2012 status of two West Greenland caribou populations

1) Ameralik,

2) Qeqertarsuatsiaat

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2012 status of two West Greenland caribou populations

1) Ameralik,

2) Qeqertarsuatsiaat

By

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*All photos presented (plus hundreds more) are available in their original >6MB size at the Greenland Institute of Natural Resources

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Summary

West Greenland (south of 69°N) has six caribou regions that in total contain eight sub-populations. This report presents new information about the South region, which is divided into two sub-populations, Ameralik and Qeqertarsuatsiaat. These were last surveyed in March 2006. Given unlimited harvests, long autumn hunting season as well as a winter hunting season, a new estimate of abundance was overdue. The March 2012 helicopter survey used different methods and analysis than those implemented in the 2001 and 2006 surveys. Line distance sampling was employed. Another change was that the boundary between Ameralik and Qeqertarsuatsiaat was returned to the Sermilik fjord and Sermeq glacier.

The overall abundance for the entire South region (Ameralik and Qeqertarsuatsiaat combined) in March 2012 was approximately 16,500 caribou, and overall caribou density was about 1.3/km^2. Although the latter is almost identical to the recommended stocking density of 1.2/km^2, the density specific to the Ameralik population exceeded this.

Individually, the Ameralik population was estimated to ca. 11,700 caribou (90 % CI: 8,500 – 16,000; CV = 0.18), with a density of 1.7 caribou/km^2. Calf (age 9-10 months) percentage was 28.2 %, calf recruitment was 63.5 calves per 100 cows. The sex ratio was ca. 62 bulls per 100 cows. The Qeqertarsuatsiaat population is estimated to ca. 4,800 caribou (90 % CI: 3,400 – 6,800; CV = 0.21), with a density of 0.8 caribou/km^2. The 2012 Ameralik population estimate is likely an underestimate because observer bias was not addressed. Further the 2012 estimate may be low in comparison with the 2006 population estimate, since the 2006 survey was less accurate but attained a similar number.

Altered and atypical Ameralik caribou distribution and choice of elevation strongly suggested that the winter harvest has a disturbance impact on caribou behavior. In future there should be an appropriate hiatus between the cessation of harvest and the initiation of monitoring. The present situation necessitates a pre-survey reconnaissance for correct allocation of survey effort. New to this survey were five crippled caribou. We suspect the immediately preceding winter hunting season (end date 29 Feb 2012) was responsible. We observed no muskoxen; however five feral sheep were seen.

The changed survey methods could have confounded a discussion of population trend since 2006. However, the 2006 and 2012 estimates of abundance are similar and are within each other's confidence intervals. Ameralik and Qeqertarsuatsiaat population abundance appears to have been relatively stable for that period. We suggest the caribou harvest in combination with continued high calf production is responsible for maintaining the population size close to the Maximum Sustainable Yield (MSY) level. Given the 2012 high calf recruitment, we advise a continued high autumn harvest pressure similar to recent levels, specifically in the light of the relatively high 2012 density for Ameralik. Although the South region taken as a whole had a density close to the recommended stocking density (1.2/km^2), Ameralik density was ca. 2/km^2 and could rise. In the interests of caribou conservation, any growth in Ameralik population size causing high density (e.g., 4/km^2 which occurred in 2001) must be prevented, because it would negatively impact vegetation, which already received overgrazing 16-20 years ago. Conserving the caribou's forage vegetation is our best method to ensure healthy caribou and enable a good annual calf production and survival.

Although caribou numbers in the South region for the period 2006-2012 were seemingly stable, there is no reason to be complacent. Hunter knowledge in 2016 suggests that caribou abundance has not declined since 2012, but may actually be rising. If true this would threaten forage vegetation and ultimately caribou numbers. Further, there are some disquieting anthropogenic changes to the caribou environment since 2012. These include altered caribou habitat use (distribution), demographics, crippling loss and new trends in hunting. These are important to consider since expected global warming will be an additional change that can bring environmental instability with negative consequences for caribou abundance.

We suggest that the commercial activities directly and indirectly involved with the harvesting of caribou now make a hitherto unrecognized substantial contribution to the Greenland economy that far exceeds the meat's market value. Meanwhile, the caribou populations in West Greenland, including Ameralik and Qeqertarsuatsiaat, are basically discrete populations inhabiting small 'islands' of land sandwiched between the Davis Strait and the Greenland Ice Cap. This makes the caribou vulnerable because these 'islands' offer nowhere-to-run-to, if and when, changes come, be these climate (e.g., drought, severe winter) or other factors (e.g., disease outbreaks, anthropogenic impacts). For wildlife management to have any chance of

mitigating future change(s), monitoring is necessary. Unfortunately lack of financial resources has suspended caribou surveys until further notice. Meanwhile the magnitude of the harvest is unknown, poaching may be substantial and winter hunting (which can increase mortality risk) is allowed, albeit on a restricted basis at present. With climate change lurking, we suspect the chances for catastrophic weather will rise. The future of our caribou populations, and hence the significant economic benefits obtained thereof, could be in jeopardy. Without monitoring data the current situation is unknown and scientifically founded recommendations for the sustainable use of caribou become impossible.

Resume (Danish)

Vestgrønland (syd for 69°N) har seks store regioner med rensdyr, der tilsammen har åtte underbestande. Denne rapport præsenterer den seneste information om Sydregionen, som er delt i to underbestande, Ameralik og Qeqertarsuatsiaat. De foregående undersøgelser her blev foretaget i marts 2006. Som følge af ubegrænset jagt, en lang jagtsæson i efteråret såvel som i vintersæsonen, var det på tide med et nyt estimat af bestanden. Helikopterundersøgelsen fra marts 2012 anvendte andre metoder og analyser end i undersøgelserne fra 2001 og 2006. Her anvendtes *line distance sampling*. En anden ændring var, at grænsen mellem Ameralik og Qeqertarsuatsiaat er blevet flyttet tilbage til Sermilik fjorden og Sermeq gletsjeren.

Den samlede bestand i hele Sydregionen (Ameralik og Qeqertarsuatsiaat) var cirka 16.500 rensdyr i marts 2012, og den generelle bestandstæthed for rensdyr var cirka 1,3 rensdyr/km^2. Selvom sidstnævnte var næsten identisk med den anbefalede bestandstæthed på 1,2 rensdyr/km^2, overskred Ameralik-bestanden denne.

Isoleret set blev Ameralik-bestanden estimeret til cirka 11.700 rensdyr (90% CI: 8.500 – 16.000; CV = 0,18) med en bestandstæthed på 1,7 rensdyr/km^2. Andelen af kalve (9-10 måneder) var 28,2%; en rekruttering på 63,5 kalve per 100 køer. Kønsfordelingen var cirka 62 tyre per 100 køer. Qeqertarsuatsiaat-bestanden er estimeret til cirka 4.800 rensdyr (90% CI: 3.400 – 6.800; CV = 0,21) med en bestandstæthed på 0,8 rensdyr/km^2. Estimatet af Ameralik-bestanden i 2012 er sandsynligvis et underestimat, da bias ikke blev overvejet i forbindelse med observationerne. Ydermere er estimatet fra 2012 muligvis

lavt i sammenligning med estimatet fra 2006, da undersøgelsen i 2006 var mindre præcis men nåede et lignende resultat.

Den forandrede og atypiske fordeling og de ændrede bevægelsesmønstre i Ameralik påviser, at vinterjagten har en forstyrrende effekt på rensdyrenes adfærd. I fremtiden bør der være et passende ophold mellem indstillingen af jagten og påbegyndelsen af monitoreringen. Den nuværende situation påpeger nødvendigheden af en rekognoscering inden undersøgelsens påbegyndelse for at sikre korrekt gennemførelse. Nyt for denne undersøgelse var, at der observeredes fem skadede rensdyr. Vi formoder, at årsagen kan findes i den forudgående vinterjagtsæson (slutdato 29. februar 2012). Vi observerede ingen moskusokser, men fem vilde får blev set.

Den ændrede undersøgelsesmetode har besværliggjort diskussionen af bestandsudviklingen siden 2006. Imidlertid er estimaterne af bestandstætheden fra 2006 og 2012 lignende og ligger inden for hinandens konfidensinterval. Ameralik og Qeqertarsuatsiaat-bestandenes tæthed lader til at have været relativ stabil i denne periode. Vi mener, at det er kombinationen af rensdyrjagten og en fortsat høj kalveproduktion, der er grunden til at bestandstørrelsen stadig ligger tæt på niveauet for Maximum Sustainable Yield (MSY). Grundet den 2012 høje rekruttering af kalve anbefaler vi en fortsat høj efterårsjagt magen til de seneste niveauer, specielt set i lyset af den relativt høje bestandstæthed i Ameralik i 2012. Selvom Sydregionen i sin helhed havde en bestandstæthed nær den anbefalede bestandstæthed (1,2/km^2), så var Ameraliks bestandstæthed ca. 2/km^2 og vil kunne stige yderligere. For at bevare rensdyrene må det understreges at enhver vækst i rensdyrbestanden, der medfører høj tæthed (for eksempel 4/km^2, som i 2001), må undgås, fordi dette kunne have negativ indflydelse på vegetationen, som for kun 16-20 år siden var udsat for overgræsning. Bevarelse af rensdyrenes fodervegetation er vores bedste middel til at sikre sunde rensdyr og en god årlig kalveproduktion og –overlevelse.

Selvom antallet af rensdyr i Sydregionen i perioden 2006-2012 tilsyneladende var stabil, er der ingen grund til at være for selvtilfreds. Jægernes erfaringer fra 2016 antyder, at rensdyrtætheden ikke er faldet siden 2012 men i virkeligheden kan være stigende. Hvis dette er sandt kan det true fodervegetationen og dermed antallet af rensdyr. Ydermere har der været nogle bekymrende menneskeskabte ændringer i rensdyrenes omgivelser siden 2012. Disse inkluderer ændringer i brugen af rensdyrhabitatet

(fordeling), demografi, skamskudte dyr og nye jagttendenser. Det er vigtigt at tage disse i betragtning, da de forventede klimaforandringer vil tilføre endnu en faktor, der kan medføre ustabilitet i omgivelserne med negative konsekvenser for bestandstætheden.

Vi mener, at de kommercielle aktiviteter, der er direkte og indirekte forbundet med rensdyrjagten, bidrager til den grønlandske økonomi i et hidtil uset omfang, der langt overgår kødets markedsværdi. Samtidigt er rensdyrbestandene i Vestgrønland, inklusiv Ameralik og Qeqertarsuatsiaat, grundlæggende separate bestande, der lever på små "øer" af land placeret imellem Davisstrædet og Indlandsisen. Denne beliggenhed gør rensdyrene udsatte, da disse øer gør det umuligt at flygte, hvis og når der sker ændringer, hvad enten disse skyldes klimaet (for eksempel tørke, hård vinter) eller andre faktorer (for eksempel udbrud af sygdom, menneskeskabte påvirkninger). Hvis forvaltningen af dyrelivet skal have en chance for at begrænse omfanget af fremtidige ændringer er monitorering nødvendig. Desværre har mangelen på finansielle ressourcer indstillet rensdyrundersøgelser indtil videre. Imens er størrelsesordenen af jagten ukendt, krybskytteri kan være omfattende og vinterjagt (som kan øge dødelighedsrisikoen) er tilladt, men dog i begrænset omfang for indeværende. Med klimaændringerne lurende om hjørnet forudser vi, at risikoen for ekstreme vejrforhold vil stige. Fremtiden for vores rensdyrbestande - og dermed det betydelige økonomiske udbytte deraf - kunne være i fare. Uden overvågningsdata er den nuværende situation ukendt og det umuliggør videnskabeligt begrundende anbefalinger for bæredygtigt brug af rensdyr.

Eqikkaaneq (Greenlandic)

Kalaallit Nunaata kimmut sineriaani (69°N-ip kujataani) arfinilinnik angisuunik, ataatsimut katillutik arfineq pingasunik mikinerusunik immikkoortortalinnik tuttoqarfeqarpoq. Nalunaarusiaq una Kujataani tuttoqarfiit pillugit kingullermik misissuisoqarneragut paasissutissutissanut pissarsiarineqartunut tunngasuuvoq, tuttoqarfillu taanna marlunnut, Ameralimmut Qeqertarsuatsiaanullu avinneqarsimavoq. Taakkunani misissuinerit kingulliit marts 2006-imi ingerlanneqarput. Killilersugaanngitsumik piniartoqartarnerata, aammalu ukiakkut ukiuuneranilu sivisuumik piniartoqartarsimanerata kingunerisaanik tuttoqassuseq nutaamik naliliiffigineqartariaqalersimavoq. Qulimiguulik atorlugu marts 2012-imi misissuinermi periutsit misissueriaatsillu 2001-imi 2006-imilu misissuissarsimanerni atorneqartuniit allaanerusut atorneqarput.

Tassani kisitseriaaseq *line distance sampling* atorneqarpoq. Allannguut alla tassaavoq tuttoqarfiit Amerallip Qeqertarsuaatsiaallu akornanni killeqarfik Sermillip Kangerluanut Sermillu sermianut uterteqqinneqarmat. Kujataata tuttoqarfiani (Ameralik aamma Qeqertarsuatsiaat) tuttut tamarmiusut marts 2012-imi 16.500-t missaanniissangatinneqarput, tuttullu eqimassusiat km^2-imut agguaqatigiissillugu tuttut amerlassusiat 1,3-inut missingerneqarsimavoq. Una kisitsit taaneqartoq tuttut eqimassusissaattut innersuussutigineqartup km^2-mut tuttut amerlassusissaat agguaqatigiissillugu 1,2-jusariaqarnerannik innersuussutigineqartumut qanikkaluarpoq, taamaattorli Ameralimmi tuttut amerlavallaarsimapput. Immikkoortillugu isigalugu Ameralimmi tuttoqassuseq 11.700-nut missingiunneqarsimavoq (90% CI: 8.500 – 16.000; CV = 0,18) tuttut km^2-imut 1,7-inik eqimassuseqarlutik. Tuttut piaqqat (qaammatit 9-10) 28,2 %-inik amerlassuseqarput; kulavaat 100-juugaangata agguaqatigiissillugu 63,5-inik piaqqisarsimapput. Suiaassutsiinut agguataaraanni kulavaat 100-gaangata angutivissat 62-it missaanniittarput. Qeqertarsuatsiaani tuttoqassuseq 4.800-it missaanniippoq (90% CI: 3.400 – 6.800; CV = 0,21) km^2-imut 0,8-inik eqimassuseqarlutik. Ameralimmi 2012-imi tuttoqassutsimik naliliineq ikinaagaasutut isigisariaqarunarpoq, naatsorsuinermi kisitseqataasut takunnissinnaanerisa nikingassusiat ilanngunneqarsimanngimmat. 2012-imilu peqassutsimik naliliineq 2006-imi naliliinermut sanilliullugu appasinaagaagunarpoq, 2006-imi misissuineq eqqoqqissaanginnerusimammat assingusumilli inerneqarsimalluni.

Ameralimmi ingerlaartarfiisa allanngorsimanerisa aammalu agguataarsimanerisa allannguuteqarsimanerisa takutippaat ukiuunerani piniartarneq tuttut pissusilersuutigisartagaannut akorngusersuutaasumik sunniuteqartartoq. Siunissami imaattariaqarpoq, piniarnerup unitsinneqarneraniit misissuinerup aallartinnissaata tungaanut piffissap naapertuuttumik sivisussuseqartariaqartarnissaa eqqarsaatigineqartariaqalermat. Pissutsit massakkut atuuttut eqqarsaatigalugit siunissami misissuisarnissat eqqortumik ingerlanneqartarnissaat qulakkeerniarlugu misissuinerit aallartinngilaattaanni alapernaarsuisoqaqqaartarnissaa pisariaqarsorinalerpoq. Misissuinermi tassani nutaartaavoq tuttunik ajoqusersimasunik tallimanik takusoqarsimammat. Ilimagaarput ukiuunerani piniartoqarsimanera peqqutaasimassasoq (29. februar 2012-imi naasoq). Umimmannik takusaqanngilagut, savanilli nujuartanik tallimanik takusoqarpoq.

Misissueriaatsip allanngortinneqarnerata kingunerisaanik tuttoqassutsip 2006-imiilli nikerarsimaneranik nalilersuineq ajornakusoornerulersippaa. 2006-imili 2012-imili amerlassusiliisimanerit imminnut eqqaanarput naatsorsuutigisalli iluinniillutik. Ameralimmi Qeqertarsuatsiaanilu eqimassusiat ukiuni pineqartuni aalaakkaasumik inissisisimasimasutut isikkoqarpoq. Tuttunniartoqartarnera ukiunilu pineqartuni

piaqqiorluaannarsimanerat patsisaaqataallutik tuttoqassuseq piujuartitsinermik tunngaveqartumik ilanngartorneqarsinnaanerata qummut killingata, Maximum Sustainable Yield (MSY) iluani, qaffasittumi inissisisimajuarsimavoq. 2012-imi piaqqiarineqarsimasut amerlanerat peqqutalluni siunnersuutigaarput ukiuni kingullernisuulli amelatigisunik ukiaanerani tuttutassiissuteqartoqartaannarallassasoq, pingaartumik 2012-imi Ameralimmi eqimassusiat eqqarsaatigalugu. Naak kujataani tuttoqarfik tamaat ataatsimut isigalugu tuttut eqimassusiat eqimassusissatut innersuussutigineqartumut qanikkaluaqisoq (1,2/km^2), peqassutsip Ameralimmi eqimassusia km^2-imut marluk missaanniittoq sulilu kisitsisitaata qaffasinnerulaarsinnaanera akuersaarneqarsinnaavoq. Tuttut piujuatinneqarnissaat qulakkeerniarlugu erseqqissaatigineqassaaq, tuttut amerleriaateqaraangata nerisassaqarnisarnerat eqqarsaatigalugu suli eqimanerulernerinik amerleriaateqarnerat kinguneqartarmat (soorlu assersuutigalugu 2001-imi km^2-imut sisamat angumalerualuallarmatigit). Tamanna pinngitsoorniartariaqarpoq, nunammi neriniarfiusartut naggorissusiat eqqarsaatigalugu ajoqutaasumik sunniuteqartussaammat, soorlumi ukiut 16-20-it siornatigut taamatut pisoqarsimasoq. Naasut tuttut nerisartagaasa paarilluarnissaat peqqissunik aammalu piaqqiorluartunik aniguisinnaasunillu tuttoqarnissaanut aqqutissatuaapput pitsaanersaat.

Kujataani tuttut amerlassusiat 2006-imiit 2012-imut aalaakkaasimagaluarpataluunniit, taamaattuaannassanasorinissaannut pissutissaqanngilagut. Tuttunniartartut 2016-imi misilittagaasa takutippaat, tuttut eqimassusiat 2012-imiilli appariarsimanngitsoq piviusumillu killormut suli qaffakkiartorunartoq. Tamanna ilumoorsimappat nunap naggorissusia ulorianartorsioriartulersimasinnaavoq, taamalu aamma naggataagut tuttut amerlassusiat ulorianartorsioertinneqalissaaq. Tuttut avatangiisaat aamma 2012-imiilli inuit pilersitaannik isumannartoqalersimapput. Tamakkununnga ilaapput tuttut agguataarsimaneri, sumiittarfii, pissanneqartartut amerlassusiat piniartarnermilu ileqquulersut nutaat. Tamakku tamaasa ilanngullugit eqqarsaatiginissaat pingaartuuvoq, tassami naatsorsuutigisatut silap pissusiata allanngornerata kingunerisaanik tuttunut sunniutissaasa ilagisinnaammassuk avatangiisit peqassutsimut pitsaanngitsumik sunnerneqarsinnaanerat.

Isumaqarpugut aningaasarsiutiginiarlugu iliuuserineqartartut, tuttunniartarnermut toqqaannartumik toqqaannanngitsumillu sunniuteqartartut, kalaallit aningaasaqarniarnerannut manna tikillugu takuneqarsimanngitsutut annertussuseqalersimasut, allaat neqit nioqqutaasarnerisa naleqassusianniit annerujussuarmik. Peqatigitillugu Kalaallit Nunaata kitaani tuttoqarfinni tuttut, Ameralik Qeqertarsuatsiaallu ilanngullugit, tunngaviatigut immikkuulaartorujussuupput, allaat Davisstrædip Sermersuullu akornanni "qeqertaaqqani" immikkoorlutik

uumasutut takorloorneqarsinnaallutik. Taamatut inissisimanerup tuttut mianernarnerulersippai, allanngornernik pisoqarpat pisoqassappalluunniit ”qeqertanit” taakkunanngaanniit qimaasoqarsinnaanngimmat, allanngornerit tamakku silap pissusiata allanngorneranik peqquteqarpata (soorlu assersuutigalugu panernermik, ukiorluuneranik) imaluunniit allanik (soorlu nappaalanrnik, inunnit sunniivigineqarnermik). Uumassusilinnik aqutsineq siunissami allanngornernut takkukkumaarsinnaasunut millisaaniarluni sillimmartaarsinnaassaguni taava uumasut malinnaaffigalugit akuttunngitsunik misissuisarnissat pisariaqarput. Ajoraluartumilli aningaasanik amikkisaaruteqarnermik peqquteqartumik tuttut pillugit misissuisarnerit unikkallarnikuupput. Taamaanneranilu qanoq piniagaatiginerat ilisimaneqanngilaq, anngiortumillusooq piniartoqartartorujussuusinnaavoq ukiuuneranilu piniartarneq (toquinnartartut amerlassusiannik qaffassaataasinnaasoq) akuerineqartarpoq, massakkorpiarli killeqakannerluni. Silap pissusiata allanngoriartornera malunnarsigaluttuinnarmat silarlukkajunnerulernissaa naatsorsuutigaarput. Tuttoqatigiit siunissaat - taamalu aamma taakku aningaasarsiutigineqarsinnaanerisa - ulorianartorsiortinneqaratalersinnaavoq. Misissuisarnertigut paasisat amigaataappata massakkorpiaq susoqarnera ilisimasinnaanngilarput, taamalu tuttut piujuartitsinermik tunngaveqartumik iluaqutigineqarnissaat pillugu ilisimatuussutsikkut tunngavilimmik siunnersuisarnissaq ajornassaaq.

Introduction

The Ameralik and Qeqertarsuatsiaat caribou are adjacent populations that occupy hunting regions 4 and 5 respectively in the South region (Fig. 1). Although fjord and ice cap separate Ameralik from Qeqertarsuatsiaat, the border is permeable permitting movement between the two, e.g., over winter sea ice. Both are under the jurisdiction of the Sermersooq municipality of West Greenland. Greenland's capital city, Nuuk (population c. 17,000), lies within the South region. These caribou are a financial resource for the region's hunters, both professional and recreational, and although the value of continuing hunting traditions and culture is difficult to quantify, caribou are treasured by all. No celebratory social gathering is complete without a caribou roast on the table.

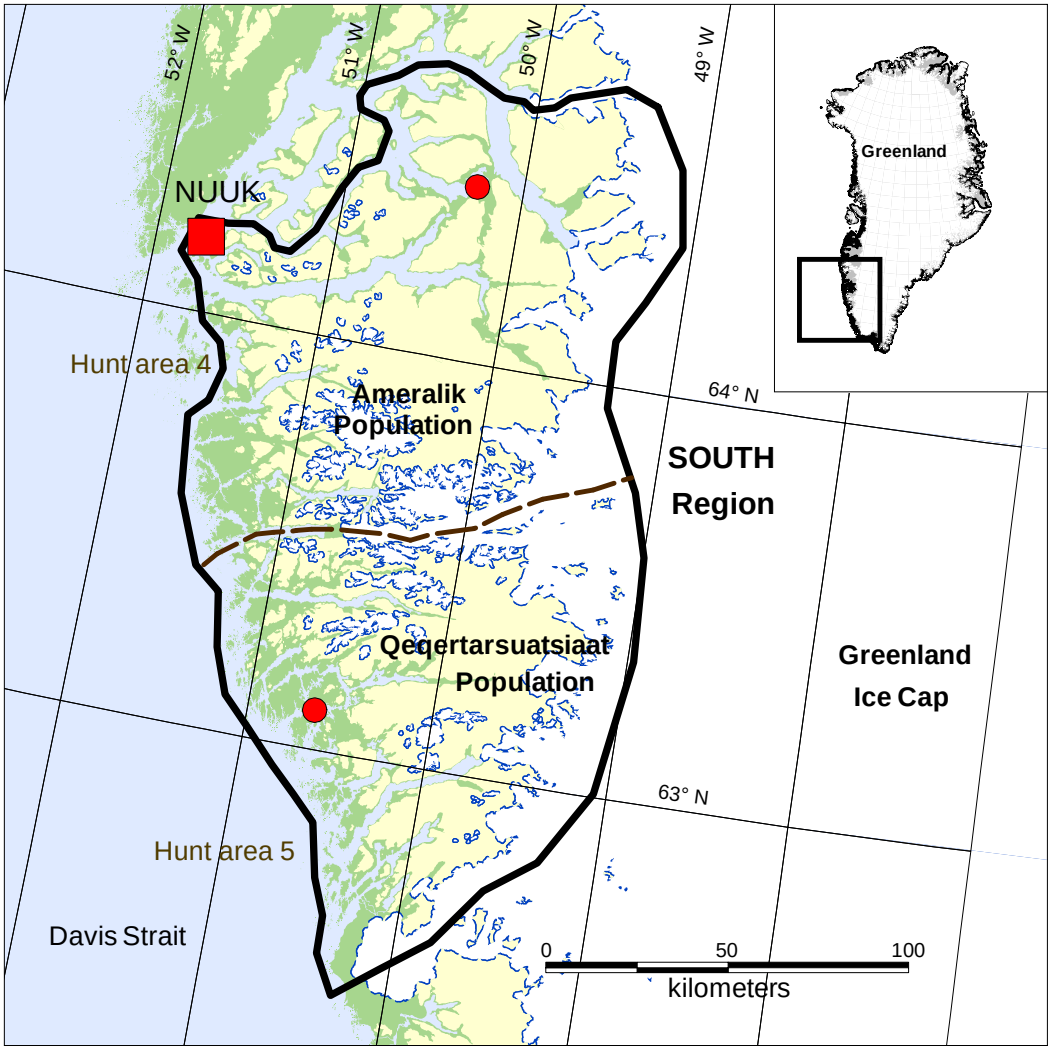


Figure 1. *Ranges of the Ameralik and Qeqertarsuatsiaat caribou populations, in the South region, West Greenland, which correspond to hunting areas 4 and 5 respectively. Sermilik fjord and Sermeq glacier form the permeable border between the two. Elevations over 200m are in light yellow, below 200m in green.*

Although both populations have been surveyed for abundance since the early 1990's, it was first in 2001 and again in 2006, that helicopter and short length random transect lines were used. The 2001 survey indicated that the density of the Ameralik population was 3.7 caribou per km^2, which was well over the recommended stocking capacity of 1.2 caribou per km^2. In contrast, the Qeqertarsuatsiaat population was approximately equal to the recommended stocking capacity. Following the 2001 survey, harvest management focused on reducing Ameralik abundance to remedy overstocking and observed range degradation due to overgrazing. The 2006 survey indicated that both populations were within the advised stocking density.

