zinc in blue mussels are still elevated 20 years after the closure of the Maarmorilik mine and up to 12 km from the mine (Søndergaard et al. 2011).

If cyanide is released into a river or in a coastal environment all fish would instantly be killed. However, cyanide degrades fast, and the impact will therefore be short-term.

Mitigation of impacts from discharges

Preventing spreading of pollutants from mining should be an integrated part of the planning of a mine site. It can be done by using the most up-to-date technology, applying the BAT and BEP-principles, by high HSE-standards and by thorough knowledge on composition and degradation of the deposited materials. Deposition of tailings could for example be in natural lakes or in deep parts of nearby fiords where sedimentation can create a cover. In the first years of the Maamorilik-mine, pollution from dust was a severe problem, which, however, was handled and met by covering all transport ways and by crushing the ore within the mine.

The environmental regulation of mining activities has to a large extend been based on project specific local studies developed as part of project specific EIA study plans. However, as the level of activity for mining projects, other industrial activities and other environmental pressures are increasing in Greenland, there is a growing need for detailed knowledge on a regional scale for planning and monitoring purposes as well as detailed understanding of how potential impacts of mining interact with natural processes.

7.2.3 Erosion and sedimentation

At mines in many parts of the world, erosion and sedimentation in rivers downstream the mine is a severe problem and it can besides wetlands also impact soil and vegetation far from the mine.

This problem is apparently not especially important in Jameson Land, where the precipitation is low, and most water courses are melt water rivers, which carry huge amounts of sediments from the runoff of meltwater from snow and glacier ice.

7.3 Impacts from mining activities – decommissioning

The environmental impacts of decommissioning a mining site in Jameson Land are expected to be nearly the same as from decommissioning a large oil production facility (Section 6.3). A significant impact may be remobilization and spreading of accumulated contaminants, which can be spread by wind and watercourses.

Decommissioning activities also include intensive transport with the risk of disturbing wildlife along transport corridors and at shipment facilities.

However, a large open pit would be difficult or impossible to remediate.

The impacts must be mitigated by careful planning, applying the BEP and BAT principles. It is moreover important to design the different constructions in a way facilitating future removal.

7.4 Impacts from unplanned incidents

The most severe environmental disasters from mining activities have occurred when tailing dams fail and release contaminated water and tailings into rivers. This happened for example in southern Spain in 1998, where 4-5 million m^3 acidic tailings with high heavy metal content were released into a river (Achtenberg et al. 1999) and in Romania in 2000 when 100,000 m^3 cyanide contaminated water was released into a nearby river, causing extensive killing of fish, impacts on fisheries and drinking water supplies (WWF 2000).

Such incidents can be avoided by placing the tailings in natural reservoirs, such as deep lakes, deep parts of fjords were water exchange is limited. However, these solutions also require careful planning and thorough background knowledge on local environment including the composition of tailings and waste rock. For example to prevent situations like the early years of the mining site at Maamorilik, when tailings were discharged to the surface waters of the nearby fjord and heavy metals were dissolved into the water column.

7.5 Cumulative impact

Cumulative effects may be expected, especially if other mining or petroleum activities are going on in Jameson Land. They would include landscape scaring and especially disturbance of the most sensitive elements such as muskoxen and geese. These may be excluded from habitats (increasing effect with expanding activities), some of which could be critical to the populations.

8 Background knowledge and missing information

8.1 Specific information needs

Due to the extensive background studies carried out in the 1980s and the bird follow-up studies in the 2000s, the general knowledge base for birds in Jameson Land is good. However, the most recent muskox studies date back to the 1980s and the numbers and distribution patterns may have undergone considerable changes since then, why there is a need for an update. There is also a need for an analysis of their annual movements and for their habitat preferences before large scale activities are initiated in Jameson Land.

Furthermore, studies on impacts of disturbance and the potential for habituation are needed both for geese and muskoxen, studies which should be carried out before a mine or an oilfield is established.

