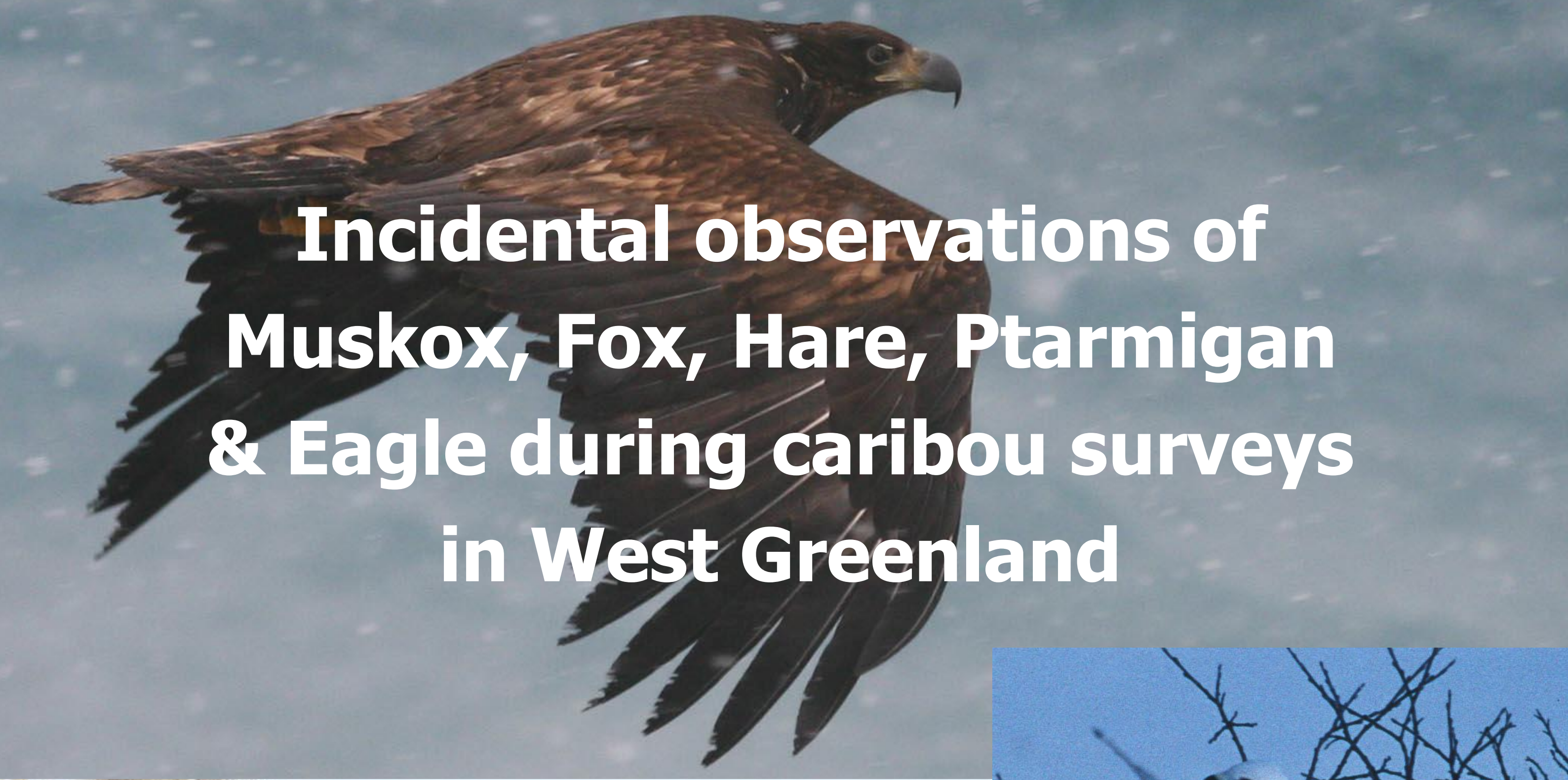
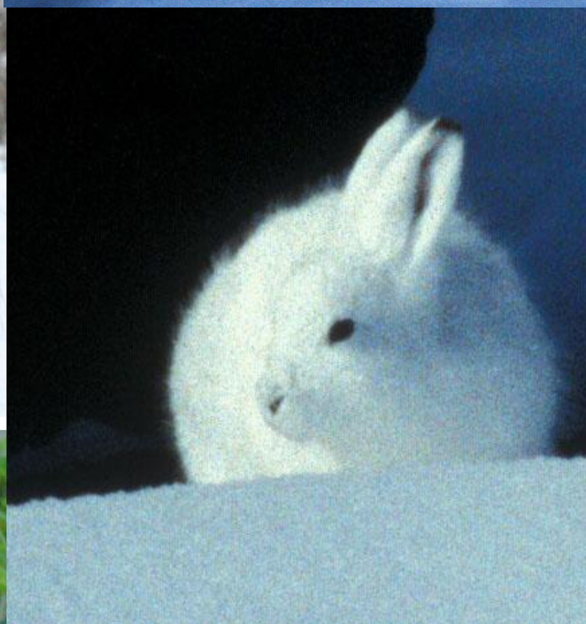


Incidental observations of Muskox, Fox, Hare, Ptarmigan & Eagle during caribou surveys in West Greenland



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Incidental observations of Muskox, Fox, Hare,Ptarmigan & Eagle during caribou surveys in West Greenland

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Summary

In March 2005 and 2006 three regions and four caribou populations were surveyed by helicopter for abundance and herd structure. During the surveys incidental observations of muskox, arctic fox, arctic hare, ptarmigan and white-tailed eagle, were recorded. Knowledge about the relative abundance or distribution of these five species in West Greenland is scarce and these opportunistically gathered observations are the only data available to describe the distribution and relative abundance of these species. We calculated indexes of abundance using the same stratification for animal densities employed to estimate caribou abundance. Since the survey methods for all regions were consistent, it was possible to describe the distribution and relative densities, providing an index abundance of these species. Thus, we produced the first regional indexes of population size for muskox, fox, hare and ptarmigan in West Greenland. The few incidental observations of white-tailed eagles were not sufficient for a population index. None of the species covered in this report are currently endangered, nor are they threatened by over hunting.

The caribou surveys were carried out during the month of March. We observed muskox only in the North region, although they are also present in the Central region. Relative to the other regions, the North region had the highest number of observations and highest density of hare and ptarmigan. Further, although not the highest, fox were also abundant in the North region, while eagles appeared scarce. The Central region had the highest number of eagle and the lowest number of fox and hare, while ptarmigan were similar or lower in number than in the South region. The South region had the highest number of fox, and the second highest number of hare and ptarmigan. The total lack of eagle observations, suggested that these were scarce in the South region in March.

The caribou surveys, which provided these incidental observations of muskox, fox, hare, ptarmigan and eagles, were not designed to provide abundance estimates of other species observed incidentally. The estimates presented below for muskox, fox, hare, ptarmigan and eagles in West Greenland are relative index estimates. These could be used to estimate population trend if surveys are repeated using the same methods. Additional concurrent and better-designed surveys tailor-made to each species could provide a critical evaluation of how well the above incidental sightings reflect actual abundance. As an alternative to the index estimates of abundance, we also provide an index estimate of the average number of animals observed per kilometre flown.

Monitoring of these species is highly desirable given the increasing probability of ecosystem change through global warming or accelerating industrial development in the hitherto relatively pristine environment of West Greenland. Roads are planned or being built in both the North and Central regions. Consumptive and non-consumptive human use will increase as access to the regions becomes easier. A proposed aluminium smelter development is planned, which will include at least two hydro power plants (with altered watersheds/ catchments areas) and extensive power transmission lines in both the North and Central

regions. Further impact to the Central region will occur with the establishment of an iron ore mine. Large-scale changes to the ecosystem are possible, including an open pit mine, pipeline (pollution runoff possible), altered watersheds, road, harbour, and possible airstrip. The challenges are many and our knowledge must be expanded beyond our only current source, hunter harvest records. Meantime, the index estimates below give the first baseline data for describing the status and trends of muskox, hare, fox, ptarmigan and white-tailed eagles in West Greenland.

North region 2005

In the area between Nordre Strømfjord and the Sukkertoppen Ice Cap, the March 2005 the index estimates of abundance, based on incidental observations were as follows:

- Muskox population was ca. 24,489 (18,410 – 30,568; 95% CI, CV= 12%, SE = 3,040). Most of these animals are in the core muskox range south of the Kangerlussuaq airport.
- Fox population was ca. 2,133, (-14 – 4,280; 95% CI, CV= 50%, SE = 1,073). The fox population index is based solely on the hi-density stratum, as no fox were observed in the low-density stratum.
- Hare population was ca. 12,667 (4,899 – 20,435; 95% CI, CV= 31%, SE = 3,884).
- Ptarmigan population ca. 207,133 (183,740 – 230,527; 95% CI, CV= 6%, SE = 11,697).

One eagle was observed, and we made no index of abundance.

Index estimates for the average number of animals sighted per kilometre flown were:

- Caribou hi-density stratum: muskox 0.1; fox 0.03; hare 0.11; ptarmigan 1.11; eagle 0
- Caribou lo-density stratum: muskox 0.8; fox 0; hare 0.02; ptarmigan 1.18; eagle 0.01

Central region 2005

In the area between the Sukkertoppen Ice Cap and Godthåbsfjord, the March 2005 index estimates of abundance, based on incidental observations were as follows:

- Fox population was ca. 343 (-1,372 – 2,058; 95% CI, CV= 249%, SE = 858). The fox population index is poor, based solely on one fox seen the hi-density stratum, as no fox were observed in the low-density stratum.
- Hare population was ca. 5,621 (1,952 – 9,289; 95% CI, CV= 31%, SE = 1,834).
- Ptarmigan population was ca. 25,447 (20,548 – 30,345; 95% CI, CV= 10%, SE = 2,449).

Five eagles were observed, and we made no index of abundance. Although muskox are known to inhabit the Central region, none were observed on the caribou survey transects.

Index estimates for the average number of animals sighted per kilometre flown were:

- Caribou hi-density stratum: muskox 0; fox 0.003; hare 0.05; ptarmigan 0.3; eagle 0.01
- Caribou lo-density stratum: muskox 0; fox 0; hare 0.01; ptarmigan 0.38; eagle 0.02

South region 2006

In the area between the Godthåbsfjord and Frederikshåb Isblink, the March, 2006 index estimates were as follows. Most animals were sighted in the northern Ameralik portion of the South region.

- Fox population was ca. 3,921 (837 – 7,005; 95% CI, CV= 39%, SE = 1,542).
- Hare population was ca. 6,709 (2,626 – 10,793; 95% CI, CV= 30%, SE = 2,042).
- Ptarmigan population was ca. 26,473 (21,946 – 31,000; 95% CI, CV= 9%, SE = 2,264),

No eagle or muskox were observed on the caribou survey transects in the South region.

Index estimates for the average number of animals sighted per kilometre flown were:

- Ameralik: muskox 0; fox 0.04; hare 0.07; ptarmigan 0.48; eagle 0
- Qeqertarsuatsiaat: muskox 0; fox 0.02; hare 0.01; ptarmigan 0.24; eagle 0

Resumé

I marts 2005 og 2006 blev tre regioner og fire rensdyrbestande overvåget fra helikopter for at undersøge bestandstætheden og flokstrukturen. I løbet af undersøgelserne blev der gjort tilfældige observationer af moskusokse, arktisk ræv, arktisk hare, fjeldrype og havørn. Vores viden om den relative forekomst eller udbredelse af disse fem arter i Vestgrønland er begrænset, og disse opportunistiske observationer er de eneste tilgængelige data, der beskriver populationens størrelse og den relative udbredelse af disse arter. Vi har beregnet et bestandsindeks ved hjælp af den samme stratificering af dyretæthed, som vi har benyttet til beregning af bestandstætheden af rensdyr. Da undersøgelsesmetoderne for alle regionerne er de samme, har det været muligt at beskrive udbredelsen og de relative tætheder, hvilket giver et tæthedsindeks over disse arters bestande. Vi har dermed skabt de første regionale indeks over bestandsstørrelsen af moskusokse, ræv, hare og fjeldrype i Vestgrønland. De få tilfældige observationer af havørne var ikke tilstrækkeligt til at kunne skabe et populationsindeks. Ingen af de arter, der er undersøgt i denne rapport, er på nuværende tidspunkt truede og er heller ikke underlagt for hård jagt.

Undersøgelsen af rensdyr fandt sted i marts måned. Vi observerede udelukkende moskusokser i Region Nord, selvom der også er en bestand i Region Midt. I forhold til de andre regioner havde Region Nord det højeste antal observationer og den højeste tæthed af hare og fjeldrype. Region Nord havde desuden en stor bestand, omend ikke den største, af ræve, mens der tilsyneladende kun var få ørne. Region Midt havde det højeste antal ørne og det laveste antal ræve og harer, mens antallet af fjeldryper svarede til eller lå under niveauet for Region Syd. Region Syd havde det største antal ræve og det næststørste antal harer og fjeldryper. De helt manglende observationer af ørne i Region Syd tyder på, at der er meget få ørne i denne region i marts måned.

Formålet med rensdyrundersøgelsen, som gav disse tilfældige observationer af moskusokse, ræv, hare, fjeldrype og ørn, har ikke været at vurdere bestandsstørrelsen af andre arter, der

blev observeret tilfældigt. De skøn, der vises nedenfor for moskusokse, ræv, hare, fjeldrype og ørn i Vestgrønland, er relative indeksestimater. De vil kunne benyttes til at vurdere udviklingen i bestandene, hvis de gentages med brug af de samme metoder. Andre tilsvarende og mere velstrukturerede undersøgelser, der er målrettet mod hver art, vil kunne give en kritisk vurdering af, i hvor høj grad ovenstående tilfældige observationer afspejler den faktiske størrelse af bestanden. Som et alternativ til indeksskønnene over bestandsstørrelser giver vi også et indeksskøn over det gennemsnitlige antal dyr, der observeres pr. fløjne kilometer.

Overvågning af disse arter er vigtigt og ønskværdigt som følge af den voksende sandsynlighed for ændringer i økosystemet pga. global opvarmning og den industrielle udvikling i det hidtil relativt uberørte vestgrønlandske miljø. Der planlægges og bygges veje i både Region Nord og Region Midt. Den forbrugende og ikke-forbrugende menneskelige udnyttelse vil stige, efterhånden som adgangen til regionerne bliver nemmere. Der er planlagt et aluminiumsanlæg, som vil betyde, at der anlægges mindst to vandkraftværker (med ændret vandstand/reservoirer) og et omfattende højspændingsnet i både Region Nord og Region Midt. Region Midt vil desuden blive påvirket af etableringen af en jernmine. Dette kan komme til at betyde store ændringer i økosystemet, herunder en åben mine, en rørledning (mulig forurening ved afstrømning), ændrede vandstande, veje, havn og muligvis en flyveplads. Der er adskillige udfordringer, og det er nødvendigt, at vi udbygger vores viden ud over vores eneste nuværende kilde, nemlig jægernes fangstudbytte. I mellemtiden giver indeksskønnene nedenfor de første data, der kan danne udgangspunkt for fremover at beskrive status og udvikling i bestanden af moskusokse, hare, ræv, fjeldrype og havørn i Vestgrønland.

Region Nord 2005

For området mellem Nordre Strømfjord og Sukkertoppen var bestandsindekset for marts 2005, baseret på tilfældige observationer, som følger:

- Bestanden af moskusokser var på ca. 24.489 (18.410 – 30.568; 95 % konfidensinterval (CI); 12 % variationskoefficient (CV) og 3.040 standardfejl (SE)). De fleste af disse dyr findes i moskusoksernes primære leveområde syd for Kangerlussuaq lufthavn.
- Rævebestanden var på ca. 2.133 (-14 – 4.280; 95 % CI, CV=50 % og SE=1.073). Populationsindekset for rævebestanden er udelukkende baseret på det stratum med høj tæthed, da der ikke blev observeret ræve i det stratum med lav tæthed.
- Harebestanden var på ca. 12.667 (4.899 – 20.435; 95 % CI, CV=31 % og SE=3.884).
- Fjeldrypebestanden var på ca. 207.133 (183.740 – 230.527; 95 % CI, CV=6 % og SE=11.697).

Der blev observeret en enkelt ørn, og vi lavede derfor ikke noget bestandsindeks.

Indeksestimaterne for det gennemsnitlige antal dyr, observeret pr. fløjne kilometer, var:

- Høj rensdyrtæthed stratum: moskus 0,1; ræv 0,03; hare 0,11; fjeldrype 1,11 og ørn 0.
- Lav rensdyrtæthed stratum: moskus 0,8; ræv 0; hare 0,02; fjeldrype 1,18 og ørn 0,01.

Region Midt 2005
For området mellem Sukkertoppen og Godthåbsfjord var bestandsindekset for marts 2005, baseret på tilfældige observationer, som følger:

- Rævebestanden var på ca. 343 (-1.372 – 2.058; 95 % CI, CV=249 % og SE=858). Populationsindekset for rævebestanden er udelukkende baseret på en enkelt ræv i det stratum med høj tæthed, da der ikke blev observeret ræve i det stratum med lav tæthed.
- Harebestanden var på ca. 5.621 (1.952 – 9.289; 95 % CI, CV=31 % og SE=1.834).
- Fjeldrypebestanden var på ca. 25.447 (20.548 – 30.345; 95 % CI, CV=10 % og SE=2.449).

Der blev observeret fem ørne, og vi lavede derfor ikke noget bestandsindeks. Selvom moskusokserne vides at leve i Region Midt, blev der ikke observeret nogen i rensdyrundersøgelsen.

Indeksestimaterne for det gennemsnitlige antal dyr, observeret pr. fløjne kilometer, var:

- Høj rensdyrtæthed stratum: moskus 0; ræv 0,003; hare 0,05; fjeldrype 0,3 og ørn 0,01.
- Lav rensdyrtæthed stratum: moskus 0; ræv 0; hare 0,01; fjeldrype 0,38 og ørn 0,02.

Region Syd 2006
I området mellem Godthåbsfjord og Frederikshåb Isblink var indekset for marts 2006 som følger. Der blev observeret flest dyr i det nordlige Ameralik-område af Region Syd.

- Rævebestanden var på ca. 3.921 (837 – 7.005; 95 % CI, CV=39 % og SE=1.542).
- Harebestanden var på ca. 6.709 (2.626 – 10.793; 95 % CI, CV=30 % og SE=2.042).
- Fjeldrypebestanden var på ca. 26.473 (21.946 – 31.000; 95 % CI, CV=9 % og SE=2.264).

Der blev ikke observeret nogen ørne eller moskusokser i Region Syd i rensdyrundersøgelsen.

Indeksestimaterne for det gennemsnitlige antal dyr, observeret pr. fløjne kilometer, var:

- Ameralik: moskus 0; ræv 0,04; hare 0,07; fjeldrype 0,48 og ørn 0.
- Qeqertarsuatsiaat: moskus 0; ræv 0,02; hare 0,01; fjeldrype 0,24 og ørn 0.