For several decades now, the Ameralik population has been a successful genetic mix of indigenous caribou (*Rangifer tarandus groenlandicus*) and feral semi-domestic reindeer (*Rangifer tarandus tarandus*) (Jepsen 1999, Jepsen *et al.* 2002). The mixing likely began in the late 1970's (Cuyler 1999). At the time of this 2012 survey the Qeqertarsuatsiaat population may also have become a genetic mix, owing to the continued southward movement into the Qeqertarsuatsiaat region by Ameralik animals (Cuyler *et al.* 2003, 2006; Local Knowledge Appendix 1).

Table 1. *Recent late winter population parameters of the Ameralik and Qeqertarsuatsiaat populations in West Greenland (Cuyler et al. 2003, 2007; Ydemann & Pedersen 1999).*

Parameter	1993	1996	2001	2006
Ameralik caribou population – SOUTH region (4)				
Population size estimate	1,200	4,500	31,880	9,680
Mean group size ± SD	3.9	3.5	4.3 ± 3.65 SD	5.4 ± 3.06 SD
Max group size			28	15
Density per sq km	0.2	0.9	3.7	1.16
Calf percentage	3.1 %	16.2 %	17.8 %	24.8 %
Recruitment (Calf / 100 Cow)	-	-	40	59.8
Sex ratio (Bull > 1 year / 100 Cow)	-	-	83	81
Qeqertarsuatsiaat caribou population – SOUTH region (5)				
Population size estimate	181	-	5,372	5,224
Mean group size ±SD	1.9	-	2.9 ± 1.29 SD	5.2 ± 3.28 SD
Max group size			6	14
Density per sq km	0.03	-	1.1	1.02
Calf percentage	14.8	-	26.2 %	8 %
Recruitment (Calf / 100 Cow)	-	-	61	32
Sex ratio (Bull > 1 year / 100 Cow)	-	-	72	275

Background - Ameralik population

The Ameralik caribou population inhabits the area between Godthåbsfjord and Sermilik fjord in hunting area 4 (details in Cuyler *et al.* 2007). Earlier fixed-wing, high altitude, high speed surveys of 1993 and 1996 resulted in late winter pre-calving population estimates of ca. 1,200 and 4,500 respectively (Ydemann D. & Pedersen C.B. 1999). Both were underestimates (Cuyler 2007). After a hiatus of four years, surveying for caribou abundance in West Greenland began again in 2000 using changed methods, which included low altitude low speed helicopters. The number of caribou observed on the new surveys far exceeded any previous survey.

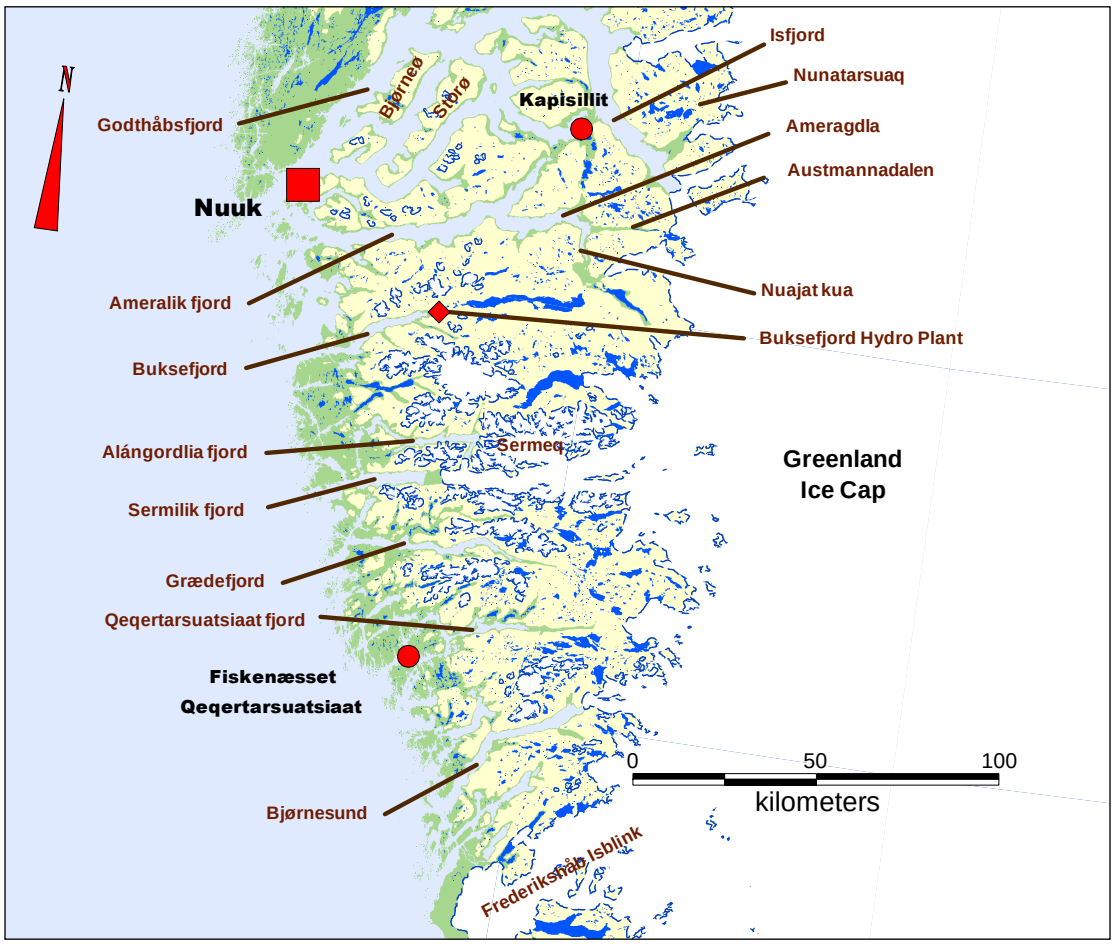


Figure 2. *The South region fjord names used to delineate areas of caribou abundance. Further place names are in Appendix 2. Elevations over 200m are shown in light yellow, below 200m are green.*

The 2001 Ameralik survey gave a late winter pre-calving population estimate of ca. 31,880 Ameralik caribou (Table 1). This was 7-fold greater than the 1996 fixed-wing estimate, and gave almost 4x the recommended stocking density, while calf percentage was low for a population without predation. When caribou density is too high and food resources limited intra-specific competition may have negative impacts on body condition and subsequently

reproduction. Local hunters had observed areas where overgrazing and trampling of the vegetation had occurred by 2001 (Cuyler *et al.* 2003). Wildlife management immediately increased quotas and season length with the goal to reduce population size and density, which would lower grazing pressure and trampling of the range and thus perhaps raise forage quantity and quality. A successful reduction in caribou number was expected to be reflected in higher calf percentages and late-winter calf recruitment (calves per 100 cows) on subsequent surveys. Increased hunter harvests between 2001 and 2006 successfully brought down the size of the Ameralik caribou population (Cuyler *et al.* 2007). The 2006 survey resulted in a late winter pre-calving population estimate of ca. 9,680 caribou, and as expected, the calf percentage and late-winter calf recruitment rose substantially. The latter suggested that a suitable winter stocking density was achieved by the time of the March 2006 survey.

Figure 3. *Deserted hamlet Lille Narsaq 28 October 1998: top c. 52 caribou with seashore in foreground, bottom zoom c. 18. An additional 29 were outside the photo frame for total of 81 caribou. (Photo Aqqalu Rosing-Asvid).*

Since the 1990's hunters have observed not only caribou abundance changes, but also distribution patterns (Cuyler *et al.* 2003). In 1998 caribou seemed "everywhere" south of Nuuk (Appendix 3, 4). Sailing for several hours along a 34 km stretch of shoreline between Ameralik Fjord and Buksefjord (Fig. 2, Appendix 3) 955 caribou were observed. The majority appeared to ignore the boat, e.g., those at abandoned Lille Narsaq continued foraging (Fig. 3). Calf production was high, density huge and maximum group size 111. While groups numbering 300-500 caribou were seen in Eqaluit ilordlit and Præstefjord valleys (Cuyler *et al.* 2003). Caribou could be shot from the beaches, and were relatively common in Nuuk's nearby Kobbefjord. At the time harvest quotas had been extremely limited for several years. In sharp contrast, by 2012 large coastal aggregations were a thing of the past for Godthåbsfjord, Ameralik, Buksefjord, Alángordlia and Sermilik fjords. Meanwhile modest aggregations were observed increasingly further south, specifically where caribou were once scarce, e.g., Grædefjord, Fiskenæsset fjord, Bjørnesund and north of the Frederikshåb Isblink (Fig. 3). Detailed background available in Cuyler *et al.* (2003).

Background - Qeqertarsuatsiaat population

Less is known about the indigenous Qeqertarsuatsiaat caribou that occur between Sermilik fjord and Frederikshåb Isblink in hunting area 5. The 1993 survey (fixed-wing, high altitude, high speed) resulted in an extremely low pre-calving population estimate of c. 181 caribou. This was an underestimate (Cuyler, 2007). A similar survey in 1995 suggested 500 caribou. A 1996 survey had no result for Qeqertarsuatsiaat. The late winter 2001 and 2006 surveys (helicopter, low altitude, and low speed) resulted in pre-calving population estimates of ca. 5,372 and 5,224 caribou respectively. Stocking density was ca. 1.1 caribou per km^2, which matched the advised stocking capacity, and the observed calf percentage and late winter recruitment were high in 2001. However, the poor calf percentage and recruitment in 2006 were unexpected. The coincident and extremely skewed sex ratio suggests the possibility of cow biased harvesting over the intervening period. Detailed historical background for the Qeqertarsuatsiaat caribou can be found in Cuyler *et al.* (2003).

Past harvest management

Prior to and including 1992, caribou hunting in all of Greenland was unregulated. The 1993 aerial survey estimated a low number of total caribou in West Greenland, ca. 9,000. Professional hunters denied the 1993 result vehemently. By 2000-2001 the estimate of ca. 9,000 was proven an

underestimate caused by inappropriate survey methods (Cuyler *et al.* 2002, 2003). Still, in 1993 wildlife management prohibited caribou hunting for two years (1993-1994) throughout Greenland. In 1995 management initiated, harvest quotas, seasons and designated permit types (professional, recreational). However, harvest quotas were meager and remained so into 1999. Total annual caribou permits for all of West Greenland started at about 2000 caribou in 1995 and rose to about 4000 by 1999. For the South region this situation first changed in the autumn hunting season of 2001, as a result of the 2001 helicopter survey's larger population size estimate. Although their hunter knowledge was finally vindicated, its rejection and the hunting ban of 1993-1994, still rankles among professional hunters 23 years on in 2016.

Given the large number and high density of Ameralik caribou in 2001, further population size increase was expected to exacerbate existing observed range degradation and possibly lead to a natural decline of population number owing to density-dependent forage limitation. Since this was contrary to sustainable use, wildlife management increased hunter harvest and aimed at reducing caribou abundance and density to a suitable stocking rate, i.e., 1.2 caribou per sq km (Cuyler *et al.* 2007). The target stocking rate was based on studies elsewhere that document associations between observed densities and changes in 1) caribou productivity, 2) dispersal, and 3) condition of the range, as described in Cuyler *et al*. (2007).

Essentially, increased hunter harvest for both the Ameralik and Qeqertarsuatsiaat populations was achieved initially by greatly raised quotas in 2001 and 2002, lengthening the autumn season, and authorizing the harvest of all sexes and ages. These were followed in 2003 by open unlimited harvests and the addition of a winter hunting season (begun 2003). Unlimited autumn harvests continued. For example, just prior to this 2012 survey, there was also a winter January-February harvest on Ameralik caribou. In contrast, there was no winter season for Qeqertarsuatsiaat in 2012.

Traditionally most caribou hunting occurred in August and September, and the majority of animals harvested were males (Loison *et al.* 2000), and the 1995 – 1999 hunting permits allowed only a bull harvest. Since 2001, harvest management approved the taking of cows and cows with calves, and the harvest of females increased substantially. The timing and length of hunting seasons has varied. Between 1996 and 2005 hunting seasons were lengthened three to seven-fold. Between 1996 and 1999 the length of the hunting season

never exceeded 27 days, 15 August to 10 September, for both recreational and professional hunters. In contrast, in 2004 the autumn season was 92 days (15 July – 15 November) for both recreational and professional hunters, with the latter receiving an additional 90-day winter season (1 December – 28 February). In 2005 the autumn season was shortened by 15 days and the winter season by one month.

The 2006 survey for abundance of Ameralik caribou resulted in an abundance estimate that was much reduced and in accord with the target stocking rate (Cuyler *et al.* 2007). Simultaneously, calf production and recruitment increased, while the adult sex ratio was unaltered. However, analyses suggested the possibility that the 2006 Ameralik population size of ca. 10,000 might drop by 50% over the next few years (Witting & Cuyler 2011). Meanwhile, the 2006 abundance of Qeqertarsuatsiaat caribou was unchanged from 2001, while demographics evidenced a skewing towards males, for which hunter preference since 2001 may have been instrumental.

Present survey

Given the unlimited autumn and winter harvests between 2006 and 2012 what changes, if any, had resulted in the abundance and demographics of the Ameralik and Qeqertarsuatsiaat caribou populations? In early March 2012 the Greenland Institute of Natural Resources (GINR) once again examined these two caribou populations of the South Region in West Greenland by aerial helicopter survey. This 2012 survey replaced the multiple short length random transect lines strip method of 2001 and 2006, with distance sampling and systematic transect lines. This report presents the 2012 pre-calving abundance for the two caribou populations in the South region and demographics for the Ameralik caribou.

Methods

Study area

The South region is currently calculated to about 12,800 km^2 of permanently ice-free area, which also excludes lakes and rivers. Older calculations, which included lakes and rivers, estimated 13,473 km^2 (Cuyler *et al.* 2003, 2007). Godthåbsfjord forms the northern border and Frederikshåb Isblink the southern border. The east and west boundaries are the Greenland Ice Cap and the Davis Strait respectively. Approximate north-south boundaries for the

South region are 64.8°N and 62.8°N. The area surveyed did not include major glaciers or the majority of large islands on the coastline between Nuuk and Frederikshåb Isblink. Bjørneø and Storø, islands in the Godthåbsfjord, were also excluded. The pre-2001 border between the Ameralik and Qeqertarsuatsiaat populations was reestablished, i.e., Sermilik fjord and the Sermeq glacier. Thus the Ameralik area is currently assessed to about 7,044 sq km, and the Qeqertarsuatsiaat about 5,756 sq km.

Common to West Greenland, the South region exhibits a climate gradient. The western seacoast is wet maritime, however, the climate becomes dry continental as one moves east towards the Greenland Ice Cap. The region is sandwiched between the dominating high pressure over the Greenland Ice Cap to the East and the frequent low-pressure oceanic storm systems that sweep up from the southwest. At the nearby capital city of Nuuk, annual precipitation is 600 mm, annual mean temperature -1.4°C, with mean July temperature 6.5°C (Tamstorf *et al.* 2005). Topography is typically mountainous between the eight fjords, which penetrate deeply towards, and often end at, the inland Ice Cap. Elevations over 300 m cover most of the region and peaks of 1000-1500 m are common. Aside from the caribou/reindeer, the only indigenous wild mammals present in the South region are arctic hare (*Lepus arcticus* Rhoads) and arctic fox (*Alopex lagopus* Linnaeus). An additional species, muskoxen (*Ovibos moschatus* Zimmermann), has recently established itself in the small northeastern area known as Nunatarssuaq. These are natural immigrants from the Kangerlussuaq population (67°N, 51°W). Also, feral sheep (*Ovis aries*), which originated from sheep farming at Kapisillit (inner Godthåbsfjord), have maintained a small presence in Austmannadalen for several decades. These are protected, but illegal harvest occurs. Further study area details are available in Witting & Cuyler (2011).

Survey design and field methods

Areas surveyed included islands, lakes and rivers, omitting Ice Caps and glaciers. Similar to previous surveys March was chosen for reasons described in Cuyler *et al.* (2007). The 2012 aerial helicopter survey differed in design and method from the 2001 and 2006 random transect line strip-counts. This survey used line distance sampling on 61 lines of variable length. Most followed a west-east axis, reflecting the climate gradient from coastal maritime to dry continental at the Ice Cap (Figs. 4, 5, 6 and 7, Appendix 5). Although lines were systematically parallel, initial start- and end-points for a stratum were

random. There were two strata, one each for expected high and low caribou density. Lines were separated by 7 and 20 km respectively. The figures 4-7show lines numbering 1 to 62, however, number 53 was omitted. Line-61 was flown 7 km further north than intended and as shown in figure 4.

Failure to detect caribou was still considered the most important source of negative bias (inaccuracy). The typical high variability of snow cover in West Greenland terrain provides the often stationary caribou perfect background camouflage (Part II; Appendices 11, 12, 13, 14 & 15). Therefore now and since 2000; we have used an AS350-B3 helicopter, which can follow terrain features while maintaining a comparatively constant altitude above ground level even flying low and slow, while observers concentrated on detecting caribou along a relatively narrow strip width. To reduce the amount of 'dead ground' hidden by landscape features (a feature of previous surveys), helicopter altitude in this 2012 survey was raised to 40m (ca. 120 feet). Flight speed averaged ca. 65 km/hour and was never below 60 km/hour.

Participants included three observers and one person recording data, i.e., distance to and size of each caribou group with associated GPS location. Observers, each with previous survey experience, included Greenland Institute of Natural Resources (GINR) research biologist, Christine Cuyler, professional hunter Aslak Jensen (Greenland Association of Professional Hunters (KNAPK)) from Nuuk, and Sisimiut Hunting Officer Hans Mølgaard (Greenland Fisheries & Licensing Control (GFLK)). Two observers collaboratively surveyed from the left side of the helicopter, while one did the right side alone. Josephine Nymand, research biologist with GINR was the data recorder. While surveying lines there was verbal contact among caribou observers and the data recorder. Definitions of terms and maps delineating all caribou populations in Greenland are available in Cuyler *et al.* (2007).

Estimating abundance

Distance sampling

In contrast to the South region surveys of 2001 and 2006, population estimates for the two caribou populations investigated in 2012 were obtained by employing line distance sampling methods, in which distances from a line to animals detected are recorded and from these distances density and/or abundance of animal populations are estimated (Buckland *et al.* 2001, Thomas *et al.* 2010).

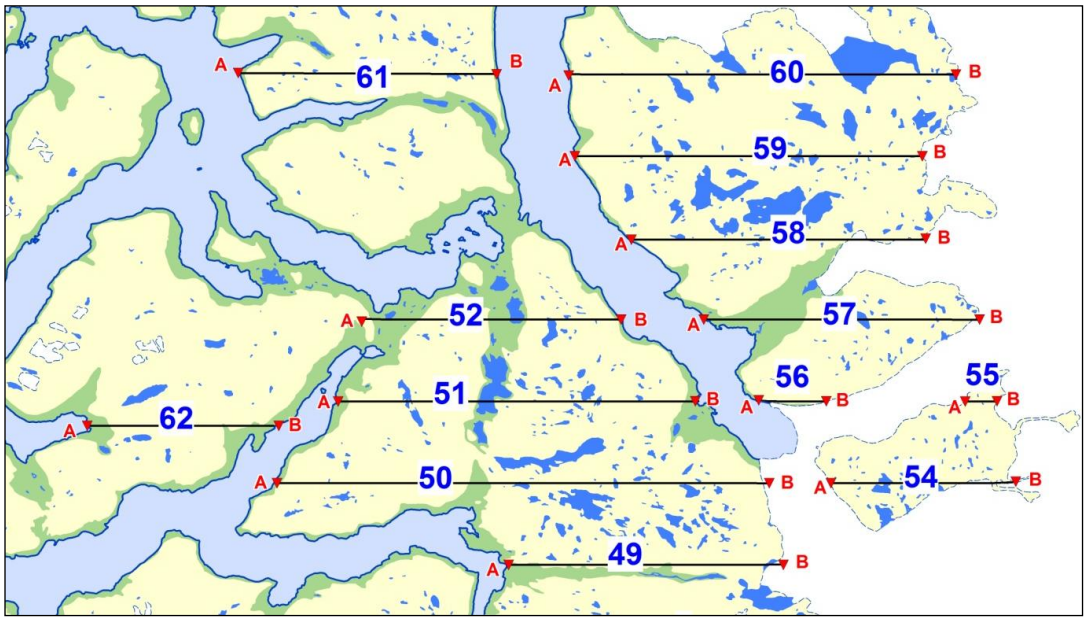


Figure 4. *Line numbers with A and B end points for the northeastern portion of the South region, caribou survey for abundance, 1-12 March 2012. Lines were separated by 7 or 20 km for high and low caribou density strata respectively. Elevations above 200m are shown in pale-yellow. Line 53 does not exist. It would have been 7km north of transect 52 running across the low elevation short neck of land.*

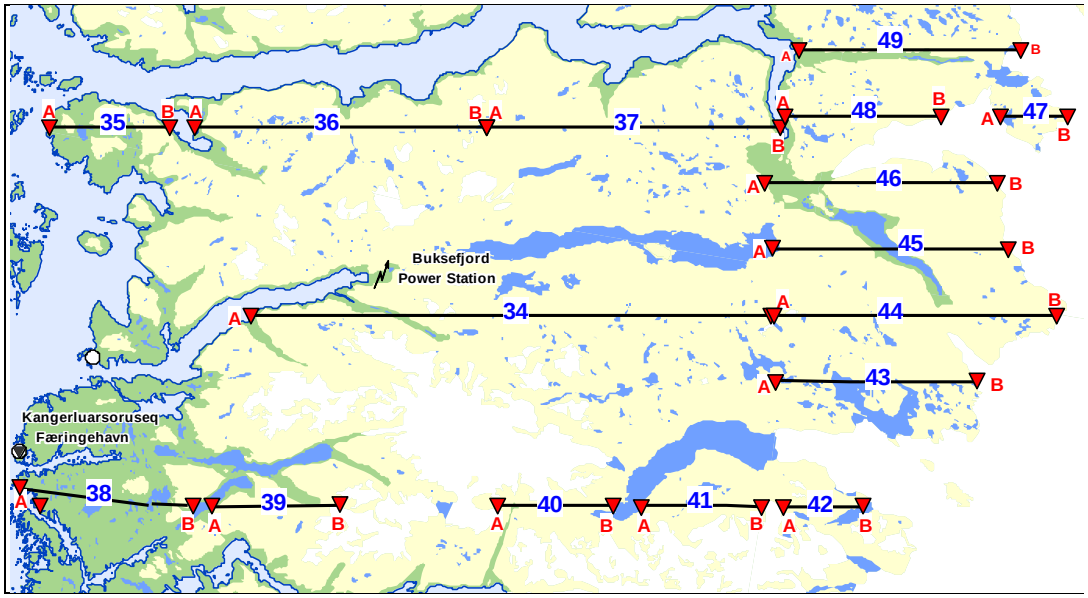


Figure 5. *Line numbers with A and B end points for the north-central portion of the South region, caribou survey for abundance, 1-12 March 2012. Lines were separated by 7 or 20 km for high and low caribou density strata respectively. Elevations above 200m are shown in pale-yellow.*

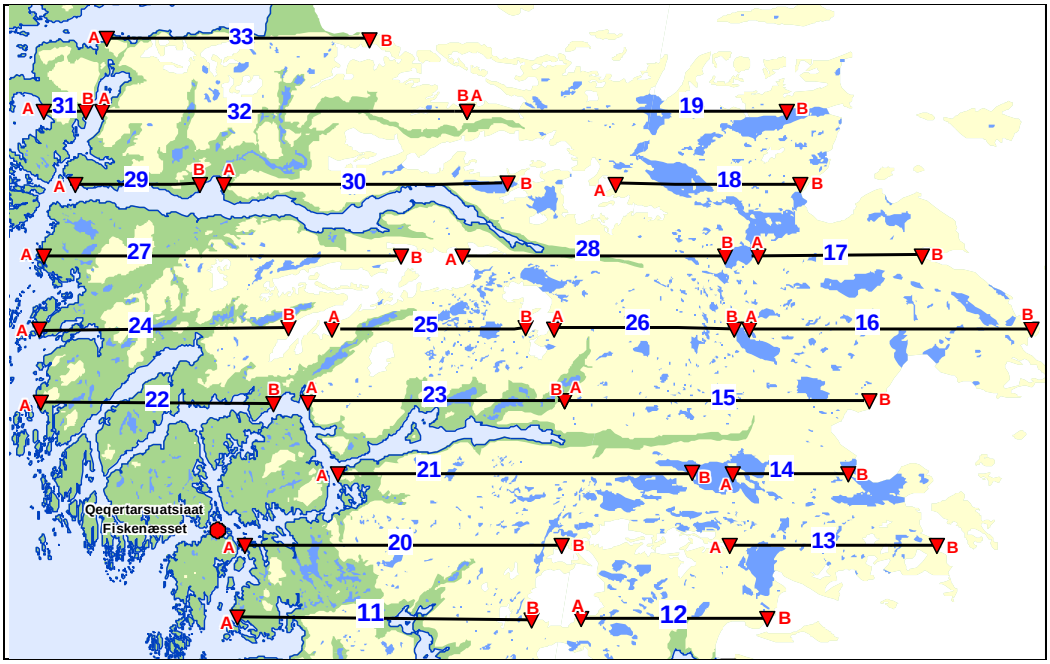


Figure 6. *Line numbers with A and B end points for the south-central portion of the South region, caribou survey for abundance, 1-12 March 2012. Lines are separated by 7 for high caribou density stratum. Elevations above 200m are shown in pale-yellow.*

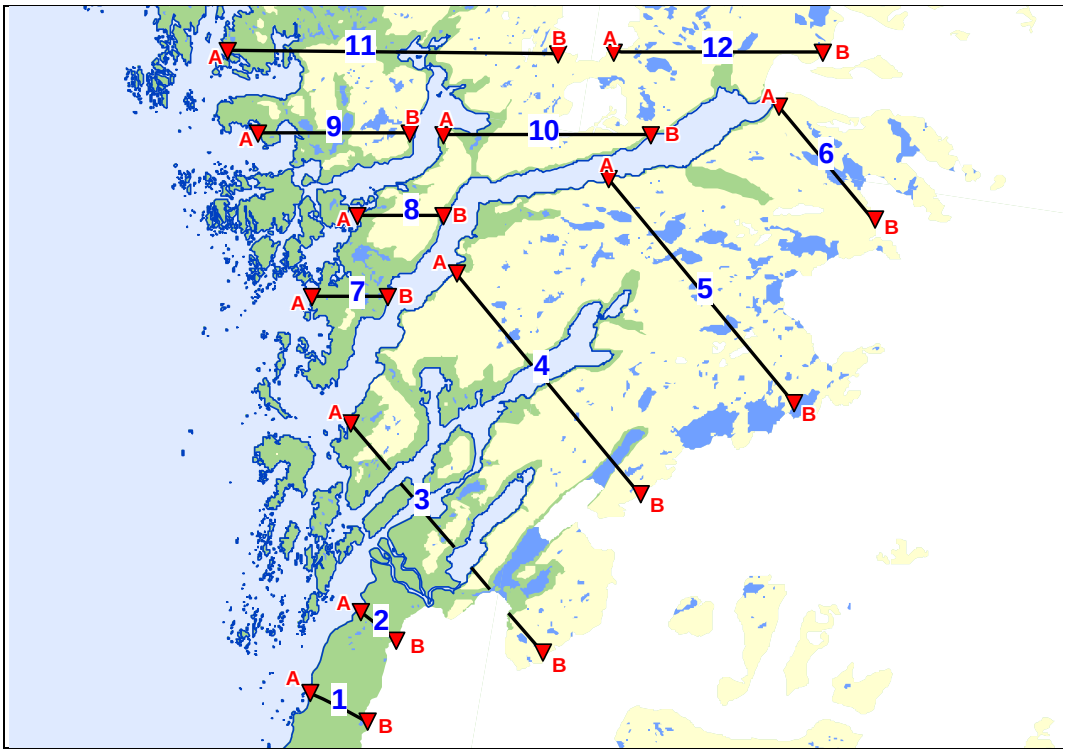


Figure 7. *Line numbers with A and B end points for the southern most portion of the South region, caribou survey for abundance, 1-12 March 2012. Lines are separated by 7 or 20 km for high and low caribou density strata respectively. Elevations above 200m are shown in pale-yellow.*

Definitions include*:*

- Distance is the perpendicular distance from the 0-line to the objects (caribou).
- A cluster (caribou group) is a relatively tight aggregation of objects.
- Distance measured is the distance to the center of the cluster from the 0-line.