Knowledge on specific location of rare plants and other localised nature conservation interests is sparse, and such information should be recorded, when specific activities and placement of infrastructure are planned. Some information can be obtained from the herbaria of the Natural History Museum of Copenhagen, where all the specimens collected in the 1990s are kept. In addition more studies are needed on the sensitivity and resilience of vegetation to traffic and dust.

As the marine area adjacent to Jameson Land is at risk from being impacted by both hydrocarbon and mineral activities, there is also a need for studies in the coastal zone and fjord; including i.e. biodiversity, important and sensitive habitats, hydrography and sedimentation patterns.

8.2 General information needs

There are several other information needs, which however also apply to oil and mining activities in other parts of Greenland and the Arctic in general.

Concentration, speciation and bio-availability of metals in rivers, lakes and coastal waters in Greenland are important missing knowledge, which should be provided before especially mining projects are established.

The effects of oil, different oil components and drilling additives on marine and limnic organisms have to some degree been studied in laboratories. However, effects in the field and especially in the Arctic are less well known. For example are Arctic food webs dependent on a few key species, and effects on these would be very relevant to study in order to mitigate potential impacts.

Degradation rates and toxicity of toxic substances from both oil and mining activities under Arctic conditions are also important to address, and assessment criteria and adequate monitoring strategies should be established.

In relation to pollution from mining and oil activities the interactions with global contaminants such as POPs and heavy metals in species from the assessment area is relevant to adress.

Also in relation to pollution from mines and oil activities, knowledge on concentrations, speciation and bio-availability of metals in rivers, lakes and coastal waters in Greenland is very relevant, e.g. to establish a baseline before activities are initiated.

And finally, the climate change perspective is important to adress when assessing impacts from mining and oil activities, as these changes may alter bidodiversity patterns and ecosystem dynamics.

8.3 Generic impact prosess studies

Here some project proposals in relation to to environmental prediction and monitoring of mining and oil activities in Greenland are listed:

A research–based decision tool for Arctic mining waste disposal and deposition will be very valuable, as more knowledge is needed for decision-makers to evaluate and decide upon different ways of depositing mine waste prior to start-up of mining operations.

An easy-applicable method for quantification of contaminated-dust fall related to mining activities in Greenland is currently needed.

New methods to monitor biologically available metals in the aquatic environment should be developed in addition to traditional water sampling and use of indicator species.

A research-based decision tool for minimizing wildlife disturbance should be developed, as most knowledge about disturbance caused by mining and oil activities is based on circumstantial or short-term studies of behavioural responses by wildlife.

8.4 Ecotoxicological monitoring

Assessment criteria have to be established in order to use biological indicators to assess if impacts are unacceptable or not. Such criteria are based on ecotoxicological tests that cover the sensitivity range of relevant species at different trophic levels, e.g. OSPAR Environmental Assessment Criteria (EAC). Toxicological tests with relevant species from the Greenland area are not available for establishing such criteria. Knowledge concerning species' sensitivity, assessment criteria as well as adequate monitoring strategies, will be relevant to have at hand before drilling activities are initiated.

8.5 Monitoring impacts from activities

Environmental monitoring of impacts from both mineral and hydrocarbon activities can be carried out on different levels:

1/ discharges from the activities locally on the site to secure that levels of toxic, bioaccumulating and slow degradable substances are within safe levels and as stated in the EIA of the activities.
2/ regionally where biological elements of the surrounding habitats are monitored in order to secure that populations are not impacted.
3/ on ecosystem level to secure that ecosystem features are not impacted.

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JAMESON LAND

A strategic environmental impact assessment of hydrocarbon and mining activities

There is an increasing interest for mineral and hydrocarbon exploration in Greenland and in both regards Jameson Land is in focus. This strategic environmental impact assessment describes the status of the biological knowledge from the area and designates potential conflicts between activities and the biological environment. Furthermore biological knowledge gaps are identified. These should be filled before specific environmental impacts assessments can be carried out and relevant studies to fill these data gaps are proposed.

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