Naalisagaq
2005-imi 2006-imilu marts qaammataagaa nunap immikkoortui pingasut tuttoqatigiillu sisamat helikopterimik alaatsinaanneqarput qanoq eqimatiginerat qanorlu katitigaanerat misissorlugu. Misissuinerup ingerlanerani takuneqartarput umimmaat, terianniat, ukallit, aqissit nattorallillu. Uumasunik taakkuninnga tallimanik qanoq peqatigineranut sumullu Kitaani siammarsimanerannut tunngatillugu ilisimasagut annertunngillat, taamatullu nalaatsornerinnangajakkut takunnittarnerit tassa qanoq peqartigineranik sumiittarnerannillu paasissutissat pigineqartutuaapput. Qanoq tamakkuninnga peqartigineranut takussutissamik naatsorsuisimavugut qanoq tuttoqartigineranik

naatsorsueriaaseq atorlugu. Nunap immikkoortuini tamani misissueriaaseq assigiimmat qanoq peqartiginera qanorlu nalinginnaatiginerat nassuiarneqarsinnaasimavoq, taamaattumillu uumasunut taakkununnga tunngatillugu qanoq peqartigineranut takussutissaqalersimalluni. Taamaalilluta nunap immikkoortuini umimmaat, terianniat, ukallit aqissillu Kitaani qanoq peqartigineranut takussutissamik aatsaat peqalersimavugut. Taamatut akuttugaluartunik nattoralinnik takusarneq qanoq nattoraleqartigineranut takussutaassalluni naammanngilaq. Uumasut nalunaarummi uani misissorneqarsimasut massakkorpiaq navianartorsiortitaanngillat annertuumilluunniit piniarneqartuunatik.

Tuttunik misissuineq qaammammi martsimi ingerlanneqarpoq. Region Nord-iinnarmi umimmannik takuvugut, naak aamma Region Midt-imi peqaraluartoq. Regioninut allanut naleqqiullugu Region Nord amerlanerpaanik takuffiuvoq aammalu ukallinik aqissinillu naammattuikulanarnerulluni. Region Nord teriannianik pilerujussuuvortaaq, immaqami peqarnerpaalluni, kisiannili soorlu nattoralii ikittuinnaasut. Region Midt nattoraleqarnersaavoq, terianniakinnersaalluni aqissiili Region Syd-misut amerlatigalutik ikinnerulaarlutilluunniit. Region Syd terianniaqarnersaavoq, ukaleqarnerpaamut aqisseqarnerpaamullu tulliulluni. Region Syd-imi nattoralinnik takkuitsuuinnikkut regionimi tassani martsip qaammataani nattorallit ikittuinnaasarsimasut pasinarpoq.

Tuttunik misissuinermi tassani nalaatsornikkut umimmannik, teriannianik, ukallinik aqissinik nattoralinnillu takuffiusumi uumasunik allanik nalaatsornikkut takusanik amerlassusiliinissaq siunertaasimanngilaq. Kitaani umimmannut, teriannianut, ukallinut, aqissinut nattoralinnullu tunngatillugu naliliinerit missingersuutaannaanerupput. Uumasoqatigiit allanngoriartornerannik naliliiniarnermi atorneqarsinnaapput periaaseq taanna atorlugu uteqqiattumik misissuiffigineqarpata. Misissuinerit allat assingusut aammalu aaqqissuussaalluarnerusut uumasunut ataasiakkaanut sammisitat peqqissaartumik naliliisitsisinnaassapput taamatut nalaatsornikkut takusat ilumut amerlassutsimut takussutissaanersut. Qanoq peqartigineranut takussutissatut naliliinermi uumasut agguaqatigiissitsisumik qanoq amerlatigisut kilometerimi ataatsimi timmisartorfiusumi takuneqarsinnaanerat pissarsiarineqarportaaq.

Uumasunik taakkuninnga Kitaani avatangiisini allannguuteqarsimanngingajalluinnartumi nakkutilliinissaq pingaaruteqarlunilu uumasoqatigiit nuanarsuarmi kiatsikkiartornerup suliffissuaqarnerullu annertusiartornerata kinguneranik allannguuteqariartornerusinnaanerat malittarisinnaajumaallugu kissaatiginarpoq. Region Nord-imi Region Midt-imilu aqqusinniornissaq pilersaarutigineqarluni ingerlanneqareerpoq. Inuit atuisut atuinngitsullu atuinerat regioninut isernissap ajornaalliartornera peqatigalugu annertusiumaarpoq. Aluminiuliorfeqalernissaa pilersaarutigineqarpoq, tamatumalu imeq atorlugu nukissiorfinnik minnerpaamik marlunnik sanasoqarnissaa (erngup qaffarneranik/imiisiveqalernermik) aammalu innaallagissap sakkortuup aqqutissarpassuinik Regionimi Nord-imi Region Midt-imilu sanaartorneq kingunerissavaa. Region Midt aamma saviminissamik piiaavimmik pilersitsiniarnermit sunnerneqartussaavoq. Tamanna uumasoqarfimmi pissutsinik annertoorujussuarnik allannguuteqartitsisinnaavoq, tassunga ilaalluni ammasumik piiaaveqalerneq, ruujorinik aqqusersuineq (seeriulaartitsinikkut mingutitsinermik kinguneqarsinnaasoq) erngup qaffasissusiata allanngornera, aqqusernit, umiarsualivik immaqalu mittarfik. Unammiugassaaluppassuupput, pisariaqarporlu ilisimasatsinnik annertusaanissarput ullumikkut pissarsiffigisagatuatta, tassa piniartut pisarisartagaasigut pissarsiarisartakkatta, saniatigut. Tamatuma tungaanut peqassutsimut takussutissiat matuma ataaniittut siunissami Kitaani umimmannut, ukallinut, teriannianut, aqissinut nattoralinnullu peqassutsimik allanngoriartortoqarneranillu misissuinermi aallaaviulersinnaapput.

Region Nord 2005

Nassuttuup Maniitsullu akornanni martsimi 2005-imi nalaatsornikkut takusat tunngavigalugit peqarneranut takussutissat makkuupput:

- Umimmaat 24.489 (18.410 – 30.568; 95 % konfidensinterval (CI); 12 % variationskoefficient (CV) og 3.040 standardfejl (SE)) missiliorpaat. Umimmaat taakkua amerlanersaat najugannaaminni Kangerlussuarmi mittarfiup kujataaniittumiipput.
- Terianniat. 2.133 (-14 – 4.280; 95 % CI, CV=50 % og SE=1.073) missiliorpaat. Terianniaqassusianut takussutissanut taamaallaat takussaaffiginerusaanni peqassusia tunngavigineqarpoq, piisaffianimi takusaqartoqanngimmat.
- Ukallit 12.667 (4.899 – 20.435; 95 % CI, CV=31 % og SE=3.884) missiliorpaat.
- Aqissit 207.133 (183.740 – 230.527; 95 % CI, CV=6 % og SE=11.697) missiliorpaat.

Nattoralik ataasiinnaq takuneqarpoq, taamaattumik peqarneranut takussutissamik sananngilagut.

Uumasunut pineqartunut ataasiakkaanut tunngatillugu kilometerimi ataatsimi timmiffiusumi takuneqartunut agguaqatigiissitsineq imaappoq:

- Peqarfimmi tuttoqartorujussuarmi: umimmak 0,1; terianniaq 0,03; ukaleq 0,11; aqisseq 1,11 aamma nattoralik 0.
- Peqarfimmi tuttuisattumi: umimmak 0,8; terianniaq 0; ukaleq 0,02; aqisseq 1,18 aamma nattoralik 0,01.

Region Midt 2005

Maniitsup Nuup Kangerluatalu akornanni martsimi 2005-imi nalaatsornikkut takusat tunngavigalugit peqarneranut takussutissat makkuupput:

- Terianniat 343 (-1.372 – 2.058; 95 % CI, CV=249 % og SE=858) missiliorpaat. Terianniaqarneranut takussutissaq taamaallaat tunngaveqarpoq peqarfiulluartumi terianniamik ataatsimik takuneq, piisaffiunerusumimi takusaqartoqanngilaq.
- Ukallit 5.621 (1.952 – 9.289; 95 % CI, CV=31 % og SE=1.834) missiliorpaat .
- Aqissit 25.447 (20.548 – 30.345; 95 % CI, CV=10 % og SE=2.449) missiliorpaat.

Nattorallit tallimat takuneqarput, taamaattumillu peqarneranut takussutissamik sananngilagut. Region Midt-imi umimmaqartoq naluneqanngikkaluartoq tuttunik misissuinermut atatillugu tamaani takusaqartoqanngilaq.

Takusssutissanik amerlassusiliinerit uumasunut pineqartunut kilometerimut timmisartorfiusumut ataatsimut agguaqatigiissinneri imaapput:

- Peqarfimmi tuttoqartorujussuarmi: umimmak 0; terianniaq 0,003; ukaleq 0,05; aqisseq 0,3 aamma nattoralik 0,01.
- Peqarfimmi tuttuisattumi: umimmak 0; terianniaq 0; ukaleq 0,01; aqisseq 0,38 aamma nattoralik 0,02.

Region Syd 2006

Nuup Kangerluata Sioqqallu akornanni martsimi 2006-imi takussutissat imaapput. Uumasut amerlanersaat Region Syd-imi Amerallup avannarpasinnerusortaani takuneqarput.

- Terianniat 3.921 (837 – 7.005; 95 % CI, CV=39 % og SE=1.542) missiliorpaat.
- Ukallit 6.709 (2.626 – 10.793; 95 % CI, CV=30 % og SE=2.042) missiliorpaat.
- Aqissit 26.473 (21.946 – 31.000; 95 % CI, CV=9 % og SE=2.264) missiliorpaat.

Region Syd-imi tuttunik misissuinermi nattoralinnik umimmannilluunniit takusoqanngilaq.

Takusssutissanik amerlassusiliinerit uumasunut pineqartunut kilometerimut timmisartorfiusumut ataatsimut agguaqatigiissinneri imaapput:

- Ameralik: umimmak 0; terianniaq 0,04; ukaleq 0,07; aqisseq 0,48 aamma nattoralik 0.
- Qeqertarsuatsiaat: umimmak 0; terianniaq 0,02; ukaleq 0,01; aqisseq 0,24 aamma nattoralik 0.

Introduction

The terrestrial ecosystem of West Greenland lacks diversity in mammalian wildlife. There are the caribou/reindeer (*Rangifer tarandus spp.*), muskox (*Ovibos moschatus*), arctic fox (*Alopex lagopus*) and arctic hare (*Lepus arcticus*), and only three of these are indigenous to West Greenland. Muskox were brought in from northeast Greenland about 45 years ago and released in the North region (Figure 1) during the 1960's. Further, few terrestrial avian species reside in West Greenland year round; among these are the ptarmigan (*Lagopus mutus*) and white-tailed eagle (*Haliaeetus albicilla*).

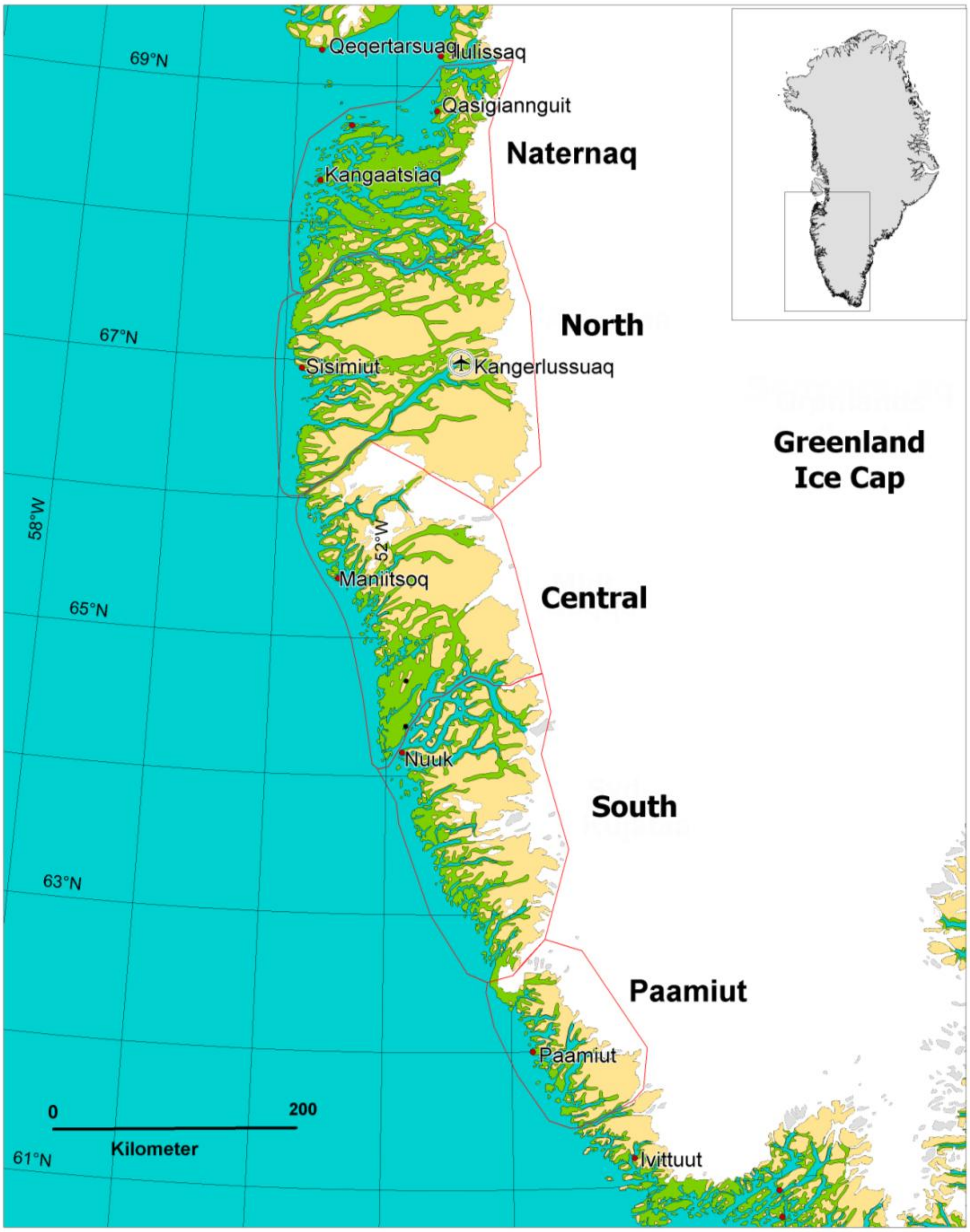

Figure 1. Caribou regions of West Greenland and basis for caribou surveys. This report describes results for the North, Central and South regions.

Because of their economic and cultural significance, aerial surveys monitoring caribou abundance have been common in West Greenland since 1990. The muskox, which have steadily gained in economic importance since their introduction, have been monitored regularly since 2000 using minimum count ground surveys. The primary focus of the minimum counts, however, has only been in the area south of the Kangerlussuaq airport and does not include the entire North region.

Although the arctic fox is not an important game species, attention has been drawn to it as a nuisance for human settlements, and some municipalities have paid a bounty for hunting them. In the 10-year period 1996 to 2005, a total average of 2,406 ± 269 (S.D.) arctic foxes were harvested annually in all of Greenland (Greenland Self Rule, unpublished data).

Arctic hare are hunted for human consumption, but their contribution to household economies is relatively low compared to other game species. A total average annual harvest of 3,294 ± 978 (S.D.) arctic hares were reported yearly in Greenland for the 10-year period 1996 to 2005 (Greenland Self Rule, unpublished data).

Ptarmigan are a popular game mainly used for private consumption, with total average annual catches of 35,478 ± 11,491 (S.D.) for the 10-year period 1996 to 2005 (Greenland Self Rule, unpublished data).

Since 1973, white-tailed eagles have been totally protected by law due to reduced population numbers. About 20 years ago, the breeding population in Greenland was estimated to number 150-170 pairs, and today the eagle is listed as "vulnerable" in the Greenland Red List (Kampp & Wille 1990; Boertmann 1994, Boertmann 2008).

An understanding of the numbers and distribution of all these species is relevant, because, beyond caribou, these species represent the entire diversity of mammalian wildlife and two principal avian species in West Greenland. To date, there have been no surveys of abundance for arctic fox, arctic hare or ptarmigan West Greenland, nor were incidental observations of these species noted in previous caribou surveys.

Background North region

The North region, also known as caribou hunting region 2, is approximately 26,000 seasonally ice-free km^2 in the vicinity of the Arctic Circle (67°N) in West Greenland (Figures 1 & 2). It is made up of mountains, open rough upland or alpine tundra. An approximately 200 km long fjord (Nordre Strømfjord) marks the northern border of the region. This fjord cuts all the way from the seacoast to the Greenland Ice Cap. The southern border is marked by the western extent of the long Kangerlussuaq fjord in combination with the relatively small ice cap, Sukkertoppen, which has also been described as a large glacial tongue of the Greenland Ice Cap. The western boundary is the Davis Strait seacoast, while the range's eastern border is the expanse of the Greenland Ice Cap. The region's largest human settlement is Sisimiut, a seacoast city of about 5,000, while a further 200-300 people live in smaller coastal settlements. Greenland's largest International airport (SFJ: Kangerlussuaq / Søndre Strømfjord) is located far inland near the Greenland Ice Cap. Roads are typically limited to the settlements, do not link settlements, and do not penetrate the terrain. The exception is the ca. 40 km dirt road linking the Kangerlussuaq airport with the Greenland Ice Cap.

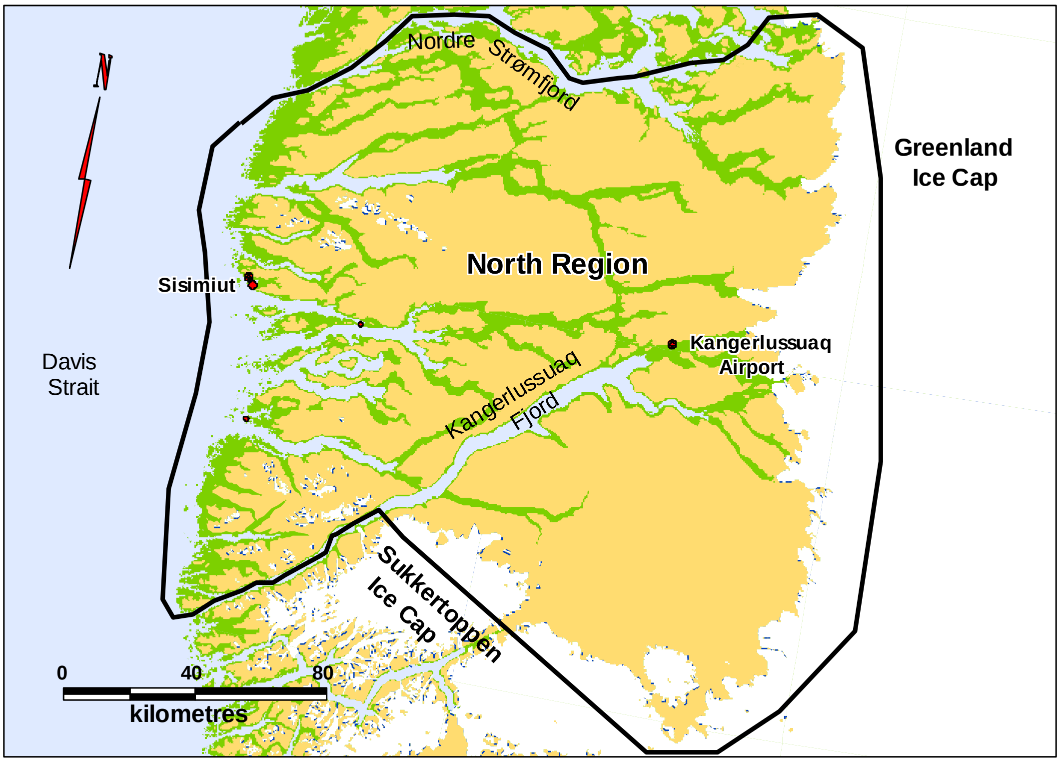

Figure 2. Details of the North region; area within black outline is ca. 26,000 sq km.