Assumptions include:

1. All caribou on the 0-line are detected. This is critical and must be true.
2. Caribou are randomly distributed. (Lacking this will not bias abundance estimates if the transect lines are randomly placed, which they were.)
3. Detection of caribou is independent. (Although detection was dependent in our survey, the lines had random start-end points, so this assumption is not violated. Further, if we assume that sampling unit, i.e., one line with its animal observations, is correct then complete observance of this assumption is not critical).
4. No caribou movement prior to detection. The method is a 'snapshot' method. In practice this assumption is not violated if the observer moves faster than the animal, e.g., if movement of caribou to the next transect line to be surveyed is rendered impossible, which it was.
5. Distance measurements are exact. Provided distance measurements are approximately unbiased, bias in line transect estimates tends to be small in the presence of measurement errors. In our survey we binned the observations into distance intervals which decrease measurement error.
6. Clusters (caribou groups) close to the 0-line are accurately sized.
7. Other assumptions made are similar to other survey types, e.g., that each population is closed, being confined within a clearly defined area.

Our surveyed sub-areas of the South region were sampled by a series of systematically spaced parallel 0-lines with random start points. Observers flew along each 0-line, recording individual or groups of caribou within different distance bins of the 0-line. The distance bins were by 100m increments up to 500m from the 0-line. Prior to initiating the survey, observers ascertained the 100, 200, 300, 400 and 500m 'bins' using a Leica range finder 1600 while hovering at the 40m altitude. Observers marked their window with masking tape accordingly to delineate the approximate distances for each bin. When possible while flying transect lines, laser range finders were used to double-check reported bin distances to detected caribou.

For data analysis we used Distance, which is a Windows-based software package for computers that facilitates design and analysis of distance sampling systematic line-transect surveys for wildlife populations (www.ruwpa.stand.ac.uk/distance/ distanceabout.html). We have used Conventional Distance Sampling (CDS) in the analyses and for each area an appropriate model (i.e., "*Half-normal key*" was used followed by cosine adjustment for better fit) was selected according to the Akaike Information Criterion (AIC) in the soft ware.

Demographics & calf recruitment

For Ameralik, demographics and recruitment were obtained on the 12th of March. All caribou sighted were sexed and aged following a brief overpass with the helicopter. A separate demographics for the Qeqertarsuatsiaat population was not possible; however, a calf percentage estimate was obtainable for each population from systematic line observations.

Table 2. *South region, 1-12 March 2012 caribou survey, summary statistics for the two sub-populations, Ameralik and Qeqertarsuatsiaat from systematic lines flown by helicopter.*

Parameter	Ameralik Density			Qeqertarsuatsiaat Density			Combined
	High	Low	Hi+Lo	High	Low	Hi+Lo	
Stratum	4	3	4+3	1	2	1+2	**1+2+3+4**
Area size (km²)	2079	4965	7044	4682	1074	5756	**12 800**
Transect lines (km)*	371.5	232.5	604	609.7	78.1	687.8	**1291.8**
Number of lines	17	11	28	29	4	33	**61**
Coverage %	17.9	4.7	8.0	13.0	7.3	11.9	**10.1**
Helicopter altitude (m)	40	40	40	40	40	40	**40**
Helicopter speed (km/hr)	60-70	60-70	60-70	60-70	60-70	60-70	**60-70**
# groups observed	185	38	223	127	6	133	**356**
Average group size	3.29	2.45	3.14	3.02	3.17	3.03	**3.1**
Median group size	2	2	2	3	4	3	**2**
Max group size			14			11	**14**
Min group size			1			1	**1**
Total caribou observed	608	93	701	384	19	403	**1104**
Calves among total	123	25	148	71	0	71	**219**
Minimum calf %	20.2	26.9	21.1	18.5	0	17.6	**19.8**

*Transect line width was 500m to either side of the transect line.

As in all previous surveys, sex was determined by the presence or absence of a vulva and/or urine patch on the rump, which reliably indicates a female on both adults and calves. Further details are found in Cuyler *et al.* (2007). We

assigned only two age classes: calf (≤ 9-10 months old) and adult (> 1 year). Both were determined by body size. 10-month old calves of both sexes are smaller than all other age classes in March. We acknowledge that 10-month old calves from feral reindeer or their descendants can be relatively large bodied, i.e., relative to calves from indigenous caribou, albeit still smaller than their dam. Observations provide percentage of calves within the total number of caribou seen and calf recruitment, which is the late-winter ratio of calves per 100 cows. Group size was based on proximity or group cohesion during a flight response. For a rough mortality estimate, we continue to apply an assumed natural mortality of 8 - 10% to the abundance estimate (Kingsley & Cuyler 2002; Details in Cuyler *et al.* 2007).

Results

Population size & demographics

Combining Ameralik and Qeqertarsuatsiaat caribou populations, the 2012 survey obtained a total of 1104 caribou observations on 61 lines (Appendix 6). Total distance was about 1292 km and area coverage was 10.1%, assuming a total transect width of 1000 m (Table 2).

Table 3. *South region, 1-12 March 2012 caribou survey, abundance estimates and densities for the two sub-populations, Ameralik and Qeqertarsuatsiaat (Appendix 6).*

Parameter	Ameralik	Qeqertarsuatsiaat
Population estimate	11,700	4,800
90 % Confidence Interval (CI)*	8,500 – 15,900	3,400 – 6,800
Coefficient of Variance (CV)	0.18	0.21
Degrees of freedom (df)	27.0	26.7
Density caribou / km²	1.66	0.83

* Similar to 2006 survey estimate we used 90% CI.

Ameralik population, South region

Estimated population size 2012

We observed a total of 701 caribou on 28 lines, totaling 604 km, which provided almost 9% coverage of the Ameralik area, assuming a total transect width of 1000m. The pre-calving population estimate for Ameralik caribou was ca. 11,700, with a density of ca. 1.66 caribou per sq km. (90% CI: 8,500 – 15,900; CV 0.18) (Table 3).

Ameralik demographics, recruitment

On 12 March 2012 we sexed and aged 167 groups of caribou, for a total of 691 animals, in the Ameralik population (Table 4: Appendix 7). Relative to the number of caribou sexed and aged in the 2006 survey, this was a ca. 4-fold increase in the number of groups and a ca. 3-fold increase in the number of caribou observed for demographics and recruitment. Mean group size was lower than 6 years earlier ($P < 0.05$). Calf percentage and calf recruitment increased by ca. 3% and 4% respectively. Meanwhile, the percentage of bulls (> 1 year) dropped by over 6%, which resulted in the lower bull (> 1 year) to cow ratio of ca. 62 bulls per 100 cows in 2012.

Table 4. *Demographics for Ameralik caribou, South region, March 2015 (Appendix 7).*

Parameter	Ameralik Caribou Population 2012
Number of groups observed	**164**
Average group size	**4.2 ± 3.3 S.D.**
Median group size	**3**
Maximum group size	**24**
Minimum group size	**1**
Total sexed & aged (*n*)	**691 (100%)**
Bull (> 1 year)	**189 (27.4 %)**
Cow (> 1 year)	**307 (44.4 %)**
Calves from previous year	**195 (28.2 %)**
Recruitment (calf / 100 cow)	**63.5**
Sex ratio (Bull >1 year / 100 Cow)	**61.6**

Figure 8. *Well antlered cow and calf of the Ameralik population. These were observed in Austmannadalen. Note the calf has a brown pelage often seen among descendants of feral reindeer. Photo C. Cuyler*

Ameralik antlers

Adult males lacked antlers while juvenile males still possessed their autumn 2011 antlers, making up 48% and 52% of all males observed respectively. Females were generally antlered, 86%, with 14% polled. The ca. 10-month old calves appeared relatively large sized relative to their dams (Fig. 8), and possessed at least one long velvet covered spike antler. Calves commonly had both antlers, in velvet, and a few evidenced a single branching at the top of one or both spikes. Brown pelage, which appears relatively common on descendants of feral reindeer, was also observed.

Qeqertarsuatsiaat population, South region

Estimated population size & rough demographics 2012

We observed a total of 403 caribou on 33 lines, totaling 688 km which provided almost 12% coverage of their area south of the Sermilik fjord and north of Frederikshåb Isblink glacier. The pre-calving population estimate for Qeqertarsuatsiaat was ca. 4,800 caribou, with a density of ca. 0.83 caribou per km^2 (90% CI: 3,400 – 6,800; CV 0.21). Although demographic details were only obtained for Ameralik, rough values for Qeqertarsuatsiaat were possible from transect-line observations. Average group size was 3.0 ± 2.1 caribou, maximum 11, and calf percentage was 18% (n=403, included 71 calves).

Mortality & injury in 2012

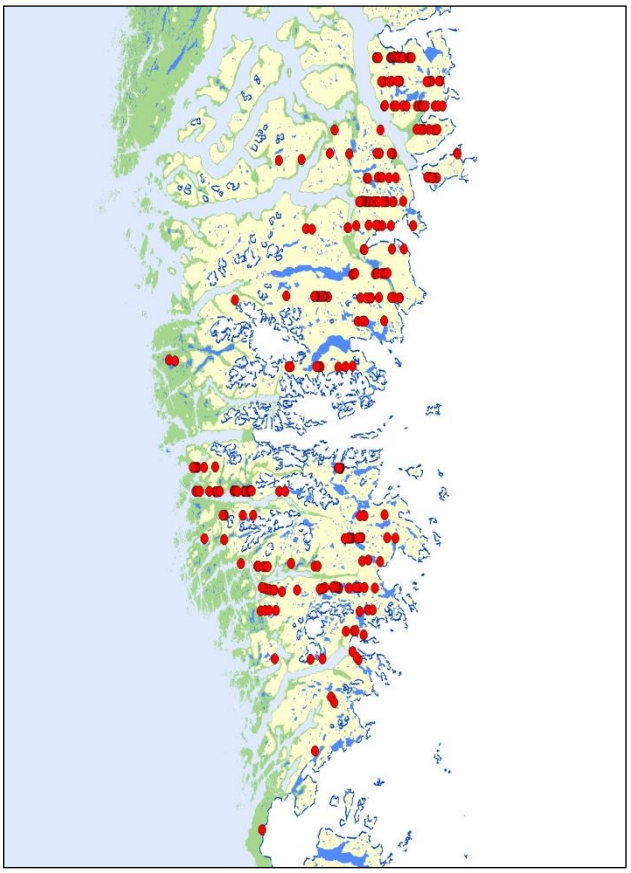
Two dead caribou were observed, and another five had injured or broken legs as evidenced by a severe limp or inability to put weight on a leg. These included three cows, one bull and one of unknown sex. Four were observed in Ameralik and one in Qeqertarsuatsiaat. We have never observed so many injured animals on previous surveys, where at most one animal might evidence an injury.

Given the absence of large predators, natural mortality in the South region might result from starvation, accidents, disease, injury, and old age related factors that feed back into the first four. Using an assumed natural mortality of 8-10% for West Greenland caribou populations in general (Kingsley & Cuyler 2002) and the current population estimates, the calculated natural mortality for the Ameralik population would be between ca. 936 and 1,170 caribou annually. Similarly the numbers for the Qeqertarsuatsiaat population would between ca. 200 and 800 caribou annually. The assumed 8-10% does not include catastrophic stochastic events.

Overall, the caribou in the South region appeared healthy with a good body condition (i.e., rounded backs, no ribs showing), while their demographics showed good calf recruitment and an acceptable sex ratio of bulls to cows.

Caribou distribution March 2012

The two populations differed in how they distributed themselves across the east-west climate gradient. In 2012 the Ameralik caribou predominantly used only the eastern continental climate portion of their range, close to the Greenland Ice Cap (Fig. 9). We observed an almost total absence of Ameralik caribou on the coastal plains forage habitat between Buksefjord and Sermilik fjord. Absence was complete in all remaining Ameralik coastal habitat.



Similar to the Ameralik population, the Qeqertarsuatsiaat caribou also utilized areas close to the Ice Cap. However, in sharp contrast to Ameralik, they also evidenced a strong presence in maritime coastal habitat.

Figure 9. *Distribution and location of the 1104 caribou observations on transect lines. Those observed off-line are not shown.*

Caribou elevation & aspect March 2012

Approximate elevations (GPS in helicopter minus 40m flight altitude) for Ameralik caribou occurrence averaged 599m ± 280 SD (median 626m, range 89-1312m). For Qeqertarsuatsiaat the results were 479m ±264 SD (median 507, range 0-1252m). Regardless of elevation, caribou typically chose south-facing slopes for cratering into the snow in search of forage. Nunatarsuaq stood out as an area with many small groups of caribou dotted across its valleys, with the majority being on the sunny south-facing sides or in the valleys. Similarly, Austmannadalen's south facing side and valley also evidenced a high abundance of caribou.

Survey logistics

In the period 1-12 March we flew seven of those days. Poor weather made five days non-flyable. Flight time totaled ca. 39 hours and 11 minutes, 13 hours more than in the 2006 survey. Refueling was necessary after about 2.5 hours of flight time. Systematic lines 34 to 62 applied to Ameralik caribou, while lines 1 to 33 to Qeqertarsuatsiaat.

Figure 10. *Six caribou, including two calves, are hardly visible at a distance of ca. 200 meters, line 60, 9 March. The six are running single-file across the center and right of centre. If stationary, as often occurs, some or all could have remained undetected under these conditions of mixed snow cover and shadows in rocky terrain. The latter were common at heavy foraging sites like this one. Photo C. Cuyler*

Caribou sightability

Once again sightability of caribou within 300 meters of the transect line was a problem. Factors included incomplete snow cover, light/shadow conditions typical to early March, sun in one's eyes and low caribou group size. The March 2012 snow cover and rocky terrain provided exceptional camouflage for caribou (Fig. 10, Part II: Appendices 11, 12, 13, 14 & 15). Detecting caribou was further compromised by the west-east orientation of most lines, which made certain that on the south-facing side of the helicopter the sun was in observer eyes and reflecting off the snow surface. Despite observers using polarized sunglasses, this intense sunlight in the eyes may have reduced sightability of caribou. It certainly increased observer fatigue.

The flight altitude of 40m, which reduced the amount of dead-ground, resulted in the sensation of increased flight speed because there was more ground to search and scan over. When combined with a long line length, the result was a feeling of stress and fatigue among observers. Further, the long length of most lines resulted in periods of diminished observer concentration, which could lower caribou detection given the ambient camouflage conditions. Finally, the helicopter windows frosted, which obscured visibility because ambient temperature was near -20°C. The frost and its constant physical removal (by credit card) could have decreased caribou detection.

Muskoxen & sheep

No muskoxen were observed, although known to inhabit the Nunatarsuaq area in the northeastern portion of the Ameralik caribou range. The area was search thoroughly and many caribou were observed. Further, five feral sheep were seen on the north (south-facing) side of Austmannadalen. Among them was a ewe with her lamb (Fig. 11). We also observed foxes, hares and ptarmigan (separate report) and one large dark phase gyrfalcon (*Falco rusticolus*). The latter was flying alongside line 58.

Figure 11. *Feral ewe stands with her almost yearling male lamb at the mouth of Austmannadalen, north side. Feral sheep have inhabited Austmannadalen since about the 1970's. Photo C. Cuyler*

Snow cover & lack thereof

Snow depth and cover varied. One specific area stood out. In contrast to most other areas surveyed, including nearby line 35, along line 36 and the western portion of line 37 there was a deep blanket of snow. By the eastern end of 37 the snow gave way to bare ground and shrubs, which were typical of lines 45, 46 and 48, owing to both the dry continental climate and the rain-shadow created by the Sermeq glacial massive to the south.

Sea ice cover

Sea ice was extensive in the fjords this year. For most fjords in the Qeqertarsuatsiaat area there was sea ice right to the mouth of the fjord and into the Davis Strait itself. Caribou tracks crossing sea ice to access islands was observed at the Sermilik fjord and Qeqertarsuatsiaat, and crossing the fjords to other mainland areas was common.

Skidoo use

Skidoo use was common in the areas south and east from the town of Kapisillit, which is about 75km ENE of Nuuk and situated in the inner Godthåbfjord. Skidoo tracks were evident all the way south to the Ameralik fjord at Kilaarsarfik/Sandness and through the mountain valleys east to the Isfjord (head of Godthåbsfjord).

Discussion

New survey method

Abundance surveys can aim to obtain population size trends by repeating the same methods over a time series of surveys. Alternately, maximizing the accuracy of population size estimates may require the adoption of new methods. The latter may be at the expense of conclusive 'trends' from the last survey. Since the same method was used for the 2001 and 2006 surveys of Ameralik and Qeqertarsuatsiaat, conclusions regarding population size trends were possible. A drawback of the 2001 and 2006 surveys was that only 2% of the total South region area was surveyed. The 2012 survey, increased area coverage to 10%, and in an effort to improve estimate accuracy, employed line distance sampling. The latter would render inconclusive any hint of trends since 2006 (unless the 2012 survey was analyzed in the same manner as the 2006 survey, which it was not). The 2012 population size estimates for both Ameralik and Qeqertarsuatsiaat caribou are similar to the estimates from

2006, which fall within the confidence intervals for 2012. If the 2012 survey is more accurate (i.e., closer to the true population size) than earlier surveys, then the absence of a trend suggests that the 2012 population size may actually be lower than the population sizes estimated in the previous surveys.

Population sizes

Ameralik

Previously, between 2001 and 2006, there was a substantial decline in Ameralik caribou abundance achieved through harvest management (Cuyler *et al.* 2007, Witting & Cuyler 2011). Bayesian model predictions using the 2001 to 2006 population decrease (from about 32,000 down to 10,000) suggested that if hunting continued at the 2006 level then by 2012 the Ameralik population might decrease to about 2,790 caribou (90%CI: 425-9164) (Witting & Cuyler 2011). This did not happen. The pre-calving 2012 Ameralik population estimate was about 11,700 caribou. That analysis highlights the uncertainty surrounding model predictions derived from using a time series of only two points. More importantly, the Ameralik population size remains relatively stable despite continued high hunting pressure, which included unlimited winter harvesting. Meanwhile, Ameralik caribou density in 2012 was 1.7/km^2. This exceeds the recommended target density, 1.2/km^2. The 2012 density of ca. 2 caribou/km^2 greatly increases the risk of overgrazing, which could ultimately negatively impact caribou abundance.

Qeqertarsuatsiaat

The 2012 Qeqertarsuatsiaat estimated abundance of ca. 4,800 caribou also indicates general stability since the first helicopter survey of 2001. Again despite increased hunting pressure and analyses that suggested harvest restrictions might be necessary (Witting & Cuyler 2011). Similar to Ameralik, the 2012 density is different from the 2006. For Qeqertarsuatsiaat it decreased, stays well below target, and the risk of overgrazing is assumed low.

Changes

The seeming stability for both populations in the South region is no reason for complacency, because there are some disquieting anthropogenic changes to the caribou environment. These include altered caribou habitat use (distribution) and demographics, crippling loss and new trends in hunting. These are important to consider since expected global warming will be an

additional change that can bring environmental instability with negative consequences for caribou abundance.

1. Altered distribution observed

From the late 1990's until 2001, caribou were year round inhabitants on the coastal lowlands between the Ameralik and Sermilik fjords (Cuyler *et al.* 2003). In March 2001 about 60% of all Ameralik caribou observed were foraging in that same coastal lowland habitat (Cuyler *et al.* 2003, 2007). This is evidence that these lowlands were preferred habitat. By 2006 the numbers of observed animals dropped to under 40 and were seen only between Buksefjord and Sermilik fjord areas. In 2012, just 7 caribou were observed, which equated to about 1% of all observed. Alternately, this is a 98% reduction in Ameralik caribou use of the lowlands since 2001.

Being coastal lowlands, the usual suspects for altered caribou distribution in March would include forage limitation due to deep snow or icing, e.g., from rain-on-snow or thaw-refreeze. Direct field measurements were not obtained, however; neither Nuuk weather data (DMI 2014) nor local knowledge (Appendix 1) implicates either of these culprits. Predation is not considered because large predators do not exist in West Greenland. Hunting, as a disturbance, is a third and very plausible suspect. There was no winter hunting in 2001 when caribou use of the coastal lowlands was high. There was, however, winter hunting in both 2006 and 2012 and immediately preceded the aerial surveys those years.

Skidoo disturbance is a further suspect since their use for hunting was first confirmed in the winter 2006 in the Buksefjord and Sermilik fjord area (Cuyler *et al.* 2007). Skidoo tracks were also seen during the 2012 survey. During winter 2012, KNAPK professional hunter Aslak Jensen (pers comm.) knew of extensive caribou hunting by skidoo in the areas around and south of Kapisillit, extending right through to Ameralik fjord. Skidoo hunting could explain the observed low numbers and density of caribou in that same area, and similarly the high numbers and density of caribou observed to the east on Nunatarssuaq and to the south of Austmannadalen. The former is a rather inaccessible adjacent area of high elevation sandwiched between the Isfjord and the Greenland Ice Cap, while the latter may be even more difficult to access by skidoo.

The winter harvest season appears to impact elevations used by the caribou. Where a wide selection of elevations is available, caribou prefer foraging lowlands in winter. Typical winter elevations preferred by Greenland caribou are less than 200 m (Cuyler unpublished). Yet the 2012 survey, which began immediately following the end of the Ameralik winter hunting season, observed habitat use at median elevations of 626 m for Ameralik and 507 m for Qeqertarsuatsiaat. This suggests that winter hunting creates disturbances that make caribou avoid their preferred optimal winter forage at lower elevations.

We suspect that winter hunting of caribou changed their natural distribution, creating areas of artificially high and low caribou density. A man-made caribou distribution will have direct impact on caribou population estimates, if surveys for abundance stratify survey effort as per expected from past natural caribou distributions. Fortunately, this study conducted a one-day reconnaissance prior to beginning the aerial survey and assigned high and low caribou strata accordingly.

Winter hunting either just prior to or during a survey that resulted in a changed caribou distribution is a serious challenge to estimating population size. Deep snow or icing could do the same. Thus a helicopter reconnaissance determining caribou distribution is necessary before any survey begins and specifically if a hunting season has just finished or a serious weather event has occurred. Although an added expense, it is a justifiable one, since the forthcoming population estimate requires a correct stratification of high and low caribou density areas for allocation of survey effort (Appendix 8). In the absence of pre-survey reconnaissance flights, a natural caribou distribution is preferable to an artificial unpredictable man-made one.

2. Crippled caribou

The 2012 total observed in the South region was 1795 caribou, i.e., combining observations from both transect lines and demographic observations. This included five crippled animals, which has never before been experienced by the survey observers despite a history of 11 surveys. One possible cause would be firearm crippling, since four of the five were Ameralik caribou where the winter 2012 hunting season had just ended. Only one cripple was a Qeqertarsuatsiaat animal where winter hunting was prohibited in 2012, but might have occurred. The majority of the crippled were cows. Their calf production, as well as survival, was likely compromised. Crippling cows, if widespread and common, could undermine the future of these two

populations, and confound wildlife management efforts, especially since the magnitude of crippled animal deaths is unknown.

The Greenland Institute of Natural Resources is aware of abundant personal stories from past autumn hunting seasons concerning observations of hunters firing in excess of 20-50 bullets at fleeing caribou. Additionally, author experience alone numbers fourteen such observations since 2001. The usual result of such erratic shooting is only a crippled animal or two and none killed, or all missed. Since 2013, on any given trip into the back country, one can seldom avoid observing limping or bleeding caribou. One hunter reported shooting dead an animal in September 2015 only to discover that it had been shot previously the same season, which rendered all of the meat inedible due to advanced septicemia. This crippled animal would have undoubtedly died shortly thereafter regardless. For improving population dynamics modeling, four North American management plans for migratory caribou herds suggest increasing annual harvest statistics by 20% to account for deaths from injuries, e.g., crippling, motor vehicle accidents and poaching. The uncertainty inherent in any suggested figure is acknowledged.

3. Demographics

Ameralik

Although not necessarily disquieting in all aspects, demographics has changed since the 2001 survey. The good news is that the late winter calf percentage and recruitment improved. In 2001 calf percentage was only 18%. By 2006 this rose to 25% and coincided with the large reduction in population size. It rose again to 28% by 2012. These indicate that caribou density on the range since 2006 promotes a maximal calf production and survival. The modest 2012 increase may be connected to the following point. The ratio of bulls to cows has declined. Although more cows typically will mean more calves, this could ultimately make regulating population numbers difficult. Initially the bull to cow ratio dropped only slightly, between 0.83 and 0.81 per cow, in the period 2001-2006. However, the 2012 value was about 0.62 bulls per cow. Finally, the observed maximum group size has swung from 28 down to 15 and back up to 24 for the same period, while average group sizes have remained generally 4-6 caribou ± 3.

Qeqertarsuatsiaat

Although not a complete data set we can discuss some demographic changes since the 2001 survey. On a positive note, while late winter calf percentage

and recruitment plummeted between 2001 and 2006 (Table 1), recovery was evident by 2012 when the rough value obtained from transect lines indicated a minimum of 18% calves. This value is under Ameralik's, however, correctly identifying calves on transect lines is difficult and many may have been misclassified, so we assume the true calf percentage was higher. Rather disquieting in 2006 was the low number of cows, which evidenced itself in the low calf percentage and a male-skewed bull to cow ratio of 2.75 bulls for every cow (Cuyler *et al.* 2007). Given that calf percentages improved by 2012, we may with some confidence assume that the relative number of cows has also improved. Unfortunately time did not allow a detailed demographic of the Qeqertarsuatsiaat caribou in 2012. Maximum group size rose between 2001 and 2006 and appears to have remained high through 2012, beginning at 6, increasing to 14 and finally being 11 respectively. Average group sizes have fluctuated. Initially, in 2001, groups were uniformly small, i.e., 3 ±1 S.D. Since then Ameralik animals have immigrated into the Qeqertarsuatsiaat range (Cuyler *et al.* 2003, 2007). Ameralik animals possess a greater tendency to aggregate, owing to their feral reindeer heritage. Although at first group size increased to 5 ±3 S.D. with the new influx, by 2012 it was again averaging 3 caribou, albeit with double the standard deviation (i.e., ±2 S.D.).

4. Hunting trends

Any discussion of the 2012 status and subsequent wildlife management implications must acknowledge that 4-years have passed between the survey and the writing of this report. Hunting has changed over the intervening period. These changes may impact caribou foraging behavior, distribution as well as movements, and the number harvested annually. Quantifying possible changes is difficult, while harvest per population remains guess work (Appendix 9) and crippling loss is unknown. Several recent trends include the following:

- More boats
- Bigger and faster boats
- Advanced GPS technologies
- Use of social media
- Recreational hunters selling their catch
- Poaching (hunters without permits)

To hunt caribou in Greenland you need a boat. Today's hunters have rapid access to the back country. Quantifying the rise in boat numbers between 2010 and 2016 proved impossible, because no records are kept and anchorages are

often ad hoc. The best source was the Godthåb Boat Club membership information. For the period 2010 and 2015 boat number increased and many were larger and faster than in the past. Hunters typically use advanced GPS equipment for both marine and terrestrial purposes. Many use local social media for immediate information about where caribou are to be found on a specific day.

Between 2010 and 2016 the population in Nuuk rose by 1,500 inhabitants, i.e., from 15,500 to 17,000 inhabitants, an increase of almost 10% (Statistics Greenland 2016). Today you can experience too many hunters in the terrain (Appendix 1). Within a 60 km radius from Nuuk there is hardly an anchorage that does not contain 5-10 boats on weekends. Even at twice the distance, Grædefjord will have at least one boat per bay (Appendix 1). Further, many lakes have also experienced a marked rise in the number of boats with small outboard engines stationed on their shores.

Previously 4 to 6 caribou annually were considered sufficient per household (Nuka Møller-Lund pers comm.). Today the primary goal for some recreational hunters is no longer the filling of the family freezer, but monetary, e.g., selling the meat. The latter is legal, but comes with several restrictive caveats (Appendix 9). We suggest there may be the potential for overharvesting, given profit motive, current open harvesting with long autumn season and lack of harvest control by Conservation Officers.

Poaching

Since 2012 there may be a sizeable number of poachers, i.e., those without hunting permits, which would result in under reported harvests in *Piniarneq*. Today the impression is that there are more hunters in the Nuuk area than ever before, however, the number of purchased hunting permits indicates the opposite. In the period between 2010 and 2015 for the Nuuk area the number of professional permits purchased annually remained steady at around 63. In contrast the number of recreational permits dropped from 1095 to 615 (APNN Nuka Møller-Lund pers comm.). This is a 44% decrease in purchased recreational permits. The situation is similar for all of Greenland in that period, i.e., professional permits purchased remained stable around 2000, while recreational permits dropped from 5548 to 3811, a decrease of 31% (APNN Nuka Møller-Lund pers comm.). The stability in the professional permits may be inaccurate. This winter 2016 the local Nuuk chapter (NAPP) of the professional hunter's union (KNAPK) accounts 83 persons among their

members, while the other hunter's union, *Neqitaq*, has about 20 members. The combined total of about 103 professional hunters in Nuuk does not match up with the 63 actual professional permits currently in use.

Given common opinion that hunters are more numerous today, two possible explanations for this might include, 1) that the remaining hunters are more active, or 2) that many hunters are not purchasing hunting permits. The latter is supported by the abrupt drop in purchased permits in 2012, which coincided with a 4x increase in purchase price, i.e., from 50 to 200 Danish kroner, which was raised again in 2015 to 250 Danish kroner. The new prices applied to both professional and recreational permits (APNN Nuka Møller-Lund pers comm.).

Since checking for hunting permit possession by Conservation Officers effectively never occurs in some municipalities, e.g., Nuuk, then purchasing one may seem an unnecessary expense to many. If the 30-40% drop among recreational permits and the discrepancy in professional numbers truly reflects the current number of poachers out hunting without hunting permits then harvest figures obtained through *Piniarneq* reporting will be below actual catch numbers.

What do the caribou need?

Requirements for maximum production

Negative consequences for caribou production often arise from environmental instability because the latter can be in opposition to what caribou require. Pathogens and some other factors notwithstanding, to achieve maximum production caribou primarily need accessible, abundant, nutritious forage. Additionally, for each season, caribou need undisturbed access to the preferred habitat associated with that period, and once on that habitat caribou need to forage and ruminate at their leisure. This is especially true of critical habitats, which include calving, late-summer-early-autumn and winter ranges. The former is necessary for production and the latter two for 'fattening-up' and survival respectively.

Autumn harvest season

Large numbers of hunters coming at the caribou from all angles over a 10 week autumn season brings several things to mind. The hunting season coincides with late-summer-early-autumn range use by the caribou, and

hunters occupy that critical range. Do caribou get enough undisturbed foraging time to fatten up for the coming winter? Do caribou get the required rumination time to allow later absorption of the nutrients they've ingested? Are they forced to less optimal habitat? Considering specifically cows, building up the body reserves depleted by reproduction, lactation and the preceding winter is a necessity if they are to attain the prerequisite body condition to participate /ovulate in the autumn rut. It goes without saying, that if fewer cows are able to enter the rut and become pregnant then overall calf production will decrease. Let us now consider winter.

Winter versus rumen microbes

Caribou are well adapted to the arctic winter, still winter decides whether a caribou survives or not to see another summer. It takes little imagination to realize that food availability, quantity and quality can all be low in winter, due to among other things deep snow, hard crust layers within the snow pack (often multiple crusts) and icing. To save energy and thus make their fat reserves and the food they eat stretch over the lean winter months, caribou typically move as little as possible in winter. Specifically February and March are the months of least activity for West Greenland caribou (Cuyler & Linnell 2004).

Caribou are ruminants. For herbivores living in the arctic being a ruminant is an advantage, because it allows effective digestion of plant material that would be impossible to break-down by chewing alone (Warenberg *et al.* 1997). That caribou are ruminants is common knowledge, however, perhaps not so common is what this 'means' and why it makes caribou vulnerable in winter. Being a ruminant is not all win-win. It means that caribou do not digest their food. They are dependent on a large healthy population of microbes in their rumen to do their digesting for them. For microbes to do their job, the food must be of a very fine particle size. In a nutshell this means that caribou can stuff their faces with food, but if they do not get enough time to properly chew their cud (regurgitate and chew all swallowed food a 2nd time, mashing it to a fine particle size) then the microbes can't digest the food. It passes through and out, unutilized (Warenberg *et al.* 1997) or in the worst cases rots and produces a fatal food poisoning (Skjenneberg & Slagsvold 1968). When the food is of poor quality, as it can be in winter, more cud chewing time is necessary if the caribou are to obtain nutrients from the food (Skjenneberg & Slagsvold 1968).

The most important thing about microbes is that they cannot survive starvation (Warenberg *et al.* 1997). Microbes require constant nourishment to maintain their numbers, without it their populations are decimated (Warenberg *et al.* 1997). If a catastrophic icing event 'locks' away the forage vegetation of an entire region for a long period, e.g., three weeks, few microbes are left alive (Skjenneberg & Slagsvold 1968). At this point, even if a caribou were to obtain all they wanted to eat, the lack of microbes would mean that the caribou would gain little or nothing and would continue to starve. About two weeks of gradual access to new forage is needed for rumen microbes to establish sufficient numbers to digest food properly for a caribou (Skjenneberg & Slagsvold 1968). Caribou winter survival can be negatively affected under such circumstances. This is an example of when an environment free from disturbances raises their chances of survival. This will be specifically true for cows, whether pregnant or with calves, which they often are still nursing (Cuyler et al. 2012).

Possible impacts of winter hunting on caribou

Hunter harvest is an activity that 'disturbs' the caribou. Skidoos and ATV's have been known to be used for winter hunting. The effects on caribou of either or both hunting and motorized vehicle use could include the following:

- A lack of time to eat
- A lack of time to chew their cud
- Frequent energy consuming flight reactions
- Avoidance of preferred and often critical forage habitat
- Injuries caused during panic reactions

A long winter hunting period/season with a large quota or unlimited harvest, could deplete body condition for many caribou. This in turn could negatively impact both overall survival and spring calf production in the affected population. Ultimately caribou abundance would decline.

Given environmental instability inherent in the climate of recent years combined with the changing hunter trends, we must beware their cumulative impacts on our caribou populations. If the Ameralik and Qeqertarsuatsiaat caribou populations were so unlucky as to suffer a catastrophic winter icing event that 'locked' away all forage in their region for an extended period the same winter as extensive hunting was allowed, then caribou survival may be reduced that winter or calf production reduced the following spring. True enough, severe catastrophic weather events can themselves cause widespread mortality (Gates *et al.* 1986, Aanes *et al.* 2000, Miller & Gunn 2003, Tyler 2010)

even in the absence of hunter harvesting. However, winter hunting is an additional stressor, and most importantly is within our control. If alert to the cumulative risk, then if and when catastrophic winter weather occurs, all winter harvest could be abruptly halted to give caribou the best chance for survival under environmental conditions we cannot change.

Meanwhile winter caribou harvests continue. Albeit the quotas are low and some populations are exempt. To date no adverse effects to abundance have been documented. However, long large winter harvests from 2003 to 2010 are suspected responsible for the low calf recruitment observed in another population. The risks winter harvesting entail for caribou abundance must be recognized.

Depending on the magnitude and duration of the harvest, winter hunting can be an effective management technique to rapidly reduce caribou populations. This is owing to previously mentioned negative impacts to survival and spring calf production that go beyond the actual number of caribou shot. The 2012 survey population estimates for Ameralik and Qeqertarsuatsiaat caribou indicate that both populations were able to maintain relative stability in numbers despite winter harvests.

Shortly after the 2012 survey, unlimited winter harvesting stopped. Quotas became 100 caribou per population and harvesting limited to professional hunters. The current allotted 22 day winter hunting season length is long as regards disturbance impact to caribou, specifically pregnant cows. To facilitate survival and calf production, cows should be uninterrupted when foraging, ruminating or resting. If winter harvests continue to be allowed, then we suggest minimizing disturbance to the cows. Winter quotas should remain low, the winter season could be bulls only and shortened in length. Given the harvesting efficiency of professional hunters, a 9-day (includes two weekends) winter hunting period/season would likely be sufficient to fill the quota of 100 caribou per caribou population, even accounting for poor weather preventing sailing for some portion of the period.

Winter hunting alters caribou distribution, yet the best survey period is 1-15 March (owing to the combination of low caribou movement and adequate day length). Since surveys are best begun after a suitable period following the end date of any hunting season, winter hunting could stop by 21 February to provide the caribou time to return to a natural distribution over the region.

Number of caribou shot in South region

Maximum sustainable yield (MSY) is a theoretical point on a population's logistic growth curve where the population size is about 56% below the K (carrying capacity) for its environment, and where population growth (calf production) is at its maximum (Braun 2005). For sustainable hunting this is the 'sweet' point to be at. The environment is always changing, however, so K is not a constant, and thus neither is the MSY value. It's a game where the 'goal-posts' are always being moved. Both are illusive, yet the 2012 survey documented population size stability and good calf production since 2006. This indicates that annual hunter harvest between 2006 and 2012 was maintaining caribou number at well below K (carrying capacity) for the South region. It seems that both the Ameralik and Qeqertarsuatsiaat populations were kept near the MSY level. We do not know, however, how many Ameralik and Qeqertarsuatsiaat caribou were shot annually. Although the government maintains a nationwide harvest data-base, *Piniarneq*, it has always revolved around a hunter's address. A Nuuk hunter may take caribou from three different populations (e.g., Akia-Maniitsoq, Ameralik and Qeqertarsuatsiaat). For example, between 2009 and 2013 Nuuk hunters took an average of about 3500 caribou annually, and this figure would include animals from all three above populations (Piniarneq 2016). It is impossible to know the quantity of caribou removed per population. Changes to the *Piniarneq* database are necessary before we can ascertain those values accurately. Still for the period 2001-2006, Witting & Cuyler (2011) estimated the combined harvest of Ameralik and Qeqertarsuatsiaat was 2000-3000 caribou annually. As luck would have it, regardless that we do not know the true harvest number, actual numbers of caribou killed annually between 2006 and 2012 appear to have been suitable at keeping both populations near their MSY. It would seem that the open unlimited harvests, long autumn season and addition of a limited winter season have been appropriate for these two caribou populations in the period 2006-2012. So far so good, but begs the question about whether this status quo has been maintained since 2012.

Caribou abundance cycles in Greenland

Given harvest trade reporting since 1721, it has been assumed that caribou populations in West Greenland can abruptly increase or decrease in abundance (Vibe 1967, Clausen *et al.* 1980, Grønnow *et al.* 1983, Roby & Thing 1985, Meldgaard 1986). Although the causes remain uncertain, they could include overgrazed ranges and subsequent density-dependent forage limitations (Skogland 1985, Staaland *et al.* 1993, Heard & Ouellet 1994), as well

as pathogens that affect reproduction or survival (Thing & Clausen 1980, Albon *et al.* 2002, Kutz *et al.* 2015). Changes in the North Atlantic Oscillation (NAO) have also been linked to periods of low and high caribou abundance (Vibe 1967). Past cycles in West Greenland caribou indicate that periods of high abundance are short-lived (30-40 years), while lows are long taking about a century or more before recovery occurs (Meldgaard 1986).

Since the 1970's caribou abundance in West Greenland has been relatively high (Cuyler *et al*. 2002, 2003, 2004, 2005, 2007, Cuyler 2007). Today, 2016, we have enjoyed 40-45 years of caribou abundance, the longest period known. To assume this situation will continue 'forever' would be folly, specifically because of the historical cycles in Greenland and because globally many caribou populations are currently in steep decline (Vors & Boyce 2009, Adamczewski *et al.* 2015). Population declines may be inevitable for West Greenland in the foreseeable future. Seen from the forage plants' perspective, a large reduction in caribou numbers would be beneficial. Most of the vegetation would not experience any grazing. Caribou scarcity lasting more than 40 years under optimal climate conditions would permit regeneration of preferred winter forage species for caribou, specifically lichens. At best lichens grow only millimeters per year and need decades to recover from grazing. Regardless of the long-term benefits to range quality, a caribou decline is incompatible with sustainable harvests of the magnitude enjoyed since the early 2000's.

At present overgrazed ranges and density-dependant forage limitation may not be the greatest cause for concern, because caribou harvest management in Greenland the past 15 years has, with some success, aimed at regulating caribou abundance at densities that are expected to be in equilibrium with their range, ca. 1.2 caribou per km^2. This density has not been at the expense of caribou abundance as hunters account it (Appendix 1), and appears to promote calf production and survival in the populations where it has been achieved. Thus to date caribou management in Greenland since 2000 appears to have avoided excessive peak abundances and their subsequent protracted declines in caribou number, owing to density-dependant factors, that might have resulted after 30-40 years of unchecked abundance.

One important concern is climate change and the variable environment this may cause for the caribou. Conceivably it can bring unstable changeable weather to the West Greenland coast with greater frequency. Although

summer droughts wreck havoc with caribou forage, it is disastrous winter weather events that play a major role in abrupt crashes of caribou populations, as these can cause near total mortality across age classes (Gates *et al.* 1986, Aanes *et al.* 2000, Miller & Gunn 2003, Tyler 2010). Events that can restrict access to winter forage include deep snow, severe thaw-refreeze and rain-on-snow followed by sub-zero temperatures. Any one or combination of these could cause abrupt population collapse if entire regions were affected.

Because of topographical barriers, all Greenland caribou populations are relatively isolated with little gene flow between them (Jepsen 1999). They inhabit very small 'islands' of land. In West Greenland most of those 'islands' are caught between the open sea of the Davis Strait and the massive expanse of the Greenland Ice Cap. If weather is severe enough to affect a population's entire specific 'island' then there is nowhere for those caribou to run and escape to. The future is unforeseeable and any given year may bring climate (severe winter, drought) or other factors (disease outbreaks) that reduce Greenland caribou abundance.

Lack of caribou surveys since 2010-2012

The international network of caribou knowledge holders, CARMA (Circumpolar Rangifer Monitoring & Assessment network), advises monitoring caribou population abundance every three years. The Greenland Institute of Natural Resources (GINR) is responsible for population monitoring. To provide adequate regional coverage Greenland surveys must be aerial. To facilitate caribou sightability Greenland surveys must be by helicopter. Both make surveys relatively expensive. While the Ameralik and Qeqertarsuatsiaat populations were last surveyed four years ago, 2012, it is six years since the Kangerlussuaq-Sisimiut and Akia-Maniitsoq populations were surveyed in 2010. Because the results of the 2010 and 2012 surveys become less relevant with each year passing, biological advice for harvest management has become increasingly untenable.

We suggest that the current caribou harvest, as developed since 2000, has major financial impact within Greenland apart from the otherwise important cultural and personal satisfaction value for hunters. Although it cannot be ignored that the sale of caribou meat is the backbone of many professional hunters' annual incomes (Aslak Jensen pers comm.), today the harvest 'industry' provides broader economic impacts that reach far beyond the mere kilo price of the meat. Figures are not available, but considerations would

include the shipping import and sale of goods involved directly or indirectly in caribou harvest (e.g., boats, fuel, navigation gear, guns, hunting gear etc.), as well as, boat service maintenance and goods, motor service and maintenance, twice annual truck transport of boats, boat storage, the establishment and upkeep of harbours, outfitting etc. and the employment of those involved in the associated industries. Not only will the income of professional hunters suffer if caribou numbers decline, but also the above service industries likely stand to lose money and employment opportunities. Widespread negative economic consequences might be felt throughout communities.

Meanwhile the magnitude of the harvest is unknown and winter hunting is sanctioned. With climate change lurking, we suspect the chances for catastrophic weather will rise. Caribou populations elsewhere around the globe are in decline, some steeply, of causes usually unknown. Greenland caribou are likely vulnerable. The future of our caribou populations, and hence the significant economic profit obtained thereof, could be in jeopardy. Monitoring, which is the foundation for updating the advice on the utilization of the caribou stocks, is out-of-date.

Among all this uncertainty, are two known's. First, after an initial successful decrease Ameralik caribou density again rose and was almost twice the recommended by 2012. Secondly, for Greenland caribou with their high reproductive capacity (Cuyler & Østergaard 2005), the precautionary principle is best applied to conservation of their range, i.e., the forage vegetation. Even if caribou density were to abruptly drop below recommended (e.g., possible causes include overharvest or catastrophic weather), Greenland caribou could recover abundance quickly where their range quality is good. Since overgrazing takes decades to repair, preventing overgrazing is the recommended method for continued caribou stocks, or for promoting recovery after a decline.

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Literature cited

Aanes R, Sæther B-E. & Øritsland N.A. 2000. Fluctuations of an introduced population of Svalbard reindeer: the effects of density dependence and climatic variation. *Ecography*. 23: 437-443.

Adamczewski J., Gunn A., Poole K.G., Hall A., Nishi J. & Boulanger J. 2015. What Happened to the Beverly Caribou Herd after 1994? *Arctic* 68(4): 407-421.

Albon S.D., Stien A., Irvine R.J., Langvatn R., Ropstad E. & Halvorsen O. 2002. The role of parasites in the dynamics of a reindeer population. *Proc. R. Soc. Lond. B* 269: 1625-1632.

Buckland S.T., Anderson D.R., Burnham K.P., Laake J.L., Borchers D.L. & Thomas L.2001. Introduction to Distance Sampling. Oxford: Oxford University Press.

Braun C.E. (editor) 2005. Techniques for wildlife investigations and management. 6th edition – March 2005. *The Wildlife Society*. Bethesda Maryland, USA. 974 pp.

CARMA (Circum Arctic Rangifer Monitoring & Assessment network). www.carma.caff.is/

Clausen B.A., Dam K., Elvestad K., Krogh H.V. & Thing H. 1980. Summer mortality among caribou calves in West Greenland. *Nord Vet. Med.* No. 31: 291-300.

Cuyler C. 2007. West Greenland caribou explosion: What happened? What about the future? Proceedings of the 11th North American Caribou Workshop, Jasper, Alberta, Canada, 23-27 April 2006. *Rangifer*, Special Issue No. 17: 219-226.

Cuyler C. & Linnell J.D.C. 2004. Årlig vandringsmønster hos satellitmærkede rensdyr i Vestgrønland. Kapitel 6: 189-210 – *In:* Aastrup P. (ed.) *Samspillet mellem rensdyr, vegetation og menneskelige aktiviteter i Vestgrønland.* Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 49. 321 pp.

Cuyler L.C., Rosing M., Egede J., Heinrich R. & Mølgaard H. 2005. Status of two West Greenland caribou populations; 1) Akia-Maniitsoq, 2) Kangerlussuaq-Sisimiut. Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 61. Part I-II, 64+44 pp.

Cuyler C., Rosing M., Heinrich R., Egede J. & Mathæussen L. 2007. Status of two West Greenland caribou populations 2006, 1) Ameralik, 2) Qeqertarsuatsiaat. Greenland Institute of Natural Resources. Technical report No. 67. 143 pp. (Part I: 1-74; Part II: 75-143).

Cuyler C., Rosing M., Linnell J.D.C., Loison A., Ingerslev T. & Landa A. 2002. Status of the Kangerlussuaq-Sisimiut caribou population (Rangifer tarandus groenlandicus) in 2000, West Greenland. Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 42. 52 pp.

Cuyler C., Rosing M., Linnell J.D.C., Lund P.M., Jordhøy P., Loison A. & Landa A. 2003. Status of 3 West Greenland caribou populations; 1) Akia-Maniitsoq, 2) Ameralik & 3) Qeqertarsuatsiaat. Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 46. 74 pp.

Cuyler C., Rosing M., Linnell J.D.C., Lund P.M., Loison A. & Landa A. 2004. Neria & Qassit caribou minimum count & herd structure, in 2000, Paamiut, West Greenland. Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 48. 46 pp.

Cuyler C., White R.G., Lewis K., Soulliere C., Gunn A., Russell D.E. & Daniel C. 2012. Are warbles and bots related to reproductive status in West Greenland caribou? 13th North American Caribou Workshop. 25-28 October 2010, Winnipeg, Manitoba, Canada. In: Rangifer, Special Issue No. 20: 243-257.

Cuyler C. & Østergaard J. 2005. Fertility in two West Greenland caribou populations 1996/97: Potential for rapid growth. *Wildlife Biology*. 11(3): 31-37.

DMI. 2014. www.dmi.dk

Gates C.C., Adamczewski J. & Mulders R. 1986. Population dynamics, winter ecology and social organization of Coats Island caribou. *Arctic*. 39(3): 216-222.

Grønnow B., Medlgaard M. & Nielsen J.B. 1983. Aasivissuit – the great summer camp. Archaeological, ethografical and zoo-archaelogical studies of a caribou hunting site in West Greenland. *Meddelelser om Grønland,* Man & Society 5: 96 pp.