Background Central region

The Central region, also known as caribou hunting region 3, is approximately 15,362 seasonally ice-free km2 of coastal plain, open rough upland, mountains, or alpine tundra between ca. 64-66°N in West Greenland (Figure 3). The northern border is marked by the long Kangerlussuaq fjord in combination with the relatively small ice cap, Sukkertoppen, which has also been described as a large glacial tongue of the Greenland Ice Cap. The southern boundary is formed by Godthåbsfjord, which cuts all the way from the seacoast to the Greenland Ice Cap. The western boundary is the Davis Strait seacoast, while the eastern border is the expanse of the Greenland Ice Cap. The region's largest human settlement is Maniitsoq, a seacoast city of about 5,000, while some hundreds more live scattered along the seacoast in 3 or 4 smaller settlements. However, Greenland's capital, Nuuk, with a population of ca. 15,000, is nearby on the south side of Godthåbsfjord. The only development in the area is a Serpentine mine located within Fiskefjord, which is accessable only by ship or boat. Outside of the immediate area of the mine, there appears to have been little impact on the region. Currently roads are limited to the settlements, do not link settlements, and do not penetrate the terrain.

In the near future, there are plans to develop an aluminium smelter in Maniitsoq, and an iron ore mine close to the icecap in the northern part of Godhåbsfjord. Both facilities will have associated infrastructure, including hydroelectric power plants, power lines, roads and harbours.

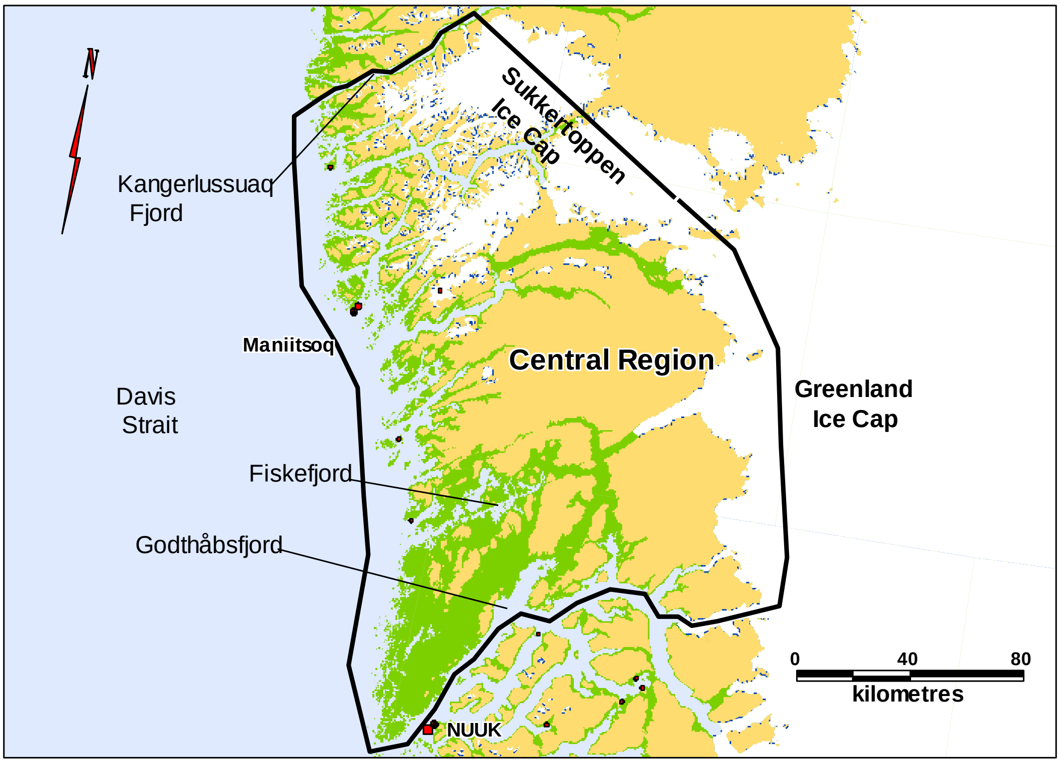

Figure 3. Details of the Central region; area within black outline is ca. 15,362 sq km.

Background South region

The South region, known as caribou hunting regions 4 & 5, is ca. 13,473 seasonally ice-free km^2. Steep sided fjords and a rugged alpine terrain characterize this region (Figure 4). Coastal lowlands are minimal and much of the region is above 200 metres elevation. The northern border is the large Godthåbsfjord, which cuts from the seacoast to the Greenland Ice Cap. The Frederikshåb Isblink, which is a large glacial tongue of the Greenland Ice Cap, forms the southern boundary. To the west is the Davis Strait seacoast, and to the east the Greenland Ice Cap. The region is divided into two areas, the northern Ameralik (8,377 km^2, hunting region 4) and the southern Qeqertarsuatsiaat (ca. 5,096 km^2, hunting region 5). The region's largest human settlement is Greenland's capital city, Nuuk, a seacoast city of about 15,000 on the region's northern border at the mouth of Godthåbsfjord. Otherwise there are only two small hamlets; Kapisillit, located in the inner reaches of Godthåbsfjord, and Qeqertarsuatsiaat, situated on the seacoast about 100 km south of Nuuk. Development of the region is limited to a hydro power plant at the head of Buksefjord, with transmission line to Nuuk. As with the North and Central regions, roads are limited to the settlements, do not link settlements, and do not penetrate the terrain.

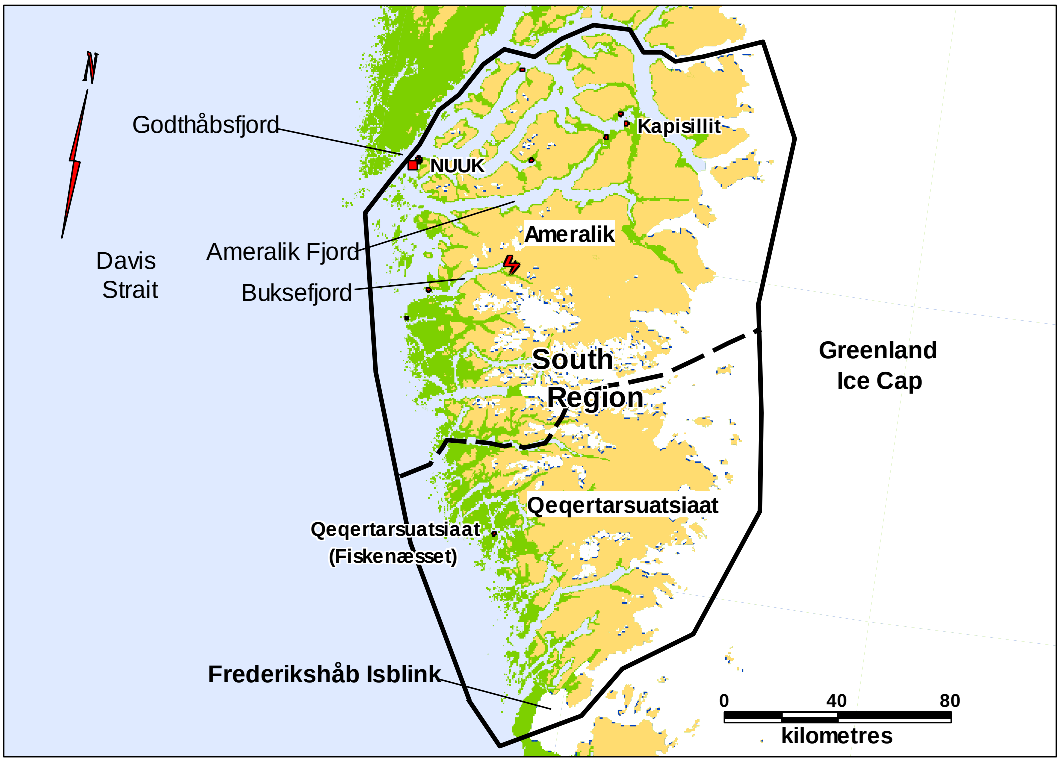

Figure 4. Details of the South region; area within solid black outline is ca. 13,473 sq km. The northern Ameralik (8,377 sq km) and southern Qeaertarsuatsiaat (5,096 sq km) areas are separated by the hatched black line.

Surveys

In March 2005 and 2006 aerial surveys by helicopter covered the North, Central and South regions of West Greenland. These surveys were designed to investigate the abundance and herd structure of four caribou populations. This report presents the incidental observations of musk ox, foxes, hares, ptarmigan and eagles, and provides rough index estimates of abundance for musk ox, fox, hare and ptarmigan.

Methods

In March 2005 and 2006, we completed caribou surveys in the North, Central and South regions of West Greenland. Details of the survey design and methods were described by Cuyler et al. (2005, 2007), can be found in appendices 1 & 2, and are given here in brief. The aerial caribou survey was designed as a stratified strip-transect count. The North and Central regions were stratified into areas of expected low and high caribou density prior to assigning random transects for survey. We do not suggest that the stratification reflecting caribou density necessarily applies to other species, specifically muskox. However, re-stratifying and analysing the incidental species after the survey was done was not attempted, because this would negate a randomised strata sample, potentially giving biased results. No stratification was used in the South region because of unclear distribution of caribou densities in the region. For all regions, computer generated random transects were presented using MapInfo software. Transects were 7.5 km long, and included islands, lakes and rivers, but omitted Ice Caps and glaciers.

Incidental observations were collected during helicopter surveys for caribous using a strip-tansect method (Cuyler et al. 2005, 2007). We used an Air Greenland AS350 helicopter (OY-HGO), which could follow terrain features, while maintaining a constant low altitude above ground level. We flew at 46-65 km/hour. Ambient wind direction and speed determined the necessary flight speed to remain airborne. We maintained a constant altitude of 15 metres (50 feet). The total strip width for caribou observations was 600 metres (300 m to either side of the helicopter). Because musk ox could be readily spotted we applied the same strip width to musk ox observations. However, arctic fox and hare were allocated a 100-metre total strip width, because these were only ever sighted on or near the zero line, i.e., directly under the helicopter or within 50 metres to the side. Ptarmigan spooked and flew at distances up to ca. 100 metres from the zero line and were given a 200-metre total strip width.

Three out of four experienced observers ((a caribou scientist, a wildlife officer and two full-time hunters) were in the survey helicopter at any one time. Two observers, on left side of helicopter, counted the same strip area, while the third observer was alone on the right. As each transect was completed and the caribou count recorded, observers then reported the number and species of other animals seen along the transect line.

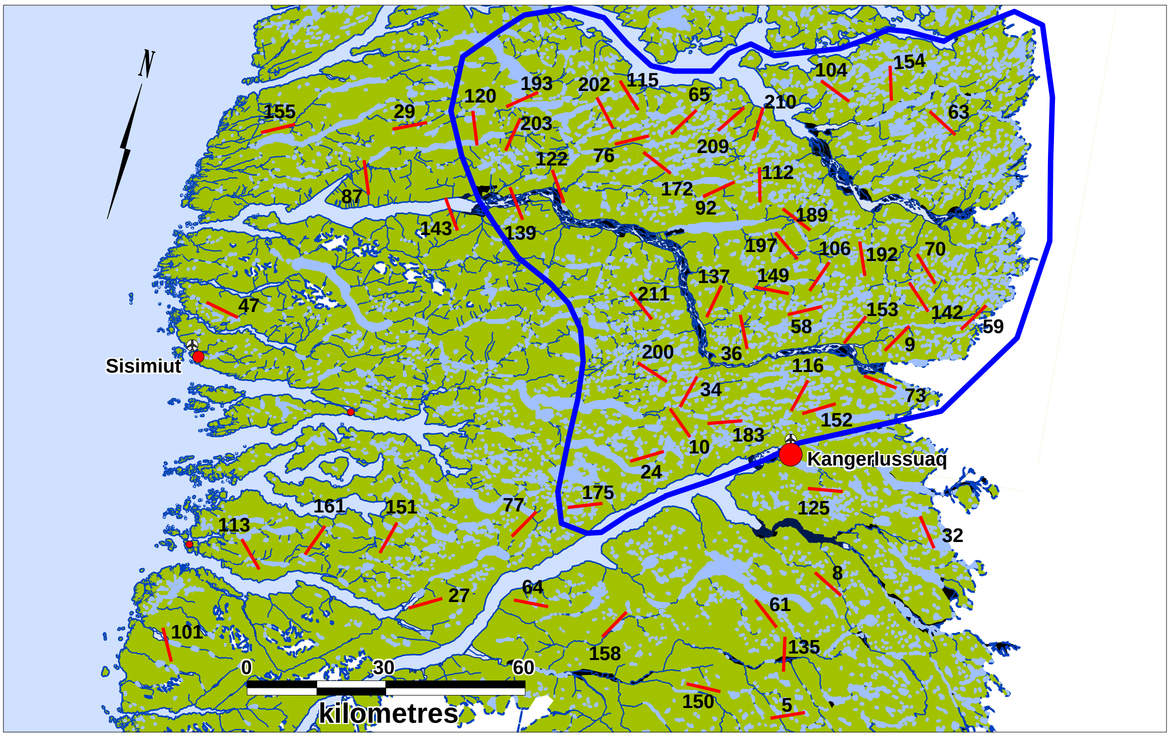

Figure 5. North region, showing the sixty transect lines, with ID numbers and stratification used for the 2005 aerial caribou survey. Caribou hi-density stratum is outlined in blue. Elevation is not shown.

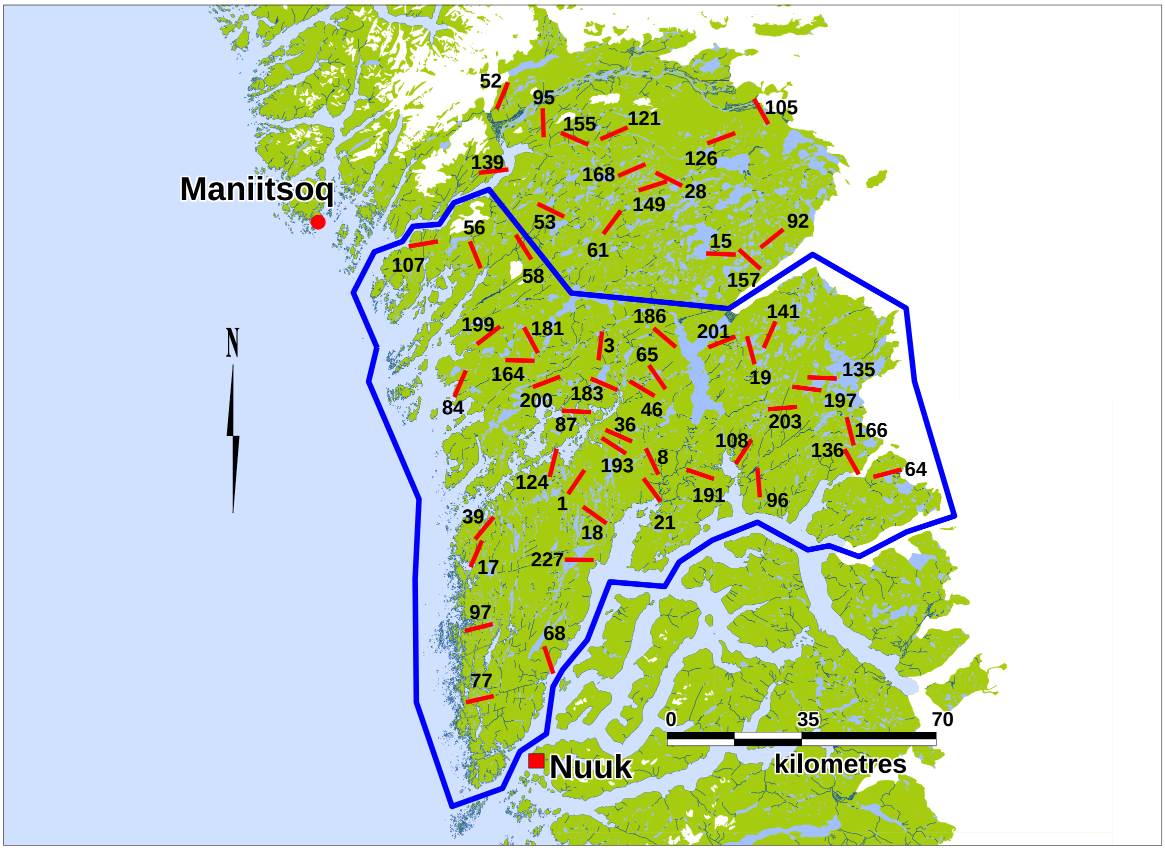

Figure 6. Central region, showing the fifty-four transect lines, with ID numbers and stratification used for the 2005 aerial caribou survey. Caribou hi- density stratum is outlined in blue. Elevation is not shown.

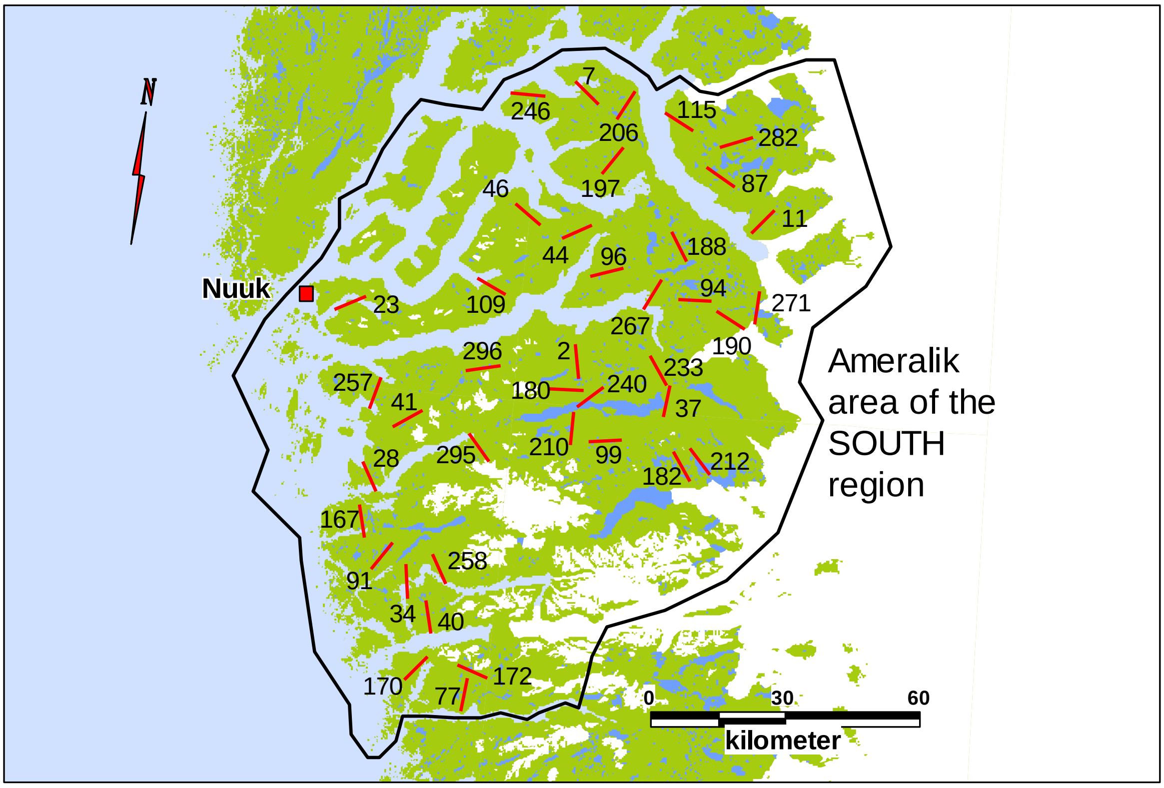

Figure 7. Forty transect lines, with ID numbers used for the 2006 aerial caribou survey of the Ameralik area in the South region. Elevation is not shown.

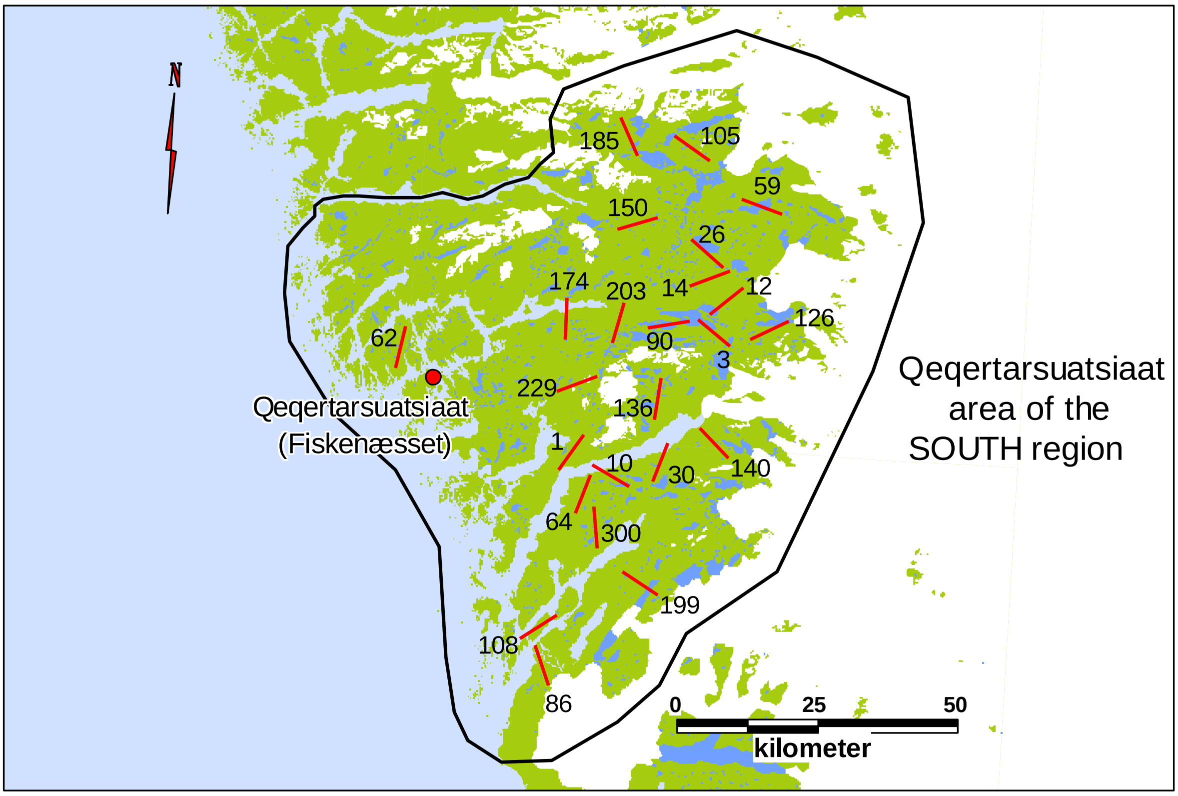

Figure 8. Twenty-four transect lines, with ID numbers used for the 2006 aerial caribou survey of the Qeqertarsuatsiaat / Fiskenæsset area in the South region. Elevation is not shown.

We surveyed the North region from 18-22 March 2005 using two strata (Figure 5). The high caribou density stratum was 8,000 km^2 and the low density was 18,000 km^2. We used a total of 60 random transects, 40 in the hi-density stratum and 20 in the lo-density stratum.

We surveyed the Central region from 14-16 March 2005 using two strata (Figure 6). The high caribou density stratum was 10,037 km^2 and the low density was 5,325 km^2. We used a total of 54 random transects, 39 in the hi-density stratum and 15 in the lo-density stratum.

We surveyed the South region from 11-15 March 2006 using a total of 64 random transects lines (Figures 7, 8). There was no stratification for caribou density. The northern Ameralik area received 40 transects, and the southern Qeaertarsuatsiaat area 24 transects.

The incidental observations presented in this report were primarily animal sighting, which were positive proof of presence. We do not claim to have seen all animals present on survey transects. Rather we assume many were missed, as hares and foxes tend to hide. Hence, although sightings of tracks depends not only on the density of animals but may also be influenced by other factors among them quality of the snow and wind, in the Central and South regions proof of presence included animal tracks. Animal tracks were accepted as evidence of animal presence if the tracks were separated by great distance, e.g. over 40 km. Twice in the Ameralik area of the South region, distance was ignored for fox tracks because it was obvious from the tracks themselves, that these were two foxes gambolling / playing with each other.

Further to the index estimates of abundance obtained through the analyses described in appendix 2, we also calculated the average number of sightings per kilometre for each species by using each transect line as a sample unit.

Results

North region

In the North region, we observed 145 muskox, 8 fox, 37 hare, 605 ptarmigan and 1 eagle (Tables 1-5; Figures 9, 10 & 14). For fox there were no observations in the lo-density stratum and therefore no variance. Our 2005 caribou survey of the North region used ca. 26 ½ hours of flying time. Weather conditions the first two days were excellent; however, snow cover was often completely lacking, and was typically patchy at best. Typical snow cover was 10-40%, although occasionally up to 99%. On the third and fourth days of the survey, a light dusting of new fallen snow produced a "salt & pepper" background, against which all animals were well camouflaged. Snow flurries and low cloud-fog further increased the difficulty in spotting animals, by obscuring strip width visibility and often creating whiteout conditions. Raw data for all regions are found in appendices 3-5.

Central region

In the Central region, we observed one fox, 16 hare, 132 ptarmigan and five eagles. We observed no muskox. Our 2005 survey of the Central region used ca. 20 hours of flying time. Weather conditions were excellent for strip visibility and animal sightability. Snow cover, however, was patchy and could vary dramatically along an individual transect. This increased the difficulty in spotting animals. Snow cover in the high-density stratum varied between 10 and 99%, but normally was 40 to 80%. As usual the low-density stratum, which is the northern portion of this region, was almost totally covered in deep snow.

South region

In the South region, we observed a total of 14 fox, 24 hare and 189 ptarmigan. We observed no muskox or eagles. Our 2006 survey of the South region used ca. 26 hours of flying time. Weather conditions between the 11 and 15 March 2006 were excellent for strip visibility.

Relative distribution & density

We observed muskox only in the North region, although they are present in at least the Central region. Relative to the other regions, the North region had the highest number of incidental observations and highest density of hare and ptarmigan (Figures 10-17). Further, although not the highest, fox were also abundant in the North region, while eagles appeared scarce. The Central region had the highest number of eagle observations and the lowest number of fox and hare, while ptarmigan were similar or lower than the South region. The South region had the highest number of fox observations, and the second highest number of hare and ptarmigan. By virtue of the absence of observations, eagles appeared scarce in the South region.

Table 1. Incidental observations of **arctic fox** (*Alopex lagopus*) made during caribou surveys in the North, Central and South regions of West Greenland. The transects/strips were 7.5 km long and 0.1 km wide, which gave each transect/strip an area of 0.75 km². Caribou Hi-density and Caribou Lo-density are the strata used for the caribou surveys, which reflect the density of caribou in the area.

ARCTIC FOX Region	Region Area (km²)	Number Transects	Total Transect Area (km²)	Arctic fox Observed	Arctic fox Density ±SD
NORTH					
Caribou Hi-density	8,000	40	30	8	0.267 ± 0.41
Caribou Lo-density	16,000	20	15	0	0
Total North	**26,000**	**60**	**45**	**8**	--------
CENTRAL					
Caribou Hi-density	10,037	39	29.25	1	0.034 ± 0.16
Caribou Lo-density	5,325	15	11.25	0	0
Total Central	**15,362**	**54**	**40.5**	**1**	--------
SOUTH					
Ameralik	8,377	40	30	11	0.367 ± 0.55
Qeqertarsuatsiaat	5,096	24	18	3	0.167 ± 0.34
Total South	**13,473**	**64**	**48**	**14**	--------

Table 2. Incidental observations of **arctic hare** (*Lepus arcticus*) made during caribou surveys in the North, Central and South regions of West Greenland. The transects/strips were 7.5 km long and 0.1 km wide, which gave each transect/strip an area of 0.75 km². Caribou Hi-density and Caribou Lo-density are the strata used for the caribou surveys, which reflect the density of caribou in the area.

ARCTIC HARE Region	Region Area (km²)	Number Transects	Total Transect Area (km²)	Arctic hare Observed	Arctic hare Density ±SD
NORTH					
Caribou Hi-density	8,000	40	30	34	1.133 ± 1.59
Caribou Lo-density	16,000	20	15	3	0.200 ± 0.37
Total North	**26,000**	**60**	**45**	**37**	--------
CENTRAL					
Caribou Hi-density	10,037	39	29.25	15	0.513 ± 0.54
Caribou Lo-density	5,325	15	11.25	1	0.089 ± 0.26
Total Central	**15,362**	**54**	**40.5**	**16**	--------
SOUTH					
Ameralik	8,377	40	30	22	0.733 ± 1.09
Qeqertarsuatsiaat	5,096	24	18	2	0.111 ± 0.41
Total South	**13,473**	**64**	**48**	**24**	--------

Table 3. Incidental observations of **ptarmigan** (*Lagopus mutus*) made during caribou surveys in the North, Central and South regions of West Greenland. The transects/strips were 7.5 km long and 0.2 km wide, which gave each transect/strip an area of 1.5 km². Caribou Hi-density and Caribou Lo-density are the strata used for the caribou surveys, which reflect the density of caribou in the area

PTARMIGAN Region	Region Area (km²)	Number Transects	Total Transect Area (km²)	Ptarmigan Observed	Ptarmigan Density ±SD
NORTH					
Caribou Hi-density	8,000	40	60	334	5.567 ± 12.45
Caribou Lo-density	16,000	20	30	271	9.033 ± 17.77
Total North	**26,000**	**60**	**90**	**605**	--------
CENTRAL					
Caribou Hi-density	10,037	39	58.5	89	1.521 ± 2.41
Caribou Lo-density	5,325	15	22.5	43	1.911 ± 3.85
Total Central	**15,362**	**54**	**81**	**132**	--------
SOUTH					
Ameralik	8,377	40	60	145	2.417 ± 5.20
Qeqertarsuatsiaat	5,096	24	36	44	1.222 ± 2.22
Total South	**13,473**	**64**	**96**	**189**	--------

Table 4. Incidental observations of **muskox** (*Ovibos moschatus*) made during caribou surveys in the North region. The transects/strips were 7.5 km long and 0.6 km wide, which gave each transect/strip an area of 4.5 km². Caribou Hi-density and Caribou Lo-density are the strata used for the caribou surveys, which reflect the density of caribou in the area.

MUSKOX North Region	Region Area (km2)	Number Transects	Total Transect Area (km2)	Muskox Observed	Muskox Density ±SD
Caribou Hi-density	8,000	40	180	29	0.161 ± 4.11
Caribou Lo-density	18,000	20	90	116	1.289 ± 11.14
Total North	**26,000**	**60**	**270**	**145**	--------

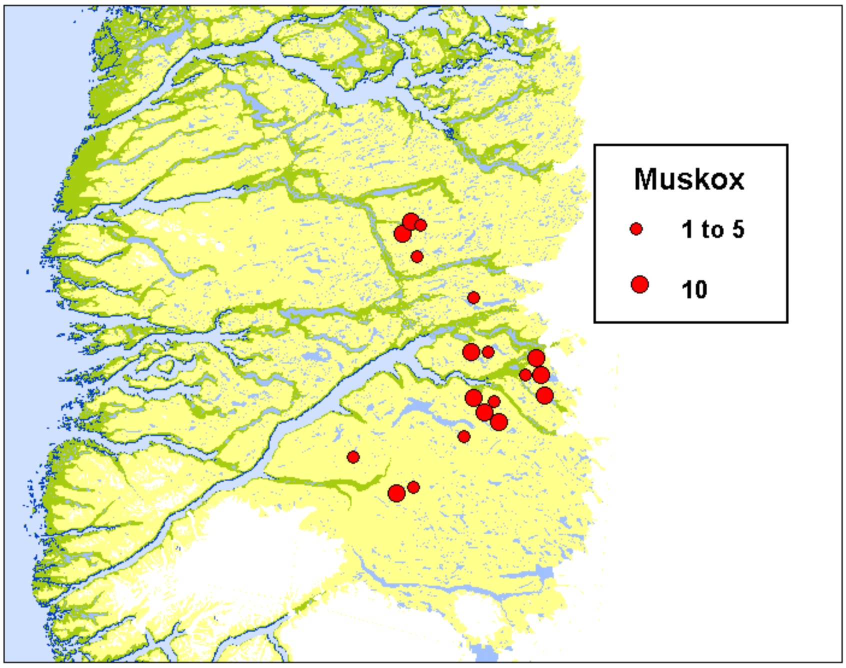

Figure 9. *Locations of incidental muskox observations in the North region, March 2005.*

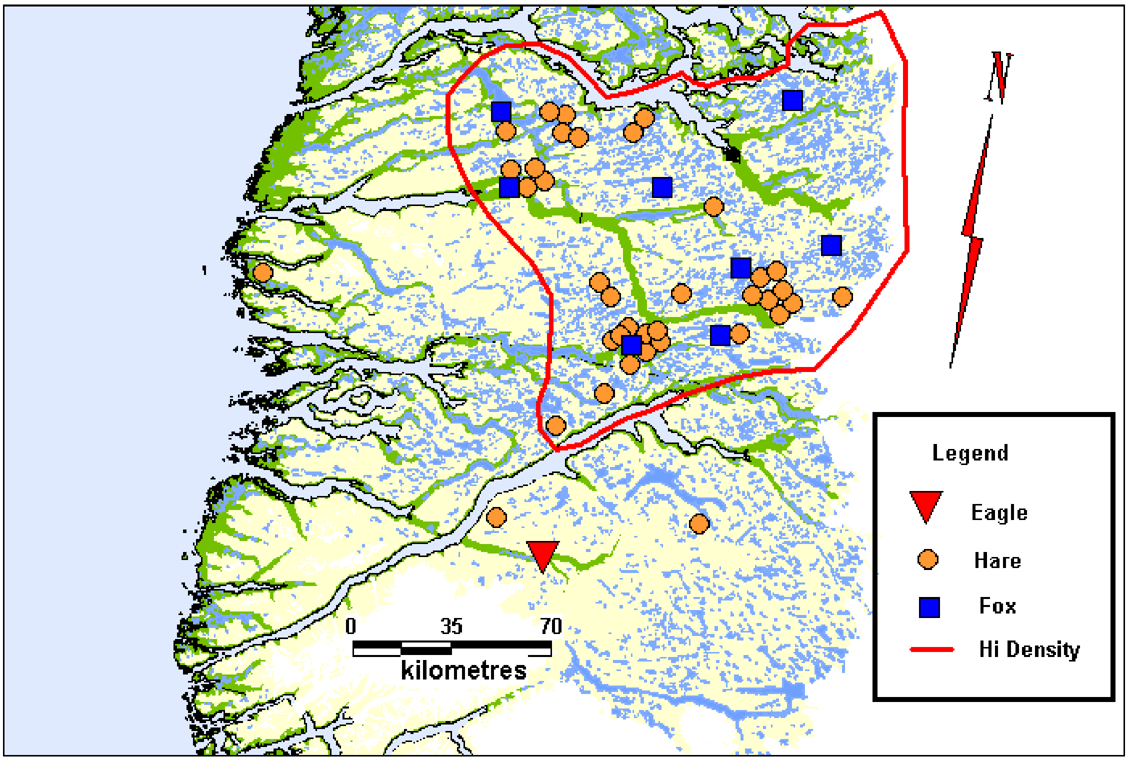

Figure 10. Locations of eagle, fox and hare observations in the North region, March 2005.

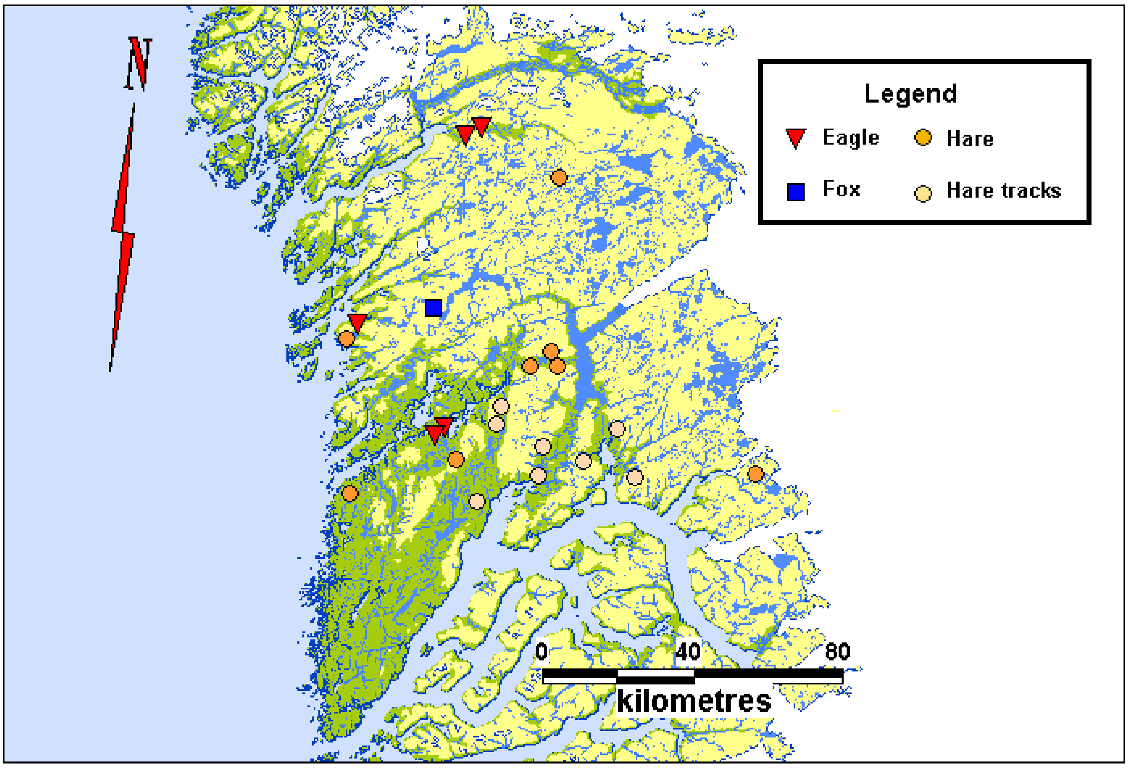

Figure 11. Locations of eagle, fox and hare observations in the Central region, March 2005.