Jepsen B.I. 1999. Populationsgenetiske studier af vildren (*Rangifer tarandus groenlandicus*) and tamren (*Rangifer tarandus tarandus*) i Vestgrønland. MSc Thesis, Botany Institute, University of Copenhagen, Denmark. 64 pp. (in Danish).

Jepsen B.I., Siegismund H.R. & Fredholm M. 2002. Population genetics of the native caribou (*Rangifer tarandus groenlandicus*) and the semi-domestic reindeer (*Rangifer tarandus tarandus*) in Southwestern Greenland: Evidence of introgression. *Conservation Genetics*. 3: 401-409.

Kutz S., Bollinger T., Branigan M., Checkley S., Davison T., Dumond M., Elkin B., Forde T., Hutchins W., Niptanatiak A. & Orsel K. 2015. *Erysipelothrix rhusiopathiae* associated with recent widespread muskox mortalities in the Canadian Arctic. *Canadian Veterinary Journal*. 56: 560-563.

Landa A., Jeremiassen S.R. & Andersen R. 2000. Rensdyr og moskusokser i Inglefield Land, Nordvestgrønland. Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 31. 21 pp.

Loison A., Cuyler C., Linnell J.D.C. & Landa A. 2000. The caribou harvest in West Greenland, 1995-1998. Pinngortitaleriffik – Greenland Institute of Natural Resources. Technical Report No. 28. 33 pp.

Meldgaard M. 1986. The Greenland caribou – zoogeography, taxonomy and population dynamics. – *Meddelelser om Grønland, Bioscience*. 20: 1-88.

Miller F. & Gunn A. 2003. Catastrophic die-off of Peary caribou on the Western Queen Elizabeth Island, Canadian High Arctic. *Arctic*. 56(4): 381-390.

Piniarneq. 2016. Jagtinformation og fangstregistrering. Naalakkersuisut, Government of Greenland. www.sullissivik.gl

Roby D.D. & Thing H. 1985. Behaviour of West Greenland caribou during a population decline. *Holarctic Ecology* 8(2): 77-87.

Skjenneberg S. & Slagsvold L. 1968. Reindriften og dens naturgrunnlag. Scandinavian University Books, Universitetsforlaget. 332 pp.

Skogland T. 1985. The effects of density-dependent resource limitations on the demography of wild reindeer. *Journal of Animal Ecology*. 54: 359–374.

Staaland, H., Scheie, J.O., Grøndahl, F.A., Persen, E., Leifseth, A.B. & Holand, Ø. 1993. The introduction of reindeer to Brøggerhalvøya, Svalbard: grazing preference and effect on vegetation. *Rangifer* 13 (1): 15–19.

Statistics Greenland. 2016. www.stat.gl

Thomas L., Buckland S.T., Rexstad E.A, Laake J.L., Strindberg S., Hedley S.L., Bishop J.R.B., Marques T.A. & Burnham K.P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *J. Appl. Ecol.* 47(1): 5-14.

Thing H. & Clausen B. 1980. Summer mortality among caribou calves in Greenland. pp. 434-437. – *In*: E. Reimers, E. Gaare and S. Skjenneberg (eds). *Proceedings of the Second International Reindeer/Caribou Symposium.* Røros, Norway 1979. Direktoratet for vilt og ferskvannsfisk. Trondheim. 779 pp.

Tyler N. 2010. Climate, snow, ice, crashes, and declines in populations of reindeer and caribou (*Rangifer tarandus* L.). *Ecological Monographs*. 80(2): 197-219.

Vibe C. 1967. Arctic animals in relation to climatic fluctuations. *Meddelelser om Grønland*. 170: 1-227.

Vors L.S. & Boyce M.S. 2009. Global declines of caribou and reindeer. *Global Change Biology*. doi: 10.1111/j.1365-2486.2009.01974.

Warenberg K., Danell Ö., Gaare E. & Nieminen M. 1997. Flora i reinbeiteland. – *In*: B. Ekendahl and K. Bye (eds). Nordisk Organ for Reinforskning og A/S Landbruksforlaget. ISBN 82-529-2139-6. 112 pp.

Witting L. & Cuyler C. 2011. Harvest impacts on caribou population dynamics in south west Greenland. 12th North American Caribou Workshop. Happy Valley/Goosebay, Labrador, Canada, 4-6 November 2008. *Rangifer* Special Issue No. 19: 135 – 145.

Ydemann D. & Pedersen C.B. 1999. Rensdyr i Vestgrønland 1993-1996. Unpublished report to Pinngortitaleriffik – Greenland Institute for Natural Resources, Nuuk, Greenland (in Danish). 68 pp.

Appendix 1

2016 Professional hunter knowledge for South region, West Greenland

Three meetings with the Nuuk Chapter of the Greenland Hunter's Union (KNAPK) took place at their head office in early 2016 (17, 18 February and 23 March). The language of the meetings was Greenlandic and Danish. This appendix is a faithfully translated and paraphrased documentation of the knowledge and opinions provided by the attending professional hunters. Contact information for the participants may be obtained from the first author of this report.

Participants

KNAPK: Nikolaj Heinrich, Morten Heinrich, Aqqaluk Lothsen, Aslak Jensen, Karl Egede, Johannes Egede, Inuk Berthelsen, Lars Mathæussen, Anqunnguaq Josefsen, Steffen Andersen, Anthon Mathæussen and Bjarne Lyberth.

Greenland Institute of Natural Resources: Christine Cuyler, Inaluk Jakobsen, Mala Broberg and Natuk Olsen.

Department for Fisheries Hunting and Agriculture: Nuka Møller Lund.

1993-1994 Hunting Ban

Professional hunters want biologists to take their knowledge seriously. Although twenty-three years ago, the hunting ban of 1993-1994 still rankles professional hunters. They were not heeded by wildlife management. Their knowledge was ignored. At that time they lacked evidence/data to support their knowledge and their Greenlandic hunting culture left them ill equipped to argue their case with 'proofs' as per Western paradigms. Today as always, the hunters are interested in maintaining caribou abundance. Harvest regulation should ensure there are not too many caribou or too few. Regular meetings of professional hunters and Greenland Institute of Natural Resources biologists for knowledge exchange would be a step in the right direction. Ideas could be shared without always being in agreement.

Ameralik knowledge

1990's caribou

There were too many caribou due to the 1993-94 hunting prohibition. – *Angunnguaq Josefsen*

Caribou even occurred in Qinngorput Bay, which today is a suburb of Nuuk. – *Lars Mathæussen*

2003 caribou

They were many caribou in the Ameralik region. – *Lars Mathæussen*

2013 & 2014 caribou

The caribou taken inside the Ameralik Fjord in the 2013 and 2014 winter hunting seasons had excellent body condition. – *Nikolaj Heinrich*

2015 caribou

Caribou are unpredictable. In the 1990's they were widespread along the outer coast, but for a period, ca. 2006-2010, they were not. Now there are many small juveniles, so they are breeding well. In 2015, for the moment, they are once again out at the coast, i.e., visible from the mouth of Ameralik Fjord south to Buksefjord, and again from the mouth of Buksefjord south to Sermilik Fjord. By November-December these animals had moved further inland.

Today's easy availability of large numbers of caribou along the outer coasts has changed hunting customs. Now, most hunting occurs on the coast. No one goes up into the back country anymore, so the animals there never see hunters, and are essentially 'protected'. – *Nikolaj Heinrich*

In autumn of 2015 there were so many caribou in the Kapisillit area that you could not count them. There are more than before. – *Steffen Andersen*

Caribou abundance seems stable and animals may be found throughout the entire region in the autumn. During the rut group sizes of 20-30 animals are common everywhere. Further, relative to the past, there are certainly not fewer mother-calf pairs. – *Lars Mathæussen*

In September and October, on the south side of Ujaragssuit pâvat (northernmost eastern corner Ameralik range) caribou were abundant and

had excellent body condition, e.g., 4-5 cm rump fat. In September many caribou were visible along the north shore of Ameralik Fjord around Qârusulik (south of Qôrqut). In October lots of caribou were in the lowland area immediately east of the bottom fjord containing Færingshavn. – *Johannes Egede*

There were plenty of caribou in the river valley south of the Nuajat kûat (Ameragdla, the inner bottom of Ameralik Fjord) during August, but then none were present in September, because they moved south. – *Karl Egede*

In late August 2015, a group of 18 caribou were seen on the north side of Alangordlia fjord (just before the 'tidal falls'). All were harvested. – *Aslak Jensen & Nikolaj Heinrich*

Caribou harvested up until 1953, when I was on my first hunt, never evidenced any warble larvae parasites. However, these appeared only two years after the 1952 release of many [263] semi-domestic reindeer in the Itivnera/Kapisillit area. – *Anqunnguaq Josefsen*

2016 caribou

On 17 February, twelve small caribou were observed in the lowlands (elevations less than 200 m) west of Itivnera. In the winter hunting season, March, caribou were easy to find in two lowland (elevations less than 200 m) areas on the headland north of Kapisillit. These were the Qinguata tasia valley (east of Amitsuarssuk Fjord) and the far eastern reaches of Kangiussaq Bay. They were also plentiful around the Qôrqut bay. – *Johannes Egede*

In March caribou were plentiful in all the lowlands (less than 200m) surrounding the Kapisigdlit Kangerdluat (fjord leading to Kapisillit) and also in Eqaluit ilorluit Bay on south shore Ameralik Fjord (Ameragdla). Caribou were also present in Præstefjord. One shot on the inner north shore was skinny (no fat), while several shot on the outer southern shores had ca. 1.5 cm rump fat. – *Inuk Berthelsen*

On 21 March there were many caribou along the coast south of Ameralik Fjord, e.g., at Lille Narsaq and also at the Qarajat iluat Bay, where he took two. The situation was similar in Præstefjord, where he took three. – *Nikolaj Heinrich*

Ameralik caribou abundance is increasing, as evidenced by the noticeably greater number of animals seen along the outer coast when we are sailing the coasts to hunt sea mammals. This indicates a high probability that the inland also has many caribou. This winter, hunters did not need to go further to fill their catch. – *Morten Heinrich*

Also in March, differences in body condition associated with warble infection intensity were noted at Buksefjord. Midway into Buksefjord in a river valley on the south shore, Karl took seven small bodied ones. All had poor body condition (little or no fat) and many warble larvae on their backs. He took a further seven big [adult] caribou at the mouth of Buksefjord on the south shore. These are far fewer warbles and had better body condition. – *Karl Egede*

2015 vegetation

Muskoxen are now inhabiting the relatively small area of Nunatarsuaq (northeastern corner of Ameralik region) and are ruining the vegetation for the caribou. – *Lars Mathæussen*

Weather & sea ice

In the 1950's the winter weather was stable and cold, and the Isfjord (innermost Godthåb/Nuuk Fjord was always ice covered, as was the fjord into Kapisillit. There was always snow for Christmas. Caribou were few then, so they hunted Arctic fox instead.

The cold and deep snow depth [ca. 1 m] of winter 2015 did not seem to adversely affect the caribou, however, what does negatively affect the caribou are layers of ice over the snow and especially covering the ground itself. If it rains and then freezes this is a problem for the caribou. – *Anqunnguaq Josefsen*

The 2013 winter hunting season was a good year for access to the Ameralik caribou, because there was little sea ice to prevent sailing and the snow depths were alright. Similarly the 2014 winter season was good, again because of the lack of sea ice, although there was lots of snow. – *Nikolaj Heinrich*

Qeqertarsuatsiaat knowledge

2015 caribou

In 1982 around the Fiskenæsset area, to find caribou hunters had to go all the way inland to the Ice Cap. In 2015 they could shoot 50 animals in one place and basically from the boat. – *Inuk Berthelsen*

In the 1950's and '60's you would be lucky to see one or two caribou in the Grædefjord area. In 2015 there are lots of animals there. Also, there are more and more mother-calf pairs. All the animals are smaller bodied now. – *Nikolaj Heinrich*

From 2012 until 2015, the general impression is that caribou abundance, distribution and group size have all remained relatively stable. In contrast, the frequency of sighting mother-calf pairs has increased. – *Aslak Jensen*

In the autumn hunting seasons of 2014 and 2015, caribou were doing well (good body condition) and the number of calves was high over the entire Qeqertarsuatsiaat region (Sermilik Fjord to Frederikshåb Isblink), however, the animals were of smaller body size and less afraid of hunters. Steffen supported these observations and added that small bodied caribou were in the lowlands, while the big sized animals were far up in the mountains. The latter came down to the lowlands only in the night, so that the only chance to get them was in the very early morning hours or to pursue them in the high mountains. – *Nikolaj Heinrich & Steffen Andersen*

The presence of warble larvae in caribou differs. North of Bjørnesund the caribou are infected with warbles, but south of Bjørnesund they are not. The animals south of Bjørnesund are huge and possess thick rump fat, and this includes even the calves. – *Nikolaj Heinrich & Steffen Andersen*

Inside Grædefjord caribou wariness for hunters could vary widely. About halfway into the fjord some animals were afraid of his boat's arrival and others appeared completely undisturbed. – *Nikolaj Heinrich*

Regarding the caribou between Sermilik Fjord and Frederikhåb Isblink, if you want big fat caribou then you must go to the area just north of Frederikshåb Isblink. Also the caribou number has been increasing in Bjørnesund; however, these do not have as much rump fat as those near Frederikshåb Isblink. With

each year that passes, it seems there are more and more caribou in the areas south of Bjørnesund, which has poorer vegetation. – *Nikolaj Heinrich*

In 2015 they saw caribou for the first time in the lake area south of Bjørnesund and east of 50°W. Initially there were 20 to 50 animals, and later more were observed. – *Aslak Jensen & Nikolaj Heinrich*

2016 caribou

In the 2016 winter hunting season, caribou were present at the very mouth of Grædefjord. The caribou were harder to spot because they hide well in this terrain, unlike further north along shores of Præstefjord and Qarajat iluat . Caribou could be seen on the north side at the mouth of Grædefjord and there were many tracks on the south side. Their body condition (fat reserves) has never been so good in wintertime. The caribou had warble infections but were still fat. The sea-ice extent in Grædefjord almost reached the fjord mouth. Almost at the edge of that sea-ice, there were caribou tracks evidencing a large number had crossed the fjord. They were moving from north to south. – *Nikolaj Heinrich*

In March, all pregnant females harvested on the south shore of the mouth of Grædefjord had good body condition (fat reserves). Other animals could have up to 4 cm of rump fat, while those adult males that lacked body fat still possessed lots of muscle and appeared to be in good condition. – *Johannes Egede*

2015 vegetation

Between Sermilik Fjord and Frederikshåb Isblink, the vegetation seems good. There has been no noticeable overgrazing or increased number of caribou trails. On the south side of Bjørnesund, about ½-way in, there is an area covered with lichen mats that was first observed in 2001 (Cuyler *et al.* 2003). Aslak has kept an eye on it ever since. Neither he nor Nikolaj have ever observed more than three caribou foraging this area in summer, and never in winter. The lichen mats are still intact and lush. – *Aslak Jensen & Nikolaj Heinrich*

In the summer and autumn of 2015 there was a mushroom explosion in elevations less than 200m on the islands at the mouth of Bjørnesund and peninsula to the south. Mushrooms were everywhere. They shot eight caribou

here and every rumen was full of mushrooms only. – *Aslak Jensen & Nikolaj Heinrich*

Hunter effort & meat sale

It remains easy to capture a full boat load of caribou each trip. – *Aslak Jensen, Nikolaj Heinrich, Steffen Andersen, Anqunnguaq Josefsen, Lars Mathæussen & Anthon Mathæussen*

Selling all of his caribou catch each year presents no difficulties. He does not worry about this and so never holds back on how many caribou he takes per trip. – *Aslak Jensen, Nikolaj Heinrich & Anthon Mathæussen*

Selling of the catch is slowed, however, when recreational hunters sell their catch. This began in 2001-2003, so I heard. – *Nikolaj Heinrich*

Number of caribou needed annually per household

Each year, Aslak Jensen needs five whole caribou carcasses in the freezer, for his family of four children and two adults. A further six entire hind legs are needed for each family member's birthday. – *Aslak Jensen*

They don't eat caribou constantly because they have fish, birds and marine mammals too. Thus three caribou per family of four is enough per year. – *Nikolaj Heinrich, Lars Mathæussen, Steffen Andersen, Anqunnguaq Josefsen & Anthon Mathæussen*

Competition from recreational hunters

Selling their catch

Recreational hunters are selling their meat. – *Nikolaj Heinrich*

Recreational hunters are selling caribou meat using social media, e.g., FaceBook. – *Steffen Andersen*

The sale of caribou meat by recreational hunters seems unfair to professional hunters. – *Lars Mathæussen*

At least three persons in possession of professional hunting permits in Nuuk have collaborated with recreational hunters (employing up to four boats) to harvest caribou for commercial sale. One sold caribou meat to a hotel restaurant in Ilulissat. Aslak found out only because the restaurant chef called him to hear if he could provide caribou meat, since the recreational hunter that used to supply them was sick that hunting season. One of the three professional hunters withdrew from collaborating with the recreational hunters when he realized how unpopular this activity was among the other professional hunters. – *Lars Mathæussen & Aslak Jensen*

Conflict

Recreational hunters are taking over hunting areas, which formerly only the professionals used. – *Nikolaj Heinrich, Lars Mathæussen & Anthon Mathæussen*

Hunting areas are filling up with people. There appears to be more people in the terrain than caribou. This annoys the professional hunters. – *Lars Mathæussen & Anthon Mathæussen*

Sometimes there are too many recreational hunters in the terrain. Specifically Grædefjord has seen a marked rise in their number the last few years. – *Aslak Jensen*

The growing number of recreational hunters in Grædefjord makes professional hunting there difficult. There are usually greater than 10 boats with recreational hunters, i.e., 2-3 boats in every bay for the entire length of the fjord. Also, recreational hunters are using social media on their smart phones to notify caribou locations to others. The disturbance this causes the caribou means that a professional hunter has to be up at first light (03:00 AM) in the morning to have a chance of obtaining caribou. So now prefer to go hunting on weekdays – *Steffen Andersen & Nikolaj Heinrich*

Fiskefjord has experienced a similar explosion in the number of boats with recreational hunters, i.e., 2-3 boats in every bay for the entire length of the fjord. – *Steffen Andersen*

The ratio of professional to recreational hunters seems unfairly in favour of the latter. Recreational hunters have lots of modern equipment. – *Lars Mathæussen*

Some professional hunters no longer hunt caribou for profit, because recreational hunters have taken over the professionals' hunting areas as well as a large market share of the sale of caribou meat. It's smarter to concentrate on fishing for a source of income, and only hunt caribou to satisfy their immediate family's needs. Alternately they buy their caribou at the local market or from other professional hunters that they know respect the caribou and nature. – *Anthon Mathæussen*

Assumed lack of hunting ethics among recreational hunters

Greenland hunters were raised with the axiom that a true hunter does not let any part of the caribou go to waste. – *Anthon Mathæussen*

Recreational hunters are observed or suspected of not taking the entire carcass home with them, e.g., taking only the hind legs. This should not continue. – *Anon*

In 2015 some recreational hunters began hunting caribou in Grædefjord on 20 July, although the season first opened on 1 August. Photos were taken and given to the police, but nothing happened to the offenders. – *Nikolaj Heinrich*

During the rut, caribou bulls smell and taste rank. Apparently many recreational hunters don't know that, so recreational hunters still shoot the big breeding bulls and sometimes the entire harem of cows. This is not good for caribou reproduction. Further, the bull meat is usually thrown away. Three years ago he observed an entire carcass of a big antlered bull floating in the sea near Sârdloq. – *Morten Heinrich*

Perspectives regarding muskoxen presence in the South region

In 2007 the professional hunters asked the Nuuk municipal government for permission to harvest the muskoxen inside Godthåb/Nuuk Fjord. There is still no formal answer, although he was told that the municipality awaits scientific advice. – *Nikolaj Heinrich*

In 2015, muskoxen are well established and increasing in number on Nunatarsuaq (northeastern corner of Ameralik region). They also now occur south of Kapisillit. – *Lars Mathæussen*

Since 2010-2011 muskoxen have been present as far south as the Nuajat kûat (Ameragdla, the inner bottom of Ameralik Fjord) and south into the valley beyond. More and more muskoxen appear with each passing year. Several hunters have been taking muskoxen there. – *Anthon Mathæussen*

Muskoxen are a problem for caribou. In order to protect caribou, the professional hunters do not want muskoxen in the Nuuk region. Further, the Nuuk area is not officially considered a muskoxen area. – *Lars Mathæussen, Nikolaj Heinrich, Anqunnguaq Josefsen, Steffen Andersen and Anthon Mathæussen*

The possibility of becoming an outfitter and developing trophy hunting for muskoxen in the Godthåb/Nuuk Fjord seemed only somewhat attractive. – *Steffen Andersen*

Appendix 2
Place Names

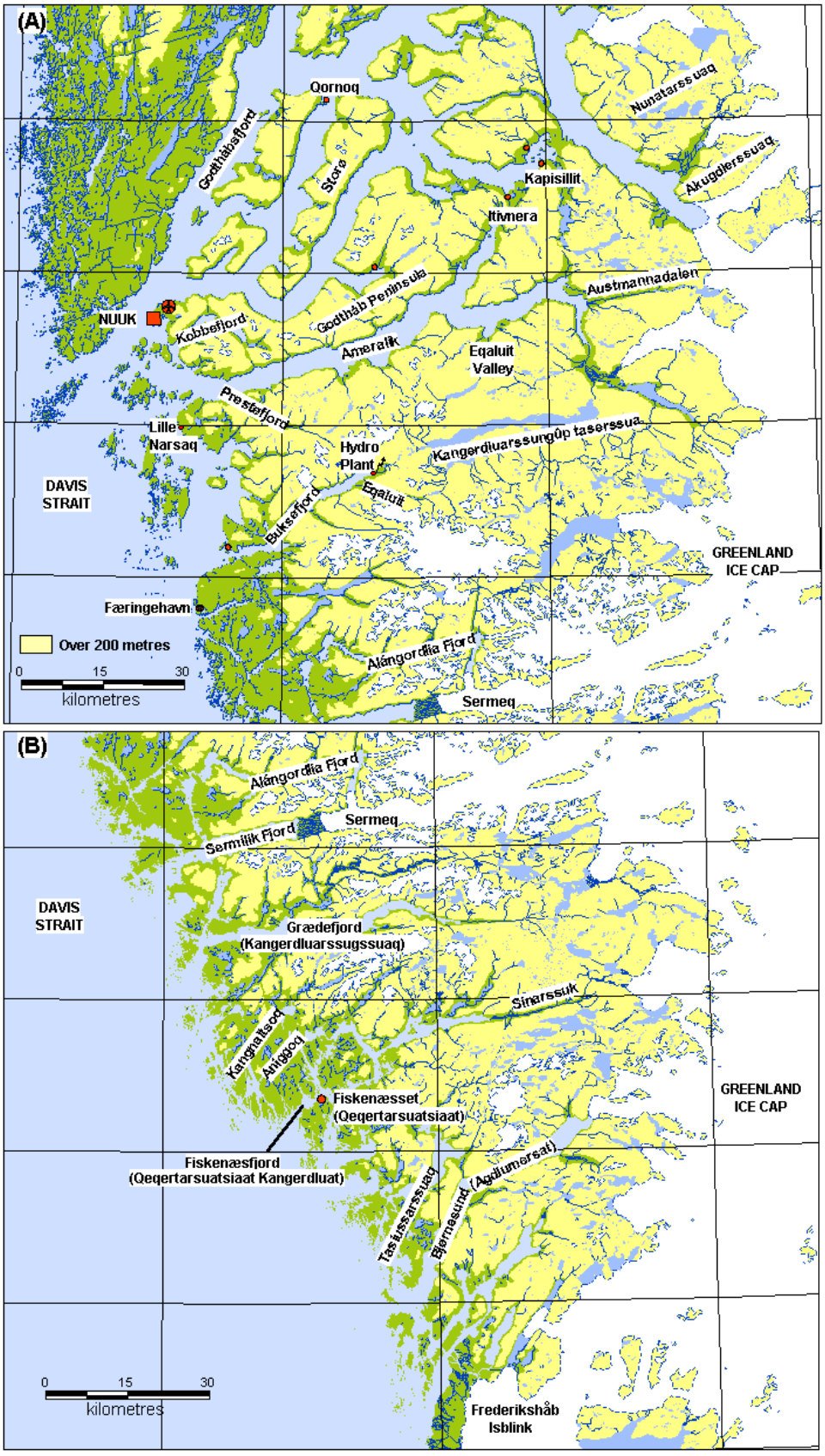

Figure 12. *Place name details taken from Cuyler et al. (2003).*

Appendix 3

1998 Field Report: October minimum count Ameralik caribou along sea shore south of Nuuk, West Greenland

Introduction

All summer and autumn caribou were reportedly numerous along the shores and on coastal islands between the Ameralik Fjord and the Buksefjord. Beginning already in March 1998 local hunters reported seeing many caribou on the coast, even sighting dead caribou lying in the snow (Appendix 4).

Purpose

The goal of this study was to investigate caribou numbers and demographics along the coastline south of Nuuk (64° 10′ 27.34″N, 51° 44′ 9.87″W), between Ameralik Fjord and Buksefjord (Fig. 12) specifically between *Sarfat* and *Utorqarmiut*.