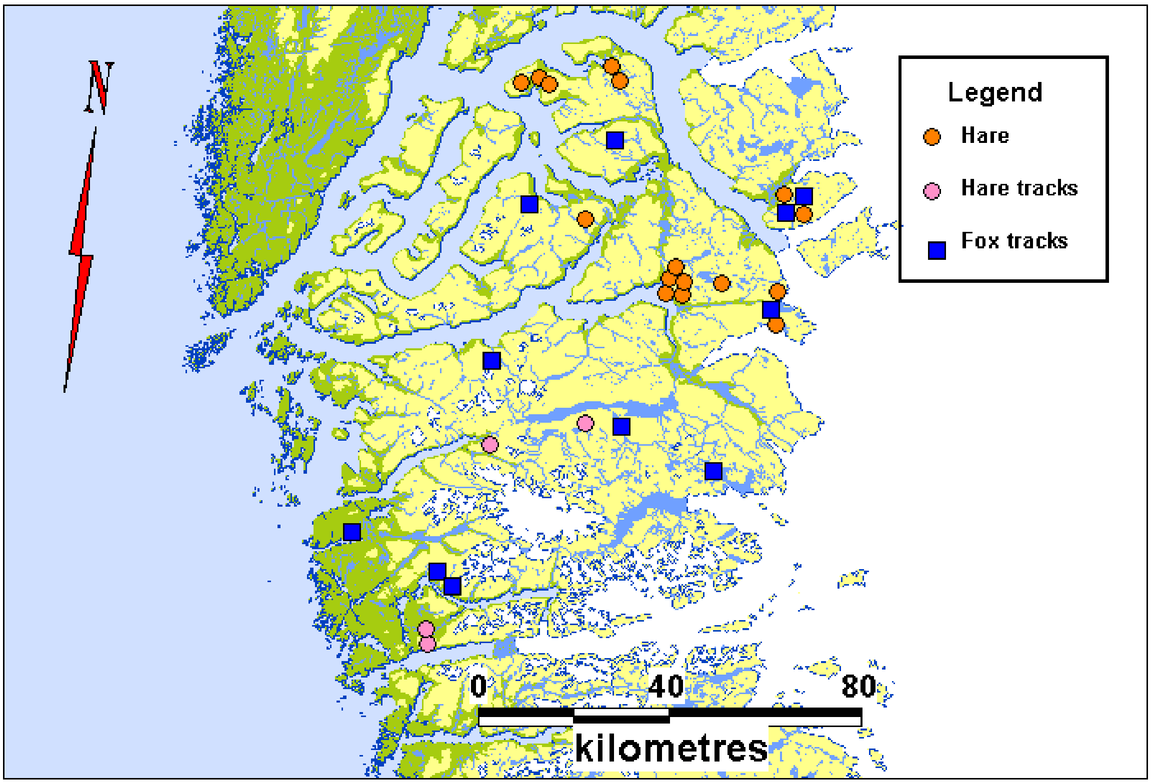

Figure 12. Locations of fox and hare observations in the South region, Ameralik, March 2005.

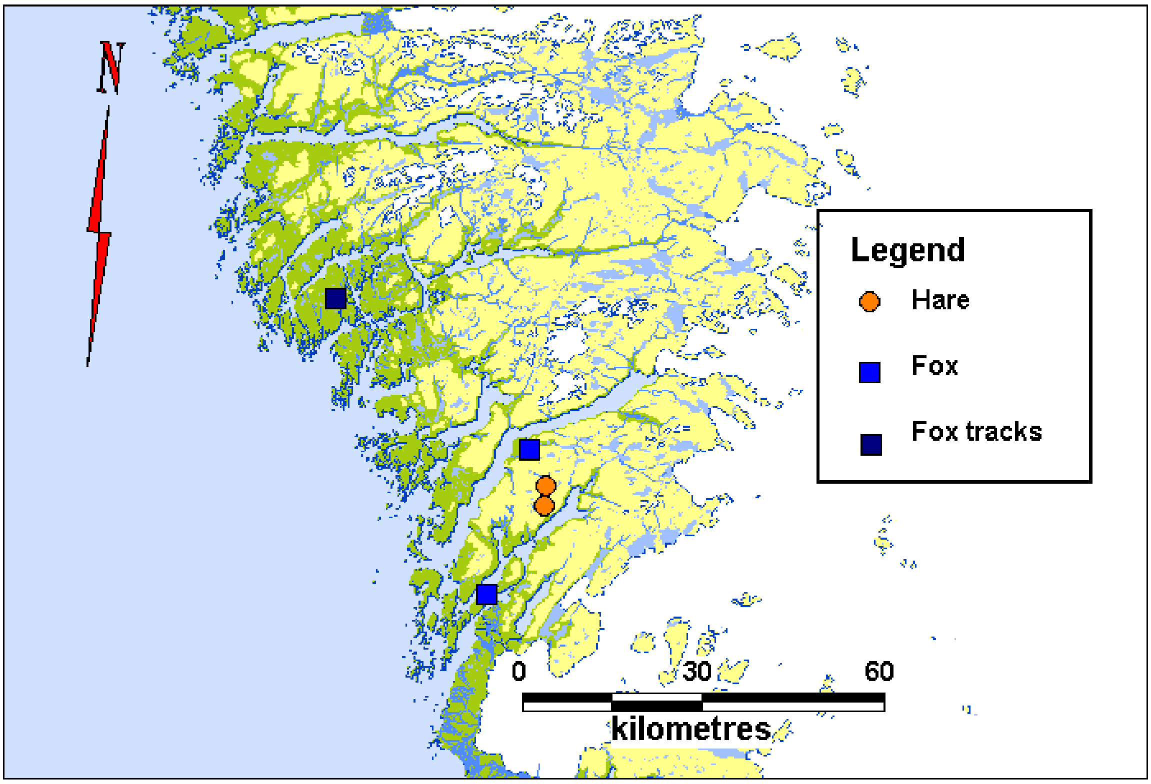

Figure 13. Locations of the three foxes and 2 hares in the South region, Qeqertarsuatsiaat, March 2005.

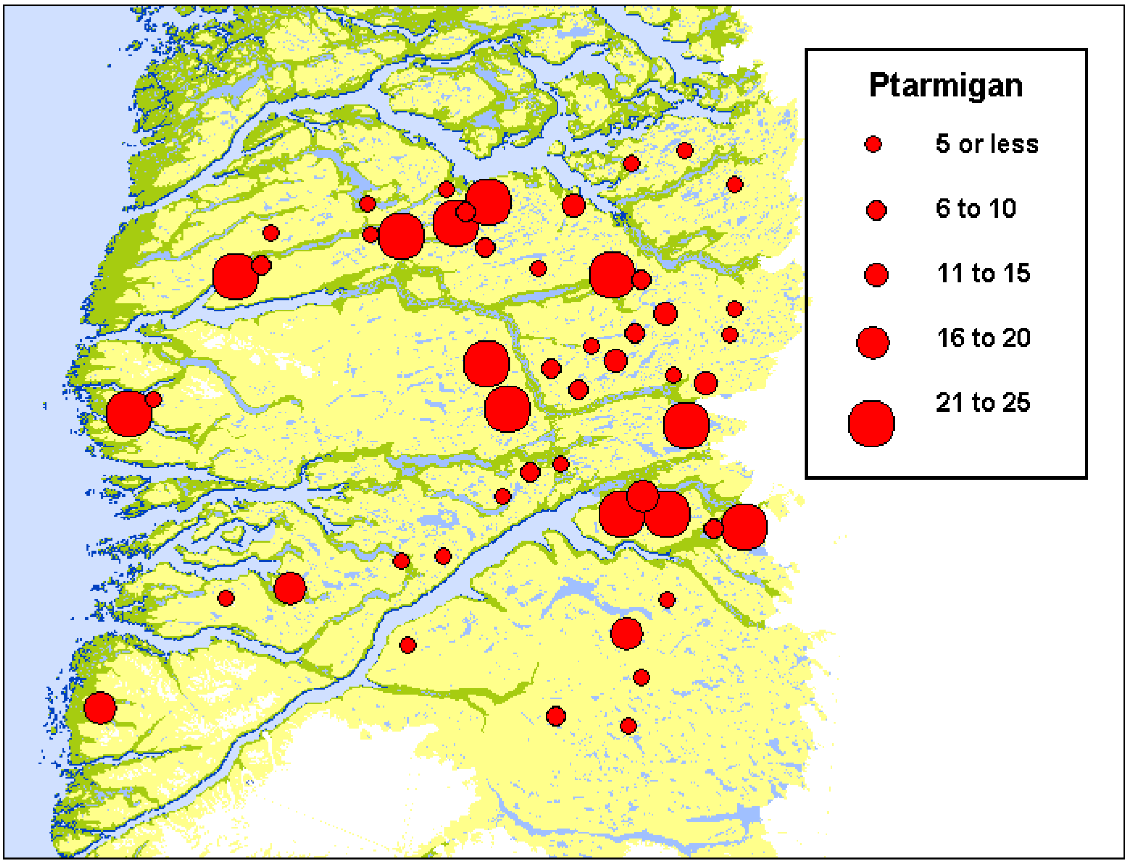

Figure 14. Locations of ptarmigan observations in the North region, March 2005.

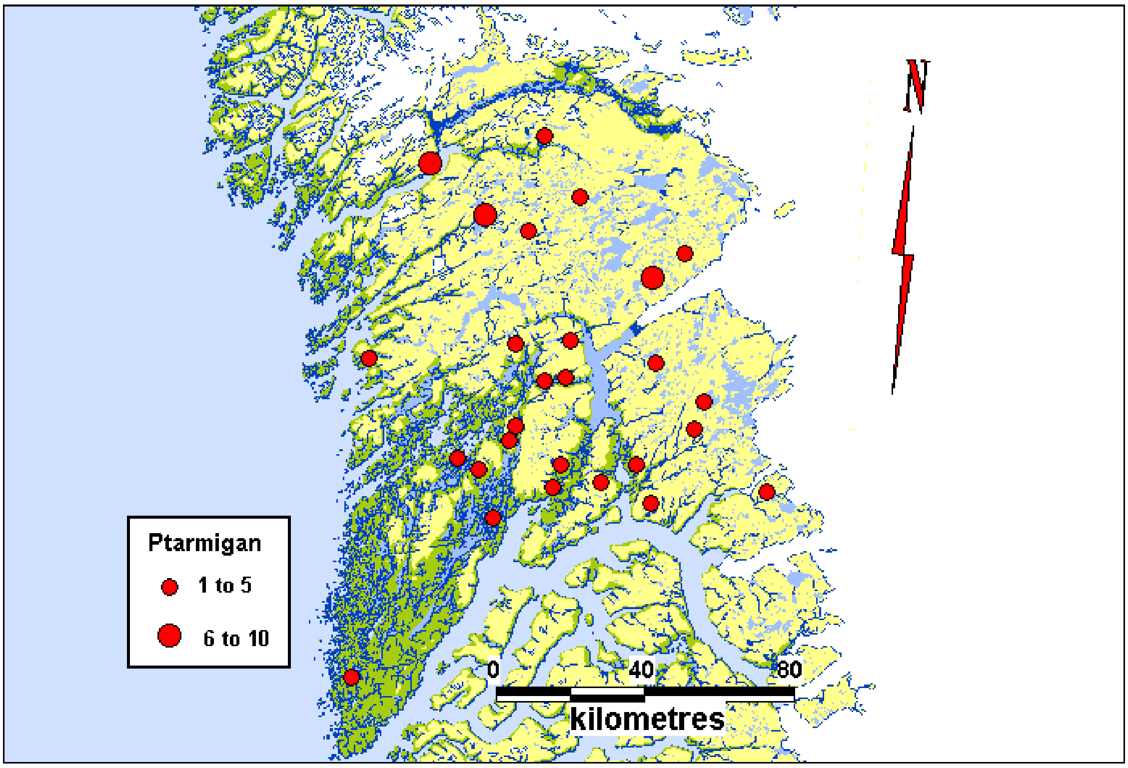

Figure 15. Locations ptarmigan in the Central region, March 2005.

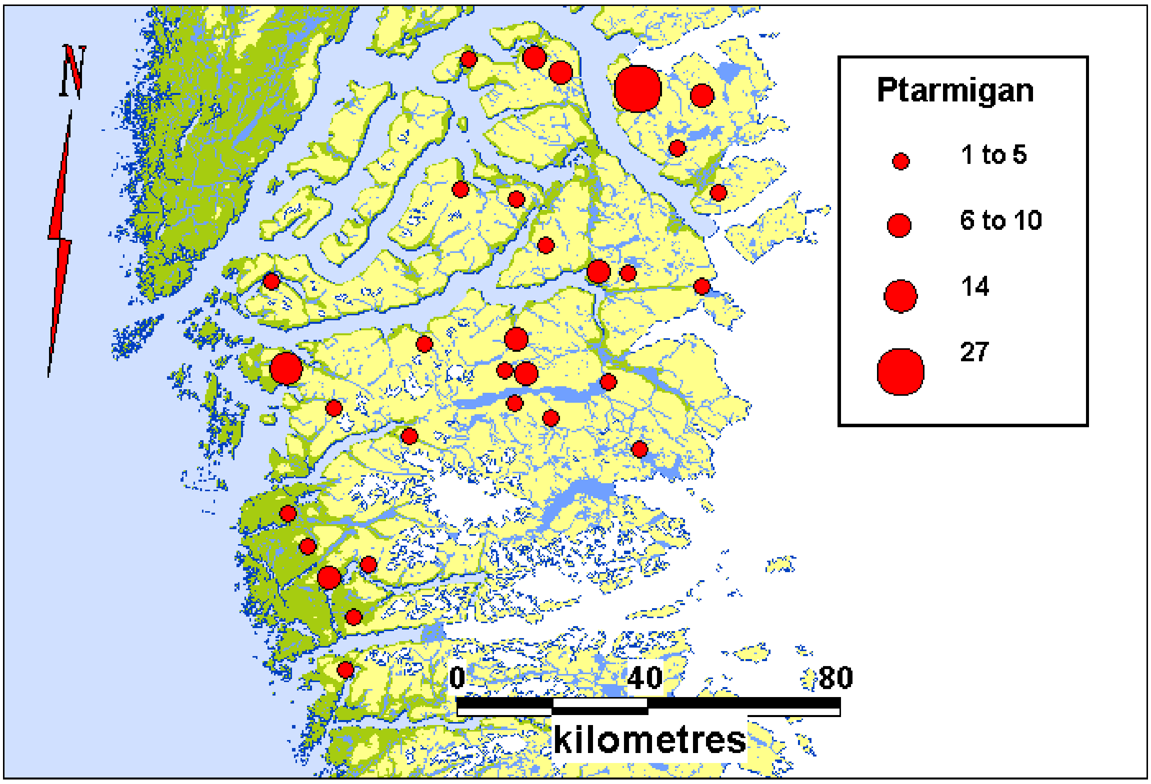

Figure 16. Locations of ptarmigan observations in the South region, Ameralik, March 2005.

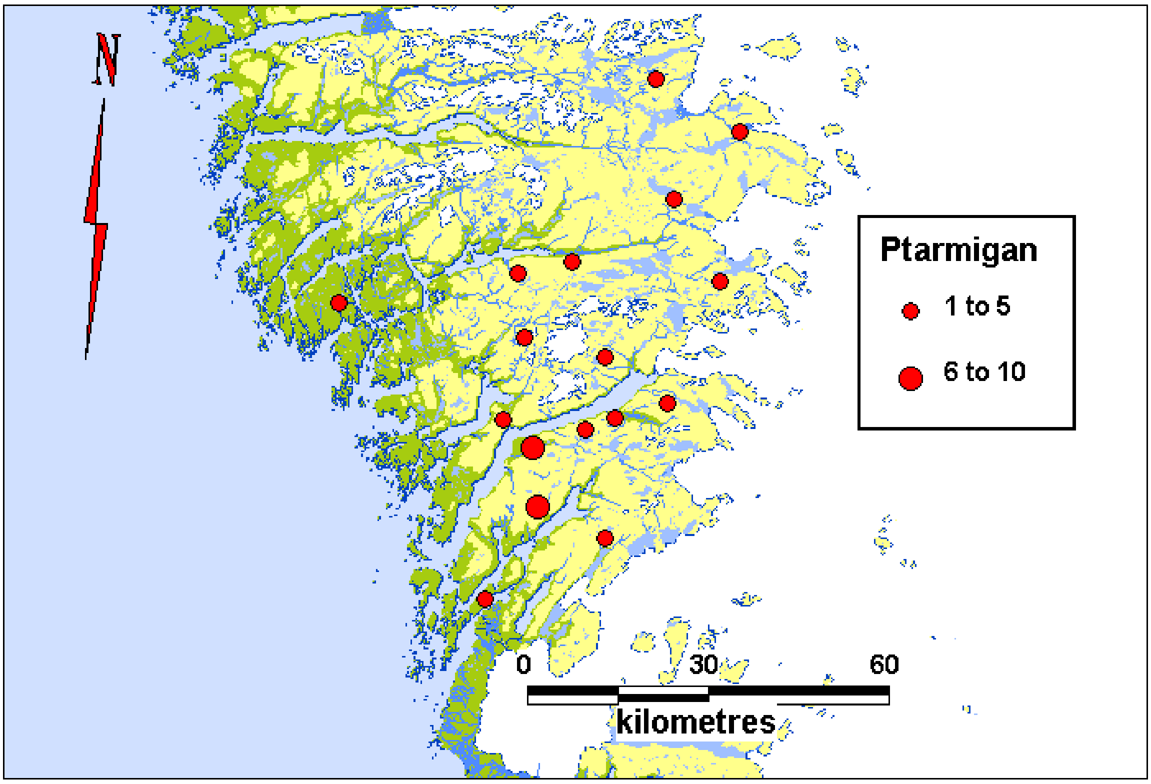

Figure 17. *Locations of ptarmigan observations in the South region, Qeqertarsuatsiaat, March 2005.*

Index estimates - Abundance

Muskox

Incidental observations of muskox occurred only in the North region, and primarily in the core muskox habitat south of the Kangerlussuaq airport (Figure 9). The latter was the primary basis for the abundance index (Table 5). No muskox were observed in the Central or South regions.

Table 5. Population index for **muskox** (*Ovibos moschatus*) in the North region of West Greenland, for the caribou hi and lo-density strata used for caribou surveys. Hi- and Lo-density describe the caribou stratification and not the muskox.

MUSKOX North Region	Abundance Index	95% Confidence Interval (CI)	Coefficient Variance (CV)	Standard Error (SE)
Caribou Hi-density	1,289	149 – 2,429		
Caribou Lo-density	23,200	17,229 – 29,171		
Total North	**24,489**	**18,410 – 30,568**	**0.12412 (12%)**	**3,040**

Arctic fox

The blue phase arctic fox was the most common seen during these surveys. Foxes were most abundant in the North and South regions (Table 6).

Table 6. Population index for **arctic fox** (*Alopex lagopus*) in the North, Central & South regions of West Greenland. Hi- and Lo-density describe the caribou stratification.

ARCTIC FOX Region	Abundance Index	95% Confidence Interval (CI)	Coefficient Variance (CV)	Standard Error (SE)
NORTH				
Caribou Hi-density	2,133	-14 – 4,280		
Caribou Lo-density	0	0		
Total North	**2,133**	**-14 – 4,280**	**0.50317 (50%)**	**1,073**
CENTRAL				
Caribou Hi-density	343	-1,372 – 2,058		
Caribou Lo-density	0	0		
Total Central	**343**	**-1,372 – 2,058**	**2.49900 (249%)**	**858**
SOUTH				
Ameralik	3,072	442 – 5,701		
Qeqertarsuatsiaat	849	-763 – 2,462		
Total South	**3,921**	**837 – 7,005**	**0.39330 (39%)**	**1,542**

Arctic hare

Table 7. Population index for **arctic hare** (*Lepus arcticus*) in the North, Central & South regions of West Greenland. Hi- and Lo-density describe the caribou stratification.

ARCTIC HARE Region	Abundance Index	95% Confidence Interval (CI)	Coefficient Variance (CV)	Standard Error (SE)
NORTH				
Caribou Hi-density	9,067	4,808 – 13,325		
Caribou Lo-density	3,600	-2,896 – 10,096		
Total North	**12,667**	**4,899 – 20,435**	**0.30663 (31%)**	**3,884**
CENTRAL				
Caribou Hi-density	5,147	1,987 – 8,307		
Caribou Lo-density	473	-1,390 – 2,336		
Total Central	**5,621**	**1,952 – 9,289**	**0.32634 (31%)**	**1,834**
SOUTH				
Ameralik	6,143	2,464 – 9,822		
Qeqertarsuatsiaat	566	-1,206 – 2,339		
Total South	**6,709**	**2,626 – 10,793**	**0.30432 (30%)**	**2,042**

Ptarmigan

Table 8. Population index for **ptarmigan** (*Lagopus mutus*) in the North, Central & South regions of West Greenland. Hi- and Lo-density describe the caribou stratification.

PTARMIGAN Region	Abundance Index	95% Confidence Interval (CI)	Coefficient Variance (CV)	Standard Error (SE)
NORTH				
Caribou Hi-density	44,533	38,582 – 50,485		
Caribou Lo-density	162,600	139,976 – 185,224		
Total North	**207,133**	**183,740 – 230,527**	**0.05647 (6%)**	**11,697**
CENTRAL				
Caribou Hi-density	15,270	11,946 – 18,594		
Caribou Lo-density	10,177	6,579 – 13,775		
Total Central	**25,447**	**20,548 – 30,345**	**0.09624 (10%)**	**2,449**
SOUTH				
Ameralik	20,244	16,216 – 24,272		
Qeqertarsuatsiaat	6,228	4,162 - 8295		
Total South	**26,473**	**21,946 – 31,000**	**0.08550 (9%)**	**2,264**

Index estimates – Sightings per kilometre

Using each transect as a sample unit we calculated the average number of sightings per transect kilometre flown for each species (Table 9). The total number of transect kilometres flown in the North region was 300 and 150 km respectively for the high and lo-density stratum. The total number of kilometres flown in the Central region was 292.5 and 112.5 km respectively for the hi- and lo-density stratum. The total number of kilometres flown in the South region was 300 and 180 km respectively for the Ameralik and Qeqertarsuatsiaat areas.

Table 9. The average number of sightings per transect kilometre flown in the North, Central & South regions of West Greenland. Hi- and Lo-density describe the caribou stratification.

Region	Average sightings per kilometre flown				
	Muskox	Fox	Hare	Ptarmigan	Eagle
NORTH					
Caribou Hi-density	0.1	0.03	0.11	1.11	---
Caribou Lo-density	0.8	---	0.02	1.81	0.01
CENTRAL					
Caribou Hi-density	---	0.003	0.05	0.30	0.01
Caribou Lo-density	---	---	0.01	0.38	0.02
SOUTH					
Ameralik	---	0.04	0.07	0.48	---
Qeqertarsuatsiaat	---	0.02	0.01	0.24	---

Sources of error on the abundance index estimates

The low surface area surveyed relative to the total regional area can affect index accuracy. Sources of negative bias, which contribute to under estimating population size, included the following. The flight altitude used (15 m), meant that "dead" ground was common on transects, because terrain features often hid portions of the strip width so that animals may have been missed because they were hidden from view. As the species discussed in this report were not the primary object of the surveys, movement was often key in detecting their presence. Immobile animals could have been overlooked. Snow cover conditions both in 2005 and 2006 gave exceptional background camouflage and there was considerable variation in snow cover along an individual transect. Detection of animals was often difficult and was further hindered by hare and fox often hiding. We consider failure to detect animals present an important source of error in our calculations. These sources of error would tend to underestimate our index of abundance. Underestimating strip width, however, would overestimate animal abundance

Discussion

This report presents incidental observations for muskox, fox, hare, ptarmigan and eagle. None of these species are currently endangered, nor are they threatened by over harvest. Although incidental, these observations of muskox, fox, hare, ptarmigan were used as the basis for the first index estimates of regional abundance for these species. We are well aware that the caribou surveys, which provided the incidental observations analyses in this report, were not designed to provide abundance estimates of other species observed incidentally during the course of the caribou survey. Further the observations are incidental, which means no attempt was made to systematically look for these species during the caribou surveys. Despite this limitation, these first ever index estimates may serve as a start point for further investigations.. The usefulness of the findings in this report will be increased when the caribou surveys are repeated in 2010 and 2011, using the same regions, stratification and methods. Additional concurrent and better designed surveys tailor-made to each species could provide a critical evaluation of how suitable incidental sightings, obtained during caribou surveys, are as a basis for rough abundance estimates. Regardless of an estimate's accuracy, because survey methods for all regions were consistent, we should be able to discern the relative densities, distribution and abundance of each species amongst regions.

Generally animals were seldom observed on the coastal plains or areas near the Davis Strait. Most observations occurred inland away from the sea, where a dryer continental climate exists. Animals may have been avoiding the greater snowfall and snow depths associated with coastal areas in West Greenland.

The volume of incidental observations was highest in the North region, specifically inland areas at least 70 km away from the Davis Strait sea coast. With 796 animal observations versus 227 for the South region and 154 for the Central region, the inland portion of the North region was clearly the most productive of the three regions. The inland area of the North region is well known for its dry continental desert steppe climate. Among other factors, perhaps the typical lack of snow cover most of the winter in the inland area of this region accounts for the relative high abundance of animal life. This report found the highest densities of hare and ptarmigan occurred here, which also coincides with the highest caribou densities in West Greenland.

Muskox

During the surveys, muskox were observed only in the North region, although they are known to be present in the Central region. None have ever been reported observed in the South region, and during the surveys no incidental observations occurred either. We calculated two indexes for abundance. The first, the index estimate for muskox abundance in the entire North region, 26,000 sq km, was ca. 24,489 (18,410 – 30,568; 95% CI, CV=12%, SE=3,040). The bulk of this index rests on the area south of the Kangerlussuaq aiport, where the majority of muskox were observed, and which had a rough index of 23,200 (17,229 – 29,171, 95% CI) muskox. The latter index would include animals inhabiting the known core muskox range in the North region. The second index, the average number of muskox per kilometre of transect flown, resulted in 0.8 muskox per kilometre within core muskox range and 0.1 outside. Both indexes have value as baseline data for comparison against data obtained in the future, which may yield population trend.

Arctic Fox

Most of the arctic fox seen were the blue phase, which are common in West Greenland. Fox observations were most abundant in the North and South regions, with more in the latter. The regional ratios of observation of prey (hare & ptarmigan) to predator (arctic fox)ranged from about 2 to 16 hares per fox, and 7 to 100 ptarmigan per fox. We suspect that the upper end of these ranges may best reflect a realistic proportion of hare / ptarmigan to fox.

Arctic Hare

The fewest hares were observed in the South region, where coincidentally the most foxes were observed. Relative to the other regions, hares were most abundant in the inland portion of the North region, where distributions appeared heavily clumped (Table 7).

Ptarmigan

The Central and South regions appeared to contain similar numbers of ptarmigan (Table 8). In contrast, there were almost 8-fold more ptarmigan in the North region than in either the Central or South region. Besides being noticeably more abundant, ptarmigan in the North region also occurred in relatively large flocks of over 20 birds. Most were inland.

White-tailed Sea Eagle

The white-tailed sea eagles, as their name implies, were always observed near water, usually salt water, e.g., either the sea or fjord shorelines, but they were also observed far inland along major freshwater rivers. We did not make any estimates of abundance because observations were few or lacking. We suggest that observations of spring / summer nesting sites would provide better data for an index of eagle abundance. Although eagles may often be seen near cities and towns during winter, this report's incidental observations indicate a few of the wilderness areas utilized by eagles in late winter.

Are the index estimates in this report useful?

The caribou surveys, which provided the incidental observations of other species, are not designed for estimating abundance of other species observed incidentally during the course of a caribou survey. Nonetheless, the index estimates presented in this report can be used to estimate population trends if similar surveys are repeated in the future. To judge the accuracy of these index estimates, we recommend designing and implementing an additional survey; aimed at a specific species.

Possible natural population cycles of animal abundance

The abundance indexes in this report are the first obtained. They do not provide us with an indication of trend for these species. Little is known about possible population cycles of abundance for the muskox, fox, hare, ptarmigan or eagle in West Greenland. However, we do know that since 1721 caribou number in West Greenland has cycled between minimums and maximums on a scale of a mouse to an elephant (Meldgaard 1986) and the better part of a century goes by before caribou populations recover from a crash in numbers (Cuyler 2007). Does the abundance of all the terrestrial species in West Greenland cycle as wildly as do caribou numbers? Further, we expect the West Greenland caribou to decline in number within the foreseeable future from natural causes and in keeping with previous cycles (Cuyler 2007; Cuyler et al., 2005, 2007). Will other species decline with them?

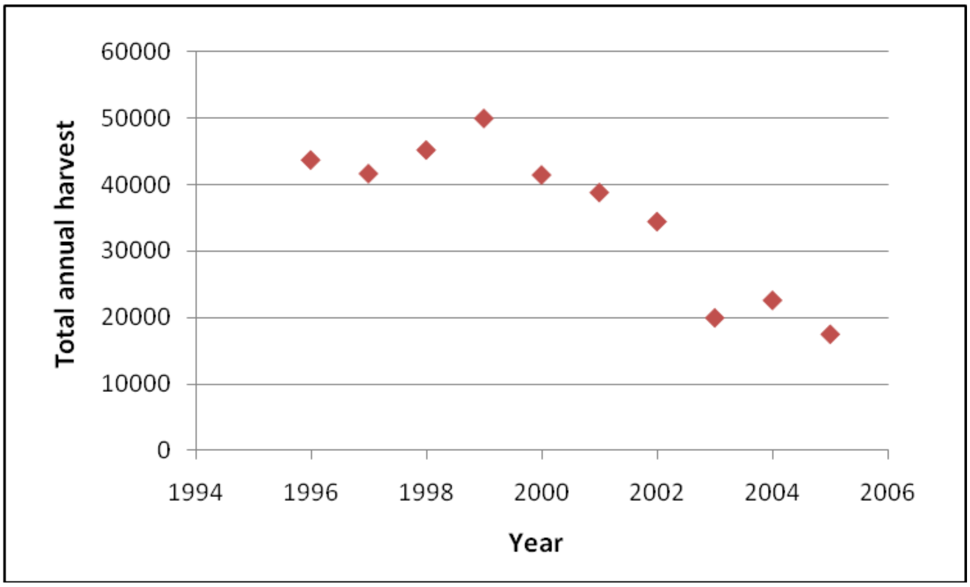

Figure 18. *Total annual harvest of ptarmigan (Lagopus mutus) for all of Greenland from 1995 to 2005 (Greenland Self Rule, unpublished).*

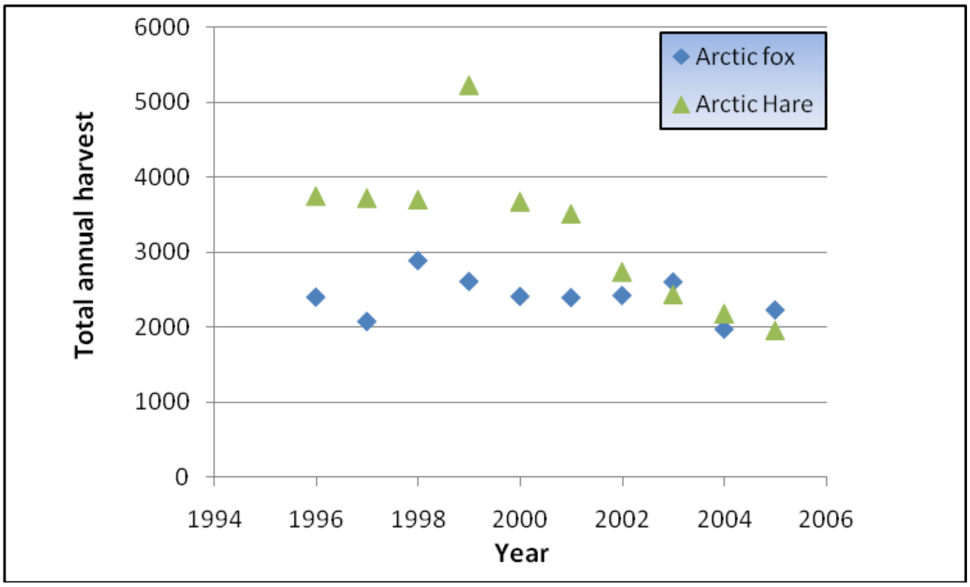

Figure 19. *Total annual harvests of arctic fox (Alopex lagopus) and arctic hare (Lepus arcticus) for all of Greenland from 1995 to 2005 (Greenland Self Rule, unpublished).*

The Greenland government harvest records are expressed as the total annual catch of each species for all of Greenland, and are available in the *Piniarneq* records (Greenland Self Rule, unpublished data). Although not specific to particular regions, *Piniarneq* shows that arctic hare and ptarmigan harvests declined 2-3 fold over the period 1995 to 2005, while the number of arctic fox has been relatively stable (Figures 18, 19). Hare harvests declined from a maximum in 1999 of ca. 5,200 to less than 2,000. Similarly, the ptarmigan harvest dropped from the 1999 maximum of ca. 50,000 to less than 20,000. While it is likely that several factors are responsible for the decline in hare and ptarmigan harvests, the magnitude of the decline strongly suggests that a declining animal abundance is prominent among these.

Possible threats – Ecosystem change

Climate change

West Greenland caribou have exhibited extreme population cycles for the past three centuries (Vibe 1967, 1982, 1984, Meldgaard 1986). Climate, in the form of unfavourable weather or disastrous weather events, in conjunction with overgrazed and trampled range caused by overstocking, may go a long way in explaining abrupt declines in caribou abundance (Cuyler et al., 2007). Global climate change in West Greenland is expected to cause increased temperatures and precipitation (Rysgaard et al. 2003), which could increase the frequency of severe stochastic weather events. Extreme conditions restricting access to forage, e.g. winter thaw-freeze icing events or excessively deep snows may adversely affect some species.

North Region – Proposed highway

Although only in the preliminary stages, a 180-200 km all-season highway / road planned between the seacoast city of Sisimiut and the inland Kangerlussuaq International airport, could pose a major habitat change for the North region. If built, this would be the first major road in West Greenland. The impacts on the terrestrial ecosystem caused by construction and subsequent human disturbance are unknown. Certainly hunters would gain year round access to areas hitherto inaccessible. Non-consumptive human use of the region would also likely increase significantly, and tourism is growing.

North & Central regions – Proposed Aluminium smelter, Hydro-power plants and transmission lines

The major potential threat animal use and distribution in both the North and Central regions is the proposed construction of an aluminium smelter on the coast of West Greenland (possibly close to the city of Maniitsoq), several hydro power plants near the Ice Cap and associated hydro power transmission lines linking the two. The transmission lines would transect all caribou migration routes between the calving grounds near the Ice Cap and wintering grounds to the west. The Danish National Environmental Research Institute and the Greenland Insitute of Natural Resources have compiled a strategic environmental assessment (Johansen et al., 2008). Construction is proposed to begin in 2010 and production by 2014.

Central Region – Proposed Iron Ore mine

Construction of an iron ore mine near the Ice Cap is planned but not yet begun. This mine would require construction of a harbour on the north shore of Godthåbsfjord, and a road and pipeline running to the mine from the harbour. The road and the pipeline would run through hitherto pristine wilderness. The impacts on the ecosystem caused by construction and subsequent human disturbance are unknown, but may mirror those caused by the highway through the North region, e.g., hunter access would increase, as would non-consumptive human use of the area. Further, an expanding infrastructure supporting the harbour and mine may be expected.

Future Management

The population indexes for muskox, fox, hare, ptarmigan and eagles in West Greenland presented in this report are only a start point, and the numbers calculated tell us nothing about the current health or productivity of these species. Knowledge must be expanded if it is to provide a firm basis for management recommendations that can meet the challenges of change in the future.

Acknowledgements

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Appendix 1

Caribou Region Stratification & Transect Allocation

Below is an account of the methods used for the caribou surveys, during which the incidental observations of other species were obtained.

How many transects are needed?

One of the most important questions that have to be answered before undertaking any survey is whether the survey will yield data of a sufficient quality to answer the question that the survey attempts to answer; animal abundance. A related question is the choice of sample size. In a helicopter survey, where flight hours in Greenland are very expensive, this question becomes very important.

An idea of the expected variance is necessary. In flight surveys the variance is intimately related to the density of animals. The prior information available before the surveys was relative densities from a previous survey in 1996 and densities found in region North in 2000. The assumption made was that although the 1996 surveys used a radically different methodology, the relative densities would remain fairly constant. Implicit in that assumption is the expectation that the caribou populations in all regions have had similar growth rates since 1996 despite that they form clearly distinct populations with different demographics.

A simulation experiment was performed in the following fashion. The highest density area in the 1996 survey was the high-density area of region North, the density of the other areas was known as a fraction of the density of that high density area. For each simulated transect the number seen is found as follows. A random transect from the high-density area in region North is chosen and the number seen there is called "s". If r is the relative density of the area in question and w is the relative width of the transects then a number seen can be simulated as a binomial:

$$Binomial(s, r \cdot w)$$

Once a simulation was done, the resulting data was analyzed using standard parametric methods, and a confidence interval found. The procedure was repeated for different total numbers of transects. The data was then plotted by taking all the confidence intervals, centering these on their common mean and plotting them against the total number of transects (Figure 20).