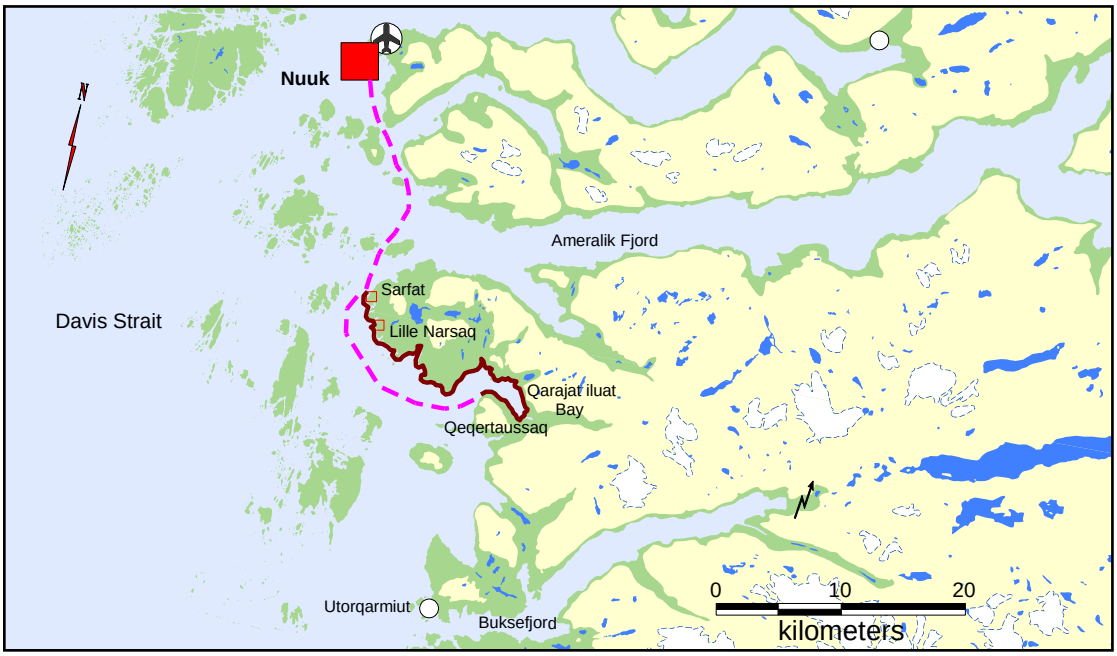

Figure 13. *Place names and route sailed 28 October 1998. Route to and from Nuuk harbor in pink. Brown solid line is The 34 km stretch of shoreline route for minimum count and demographics from Sarfat past Lille Narsaq around the Qarajat iluat Bay and finally along the northeastern side of the Qeqertaussaq. Elevations between 0 and 200 m are green; those over 200 m are yellow.*

Methods

On the 28 October 1998, we sailed Aqqalu Rosing-Asvid's 27 foot, 40 H.P. diesel engine boat (cruising speed 8-9 knots) along a 34 km stretch of coastline (Fig. 12). Given the slow speed, we used +9-hours for this minimum count

(departure 08.00, return 17:20). Counting of caribou began at *Sarfat* and finished at the northern most point of *Qeqertaussaq* in *Qarajat iluat* bay. Boat to shore distance was typically about 200 m.

Participants included the following from the Greenland Institute of Natural Resources, project leader Christine Cuyler (research scientist), Sofie Jeremiassen (biology assistant), Arild Landa (Department Head), Aqqalu Rosing-Asvid (research scientist), and a friend of Aqqalu, Hans Bådsgård.

Determining caribou sex & age

Although a spotting scope (32 x magnifications) was onboard it was unusable owing to the movement and rocking of the boat. Leitz binoculars (8 x magnifications) were used for all observations.

For this study, positive sex identification was determined by the presence or absence of a vulva and/or urine patch on the rump, which reliably indicates a female. Although antler size and shape is unreliable for sex and age determination, extremely large well developed antlers always indicate a mature bull. Smaller thinner antlers with a definite forward-pointing 'attack' aspect can be juvenile males. Similar antlers but with a backward-flip to the top point are typically adult females. General body shape (rectangular female, 'V' male) and longer face/head on mature males can also aid sex and age determination.

We assigned only two age classes: calf (age ≤ 6-months) and adult (age > 1-year). Both were determined by body size, since 6-month old calves of both sexes are smaller than all other age classes in October. Observations provide percentage of calves within the total number of caribou seen and calf recruitment, which is the ratio of calves per 100 cows. Group size was based on proximity or group cohesion during a flight response.

Results

Weather & snow conditions

Sunny and clear all day, little wind, air temperature approximately -4°C. A relatively thin layer of snow covered much of the terrain, albeit in a patchy manner. Only the tidal zone, boulders and steep mountain cliffs were snow-free. Making notes and observations took more time than expected owing to the large numbers of caribou. Therefore there was not time enough to sail the

planned route, which would have taken us all the way south to *Utorqarmiut*, at the mouth of the Buksefjord.

Caribou number

Already beginning at *Lille Narsaq* (abandoned hamlet about 20 km south of Nuuk) caribou were noticeably abundant. There we observed 133 in the near vicinity of the buildings. The entire minimum count netted a total of 955 caribou (Table 5) which were by and large within 300-500 meters of the shoreline along a 34 km stretch of coast south of Nuuk (Fig. 13). Group size averaged 12.6 ± 19.4, median was 6, maximum was 111 caribou and minimum was one (Table 6).

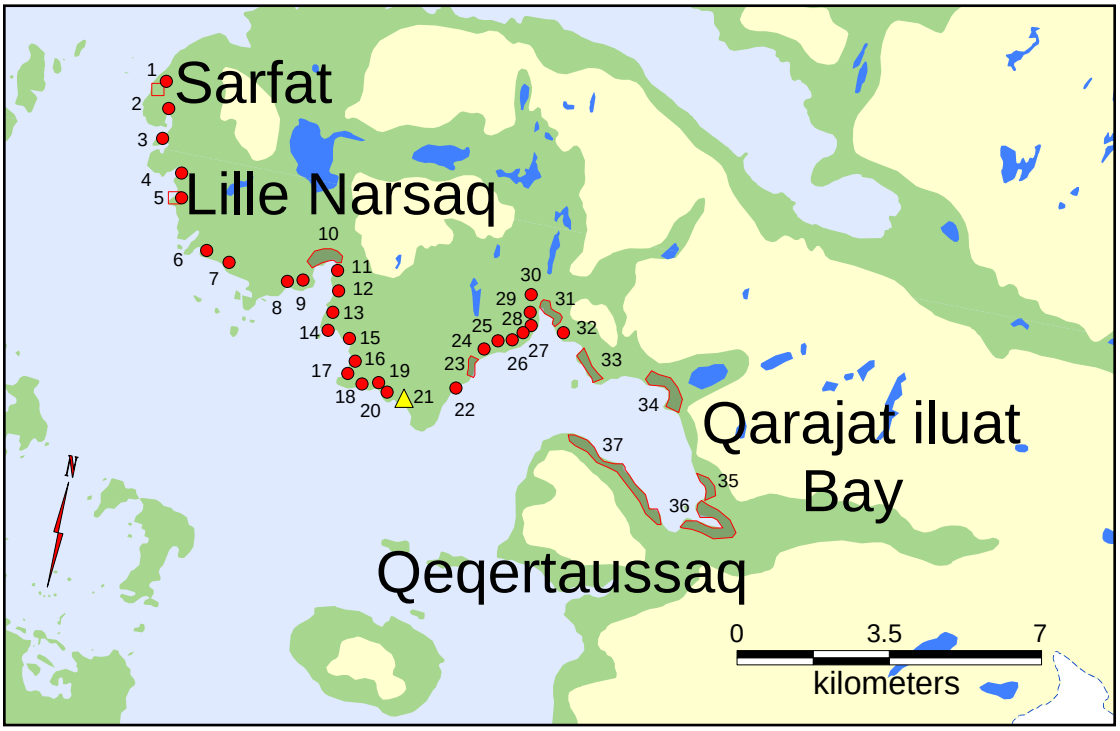

Figure 14. *Numbered caribou observations, groups (●), areas (red hatching), 28 October 1998. Two caribou had antlers caught in piles of fishnet at Qarajat summer houses (▲ 21). Table 6 contains corresponding details for each observation number. Elevations between 0 and 200 m are green; over 200 m are yellow.*

Table 5 *Caribou minimum count and demographics, 28 October 1998, from a subsection of the Ameralik population, South region, West Greenland.*

Caribou sex & age	Percentage[1]	Observed
Female adult	43.9 %	107
Calf (age < 6 months)	31.1 %	76
Male adult	25.0 %	61
Unknown sex & age	-	711
TOTAL	**100 %**	**955**

[1] Only for those sexed and aged

Demographics
The similarity of antler growth between mature females and juvenile males made positive sexing and ageing by identifying a vulva patch too time consuming for the number of animals involved. This and also the long observation distances, large group sizes, and group movements mixing animals about, made it only possible to definitively sex and age 244 of the total 955 caribou seen (Table 5). Autumn calf recruitment was 71 calves per 100 cows. The bull to cow ratio was 57 bulls to every 100 cows.

Many caribou were immediately above the tidal zone or beaches. They appeared to be eating grasses growing at the shoreline and on the grassy mounds of past human habitation. Caribou that had been feeding on what appeared to be grasses near the two *Qarajat* summer houses (Fig. 13, yellow triangle no.21) had left behind apricot coloured urine everywhere in the surrounding snow. The grass species was identified as *Calamagrostis* spp (Danish rørhvene; Greenlandic, siorpaaluk).

Pelt colour variation
Although most caribou seen possessed coloration normal to wild indigenous caribou, still there were many with an overall unusually dark pelage. Also, one all white animal and two near all white caribou were observed.

Antlers
Approximately 10 to 12 mature bulls (age > 4-years) had already lost their antlers. One mature bull had lost only one antler. Most adults had antlers including the females, whether with a calf-at-heel or not. The calves themselves often had noticeably long antler pegs. The majority of adult females possessed two antlers, which typically were as well developed as antlers on sub-adult males (age 2-3 years).

Death by fishnet
Two caribou were found with their antlers entangled in fishing nets. One was dead. This was the only dead caribou we observed. Fish nets had been stored on land above the tide line on both sides of the little *Qarajat* cove where there were two summer houses. In each instance the nets were loosely piled into a large mound. On the west-side of this tiny cove was a female that had died recently, i.e. within the past 2-12 hours, of a twisted and broken neck. Ravens had only just begun to feed at her anal region, the mouth and nose being

twisted under the neck and head were as yet intact. On the east-side of the cove, a young male was entangled. He was alive. We freed him.

Vegetation

The caribou appeared to be feeding upon a tall grass that grew at the shoreline and around the grassy mounds of past and present human habitation. We took a grass sample, which was later identified as *Calamagrostis* spp. (Danish *rørhvene*; Greenlandic, *siorpaaluk*).

Miscellaneous Wildlife Observations

We also observed two sea eagles (*Haliaetus albicilla*). These were on the north side of the *Qarajat iluat* Bay. Several harp seals (*Phoca groenlandicus*) poked their heads up above the sea surface. Ravens (*Corvus corax*) were numerous at several sites.

Table 6. *Raw data[1] for numbered caribou locations figure 13. 28 October 1998.*

ID	Time	Group size	Unknown sex & age	Cow adult	Calf	Bull adult	Caribou Distance to shore (m)
1	09:40	4	0	0	0	4	≤ 20
2	09:43	7	6			1	≤ 300
3	09:46	8	4	2	2	0	≤ 300
4	09:50	81	13	35	20	13	≤ 100
5	10:30	5	5				≤ 100
6	10:38	8	8				≤ 10
7		8	8				10-50
8		7	5	1	1	0	10-50
9		5	5				10-50
10		23	23				≤ 100
10		6	6				≤ 100
10		14	14				≤ 100
10		2	2				≤ 100
10		2	2				≤ 100
10		2	2				≤ 100
11		28	7	10	8	3	10-5
12		6	6				10-5
13		3	3				10-50
13		2	2				10-50
13		1	1				10-50
13		3	3				10-50
13		7	7				10-50
14		17	17				10-50

15		5	5				10-50
16		6	0	3	2	1	10-50
17		4	0	2	2	0	≤ 100
18		18	18				≤ 300
19		7	7				≤ 300
20		6	6				≤ 300
21	11:30	1	0	0	0	1	5
22		2	0	1	0	1	≤ 300
23		9	0	4	4	1	≤ 300
23		6	0	5	1	0	≤ 300
23		4	0	0	0	4	≤ 300
24	12:30	80	80				≤ 300
25	12:30	5	1	1	1	2	≤ 300
26	12:30	8	0	4	4	0	≤ 300
27	12:30	20	20				≤ 300
28	12:30	12	11			1	≤ 300
29		4	0	0	0	4	≤ 300
30		7	0	3	3	1	≤ 300
31		5	0	3	2	0	≤ 300
31		2	0	1	1	0	≤ 300
31		2	0	1	1	0	≤ 300
31		1	0	0	0	1	≤ 300
31		5	0	2	2	1	≤ 300
31		2	0	1	1	0	≤ 300
31		2	0	0	0	2	≤ 300
31		4	0	2	2	0	≤ 300
32		7	7				≤ 300
33		54	54				≤ 300
33		50	50				≤ 300
33		2	0	0	0	2	≤ 300
33		7	0	0	0	7	≤ 300
33		3	0	0	0	3	≤ 300
33		4	0	1	1	2	≤ 300
34		6	6				≤ 300
34		1	1				≤ 300
34		7	7				≤ 300
34		27	27				≤ 300
34		8	0	4	4	0	≤ 300
34		7	0	3	3	1	≤ 300
34		111	111				≤ 300
34		50	50				≤ 300
34		14	14				≤ 300
35	15:00	13	13				≤ 500
35	15:00	7	7				≤ 500
35	15:00	3	3				≤ 500

35	15:00	30	30				≤ 500
35	15:00	16	16				≤ 500
35	15:00	1	1				≤ 500
36		22	4	9	5	4	≤ 500
37		1	1				≤ 500
37		4	4				≤ 500
37		16	0	9	6	1	≤ 500
37	15:50	8	8				≤ 500
TOTALS		**955 ALL**	**711 Unknown**	**107 COW**	**76 CALF**	**61 BULL**	

[1] Blank cells indicate where there was no data recorded or unknown. Where zeros occur indicates no animals of that sex or age.

Discussion

Ameralik caribou are a genetic mix of indigenous wild caribou (*Rangifer tarandus groenlandicus*) and Norwegian semi-domestic reindeer (*Rangifer tarandus tarandus*) and this was reflected in the variety of pelt colours among individuals. Most possessed the usual pelage common to indigenous caribou, however, white, near all white as well as many that had an unvarying overall dark brown pelt also were observed.

The well developed antler growth on females was in sharp contrast to what is typical of female caribou observed on Akia-Nordlandet, which seldom have both antlers, if any at all (Cuyler unpublished). (Caribou on Akia-Nordlandet, which is opposite Nuuk to the north, belong to what is now known as the Akia-Maniitsoq population). Being the 28th of October, the peak period for the autumn breeding rut would have finished. So several mature males (age > 4-years) having already dropped at least one antler was not surprising.

Uncovered fishnet stored in piles at the shore can entangle the antlers of caribou and cause mortality. Since caribou appear to actively seek the forage surrounding summer houses, we recommend that piles of old or unused fishnets should be securely covered, e.g., by tarpaulin, or burnt. Alternatively, discarded fishnets could be returned to Nuuk for disposal at the municipality incinerator.

This study observed 955 caribou that belonged to the Ameralik population. The autumn calf percentage and recruitment (respectively 31% and 71 per 100 cows) indicate that both calf production and survival is optimal and high. The bull to cow ratio may be a reflection of the bull only harvesting over the past

four years. We do not expect the ratio to impede or reduce conception among cows.

Most caribou were observed within 500 meters of the shoreline, and many were within 100 meters. Since the length of shoreline was 34 km, then a maximum estimate of the area surveyed would be approximately 17 km^2 (0.5 x 34 km), which would give a conservative density of 56.2 caribou per km^2. This supports the numerous reports in 1998 by local hunters that there were 'many' caribou south of Nuuk. The density 56/km^2 can only be regarded as enormous. Ameralik caribou are known to aggregate in groups numbering hundreds of animals. This is the direct result of their feral semi-domestic reindeer heritage. Thus we do not assume this density applies to the entire 12,800 km^2 area of the Ameralik region. Regardless, 56.2 caribou / km^2 are not compatible with sustainable caribou grazing on the vegetation and lichens. What we observed is 46x larger than the recommended target density of 1.2 caribou/km^2. Overgrazing will occur.

Conclusions

In late October 1998, there were many caribou south of Nuuk along the sea shore. Caribou density was abnormally high and would quickly cause overgrazing. Calf production among the observed caribou suggests that the 1998 Ameralik population had the potential for an explosive growth in numbers.

Appendix 4

1998 Field report: Caribou winter mortality, near Nuuk area

By Christine Cuyler, Sofie Ruth Jeremiassen & Vittus Nielsen

Introduction

In March and April 1998, the Greenland Institute of Natural Resources (GINR) received several telephone calls from agitated locals. All had observed many dead caribou at several locations south of the capital city Nuuk (64° 10′ 27.34″N, 51° 44′ 9.87″W). These included the bottom of Kobbefjord, the *Kingittorsuaq* (Hjortetakken) Mountain, the *Ugpik* bay/fjord area, and the bottom of Buksefjord (Fig. 14). At the first two locations some carcasses were close to shore and others on the mountainsides, but all were visible from the shore. At Buksefjord the dead caribou were reported frozen into the fjord sea ice. There were 20 visible caribou carcasses, curled up as if sleeping, and several 'holes' where further bodies may have been and already sunk through the thin ice (Jens Bjerge pers comm.). For the first time in living memory, large numbers of dead caribou were being seen in the Nuuk region. The locals voiced their concern that the caribou had starved to death, because caribou abundance appeared high in near shore areas. For example locals out sailing would always spot a number of caribou on any boat trip.

Purpose

The goal of this investigation was to find out how many caribou had died, where they had died and the cause(s), which could include disease, accidents, starvation and poaching.

Methods

Biology assistant Sofie Ruth Jeremiassen led the sample collection. The Greenland Fisheries and Licensing Control (GFLK) provided their Nuuk Conservation Officer, Vittus Nielsen and his assistant Jokum, and the two GFLK boats used.

We made two boat trips. We sailed south of Nuuk on 20 April 1998 in an 18 foot aluminum outboard open dory and scouted the bottom of Kobbefjord, about the *Kingittorsuaq* Mountain and then the *Ugpik* bay/fjord. The second trip was 14 May 1998 when we sailed a larger 25 foot cabin boat into the

bottom of Buksefjord and also scouted the *Qeqertaussaq* shoreline. We scanned the shores and mountains with binoculars (8 x magnifications) to locate caribou carcasses, and then went ashore to collect carcass samples and data. Carcass data collected included Global Positioning System (GPS) location, elevation and comments regarding possible cause of death. Samples collected were the mandibles, metacarpus (foreleg) and metatarsus (hind leg) when these remained at the carcass site.

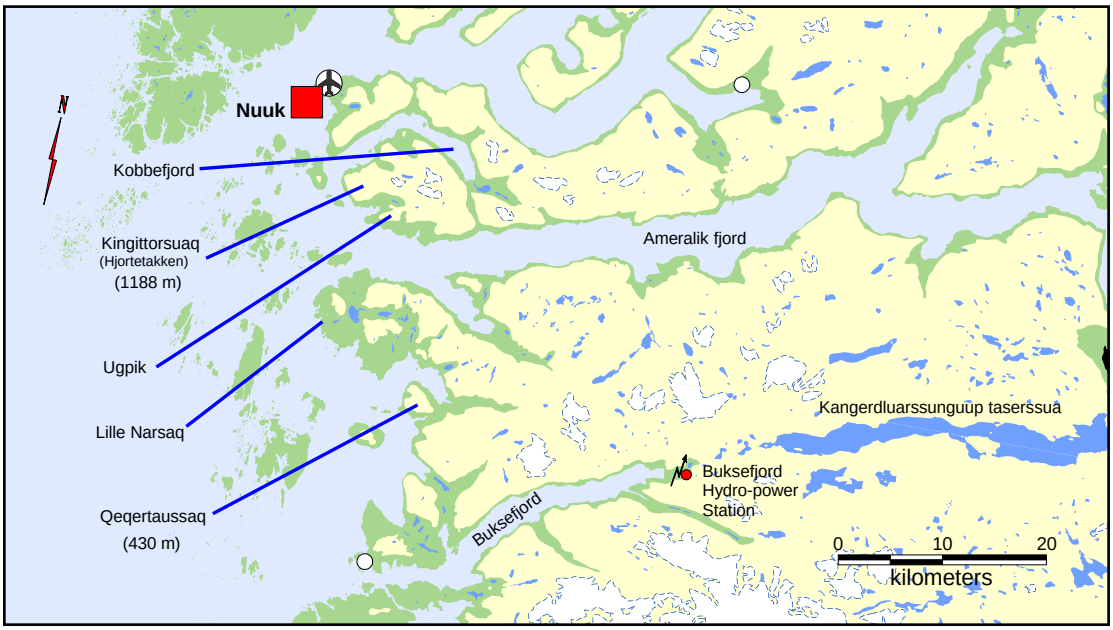

Figure 15. *Place names relevant to the caribou carcass locations south of Nuuk in April-May 1998.*

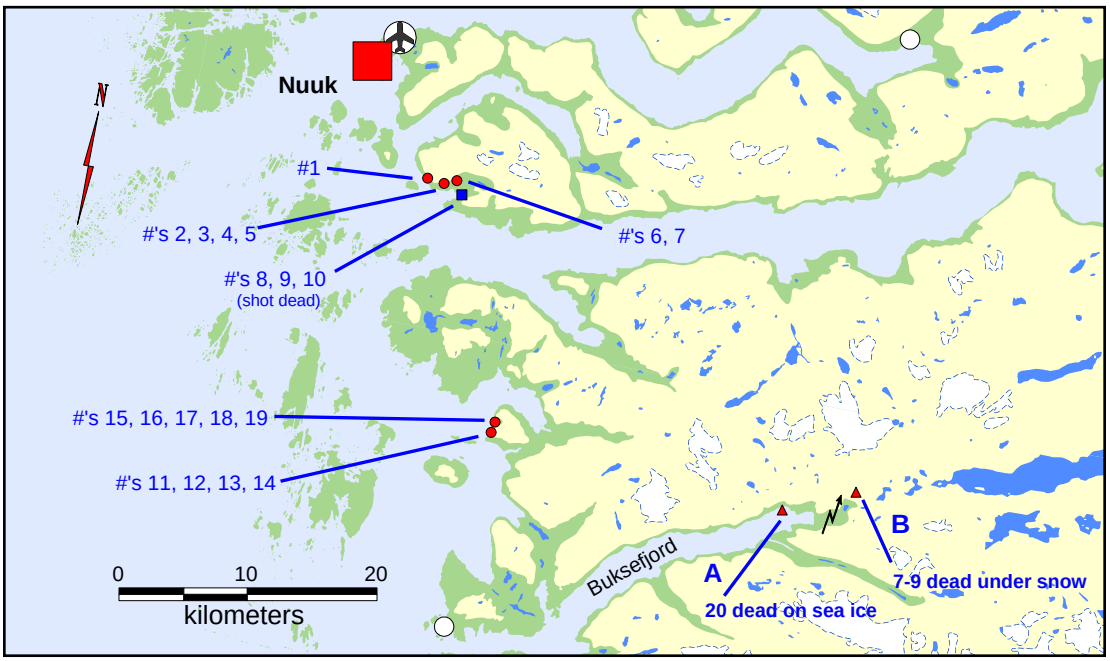

Figure 16. *Caribou carcass locations south of Nuuk in April-May 1998.*

***Table 7**. Raw data[1] on caribou carcasses located in April-May 1998 on sea coast south of Nuuk; female (F), male (M), unknown (-).*

Date	ID	Sex	Age class	Location	Elevation	Latitude	Longitude
20 Apr	1	F	Adult	Kingittorsuaq	-	64° 6′ 48.6″	51° 36′ 48.6″
20 Apr	2	M	Juvenile	Kingittorsuaq	-	64° 6′ 3.5″	51° 35′ 10.5″
20 Apr	3	M	Adult	Kingittorsuaq	-	64° 6′ 3.5″	51° 35′ 10.5″
20 Apr	4	-	-	Kingittorsuaq	-	64° 6′ 3.5″	51° 35′ 10.5″
20 Apr	5	F	Juvenile	Kingittorsuaq	-	64° 6′ 3.5″	51° 35′ 10.5″
20 Apr	6	-	-	Kingittorsuaq	-	64° 6′ 16″	51° 34′ 2.2″
20 Apr	7	F	Juvenile	Kingittorsuaq	-	64° 6′ 16″	51° 34′ 2.2″
20 Apr	8	M	Adult	Ugpik	10 m	64° 5′ 44.3″	51° 33′ 18.1″
20 Apr	9	M	Adult	Ugpik	10 m	64° 5′ 44.3″	51° 33′ 18.1″
20 Apr	10	M	Adult	Ugpik	10 m	64° 5′ 44.3″	51° 33′ 18.1″
14 May	11	F	Adult	Qeqertaasaq	105 m	63° 56.254′	51° 26.050′
14 May	13	-	Calf	Qeqertaasaq	105 m	63° 56.254′	51° 26.050′
14 May	12	M	Adult	Qeqertaasaq	105 m	63° 56.254′	51° 26.050′
14 May	14	-	Calf	Qeqertaasaq	105 m	63° 56.254′	51° 26.050′
14 May	15	M	Adult	Qeqertaasaq	18 m	63° 56.497′	51° 26.068′
14 May	16	M	Adult	Qeqertaasaq	18 m	63° 56.497′	51° 26.068′
14 May	17	M	Adult	Qeqertaasaq	18 m	63° 56.497′	51° 26.068′
14 May	18	M	Adult	Qeqertaasaq	18 m	63° 56.497′	51° 26.068′
14 May	19	M	Adult	Qeqertaasaq	18 m	63° 56.497′	51° 26.068′
May	A	-	-	Buksefjord ice	0 m	63° 55′ 25″	50° 57′ 46″
June	B	-	-	Buksefjord	-	63° 56′ 43″	50° 51′ 13″

[1] Now corrected for original data entry errors on sex and age.

Results

In total, 19 dead caribou were found (Fig. 15, Table 7). Owing to activity by scavengers, e.g., ravens and gulls, typically little but bones remained by the time we visited the sites. On April 20, seven caribou skeletons were located in the *Kingittorsuaq* area on the Hjortetakken Mountain. The cause of death was a snow avalanche. Nearby in *Ugpik*, the skeletons of three large mature bull caribou were found. All three had been shot dead and their hind legs removed. The bottom of Kobbefjord was full of sea ice and therefore could not be reached by boat for scouting. By 14 May when we made our second boat trip, the fjord ice in the bottom of Buksefjord was breaking up and melting. The reported 20 caribou carcasses had disappeared. Our scouting of the sea shore and cliffs in Buksefjord revealed no further carcasses. Leaving the mouth of Buksefjord, we observed about 10 caribou walking down out of the

mountains making their way to the sea coast. There were also fresh caribou tracks in that area. We continued to scout the sea shore and mountains while returning to Nuuk. On the sides of *Qeqertaasaq*, we located four caribou carcasses. These included a cow, a bull and two calves. All had died in a snow avalanche. Still on *Qeqertaasaq* we located a further five caribou carcasses, all adult bulls, again the result of yet another snow avalanche. Data from the mandibles will be included in a separate technical report.