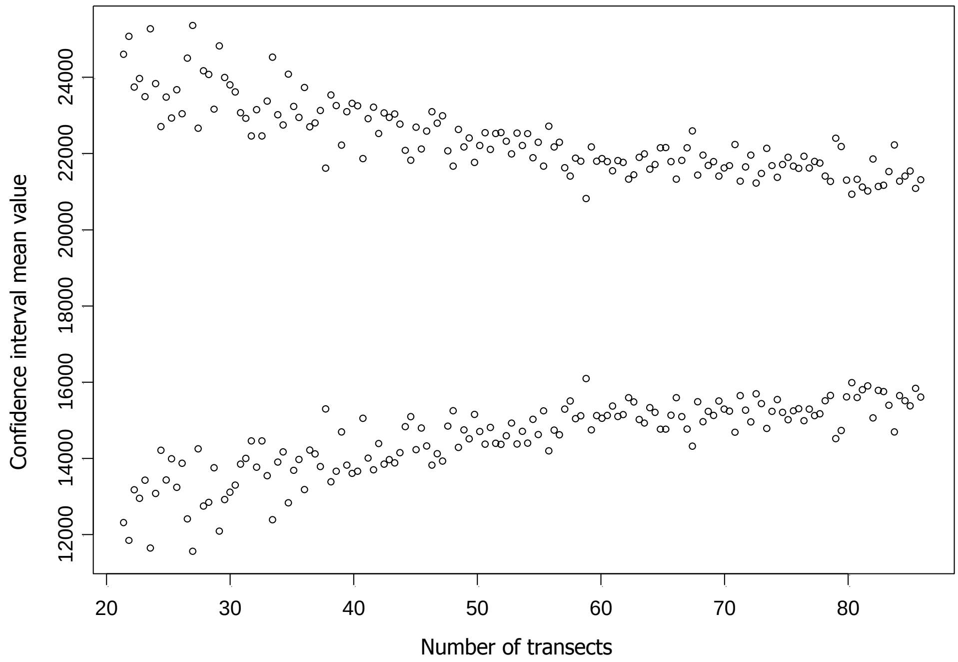

Figure 20. How many transect lines needed for a relatively accurate and precise survey of region Central? Simulation of confidence interval mean values versus the number of transects used.

From the graph it is obvious that an effort smaller than 40 lines will result in a wide confidence interval, whereas a number larger than 60 will be a waste of resources. Note that the picture here is slightly misleading since it takes into account only the width of the confidence interval around the grand mean of the estimates. In reality the means will jump around less for higher sample sizes. For economic reasons the final number of transect lines in 2005 was set to 54 for the Akia-Maniitsoq herd in region Central, while 60 transects were again applied for the Kangerlussuaq-Sisimiut herd in region North.

Transect allocation

Since region Central is divided into two strata with different expected densities, transect allocation must be decided. Here a simple mathematical method was used for allocating transects to each strata. The standard method for allocation of transects to strata is to allocate proportional to the product of the area and the expected standard deviation of each strata.

If : A_i is the area of strata i

d_i is the expected density of strata i then the best allocation is proportional to

$$A_i \cdot d_i^{\alpha}$$

where: $\alpha = 0.5$ corresponds to the square root of the expected density.

Note that it is sufficient to have the expected relative densities and areas. For areas {1,..,i} the proportions of transects allocated to area 1 will be.

$$p_1 = \frac{A_1 \cdot d_1^{\alpha}}{\sum_i A_i \cdot d_i^{\alpha}} = \frac{1}{\sum_i \frac{A_i \cdot d_i^{\alpha}}{A_1 \cdot d_1^{\alpha}}} = \frac{1}{\sum_i \frac{A_i}{A_1} \cdot \frac{d_i^{\alpha}}{d_1^{\alpha}}} = \frac{1}{\sum_i \left(\frac{A_i}{A_1}\right) \cdot \left(\frac{d_i}{d_1}\right)^{\alpha}}$$

There are several ways of choosing α. For animals that tend to be in groups the question centres on whether they tend to increase the group size when the density is higher. If the group size is the same regardless of density then α = 0.5. If on the other hand the group size tends to go up with higher density without the number of groups changing then α = 1. In this case we chose α = 0.75 as a compromise solution.

The allocation assumed that the relative densities remained unchanged since the last caribou survey of 1996. The stratification was not the same as in the last survey, but was altered based on the observed densities in 1996. The Central and North regions were divided into two strata, a high and low density stratum. On the basis of the above mentioned formulas, in 2005 region Central was allocated 15 transects to the low density area and 39 transects to the high density area. Similarly region North was allocated 20 transects to the low density area and 40 transects to the high density area.

Appendix 2

Caribou Survey field method and statistical design

Accuracy equates to the population size calculated being close to the true value. Bias results in inaccuracy, because it makes the calculated population size depart from reality,. There can be bias in your counting, sampling design or even analysis. Precision is the measure of variation in the numbers of caribou on each of the transects. Poor precision can result from sampling errors, e.g. if group size and distribution were highly variable within a stratum.

Index of abundance estimates for the incidental species observed during the caribou surveys were calculated using the same methods described below for caribou, excepting the correction for missed animals.

Field methods

Reducing negative bias: Sightability of caribou on transect

To reduce the negative bias associated with violation of the assumption that all caribou within the strip are observed, the following survey field methods were used.
Narrow strip width, 300x2 metres,
Slow flying speed, ca 46-65 kilometre/hour,
Low altitudes, 15 metres,
Sun typically behind observers,
Short transect length, 7.5 kilometres (promoted concentration and reduced fatigue),
Statistical correction for missed caribou.

Statistical design

Caribou population estimates can be calculated as follows:
For each stratum we have:

$$\hat{N}_j = A_j \cdot \frac{\sum_i y_i}{\sum_i A_i} = \frac{A_j}{\bar{A}} \cdot \bar{y} \qquad (0.1)$$

Where

$\hat{N}_j$	is the estimated total in the j^{th} strata
y_i	is the total number of caribou observed in strip i
A_j	is the total area of strata j
A_i	is the area of strip i
$\bar{A}$	is the mean area of the strips in the stratum

Because the area of each strip is constant the calculation of variance is

$$Var(\hat{N}_j) = Var(\frac{A_j}{\overline{A}} \cdot \overline{y}) =$$

$$\left(\frac{A_j}{\overline{A}}\right)^2 Var(\overline{y}) = \left(\frac{A_j}{\overline{A}}\right)^2 \cdot Var(\frac{\sum_i y_i}{n}) = \left(\frac{A_j}{\overline{A}}\right)^2 \cdot \frac{1}{n} Var(\sum_i y_i) =$$

$$\left(\frac{A_j}{\overline{A}}\right)^2 \cdot \frac{1}{n^2} Var(\sum_i y_i) = \left(\frac{A_j}{\overline{A}}\right)^2 \cdot \frac{1}{n^2}(n \cdot Var(y_i)) = \left(\frac{A_j}{\overline{A}}\right)^2 \cdot \frac{Var(y_i)}{n}$$

$$\hat{V}ar(y_i) = s^2 = \frac{1}{n-1}\sum_i (y_i - \overline{y})^2$$

Since the total number of caribou in the area is the sum of the totals in each stratum the variance of the total will be the sum of the variances in the strata.

$$\hat{N} = \sum_j \frac{A_j}{\overline{A}} \cdot \overline{y}_j$$

$$Var(\hat{N}) = \sum_j \left(\frac{A_j}{\overline{A}}\right)^2 \cdot \frac{Var(y_i)}{n}$$

Appendix 3

Raw data North Region aerial survey 2005, West Greenland

Table 10. Raw data incidental observations of muskox, arctic fox, arctic hare, ptarmigan and eagle during aerial survey for caribou in the North region, West Greenland, March 2005. Survey observers: Christine Cuyler, Rink Heinrich , and Hans Mølgaard.

Date ddmmyy	Transect number	Caribou Density Stratum	Number of Incidental observations on transect				
			Muskox	Arctic Fox	Arctic Hare	Ptarmigan	Eagle
18.03.05	77	Low	0	0	0	5	0
18.03.05	64	Low	16	0	1	5	0
18.03.05	27	Low	0	0	0	0	0
18.03.05	151	Low	0	0	0	20	0
18.03.05	161	Low	0	0	0	3	0
18.03.05	113	Low	0	0	0	0	0
18.03.05	101	Low	0	0	0	20	0
18.03.05	47	Low	0	0	1	30	0
18.03.05	155	Low	0	0	0	0	0
18.03.05	87	Low	0	0	0	35	0
18.03.05	29	Low	0	0	0	5	0
18.03.05	120	High	0	0	0	0	0
18.03.05	193	High	0	**1**	0	3	0
18.03.05	203	High	0	0	1	30	0
18.03.05	143	Low	0	0	0	0	0
18.03.05	139	High	0	**1**	2	0	0
18.03.05	122	High	0	0	2	0	0
18.03.05	202	High	0	0	4	0	0
18.03.05	115	High	0	0	0	2	0
18.03.05	76	High	0	0	0	60	0
18.03.05	172	High	0	0	0	7	0
18.03.05	211	High	0	0	2	25	0
18.03.05	200	High	0	0	0	25	0
19.03.05	125	Low	12	0	0	70	0
19.03.05	32	Low	35	0	0	35	0
19.03.05	8	Low	35	0	0	5	0
19.03.05	61	Low	3	0	1	20	0
19.03.05	135	Low	0	0	0	5	0
19.03.05	5	Low	0	0	0	5	0
19.03.05	150	Low	13	0	0	8	0
19.03.05	158	Low	2	0	0	0	1
19.03.05	175	High	0	0	1	2	0
19.03.05	24	High	0	0	1	5	0
19.03.05	10	High	0	0	0	9	0
19.03.05	34	High	0	1	8	0	0
19.03.05	183	High	0	0	0	5	0
19.03.05	137	High	26	0	0	10	0
19.03.05	36	High	1	0	1	8	0
19.03.05	116	High	0	1	1	0	0

19.03.05	152	High	2	0	0	0	0
21.03.05	73	High	0	0	0	25	0
21.03.05	9	High	0	0	4	15	0
21.03.05	153	High	0	0	3	3	0
21.03.05	142	High	0	0	0	2	0
21.03.05	192	High	0	0	0	12	0
21.03.05	106	High	0	0	0	9	0
21.03.05	58	High	0	**1**	0	15	0
21.03.05	149	High	0	0	0	3	0
21.03.05	197	High	0	0	0	0	0
21.03.05	189	High	0	0	1	35	0
22.03.05	59	High	0	0	1	0	0
22.03.05	70	High	0	**1**	0	2	0
22.03.05	63	High	0	0	0	3	0
22.03.05	154	High	0	**1**	0	2	0
22.03.05	104	High	0	0	0	4	0
22.03.05	210	High	0	0	0	12	0
22.03.05	209	High	0	0	0	0	0
22.03.05	65	High	0	0	2	0	0
22.03.05	112	High	0	0	0	0	0
22.03.05	92	High	0	**1**	0	1	0
		TOTAL	**145**	**8**	**37**	**605**	**1**

* Blue phase arctic foxes are indicated in bold black numbers

Appendix 4

Raw data Central Region aerial survey 2005, West Greenland

Table 11. Raw data incidental observations of arctic fox, arctic hare, ptarmigan and eagle during aerial survey for caribou in the Central region, West Greenland, March 2005. There were no incidental observations of muskox. Survey observers: Christine Cuyler, Rink Heinrich , and Johannes Egede.

Date ddmmyy	Transect number	Caribou Density Stratum	Number of Incidental observations on transect			
			Arctic Fox	Arctic Hare	Ptarmigan	Eagle
14.03.05	77	High	0	0	1	0
14.03.05	97	High	0	0	0	0
14.03.05	17	High	0	0	0	0
14.03.05	39	High	0	1	0	0
14.03.05	84	High	0	1	5	1
14.03.05	199	High	0	0	0	0
14.03.05	164	High	0	0	0	0
14.03.05	181	High	1	0	0	0
14.03.05	58	High	0	0	0	0
14.03.05	56	High	0	0	0	0
14.03.05	107	High	0	0	0	0
14.03.05	200	High	0	0	0	0
14.03.05	183	High	0	0	0	0
14.03.05	3	High	0	0	5	0
14.03.05	87	High	0	0	0	0
14.03.05	124	High	0	0	5	2
14.03.05	227	High	0	0	0	0
14.03.05	68	High	0	0	0	0
15.03.05	18	High	0	1	5	0
15.03.05	1	High	0	1	5	0
15.03.05	21	High	0	1	5	0
15.03.05	8	High	0	1	5	0
15.03.05	193	High	0	1	5	0
15.03.05	36	High	0	1	5	0
15.03.05	191	High	0	1	5	0
15.03.05	108	High	0	1	5	0
15.03.05	96	High	0	1	5	0
15.03.05	64	High	0	1	5	0
15.03.05	136	High	0	0	0	0
15.03.05	166	High	0	0	0	0
15.03.05	203	High	0	0	2	0
15.03.05	197	High	0	0	5	0
15.03.05	135	High	0	0	0	0
15.03.05	141	High	0	0	0	0
15.03.05	19	High	0	0	3	0
15.03.05	201	High	0	0	0	0
15.03.05	46	High	0	1	5	0
15.03.05	65	High	0	2	5	0

15.03.05	186	High	0	0	3	0
16.03.05	95	Low	0	0	0	2
16.03.05	155	Low	0	0	0	0
16.03.05	121	Low	0	0	4	0
16.03.05	168	Low	0	0	0	0
16.03.05	28	Low	0	0	0	0
16.03.05	149	Low	0	1	5	0
16.03.05	61	Low	0	0	5	0
16.03.05	53	Low	0	0	8	0
16.03.05	15	Low	0	0	0	0
16.03.05	157	Low	0	0	10	0
16.03.05	92	Low	0	0	1	0
16.03.05	126	Low	0	0	0	0
16.03.05	105	Low	0	0	0	0
16.03.05	139	Low	0	0	10	0
16.03.05	52	Low	0	0	0	0
		TOTAL	**1**	**16**	**132**	**5**

*The one arctic fox seen (on transect number 181) was a blue phase fox.

Appendix 5

Raw data South Region aerial survey 2006, West Greenland

Table 12. Raw data incidental observations of arctic fox, arctic hare, and ptarmigan during aerial survey for caribou in the South region, West Greenland, March 2006. There were no incidental observations of muskox or eagles. Survey observers: Christine Cuyler, Rink Heinrich, Johannes Egede, and Lars Mathæussen.

Date ddmmyy	Transect number	Caribou Area	Number of Incidental observations on transect		
			Arctic Fox	Arctic Hare	Ptarmigan
11.03.06	246	Ameralik	0	3	1
11.03.06	7	Ameralik	0	2	8
11.03.06	206	Ameralik	0	0	10
11.03.06	115	Ameralik	0	0	27
11.03.06	282	Ameralik	0	0	8
11.03.06	87	Ameralik	0	0	4
11.03.06	11	Ameralik	2	2	3
11.03.06	271	Ameralik	1	2	1
11.03.06	190	Ameralik	0	0	0
11.03.06	188	Ameralik	0	0	0
11.03.06	94	Ameralik	0	1	1
11.03.06	267	Ameralik	0	5	10
13.03.06	109	Ameralik	0	0	0
13.03.06	46	Ameralik	1	0	1
13.03.06	44	Ameralik	0	1	4
13.03.06	197	Ameralik	1	0	0
13.03.06	96	Ameralik	0	0	3
13.03.06	296	Ameralik	1	0	1
13.03.06	41	Ameralik	0	0	4
13.03.06	28	Ameralik	0	0	0
13.03.06	167	Ameralik	1	0	2
13.03.06	257	Ameralik	0	0	14
13.03.06	23	Ameralik	0	0	2
13.03.06	210	Ameralik	0	2	1
13.03.06	240	Ameralik	0	0	9
13.03.06	2	Ameralik	0	0	10
13.03.06	180	Ameralik	0	0	3
13.03.06	99	Ameralik	1	0	1
13.03.06	182	Ameralik	0	0	0
13.03.06	212	Ameralik	1	0	3
13.03.06	37	Ameralik	0	0	1
13.03.06	233	Ameralik	0	0	0
13.03.06	295	Ameralik	0	1	1
13.03.06	258	Ameralik	2	1	1
13.03.06	40	Ameralik.	0	2	1
13.03.06	34	Ameralik.	0	0	6
13.03.06	91	Ameralik	0	0	2
14.03.05	170	Ameralik	0	0	2
14.03.05	172	Ameralik.	0	0	0
14.03.05	77	Ameralik.	0	0	0
		Ameralik TOTAL	**11**	**22**	**145**
14.03.05	150	Qeqertar.	0	0	0

14.03.05	185	Qeqertar.	0	0	0
14.03.05	105	Qeqertar.	0	0	1
14.03.05	59	Qeqertar.	0	0	1
14.03.05	229	Qeqertar.	0	0	1
14.03.05	174	Qeqertar.	0	0	1
14.03.05	203	Qeqertar.	0	0	3
14.03.05	90	Qeqertar.	0	0	0
14.03.05	3	Qeqertar.	0	0	0
14.03.05	126	Qeqertar.	0	0	1
14.03.05	12	Qeqertar.	0	0	0
14.03.05	14	Qeqertar.	0	0	0
14.03.05	26	Qeqertar.	0	0	2
14.03.05	62	Qeqertar.	1	0	2
15.03.05	86	Qeqertar.	0	0	0
15.03.05	108	Qeqertar.	1	0	1
15.03.05	199	Qeqertar.	0	0	1
15.03.05	300	Qeqertar.	0	2	8
15.03.05	64	Qeqertar.	1	0	8
15.03.05	10	Qeqertar.	0	0	3
15.03.05	30	Qeqertar.	0	0	4
15.03.05	140	Qeqertar.	0	0	3
15.03.05	136	Qeqertar.	0	0	2
15.03.05	1	Qeqertar.	0	0	2
Qeqertarsuatsiaat TOTAL			**3**	**2**	**44**
Both Areas SUM TOTAL			**14**	**24**	**189**

Appendix 6

Random transects for the North, Central and South regions.

Table 13. Random transects for aerial survey, **North** region, March 2005.

Direction flown	Transect number	Transect start		Transect end	
		Latitude	Longitude	Latitude	Longitude
NE-SW	5	66° 30.3'	50° 24.5'	66° 28.9'	50° 34.0'
SE-NW	8	66° 44.4'	50° 20.4'	66° 46.5'	50° 29.2'
SW-NE	9	67° 13.0'	50° 20.4'	67° 16.4'	50° 14.4'
SE-NW	10	66° 59.1'	51° 12.8'	67° 01.9'	51° 20.3'
WSW-ENE	24	66° 56.9'	51° 19.6'	66° 55.0'	51° 28.7'
NE-SW	27	66° 35.0'	52° 14.4'	66° 33.1'	52° 23.3'
WSW-ENE	29	67° 26.8'	52° 59.0'	67° 28.5'	52° 49.3'
SE-NW	32	66° 51.7'	49° 56.0'	66° 55.1'	50° 01.7'
SW-NE	34	67° 02.3'	51° 17.5'	67° 06.2'	51° 14.3'
S-N	36	67° 14.2'	51° 05.3'	67° 10.5'	51° 01.3'
ESE-WNW	47	67° 01.5'	53° 31.1'	67° 02.4'	53° 41.2'
W-E	58	67° 15.3'	50° 51.3'	67° 16.9'	50° 41.8'
SW-NE	59	67° 17.2'	49° 59.5'	67° 20.5'	49° 53.3'
SE-NW	61	66° 39.4'	50° 37.2'	66° 42.1'	50° 44.8'
SE-NW	63	67° 39.3'	50° 11.7'	67° 41.5'	50° 20.7'
NW-SE	64	66° 36.6'	51° 53.9'	66° 36.6'	51° 43.7'
NE-SW	65	67° 33.1'	51° 36.5'	67° 36.5'	51° 30.4'
SE-NW	70	67° 21.9'	50° 09.6'	67° 24.9'	50° 16.6'
WNW-ESE	73	67° 09.9'	50° 25.6'	67° 09.2'	50° 15.4'
W-E	76 *	67° 30.7'	51° 52.5'	67° 34.1'	51° 47.2'
SW-NE	77	66° 47.1'	51° 52.8'	66° 43.7'	51° 58.3'
S-N	87	67° 18.8'	53° 01.6'	67° 22.6'	53° 05.2'
NE-SW	92	67° 29.2'	51° 14.7'	67° 26.8'	51° 23.2'
SSE-NNW	101	66° 21.0'	53° 26.8'	66° 24.6'	53° 31.4'
SE-NW	104	67° 40.9'	50° 45.4'	67° 42.6'	50° 55.0'
NE-SW	106	67° 22.4'	50° 42.1'	67° 18.6'	50° 46.3'
S-N	112	67° 27.4'	51° 06.0'	67° 31.4'	51° 08.2'
SE-NW	113	66° 33.7'	53° 08.1'	66° 36.6'	53° 15.1'
NW-SE	115	67° 35.1'	51° 47.6'	67° 38.0'	51° 55.0'
SW-NE	116	67° 04.4'	50° 44.9'	67° 08.2'	50° 41.7'
SSE-NNW	120	67° 27.1'	52° 33.1'	67° 30.9'	52° 36.6'
SSE-NNW	122	67° 26.2'	52° 09.4'	67° 22.8'	52° 03.8'
E-W	125	66° 56.3'	50° 35.8'	66° 55.9'	50° 25.5'
S-N	135	66° 34.5'	50° 32.9'	66° 38.5'	50° 34.3'
SW-NE	137	67° 13.2'	51° 15.0'	67° 17.1'	51° 12.5'
SSE-NNW	139	67° 23.2'	52° 20.7'	67° 19.9'	52° 14.9'
NW-SE	142	67° 18.6'	50° 10.2'	67° 21.5'	50° 17.4'
SSE-NNW	143	67° 20.4'	52° 38.9'	67° 17.0'	52° 33.2'
E-W	149	67° 17.7'	51° 02.7'	67° 17.7'	50° 52.2'
E-W	150	66° 30.9'	50° 49.8'	66° 31.0'	50° 59.9'
SSW-NNE	151	66° 38.6'	52° 34.9'	66° 42.5'	52° 31.9'
WSW-ENE	152 **	67° 04.3'	50° 41.5'	67° 06.2'	50° 32.3'
SW-NE	153	67° 13.2'	50° 33.2'	67° 16.8'	50° 28.2'
S-N	154	67° 41.9'	50° 32.8'	67° 45.8'	50° 35.2'
WSW-ENE	155	67° 22.9'	53° 37.2'	67° 24.8'	53° 27.9'
SW-NE	158	66° 34.4'	51° 26.5'	66° 37.8'	51° 21.0'
SSW-NNE	161	66° 36.5'	52° 56.1'	66° 40.3'	52° 52.3'
NW-SE	172	67° 30.5'	51° 43.6'	67° 28.7'	51° 34.1'

WSW-ENE	175	66° 48.3'	51° 44.0'	66° 49.6'	51° 34.3'
W-E	183 ***	67° 01.1'	51° 08.6'	67° 02.2'	50° 58.6'
NW-SE	189	67° 25.4'	50° 49.5'	67° 27.2'	50° 58.9'
SE-NW	192	67° 21.4'	50° 30.8'	67° 25.5'	50° 34.3'
SW-NE	193	67° 32.3'	52° 27.0'	67° 34.7'	52° 18.5'
SE-NW	197	67° 21.8'	50° 51.6'	67° 24.3'	50° 59.8'
NW-SE	200	67° 04.9'	51° 22.7'	67° 06.4'	51° 32.4'
SE-NW	202	67° 35.5'	52° 00.8'	67° 32.4'	51° 54.0'
SW-NE	203	67° 31.2'	52° 22.1'	67° 27.3'	52° 24.4'
SW-NE	209	67° 34.6'	51° 22.8'	67° 37.9'	51° 16.4'
NNE-SSW	210	67° 34.3'	51° 11.7'	67° 38.3'	51° 10.7'
NW-SE	211	67° 11.6'	51° 30.9'	67° 14.2'	51° 38.9'

Table 14. Random transects for aerial survey, **Central** region, March 2005.

Direction flown	Transect number	Transect start		Transect end	
		Latitude	Longitude	Latitude	Longitude
SW-NE	1	64° 47.14'	51° 32.91'	64° 50.49'	51° 27.56'
S-N	3	65° 05.79′	51° 22.96′	65° 09.80′	51° 21.80′
SE-NW	8	64° 49.86′	51° 03.41′	64° 53.51′	*51° 07.52′*
W-E	15	65° 20.68′	50° 47.81′	65°20.52′	50°38.12′
S-N	17	64° 36.97′	52° 04.81′	64° 40.68′	52° 01.00′
SE-NW	18	64° 43.05′	51° 20.32′	64° 45.39′	51° 28.05′
SSE-NNW	19	65° 05.24′	50° 31.98′	65° 09.15′	50° 34.45′
SE-NW	21	64° 46.09′	51° 02.62′	64° 49.33′	51° 08.32′
NW-SE	28	65° 31.96′	51° 04.32′	65° 30.11′	50° 55.63′
NW-SE	36	64° 56.09′	51° 20.72′	64° 54.46′	51° 11.98′
S-N	39	64° 40.85′	52° 03.31′	64° 43.95′	51° 57.21′
NW-SE	46	65° 02.89′	51° 12.83′	65° 00.80′	51° 04.61′
SSW-NNE	52	65° 40.79′	51° 56.24′	65° 44.54′	51° 52.55′
NW-SE	53	65° 27.61′	51° 42.92′	65° 25.81′	51° 34.19′
SSE-NNW	56	65° 18.61′	52° 01.44′	65° 22.37′	52° 05.01′
SSE-NNW	58	65° 19.84′	51° 44.91′	65° 23.29′	51° 49.99′
SW-NE	61	65° 23.39′	51° 21.39′	65° 26.66′	51° 15.66′
SW-NE	64	64° 49.53′	49° 53.16′	64° 50.56′	49° 43.96′
NW-SE	65	65° 05.11′	51° 06.50′	65° 01.78′	51° 01.07′
N-S	68	64° 25.95'	51° 40.69'	64° 22.11'	51° 37.73'
W-E	77	64° 18.11′	52° 06.29′	64° 18.99′	51° 57.18′
S-N	84	65° 00.67′	52° 10.06′	65° 04.40′	52° 06.31′
W-E	87	64° 58.78′	51° 34.97′	64° 58.55′	51° 25.42′
SW-NE	92	65° 21.48′	50° 30.04′	65° 24.06′	50° 22.56′
S-N	95	65° 36.87′	51° 40.90′	65° 40.92′	51° 41.22′
S-N	96	64° 46.69′	50° 30.23′	64° 50.72′	50° 31.05′
W-E	97	64° 28.06′	52° 06.60′	64° 29.03′	51° 57.48′
SSE-NNW	105	65° 38.69′	50° 27.48′	65° 42.25′	50° 32.19′
E-W	107	65° 22.37′	52° 15.41′	65° 21.66′	52° 24.97′
SW-NE	108	64° 51.34′	50° 38.18′	64° 54.72′	50° 32.96′
SW-NE	121	65° 36.60′	51° 22.38′	65° 38.27′	51° 13.44′
N-S	124	64° 53.44′	51° 36.66′	64° 49.51′	51° 38.92′
SW-NE	126	65° 36.02′	50° 47.44′	65° 37.47′	50° 38.29′
W-E	135	65° 03.43′	50° 14.72′	65° 03.25′	50° 05.14′
SE-NW	136	64° 49.88′	49° 57.96′	64° 53.40′	50° 02.64′
W-E	139	65° 31.92′	52° 02.11′	65° 32.39′	51° 52.4′
SW-NE	141	65° 07.52′	50° 28.98′	65° 11.23′	50° 25.13′

SW-NE	149	65° 29.47′	51° 09.85′	65° 30.74′	51° 00.58′
NW-SE	155	65° 37.49′	51° 35.26′	65° 35.85′	51° 26.31′
NW-SE	157	65° 21.24′	50° 37.14′	65° 18.50′	50° 30.00′
W-E	164	65° 05.81′	51° 53.45′	65° 05.72′	51° 43.85′
SSE-NNW	166	64° 53.92′	49° 59.59′	64° 57.85′	50° 01.89′
SW-NE	168	65° 31.49′	51° 16.54′	65° 33.14′	51° 07.62′
SE-NW	181	65° 06.81′	51° 42.78′	65° 10.39′	51° 47.28′
W-E	183	65° 03.25′	51° 25.54′	65° 01.64′	51° 16.74′
NW-SE	186	65° 10.27′	51° 04.97′	65° 07.62′	50° 57.69′
W-E	191	64° 50.56′	50° 54.21′	64° 49.24′	50° 45.21′
SE-NW	193	64° 52.77′	51° 13.97′	64° 54.99′	51° 21.95′
W-E	197	65° 02.10′	50° 19.68′	65° 01.59′	50° 10.18′
SW-NE	199	65° 08.02′	52° 02.68′	65° 10.53′	51° 55.12′
W-E	200	65° 02.04′	51° 44.44′	65° 03.51′	51° 35.50′
NE-SW	201	65° 09.10′	50° 38.21′	65° 07.59′	50° 47.14′
W-E	203	64° 58.96′	50° 27.64′	64° 59.29′	50° 18.10′
W-E	227	64° 38.00'	51° 33.97'	64° 37.95'	51° 24.53'

Table 15. Random transects aerial survey Ameralik, **South** region, March 2006.

Direction flown	Transect number	Transect start		Transect end	
		Latitude	Longitude	Latitude	Longitude
SSE-NNW	2	64° 07.29′	50° 29.33′	64° 03.30′	50° 27.78′
NW-SE	7	64°38.98′	50° 35.83′	64° 36.38′	50° 28.59′
NE-SW	11	64° 22.34′	49° 43.68′	64° 25.41′	49° 37.58′
SW-NE	23	64° 08.79′	51° 35.85′	64° 10.78′	51° 27.77′
SSE-NNW	28	63° 51.02′	51° 24.10′	63° 47.51′	51° 19.54′
NW-SE	34	63° 39.08′	51° 09.81′	63° 35.08′	51° 08.49′
SSW-NNE	37	63° 59.41′	50° 03.76′	64° 03.44′	50° 02.78′
NW-SE	40	63° 35.05′	51° 03.50′	63° 31.13′	51° 01.22′
NE-SW	41	63° 55.42′	51° 16.78′	63° 57.73′	51° 09.22′
SW-NE	44	64° 19.89′	50° 35.79′	64° 21.79′	50° 27.54′
SE-NW	46	64° 23.58′	50° 49.45′	64° 21.21′	50° 41.87′
S-N	77	63° 22.12′	50° 51.44′	63° 26.15′	50° 50.58′
NW-SE	87	64° 29.99′	49° 57.17′	64° 27.81′	49° 49.27′
SW-NE	91	63° 38.14′	51° 19.09′	63° 41.52′	51° 14.06′
W-E	94	64° 13.81′	50° 02.19′	64° 13.93′	49° 52.88′
SW-NE	96	64° 15.74′	50° 26.94′	64° 16.98′	50° 18.07′
W-E	99	63° 55.88′	50° 23.52′	63° 56.31′	50° 14.37′
NW-SE	109	64° 14.15′	50° 58.05′	64° 12.56′	50° 49.49′
NW-SE	115	64° 36.12′	50° 10.24′	64° 34.14′	50° 02.02′
SSE-NNW	167	63° 45.73′	51° 23.67′	63° 41.79′	51° 21.61′
SW-NE	170	63° 25.19′	51° 07.12′	63° 28.36′	51° 01.50′
NW-SE	172	63° 27.71′	50° 53.65′	63° 26.36′	50° 45.12′
W-E	180	64° 01.82′	50° 35.41′	64° 01.86′	50° 26.17′
SE-NW	182	63° 55.35′	50° 00.31′	63° 52.03′	49° 55.05′
SE-NW	188	64° 21.88′	50° 05.34′	64° 18.39′	50° 00.62′
SE-NW	190	64° 12.64′	49° 51.57′	64° 10.74′	49° 43.36′
SW-NE	197	64° 28.05′	50° 26.06′	64° 31.40′	50° 20.77′
SW-NE	206	64° 34.78′	50° 23.33′	64° 38.37′	50° 18.99′
S-N	210	63° 55.23′	50° 28.25′	63° 59.28′	50° 28.21′
SE-NW	212	63° 56.02′	49° 55.89′	63° 52.95′	49° 49.88′
SE-NW	233	64° 06.68′	50° 08.85′	64° 03.32′	50° 03.68′
SW-NE	240	63° 59.75′	50° 27.49′	64° 02.59′	50° 20.90′

W-E	246	64° 36.77′	50° 53.28′	64° 36.71′	50° 43.84′
SW-NE	257	63° 57.00′	51° 24.00′	64° 01.24′	51° 21.40′
NW-SE	258	63° 40.68′	51° 03.13′	63° 37.18′	50° 58.55′
SW-NE	267	64° 12.31′	50° 11.37′	64° 15.90′	50° 07.09′
S-N	271	64° 11.48′	49° 40.51′	64° 15.52′	49° 39.83′
SW-NE	282	64° 32.36′	49° 53.98′	64° 33.86′	49° 45.24′
SE-NW	295	63° 55.46′	50° 55.96′	63° 52.37′	50° 50.03′
ENE-WSW	296	64° 03.06′	50° 58.47′	64° 04.00′	50° 49.48′

Table 16. Random transects aerial survey Qeqertarsuatsiaat, **South** region, March 2006.

Direction flown	Transect number	Transect start		Transect end	
		Latitude	Longitude	Latitude	Longitude
NE-SW	1	62° 56.89′	50° 10.86′	63° 00.40′	50° 06.42′
NW-SE	3	63° 12.30′	49° 44.23′	63° 09.89′	49° 37.02′
NW-SE	10	62° 57.61′	50° 04.06′	62° 55.81′	49° 56.09′
SW-NE	12	63° 12.89′	49° 41.72′	63° 15.57′	49° 35.00′
NE-SW	14	63° 15.47′	49° 46.36′	63° 17.15′	49° 38.18′
NW-SE	26	63° 19.83′	49° 46.79′	63° 17.32′	49° 39.73′
SW-NE	30	62° 56.35′	49° 51.16′	63° 00.22′	49° 48.53′
NW-SE	59	63° 24.04′	49° 36.67′	63° 22.87′	49° 28.02′
SSW-NNE	62	63° 05.32′	50° 46.84′	63° 09.34′	50° 45.76′
SW-NE	64	62° 52.73′	50° 06.93′	62° 56.60′	50° 04.29′
SSE-NNW	86	62° 39.78′	50° 12.95′	62° 36.03′	50° 09.64′
SW-NE	90	63° 11.06′	49° 54.53′	63° 12.07′	49° 45.84′
NW-SE	105	63° 29.69′	49° 51.97′	63.27.53′	49° 44.31′
SW-NE	108	62° 40.44′	50° 16.14′	62° 42.84′	50° 09.05′
SW-NE	126	63° 10.74′	49° 32.93′	63° 12.78′	49° 25.17′
SSW-NNE	136	63° 02.39′	49° 51.73′	63° 06.42′	49° 51.04′
SE-NW	140	63° 01.89′	49° 42.16′	62° 59.15′	49° 35.60′
SW-NE	150	63° 20.24′	50° 02.82′	63° 21.74′	49° 54.44′
S-N	174	63° 13.43′	50° 12.20′	63° 09.38′	50° 12.00′
SE-NW	185	63° 31.05′	50° 03.93′	63° 27.47′	49° 59.70′
NW-SE	199	62° 47.60′	49° 56.17′	62° 45.60′	49° 48.48′
SSW-NNE	203	63° 09.42'	50° 01.98'	63° 13.37'	50° 00.09'
SW-NE	229	63° 04.40′	50° 12.64′	63° 06.10′	50° 04.53′
SSE-NNW	300	62° 53.58′	50° 02.95′	62° 49.58′	50° 01.54′

Appendix 7
List of terms

Accuracy –how well a survey estimate or index for animal numbers reflects the true population size.

Bias – describes how far the average value of the estimator is from the true population value. An unbiased estimator centres about the true value for the population. Bias is the extent to which an estimate or index is systematically wrong. Bias decreases the accuracy of a survey. In popular terms, negative bias in surveys moves the final estimate or index to below the true population size and positive bias can move it above the true population size.

Coefficient of Variance (CV) – statistical term for an index of precision that is derived by dividing the standard error (SE) by the mean estimated abundance.

Confidence interval – statistical term for when the standard error (SE) is combined with a probability (P) level to yield confidence limits (CL) and their interval, the confidence interval (CI). For example: at a $P = 0.90$ ($\alpha = 0.1$) then assuming no bias a 90% CI is likely to contain the true population size in 90% of surveys of the same type and intensity. NOTE: it is incorrect to state that there is a 90% chance that the actual number of caribou in a survey area is within the CI.

Density – the number of animals per square kilometre of land area.

Estimate – a calculation as to the likely or approximate size of an animal population.

Management – e.g. wildlife management, which is the act of manipulating, directing, controlling, regulating and/or administrating a wildlife resource and any number of the factors affecting that wildlife resource.

Index – a value, which is assumed directly related to animal density, and may be used to monitor population changes.

Population – All the animals of the same species living in a specific region, which do not mix with animals of the same species from other regions, i.e. they are reproductively isolated. A population is a demographic unit distinct by virtue of its unique density, distribution, birth & death rate, sex & age structure, immigration & emigration rates, and other demographic parameters.

Precision – is a measure of the quality of the survey estimate for animal number, i.e. how close you could expect the estimate to approximate its expected value. Precision refers to the variation in repeated measurement of the same quantity. Precision is determined primarily by the variation in the population and the size of the sample. An indicator of the precision of an estimate is the confidence interval.

Sightability – the probability of actually seeing a caribou present within the strip flown.

Standard deviation (SD) – standard deviation is the square root of the variance.

Standard error (SE) – standard error is the standard deviation (SD) divided by the square root of sample size (n) or (n-1) if SD is calculated using n and not n-1. Sampling error would be zero if the same number of caribou were seen on each transect flown.

Strata – (plural of stratum) in this report refers to the division of the major regions according to caribou density present.

Variance – statistical term for the amount of variation in measurements. Variance is the expected square deviance regardless of the distribution. Note: variance is distribution independent, and is simply the expected square deviation.