Discussion

Natural mortality

We confirmed that 16 caribou died in snow avalanches. Additional caribou may have died by avalanche in the spring of 1998. For example locals reported dead caribou in Kobbefjord but we were unable to examine the area. Further, with the snow melt in early June, seven to nine carcasses finally became visible under the steeps mountainsides between the Buksefjord power station and the long *Kangerdluarssunguup taserssua* Lake, where avalanches had occurred that spring and snow depths in the valley exceeded 1½ meters (Jack Frederiksen, pers comm.).

We were unable to confirm possible carcasses in Kobbefjord. We were also unable to confirm the 20 carcasses reported on the Buksefjord fjord ice, but owing to spring melt we assume these sunk before our arrival at the scene. Given the reliability of our Buksefjord sources, these 20 and the further 7-9 carcasses beyond the Buksefjord power station may be added to the 16 deaths by avalanche for a total of 43-45 confirmed natural caribou deaths in the spring of 1998.

Why the 20 caribou were lying curled up on the Buksefjord fjord ice is a mystery. Locals hypothesized that these caribou had lain down on the sea ice and become frozen to it unable to move. Caribou are adapted to lying down on snow and ice without adverse consequences. Any ungulate becoming frozen onto the substrate they have lain upon is undocumented in the literature. It is conceivable, however, if both ice and fur were wet when the animals lay down and there followed a sharp temperature drop to well below freezing before the animals thought to rise again. Late winter rain storms followed by freezing temperatures are common in the Nuuk area and could provide this sequence of events. The reported deep snows in the Buksefjord

area may already have predisposed this group to starvation, which could have hastened their demise if once rendered immobile. Further speculation without information is fruitless.

Poaching (illegal hunting)

Winter hunting was illegal in 1998. Regardless, three of the dead caribou were poached. All were immediately beside the sea shore, and all hind legs had been removed while the rest of the carcasses were left otherwise intact.

Conclusions

Snow avalanches appear to have been common in the late-winter (April) of 1998, and coincided with caribou foraging in steep terrain. Both suggest snow may have been unusually deep that spring, which is supported by Buksefjord local knowledge. Although poaching was confirmed in three deaths, the rest were natural. At least 23-25 caribou died in snow avalanches and a further 20 of unknown natural cause(s). For caribou, deep snow is always associated with the potential for starvation, and may have been a contributing factor behind those 20 found lying curled up and dead on the Buksefjord sea ice.

Appendix 5

Transect line details: March 2012 aerial caribou survey by helicopter in South region, West Greenland

Transect lines 34 to 62 (line 53 omitted) were for Ameralik caribou: hunting area 4.
Transect lines 1 to 33 were for Qeqertarsuatsiaat caribou: hunting area 5.

Table 8. *South region caribou survey details for transect lines flown 1-12 March 2012.*

Date	Line No.	Line Length (km)	Axis Flown	Latitude Dec.degree A	Longitude Dec.degree A	Latitude Dec.degree B	Longitude Dec.degree B
1	61	21.4	W to E	64.53716	-50.70651	64.57172	-50.26867
2	9	13.5	E to W	62.95680	-50.53289	62.97750	-50.27948
2	11	38	W to E	63.01490	-50.60559	63.05680	-50.05747
2	12	19	W to E	63.06560	-49.96696	63.09280	-49.61775
2	13	18	W to E	63.14902	-49.71183	63.17821	-49.32460
2	14	14.2	E to W	63.21068	-49.72761	63.22698	-49.51182
2	21	33.8	E to W	63.15279	-50.46763	63.20582	-49.80510
2	Refuel						
2	20	30.4	W to E	63.07688	-50.61793	63.12494	-50.02623
2	15	29	W to E	63.24844	-50.06896	63.29252	-49.49560
2	16	27.5	E to W	63.33681	-49.74549	63.37658	-49.21205
2	26	18.3	E to W	63.30864	-50.11099	63.33486	-49.77433
2	25	17.5	E to W	63.27494	-50.53018	63.30469	-50.16556
2	23	23.6	W to E	63.20914	-50.54853	63.24844	-50.06896
2	Refuel						
3	35	12.2	E to W	64.00403	-51.63586	64.02590	-51.38608
3	36	30.4	E to W	64.03031	-51.33422	64.08178	-50.72139
3	37	30.4	E to W	64.08169	-50.72136	64.13065	-50.10547
3	34	53.5	W to E	63.86552	-51.13731	63.95341	-50.05429
7	19	33.7	E to W	63.48039	-50.34929	63.52791	-49.74385
7	18	23.4	W to E	63.44080	-50.04350	63.46787	-49.69460
7	17	18.5	E to W	63.40008	-49.75208	63.42348	-49.44189
7	28	25.3	E to W	63.35648	-50.30883	63.39590	-49.81231
7	Refuel						
7	8	7.3	W to E	62.90880	-50.34238	62.92040	-50.19977
7	7	6.5	E to W	62.84090	-50.39388	62.85130	-50.26758
7	3	17.9	NW- SE	62.75170	-50.29288	62.60370	-49.91366
7	2	3.9	SE-NW	62.61102	-50.22238	62.59351	-50.15459
7	1	5.4	W to E	62.54300	-50.28098	62.52930	-50.18077
7	4	23	S to N	62.87790	-50.16237	62.73550	-49.79616
7	5	24.3	N to S	62.96890	-49.93846	62.82340	-49.56825
7	6	12.9	S to N	63.04620	-49.67585	62.97230	-49.48595
7	10	19	E to W	62.98100	-50.22590	63.00840	-49.87976
7	Refuel						

7	22	22.2	E to W	63.16714	-51.04935	63.20273	-50.61300
7	24	24	W to E	63.22904	-51.07766	63.26859	-50.61174
7	27	34.3	E to W	63.29099	-51.09605	63.34744	-50.42357
8	33	26.6	W to E	63.48565	-51.05378	63.52774	-50.55834
8	32	33.6	E to W	63.42337	-51.03750	63.48051	-50.34933
8	31	4	E to W	63.41413	-51.14693	63.42107	-51.06738
8	29	12.6	W to E	63.35752	-51.06097	63.37746	-50.82794
8	30	26.6	W to E	63.38129	-50.78225	63.43284	-50.14854
8	Refuel						
8	45	24.4	W to E	64.01724	-50.05966	64.05329	-49.58109
8	44	29.3	E to W	63.95434	-50.04783	63.99893	-49.45641
8	43	21	W to E	63.89299	-50.02153	63.92431	-49.61255
8	42	8.4	E to W	63.77851	-49.95775	63.78997	-49.80906
8	41	15.6	E to W	63.75544	-50.25370	63.77504	-50.00432
8	40	12	E to W	63.73182	-50.55262	63.75119	-50.31393
8	Refuel						
8	46	23.4	W to E	64.07612	-50.11749	64.11153	-49.65223
8	47	7	E to W	64.17536	-49.64788	64.18574	-49.50627
8	48	16.6	E to W	64.14123	-50.10021	64.16631	-49.77011
9	60	32.5	W to E	64.58360	-50.13438	64.63259	-49.47255
9	59	29.2	E to W	64.52197	-50.10894	64.56663	-49.50674
9	58	24.7	W to E	64.46690	-49.98042	64.50281	-49.49387
9	57	23.2	E to W	64.41545	-49.83618	64.44883	-49.37894
9	52	21.7	E to W	64.37175	-50.40597	64.40473	-49.97882
9	Refuel						
9	51	30.3	E to W	64.30615	-50.43106	64.35279	-49.82616
9	50	41.2	W to E	64.23558	-50.51847	64.29961	-49.68527
9	56	5.9	W to E	64.36219	-49.69792	64.36943	-49.60084
9	55	2.7	W to E	64.38664	-49.36103	64.39065	-49.30631
9	54	15.3	E to W	64.30815	-49.56883	64.32971	-49.26902
9	49	23.1	E to W	64.20505	-50.09690	64.23918	-49.64352
12	62	15.7	W to E	64.25241	-50.86119	64.27819	-50.54216
12	39	19.4	E to W	63.68287	-51.14182	63.70368	-50.89607
12	38	13.6	E to W	63.65173	-51.49753	63.67924	-51.18259

Appendix 6
Raw data from March 2012 aerial caribou survey by helicopter: South region, West Greenland

Table 9. *Ameralik caribou population raw data from transect line survey, March 2012.All lines included, also those with zero caribou observed.*

Date	Line No.	Side	Total Caribou	Calf	Distance to animal (m)	Approx. Elevation (m)	Latitude Dec.degree	Longitude Dec.degree
1 Mar	61		0	0				
3 Mar	35		0	0				
3 Mar	36		0	0				
3 Mar	37	right	9	2	150	300	64.1034	-50.4715
3 Mar	37	right	3	0	150	300	64.1034	-50.4715
3 Mar	37	right	1	0	150	462	64.1063	-50.4247
3 Mar	37	0	3	2	0	639	64.1321	-50.1395
3 Mar	37	left	3	1	30	496	64.1326	-50.1342
3 Mar	34	right	2	1	186	775	63.9424	-50.2239
3 Mar	34	right	2	1	100	680	63.9409	-50.2552
3 Mar	34	left	1	0	370	668	63.9406	-50.259
3 Mar	34	left	2	1	381	640	63.9401	-50.2681
3 Mar	34	left	1	0	121	631	63.9399	-50.2706
3 Mar	34	left	2	1	181	631	63.9399	-50.2706
3 Mar	34	right	3	1	250	607	63.9385	-50.2904
3 Mar	34	left	1	0	289	643	63.9372	-50.3089
3 Mar	34	left	2	1	87	794	63.9357	-50.3228
3 Mar	34	left	1	0	500	870	63.9352	-50.3264
3 Mar	34	left	4	2	200	930	63.9351	-50.33
3 Mar	34	right	6	1	300	998	63.9349	-50.3344
3 Mar	34	right	2	1	300	813	63.9185	-50.5573
3 Mar	34	right	2	1	250	605	63.8747	-50.9633
8 Mar	45	left	3	1	300	310	64.0152	-50.0534
8 Mar	45	right	1	0	50	307	64.0176	-50.0415
8 Mar	45	right	2	0	350	471	64.0194	-50.0319
8 Mar	45	right	3	0	150	438	64.0302	-49.8728
8 Mar	45	right	4	0	150	438	64.0302	-49.8728
8 Mar	45	left	2	0	300	438	64.0302	-49.8728
8 Mar	45	0	5	0	0	288	64.0318	-49.8588
8 Mar	45	left	8	2	20	288	64.0318	-49.8588
8 Mar	45	left	2	0	50	288	64.0318	-49.8588
8 Mar	45	right	5	0	300	180	64.0322	-49.8542
8 Mar	45	right	13	0	0	180	64.0322	-49.8542
8 Mar	45	left	3	0	50	180	64.0322	-49.8542
8 Mar	45	right	7	0	0	147	64.0355	-49.8185
8 Mar	45	0	1	0	0	147	64.0373	-49.797
8 Mar	45	left	3	1	200	147	64.0373	-49.797

8 Mar	45	left	1	0	200	150	64.0378	-49.7925
8 Mar	45	right	3	0	600	159	64.0384	-49.7875
8 Mar	45	left	2	1	200	159	64.0384	-49.7875
8 Mar	45	left	4	1	250	159	64.0384	-49.7875
8 Mar	45	right	3	1	100	224	64.0403	-49.7716
8 Mar	44	left	2	0	350	581	63.9841	-49.6481
8 Mar	44	left	2	1	50	518	63.9837	-49.6547
8 Mar	44	right	3	0	800	387	63.981	-49.696
8 Mar	44	left	2	1	150	349	63.9808	-49.6967
8 Mar	44	right	4	1	200	254	63.9798	-49.7188
8 Mar	44	right	2	1	50	615	63.9718	-49.8155
8 Mar	44	right	3	0	800	638	63.9669	-49.8786
8 Mar	44	left	2		200	722	63.9655	-49.8947
8 Mar	44	right	2	1	50	708	63.9632	-49.9157
8 Mar	44	right	3	1	850	876	63.9599	-49.9665
8 Mar	43	right	2	1	75	1091	63.8977	-49.9633
8 Mar	43	left	1	1	150	1048	63.9002	-49.9262
8 Mar	43	left	1	0	1000	1047	63.9024	-49.9064
8 Mar	43	right	5	2	200	933	63.9145	-49.7518
8 Mar	42	left	2	1	120	1312	63.7797	-49.9595
8 Mar	42	left	1	0	200	1312	63.7797	-49.9595
8 Mar	41	right	3	0	400	940	63.7737	-50.0131
8 Mar	41	0	3	1	0	912	63.7688	-50.0687
8 Mar	41	right	1	0	300	912	63.7688	-50.0687
8 Mar	41	right	1	0	50	1164	63.7587	-50.2129
8 Mar	41	left	1	0	50	1073	63.7577	-50.2248
8 Mar	41	left	2	0	800	981	63.7567	-50.2361
8 Mar	41	right	1	0	50	857	63.7559	-50.2449
8 Mar	41	left	2	1	250	857	63.7559	-50.2449
8 Mar	41	left	1	0	700	857	63.7559	-50.2449
8 Mar	40	0	2	1	0	954	63.7396	-50.4475
8 Mar	40	right	2	1	20	873	63.7381	-50.4655
8 Mar	40	left	1	0	300	873	63.7381	-50.4655
8 Mar	46	right	2	1	50	274	64.0858	-49.9871
8 Mar	46	right	3	1	300	299	64.0863	-49.9816
8 Mar	46	left	2	1	50	760	64.1049	-49.7615
8 Mar	46	right	3	0	75	767	64.1111	-49.6642
8 Mar	47	right	4	0	50	699	64.1778	-49.6141
8 Mar	48	left	6	1	300	813	64.1642	-49.7944
8 Mar	48	left	3	0	300	650	64.1593	-49.8613
8 Mar	48	left	2	1	100	535	64.1575	-49.889
8 Mar	48	left	2	0	300	531	64.1564	-49.9029
8 Mar	48	right	4	1	300	551	64.1557	-49.9134
8 Mar	48	right	2	1	25	645	64.1516	-49.974
8 Mar	48	left	4	0	0	468	64.1434	-50.0725

9 Mar	60	left	2	1	30	776	64.587	-50.0891
9 Mar	60	right	1	0	50	740	64.5873	-50.0828
9 Mar	60	left	1	0	250	684	64.5883	-50.0669
9 Mar	60	left	5	2	500	684	64.5883	-50.0669
9 Mar	60	right	5	2	100	626	64.5957	-49.9723
9 Mar	60	right	4	1	300	626	64.5957	-49.9723
9 Mar	60	right	1	0	0	626	64.5957	-49.9723
9 Mar	60	left	1	0	100	626	64.5957	-49.9723
9 Mar	60	left	5	0	500	569	64.5962	-49.9615
9 Mar	60	left	2	1	200	569	64.5962	-49.9615
9 Mar	60	left	9	0	500	530	64.5972	-49.9529
9 Mar	60	left	1	0	350	530	64.5972	-49.9529
9 Mar	60	0	5	2	0	507	64.5983	-49.9453
9 Mar	60	0	6	2	0	508	64.5987	-49.9419
9 Mar	60	right	1	0	300	513	64.5989	-49.9404
9 Mar	60	left	1	0	600	579	64.5999	-49.9402
9 Mar	60	0	2	1	0	684	64.6007	-49.92
9 Mar	60	left	2	1	20	684	64.6007	-49.92
9 Mar	60	right	1	0	0	603	64.6014	-49.9043
9 Mar	60	right	11	3	100	603	64.6014	-49.9043
9 Mar	60	right	1	0	50	603	64.6014	-49.9043
9 Mar	60	left	4	1	50	568	64.6016	-49.8992
9 Mar	60	left	3	1	500	539	64.6019	-49.8954
9 Mar	60	right	1	1	50	469	64.6034	-49.8733
9 Mar	60	right	1	0	200	462	64.6042	-49.8635
9 Mar	60	left	2	1	150	334	64.6063	-49.821
9 Mar	60	left	2	0	250	334	64.6063	-49.821
9 Mar	60	0	4	2	0	317	64.6073	-49.8091
9 Mar	60	0	2	0	0	317	64.6073	-49.8091
9 Mar	60	left	2	0	150	317	64.6073	-49.8091
9 Mar	60	right	3	0	300	336	64.6082	-49.8019
9 Mar	60	right	5	0	100	353	64.6085	-49.7999
9 Mar	60	left	2	0	20	353	64.6085	-49.7999
9 Mar	60	right	2	1	300	423	64.6091	-49.7952
9 Mar	60	left	6	0	0	423	64.6091	-49.7952
9 Mar	59	left	1	0	100	829	64.565	-49.5373
9 Mar	59	left	2	1	100	840	64.5642	-49.5486
9 Mar	59	left	2	1	500	818	64.5597	-49.6102
9 Mar	59	right	3	0	0	770	64.558	-49.6272
9 Mar	59	right	1	0	300	718	64.5561	-49.6444
9 Mar	59	right	2	1	200	718	64.5561	-49.6444
9 Mar	59	right	1	0	100	718	64.5561	-49.6444
9 Mar	59	left	3	1	300	713	64.5558	-49.6498
9 Mar	59	left	6	0	150	1228	64.541	-49.8669
9 Mar	59	left	2	1	100	1228	64.541	-49.8669

9 Mar	59	left	8	0	300	1228	64.541	-49.8669
9 Mar	59	0	2	1	0	1074	64.5396	-49.8733
9 Mar	59	left	2	1	300	1049	64.5392	-49.8884
9 Mar	59	left	1	0	20	1029	64.5357	-49.9376
9 Mar	59	right	2	0	0	970	64.5335	-49.9542
9 Mar	59	right	3	1	0	978	64.53	-49.9958
9 Mar	59	right	1	0	0	978	64.53	-49.9958
9 Mar	59	left	2	1	150	915	64.5286	-50.0092
9 Mar	59	right	4	0	800	903	64.528	-50.0185
9 Mar	58	left	2	1	100	264	64.467	-49.9695
9 Mar	58	left	2	1	200	264	64.467	-49.9695
9 Mar	58	right	5	2	200	327	64.4688	-49.9654
9 Mar	58	left	4	2	0	716	64.4731	-49.8931
9 Mar	58	right	2	0	100	631	64.4742	-49.8741
9 Mar	58	right	1	0	100	631	64.4742	-49.8741
9 Mar	58	left	1	0	30	646	64.4786	-49.8185
9 Mar	58	left	2	1	20	736	64.4814	-49.7876
9 Mar	58	right	3	1	50	846	64.4871	-49.7035
9 Mar	58	right	2	1	100	832	64.4884	-49.6894
9 Mar	58	left	7	2	300	722	64.4901	-49.6672
9 Mar	58	right	2	0	300	738	64.4904	-49.6614
9 Mar	58	0	3	1	0	688	64.4908	-49.6557
9 Mar	58	left	2	1	200	572	64.4927	-49.6334
9 Mar	58	0	2	1	0	558	64.4982	-49.5563
9 Mar	58	left	1	0	500	638	64.5001	-49.5315
9 Mar	58	left	2	0	200	720	64.503	-49.4934
9 Mar	57	left	1	0	200	959	64.4387	-49.5133
9 Mar	57	left	4	1	0	959	64.4387	-49.5133
9 Mar	57	right	3	0	200	933	64.4379	-49.5222
9 Mar	57	right	2	0	20	886	64.4365	-49.5383
9 Mar	57	right	1	0	0	758	64.4341	-49.5813
9 Mar	57	left	1	0	500	707	64.4308	-49.6254
9 Mar	57	left	4	1	250	708	64.4304	-49.6333
9 Mar	57	left	2	1	300	778	64.4295	-49.6522
9 Mar	57	left	3	0	300	778	64.4295	-49.6522
9 Mar	57	left	2	0	200	698	64.4273	-49.6834
9 Mar	57	left	3	0	0	698	64.4273	-49.6834
9 Mar	52	left	12	0	550	144	64.4033	-49.9764
9 Mar	52	left	1	1	300	419	64.3752	-50.3458
9 Mar	51	0	4	2	0	318	64.3498	-49.8488
9 Mar	51	right	7	1	250	318	64.3498	-49.8488
9 Mar	51	right	5	0	300	354	64.3501	-49.8611
9 Mar	51	right	4	1	300	354	64.3501	-49.8611
9 Mar	51	left	1	1	50	421	64.3497	-49.8676
9 Mar	51	left	3	1	250	964	64.3425	-49.9572

9 Mar	51	left	4	2	100	925	64.3408	-49.982
9 Mar	51	right	12	1	150	219	64.3233	-50.2028
9 Mar	51	0	6	2	0	538	64.3121	-50.3607
9 Mar	50	left	8	0	500	701	64.2714	-50.0372
9 Mar	50	left	2	1	250	701	64.2714	-50.0372
9 Mar	50	right	2	1	200	723	64.2724	-50.0261
9 Mar	50	left	4	2	100	723	64.2724	-50.0261
9 Mar	50	right	3	0	0	920	64.2808	-49.9469
9 Mar	50	right	2	1	200	823	64.2824	-49.9209
9 Mar	50	right	8	2	550	790	64.2827	-49.9139
9 Mar	50	right	8	2	100	728	64.2865	-49.8557
9 Mar	50	right	4	2	100	724	64.2904	-49.8016
9 Mar	56		0	0				
9 Mar	55	0	2	1	0	929	64.3887	-49.3297
9 Mar	55	left	2	1	500	959	64.3889	-49.324
9 Mar	54	right	1	0	20	802	64.3152	-49.4669
9 Mar	54	0	2	1	0	761	64.3125	-49.4987
9 Mar	54	right	3	1	100	770	64.3124	-49.5002
9 Mar	54	right	2	1	300	834	64.3123	-49.5088
9 Mar	54	right	2	0	10	861	64.3114	-49.527
9 Mar	54	right	1	0	150	859	64.3101	-49.5426
9 Mar	54	right	1	0	250	853	64.31	-49.5477
9 Mar	49	left	2	1	350	709	64.2344	-49.7187
9 Mar	49	left	6	2	0	593	64.2275	-49.7962
9 Mar	49	right	11	0	0	553	64.2269	-49.805
9 Mar	49	left	3	0	400	553	64.2269	-49.805
9 Mar	49	left	4	1	250	553	64.2269	-49.805
9 Mar	49	left	3	1	800	553	64.2269	-49.805
9 Mar	49	left	5	0	500	553	64.2269	-49.805
9 Mar	49	left	6	0	600	300	64.2235	-49.8485
9 Mar	49	left	2	1	150	361	64.2223	-49.8663
9 Mar	49	left	7	0	500	349	64.2216	-49.8723
9 Mar	49	left	2	1	150	339	64.2206	-49.8837
9 Mar	49	left	2	1	150	231	64.2179	-49.9176
9 Mar	49	left	7	2	50	245	64.2166	-49.9344
9 Mar	49	right	9	2	20	250	64.215	-49.9532
9 Mar	49	left	1	0	250	268	64.2146	-49.9594
9 Mar	49	right	3	1	230	185	64.2125	-49.9884
9 Mar	49	left	5	2	20	167	64.2118	-49.9955
9 Mar	49	right	5	1	150	222	64.2105	-50.0154
9 Mar	49	right	2	0	250	230	64.2103	-50.0197
9 Mar	49	right	2	1	300	230	64.2103	-50.0197
9 Mar	49	right	3	0	250	230	64.2103	-50.0197
9 Mar	49	right	14	0	0	236	64.2097	-50.0392
9 Mar	49	right	2	1	100	199	64.2095	-50.0422

9 Mar	49	right	2	0	250	110	64.2085	-50.0525
9 Mar	49	left	3	0	250	110	64.2085	-50.0525
9 Mar	49	right	2	1	0	89	64.2068	-50.0618
9 Mar	49	left	8	2	200	89	64.2068	-50.0618
9 Mar	49	left	2	1	10	91	64.2065	-50.072
12 Mar	62	right	3	1	50	723	64.2605	-50.7644
12 Mar	62	left	11	2	650	536	64.2781	-50.582
12 Mar	38	right	1	0	30	198	63.67716	-51.3682
12 Mar	38	right	2	0	100	198	63.67716	-51.3682
12 Mar	38	left	3	1	500	139	63.67592	-51.4169
12 Mar	39		0	0				
			All	**Calf**		**Elevation (m)**		
	Ameralik TOTALS		**701**	**148**		599	Average elevation	
	Calf percentage %		21.1			280	S.D.	
	Sub-total Right		322			626	Median elevation	
	Sub-total Left		325			1312	Maximum elevation	
	Sub-total 0-line		54			89	Minimum elevation	

Table 10. *Qeqertarsuatsiaat caribou population raw data from transect line survey, March 2012. All lines included, also those with zero caribou observed.*

Date	Line No.	Side	Total Caribou	Calf	Distance to animal (m)	Approx. Elevation (m)	Latitude Dec.degree	Longitude Dec.degree
2 Mar	9		0	0				
2 Mar	11		0	0				
2 Mar	12	right	6	0	50	381	63.0942	-49.7483
2 Mar	12	left	2	1	200	478	63.0999	-49.6902
2 Mar	12	left	1	0	0	549	63.0999	-49.6757
2 Mar	12	left	1	0	50	840	63.0947	-49.6083
2 Mar	13	left	3	0	352	657	63.1523	-49.6602
2 Mar	13	right	4	1	100	816	63.162	-49.5991
2 Mar	13	left	2	0	200	835	63.1621	-49.5968
2 Mar	13	right	7	2	200	868	63.1643	-49.5618
2 Mar	14	right	1	0	300	848	63.2218	-49.5636
2 Mar	14	right	1	0	200	733	63.2177	-49.6456
2 Mar	14	left	2	0	0	524	63.2145	-49.6884
2 Mar	14	left	3	1	600	524	63.2145	-49.6884
2 Mar	14	right	4	1	250	495	63.2123	-49.7138
2 Mar	14	left	1	0	300	483	63.2072	-49.7677
2 Mar	21	right	3	0	129	676	63.2013	-49.8436
2 Mar	21	left	3	1	20	675	63.2015	-49.8506
2 Mar	21	left	4	1	333	676	63.2016	-49.8602
2 Mar	21	left	1	0	333	676	63.2016	-49.8602

2 Mar	21	right	2	1	20	688	63.2019	-49.8715
2 Mar	21	left	1	0	0	730	63.2012	-49.8829
2 Mar	21	right	2	0	200	763	63.2002	-49.8926
2 Mar	21	left	1	1	298	797	63.1931	-49.9536
2 Mar	21	right	3	1	210	700	63.1896	-49.9724
2 Mar	21	left	3	2	50	700	63.1896	-49.9724
2 Mar	21	left	2	0	0	682	63.1874	-49.9883
2 Mar	21	right	3	0	200	709	63.187	-49.994
2 Mar	21	0	2	0	0	719	63.1696	-50.1676
2 Mar	21	right	3	0	255	697	63.1568	-50.2858
2 Mar	21	left	2	1	100	587	63.1553	-50.3461
2 Mar	21	left	1	0	300	512	63.1552	-50.3533
2 Mar	21	left	2	1	0	246	63.1543	-50.3828
2 Mar	21	left	1	0	10	23	63.154	-50.4078
2 Mar	21	right	7	0	0	134	63.1538	-50.4282
2 Mar	21	right	1	0	150	264	63.1539	-50.4466
2 Mar	21	left	4	0	0	264	63.1539	-50.4466
2 Mar	20	0	4	1	0	388	63.0936	-50.4322
2 Mar	20	right	2	1	150	468	63.0969	-50.3972
2 Mar	20	right	5	0	600	567	63.1001	-50.364
2 Mar	20	right	2	1	50	560	63.1042	-50.3133
2 Mar	15	right	1	1	50	653	63.2417	-50.0551
2 Mar	15	left	2	0	200	741	63.2444	-50.0338
2 Mar	15	right	6	2	20	366	63.2843	-49.6906
2 Mar	15	right	2	0	200	446	63.2896	-49.6432
2 Mar	15	0	3	1	0	824	63.2927	-49.5492
2 Mar	16	right	3	0	350	943	63.3627	-49.4519
2 Mar	16	right	2	0	150	893	63.3589	-49.5155
2 Mar	16	right	1	0	150	893	63.3589	-49.5155
2 Mar	16	right	1	0	20	636	63.3436	-49.718
2 Mar	16	left	2	0	500	589	63.3426	-49.7282
2 Mar	16	right	4	1	320	509	63.3405	-49.7471
2 Mar	26	left	3	0	30	595	63.3365	-49.7913
2 Mar	26	left	4	0	30	595	63.3365	-49.7913
2 Mar	26	0	1	0	0	602	63.3361	-49.8008
2 Mar	26	right	2	1	180	581	63.3358	-49.8052
2 Mar	26	right	4	0	200	557	63.3356	-49.8088
2 Mar	26	right	4	0	100	540	63.3348	-49.818
2 Mar	26	right	2	1	150	555	63.3343	-49.8218
2 Mar	26	left	2	0	500	575	63.3318	-49.8478
2 Mar	25		0	0				
2 Mar	23	left	2	0	279	515	63.2063	-50.5037
2 Mar	23	left	2	0	0	487	63.2073	-50.4953
2 Mar	23	left	3	0	400	367	63.2092	-50.4557

2 Mar	23	right	3	2	50	625	63.2108	-50.4366
2 Mar	23	left	1	0	232	677	63.212	-50.422
2 Mar	23	left	2	1	100	-9	63.2343	-50.2425
7 Mar	19	left	1	0	250	612	63.5097	-49.9509
7 Mar	19	left	1	0	0	572	63.5095	-49.9546
7 Mar	19	left	3	0	450	549	63.5094	-49.9573
7 Mar	19	right	2	1	400	525	63.5092	-49.9672
7 Mar	19	right	2	0	400	531	63.5091	-49.9705
7 Mar	17	left	2	1	800	854	63.4164	-49.56
7 Mar	17	left	1	0	50	826	63.4026	-49.7148
7 Mar	17	right	3	1	400	790	63.4022	-49.7211
7 Mar	17	left	2	1	500	523	63.3996	-49.7523
7 Mar	9	0	10	0	50	234	62.9794	-50.2722
7 Mar	1	right	4	2	731	20	62.5319	-50.2006
7 Mar	1	right	3	0	731	20	62.5319	-50.2006
7 Mar	1	right	4	2	731	20	62.5319	-50.2006
7 Mar	2		0	0				
7 Mar	3		0	0				
7 Mar	4	left	4	0	500	507	62.7672	-49.872
7 Mar	5	right	3	0	500	707	62.916	-49.8016
7 Mar	5	left	4	0	600	783	62.9028	-49.7691
7 Mar	6	right	4	0	0	1080	63.0277	-49.625
7 Mar	6	right	2	0	500	966	63.0336	-49.642
7 Mar	6	0	2	0	0	755	63.0453	-49.6768
7 Mar	7		0	0				
7 Mar	8		0	0				
7 Mar	10	right	4	0	400	891	63.0091	-49.9034
7 Mar	10	left	2	1	80	1252	62.9999	-49.9964
7 Mar	22	left	2	1	50	182	63.2022	-50.6334
7 Mar	24	left	8	0	200	139	63.2424	-50.942
7 Mar	24	left	3	0	250	139	63.2424	-50.942
7 Mar	24	left	4	0	711	139	63.2424	-50.942
7 Mar	24	left	3	1	700	222	63.2534	-50.789
7 Mar	27	right	4	1	100	339	63.334	-50.5867
7 Mar	27	right	1	0	250	465	63.3278	-50.6697
7 Mar	27	right	4	1	150	254	63.3156	-50.8104
7 Mar	27	right	1	0	50	240	63.3153	-50.8135
7 Mar	27	right	1	0	0	240	63.3153	-50.8135
7 Mar	27	left	3	1	200	254	63.3156	-50.8104
7 Mar	27	left	5	3	300	227	63.314	-50.8264
8 Mar	33		0	0				
8 Mar	32	left	2	1	500	523	63.4339	-50.9368
8 Mar	32	left	1	0	80	450	63.4246	-51.0211
8 Mar	31	right	1	0	0	214	63.4203	-51.0759

8 Mar	31	left	3	1	150	180	63.4194	-51.0866
8 Mar	31	left	5	2	100	176	63.4188	-51.0936
8 Mar	31	left	4	0	0	176	63.4188	-51.0936
8 Mar	31	left	1	0	100	227	63.418	-51.1036
8 Mar	31	left	3	0	300	227	63.418	-51.1036
8 Mar	31	right	2	1	0	302	63.4175	-51.1103
8 Mar	29	left	1	0	200	78	63.3574	-51.0618
8 Mar	29	left	10	1	220	60	63.3585	-51.051
8 Mar	29	left	3	0	800	86	63.3604	-51.0287
8 Mar	29	left	1	0	200	67	63.3667	-50.955
8 Mar	29	right	2	0	300	58	63.3696	-50.9086
8 Mar	29	right	4	2	200	58	63.3696	-50.9086
8 Mar	29	0	2	1	0	75	63.3704	-50.9002
8 Mar	29	right	2	0	50	75	63.3704	-50.9002
8 Mar	29	left	4	2	50	75	63.3704	-50.9002
8 Mar	29	right	5	2	300	88	63.3713	-50.8909
8 Mar	29	left	1	0	1000	221	63.3734	-50.8748
8 Mar	30	left	2	0	250	104	63.3843	-50.7674
8 Mar	30	left	4	1	300	215	63.3853	-50.7588
8 Mar	30	right	2	0	0	384	63.3857	-50.7474
8 Mar	30	right	2	1	300	454	63.3862	-50.7342
8 Mar	30	right	11	0	600	466	63.3896	-50.6864
8 Mar	30	right	9	0	300	466	63.3896	-50.6864
8 Mar	30	right	7	0	200	423	63.391	-50.675
8 Mar	30	right	6	2	200	442	63.3917	-50.6667
8 Mar	30	right	11	3	150	477	63.3932	-50.6476
8 Mar	30	right	6	0	125	477	63.3932	-50.6476
8 Mar	30	right	4	1	350	448	63.3943	-50.6373
8 Mar	30	0	3	1	0	458	63.3953	-50.6306
8 Mar	30	right	2	1	75	458	63.3953	-50.6306
8 Mar	30	right	3	0	200	476	63.3958	-50.6253
8 Mar	30	right	3	1	50	436	63.4126	-50.4091
8 Mar	30	right	5	2	50	584	63.4163	-50.3611

	All	Calf		Elevation (m)	
TOTALS	**403**	**71**		479	Average elevation
Calf percentage %		17.6		264	S.D.
Sub-total Right	220	40		507	Median elevation
Sub-total Left	156	27		1252	Maximum elevation
Sub-total 0-line	27	4		0	Minimum elevation

Appendix 7

Raw data 12 March 2012 demographics & antlers, Ameralik caribou population, South region, West Greenland

Table 11. *Ameralik caribou survey raw data for demographics and antler possession among females, 12 March 2012.*

Group Size	Male juvenile	Male adult	Female with antlers	Female with no antlers	Calf	Location
7	2	1	2		2	Nunatarsuaq
2			1		1	Nunatarsuaq
3			2		1	Nunatarsuaq
4			2		2	Nunatarsuaq
4			2	1	1	Nunatarsuaq
1	1					Nunatarsuaq
4			1	2	1	Nunatarsuaq
8			3	2	3	Nunatarsuaq
2			1		1	Nunatarsuaq
2			1		1	Nunatarsuaq
7	1		2	1	3	Nunatarsuaq
3		1	1		1	Nunatarsuaq
4		1	1	1	1	Nunatarsuaq
14	2	1	7		4	Nunatarsuaq
2	1		1			Nunatarsuaq
4			1	1	2	Nunatarsuaq
5	2		1	1	1	Nunatarsuaq
3			2		1	Nunatarsuaq
4			3		1	Nunatarsuaq
2			1		1	Nunatarsuaq
2			1		1	Nunatarsuaq
4			2		2	Nunatarsuaq
3			1		2	Nunatarsuaq
4		1	1	1	1	Nunatarsuaq
2			1		1	Nunatarsuaq
1			1			Nunatarsuaq
3			1		2	Nunatarsuaq
4			2		2	Nunatarsuaq
2			1		1	Nunatarsuaq
4			2	1	1	Nunatarsuaq
3			1	1	1	Nunatarsuaq
2			1		1	Nunatarsuaq
3			2		1	Nunatarsuaq
3			2		1	Nunatarsuaq
3			1	2		Nunatarsuaq

3			2		1	Nunatarsuaq
3	1		1		1	Nunatarsuaq
3	2				1	Nunatarsuaq
2			1	1		Nunatarsuaq
2			2			Nunatarsuaq
2			1		1	Nunatarsuaq
2			1		1	Nunatarsuaq
2			1		1	Nunatarsuaq
1		1				Nunatarsuaq
2			1		1	Nunatarsuaq
6	1		3		2	Nunatarsuaq
6		1	2		3	Nunatarsuaq
1	1					Nunatarsuaq
2				1	1	Nunatarsuaq
3	1		1	1		Nunatarsuaq
4	1		2		1	Nunatarsuaq
5	1			3	1	Nunatarsuaq
1		1				Nunatarsuaq
2				1	1	Nunatarsuaq
2	1	1				Nunatarsuaq
2			1		1	Nunatarsuaq
3			2		1	Nunatarsuaq
2			1		1	Nunatarsuaq
6	1		4	1		Nunatarsuaq
1		1				Nunatarsuaq
4		4				Nunatarsuaq
1		1				Nunatarsuaq
2		2				Nunatarsuaq
4	4					Nunatarsuaq
2		1		1		Nunatarsuaq
3	1		1		1	Nunatarsuaq
3				1	2	Nunatarsuaq
1		1				Nunatarsuaq
1		1				Nunatarsuaq
2		2				Nunatarsuaq
3		3				Nunatarsuaq
1		1				Nunatarsuaq
1			1			Isfjord
1	1					Austmannadalen N side
2			1		1	Austmannadalen N side
15	1		11		3	Austmannadalen N side
4			2		2	Austmannadalen N side
7	1		3		3	Austmannadalen N side
2			1		1	Austmannadalen N side

3	1		1		1	Austmannadalen N side
1			1			Austmannadalen N side
3	3					Austmannadalen N side
9	2		5		2	Austmannadalen N side
2			1		1	Austmannadalen N side
1	1					Austmannadalen N side
5	1	2	1		1	Austmannadalen N side
10	2	1	5		2	Austmannadalen N side
2	1	1				Austmannadalen N side
10	2		5		3	Austmannadalen N side
7	1		5		1	Austmannadalen N side
7			5		2	Austmannadalen N side
2			1		1	Austmannadalen N side
10	3		5		2	Austmannadalen N side
3		1	2			Austmannadalen N side
3	1		1		1	Austmannadalen N side
4			4			Austmannadalen N side
4			2		2	Austmannadalen N side
6			3		3	Austmannadalen N side
2			1		1	Austmannadalen N side
3			1	1	1	Austmannadalen N side
11	3	2	6			Austmannadalen N side
1		1				Austmannadalen N side
6	1		3		2	Austmannadalen N side
3	2	1				Austmannadalen N side
11	1	2	6		2	Austmannadalen N side
6	2		2		2	Austmannadalen N side
2					2	Austmannadalen N side
6	2		3		1	Austmannadalen S side
6	2		3		1	Ameragdla-Nuajat kua
1		1				Ameragdla-Nuajat kua
6	1	2	3		1	Ameragdla-Nuajat kua
4	1		2		1	Ameragdla-Nuajat kua
3		3				Ameragdla-Nuajat kua
3			1		2	Ameragdla-Nuajat kua
11			6		5	Ameragdla-Nuajat kua
1		1				Ameragdla-Nuajat kua
1		1				Ameragdla-Nuajat kua
6	1		2		2	Ameragdla-Nuajat kua
6	1	4	1			Ameragdla-Nuajat kua
2				1	1	Ameragdla-Nuajat kua
2			1		1	Buksefjord Hydro Plant
1		1				Buksefjord Hydro Plant
24	2	4	12		6	Sermilik mouth N side

9	1	1	4		3	Sermilik mouth N side
2	1	1				Sermilik mouth N side
6	1	1	2		2	Sermilik mouth N side
12	1	4	3		4	Sermilik mouth N side
4				1	3	Sermilik mouth N side
8	3	5				Grædefjord N side
2		1	1			Grædefjord N side
2				1	1	Grædefjord N side
5	1		2		2	Grædefjord N side
4	1		2		1	Grædefjord N side
3			1		2	Grædefjord N side
2			1	1		Grædefjord N side
5			1	2	2	Grædefjord N side
5	1			3	1	Grædefjord N side
1				1		Grædefjord N side
7			1	1	5	Grædefjord N side
6		1	3		2	Grædefjord N side
4			2	1	1	Grædefjord N side
2			1		1	Grædefjord N side
3	1		1		1	Grædefjord N side
11		9	2			Grædefjord S side
5			1	1	3	Grædefjord S side
6	1		3		2	Grædefjord S side
4		4				Grædefjord S side
1		1				Grædefjord S side
9	3		5		1	Grædefjord S side
7	1		3		3	Grædefjord S side
14	1	4	5		4	Grædefjord S side
2	1		1			Grædefjord mouth islands
3	1		1		1	Grædefjord mouth islands
8	4		2		2	Grædefjord mouth islands
3	3					Grædefjord mouth islands
5			2	1	2	Grædefjord mouth islands
6				3	3	Grædefjord mouth islands
1	1					Grædefjord mouth islands
3			1		2	Grædefjord mouth islands
7			3		4	Sermilik mouth S side
12	4	1	4	1	2	Sermilik mouth S side
6			3		3	Sermilik mouth S side
9	3	4		1	1	Sermilik mouth S side
2			1		1	Sermilik mouth S side
Group size	**Male juvenile**	**Male adult**	**Female antlers**	**Female no antlers**	**Calf**	
164	**98**	**91**	**263**	**44**	**195**	**TOTAL**

Appendix 8

Recommendations for improving future surveys

Aerial survey methods & design

Methods for the line transect detection function and the model selection for the line-distance sampling must be clearly described for future surveys. Although for this analysis of the 2012 data the model named "*Half-normal key*" was used followed by cosine adjustment to fit the model better, this was insufficient documentation of the results. Therefore, the 2012 estimates may receive an update following a quality-check completed before the end of 2016.

We also recommend using a double observer platform, at least for the left-side of the helicopter, since this would permit estimating observer bias. Further, an alternate adjustment might be used for adjusting the fit of the model used, e.g., one based on lumping into one bin all observations beyond 500m (or 1000m) of the 0-line. Considering the uncertainty of distance estimates beyond 300-400 m, this seems a reasonable improvement.

In 2006 and again in 2012, the winter hunting season ended just prior to the survey. Not surprisingly, hunting appears to change caribou distribution. Thus a helicopter reconnaissance determining caribou distribution is necessary before any survey begins and especially if hunting just finished. Although an added expense it is a justifiable one, since the forthcoming population estimate requires a correct stratification of high and low caribou density areas for allocation of survey effort.

The increased survey coverage in 2012 promotes accuracy of abundance estimates, and should be continued for future surveys of the South region to provide trend in abundance. The boundary between the two populations should remain as shown in figure 1 for this 2012 survey. Stratification of the systematic transect lines was necessary, because Ameralik and Qeqertarsuatsiaat populations have both shown clumped distribution in the past, and group sizes can be large relative to other populations.

The flight altitude should be reduced to 30-35 m. The flight altitude of 40m while observers scanned the landscape out to 500m from the 0-line was mentally exhausting for the observers. This was because the amount of terrain to be scanned was too great for the speed flown, given the high degree of

background camouflage the terrain provides caribou. This exhaustion increased with line length and was especially present when line length exceeded 10km. Future surveys might consider using an altitude of 30-35m to ensure that caribou are not 'missed'. Not detecting caribou that are present contributes to inaccurate abundance estimates. Even the distance sampling method will underestimate population abundance if animals are regularly missed in all bins, i.e., at 0-line, 100, 200, 300, 400 and 500m.

The time period for aerial surveys could remain March. Past surveys have chosen March because caribou movements are least that month, while day length permits 7 hours flying per day, and there is the possibility of best snow cover. Full snow cover makes detection of caribou present on lines easier. In contrast, patchy snow cover or "salt & pepper" backgrounds makes detection difficult. The former can occur due to early spring melt and the latter when ground or vegetation show through a light snow covering. Experience from seven surveys since 2000 has clearly illustrated that snow cover can vary widely regardless of the winter time period chosen. Thus low caribou movement, which avoids double counting, and enough day length are the primary reasons for choosing March.

Improving demographics

The minimum calf percentages in table 2 are much lower than observed during the specific examination of Ameralik demographics on 12 March. The latter resulted in 28.2% calves (Table 4). The explanation is that when flying transect lines the distances to caribou groups often made identification of calves impossible, i.e., calves were not classified as calves and so calf percentages shown in Table 2 are underestimates. This illustrates clearly the importance of flying specifically for demographics separate from flying the systematic transect lines if a true reflection of demographics is to be obtained.

Logistics

Other options for helicopters should be investigated if ever possible. The smallest helicopters, AS350, currently available from Air Charter (Air Greenland) are larger than necessary for caribou surveys, and of poor window design for observing caribou. Side windows are small with several bar/struts, which limit vision. Bigger windows without bars and struts would improve viewing. Further, under cold ambient temperatures the side windows of the AS350 always fog with ice-frost, which makes seeing anything difficult, including caribou.

Air Charter requires their pilots to radio check-in with air controllers every 30 minutes. This can necessitate 'wasting' helicopter time first to gain an altitude ≥1500 meters and then remaining there long enough for communication to occur. This problem will occur, even when a satellite telephone is available to presumably assure contact. It does not. The solution is to establish GPS positions throughout the study area prior to flying (Fig 12). The pilot contacts Air Control to say he will be operating within a 20 km radius of the given GPS position for the next 2 to 2½ hours, and check-in will be at the end of that period, or when moving to operate around a new GPS position. This reduces the number of radio check-ins with Air Control.

Tips & hints

The cost to keep an airport open is a minimum 4500 Danish kroner for the first hour, and extra hours cost more. Refueling the helicopter must be finished 15 minutes before an airport closes, therefore must arrive for refueling 45 minutes before closing.

Weekly limit is a maximum 50 flying hours per pilot per week. Daily limit is a maximum 7 flying hours per pilot per day. Initiating a flight is not permitted if expected flight time will exceed these limits.

Cuyler *et al.* (2007) contains further details regarding booking and use of Air Charter helicopters, their limitations, airport closings, satellite telephones in cockpit, etc.

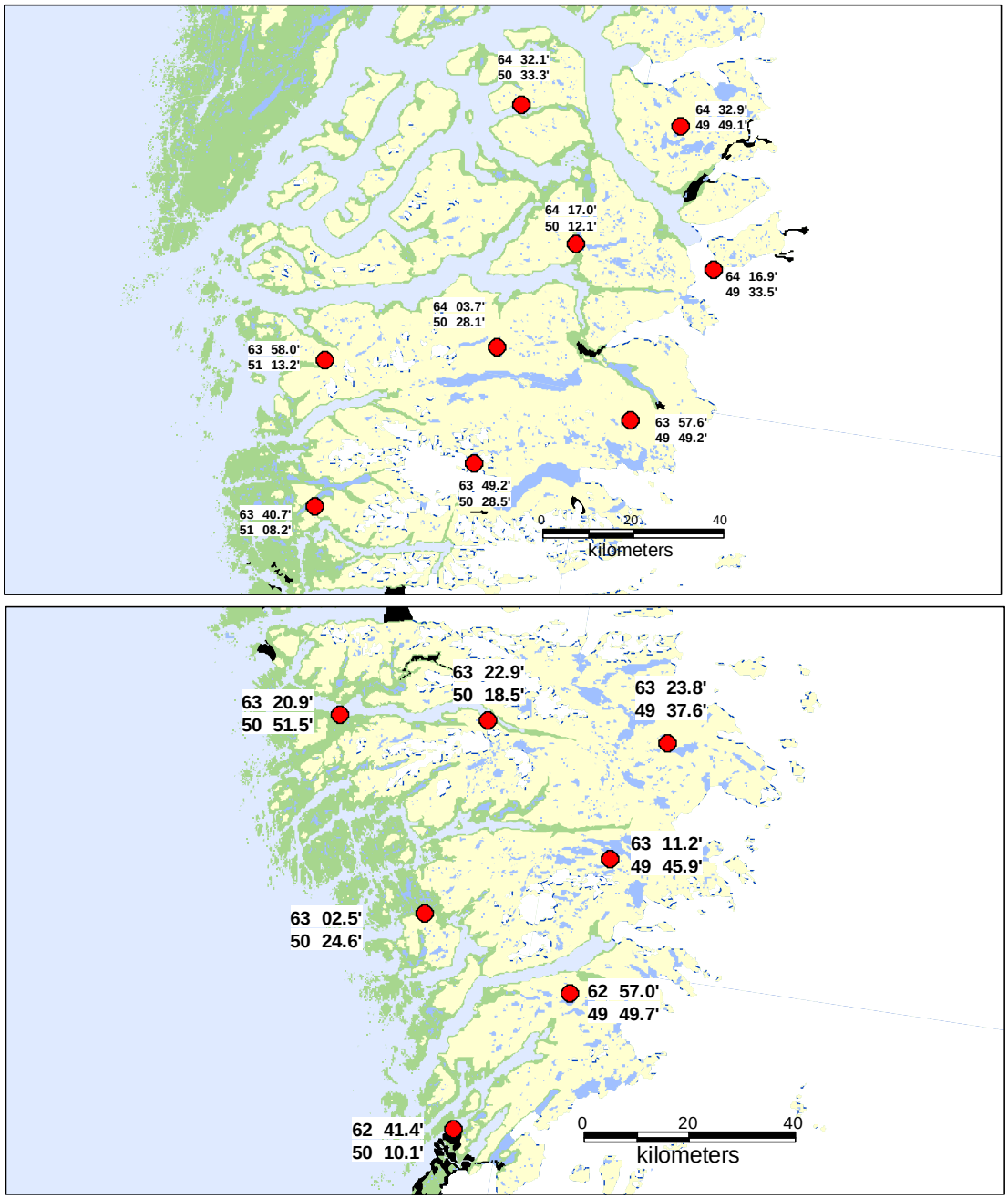

Figure 17. *Examples of the GPS positions provided to Air Charter pilots for the Ameralik (above) and Qeqertarsuatsiaat (below) areas. Each represents the mid-point of a circle with a 20 km working radius.*

Appendix 9

2016 Regulations for caribou hunting and subsequent sale of meat

Current harvest regulation of Ameralik & Qeqertarsuatsiaat

There are three possible hunting permit types, professional, recreational and trophy. This appendix deals only with regulations concerning the first two. Professional and recreational permits may also be referred to in other publications as commercial and sport.

For professional permits 50% of their annual taxed income must be derived from catch sales, which are often a combination of game and fish. For both professional and recreational permits, rifle calibers down to .222 are permissible for caribou. Current regulations included a 2015 autumn season with open harvest. The season was 10 weeks, beginning 1 August and ending 15 October, for recreational and professional permits. The 2016 winter season was for professional permits only. A quota of 100 caribou was given for each population, Ameralik and Qeqertarsuatsiaat, for a total of 200 animals from the South region. The 2016 winter season was three weeks, between 18 February and 10 March. It was illegal to use skidoos, ATV's or other motorized vehicles to follow/chase caribou including for the purpose of hunting them.

It is mandatory that all permit types pick up a caribou 'hunter report' from the municipal offices prior to going caribou hunting. Recreational hunters were allowed five caribou per 'hunter report', and could obtain a new report each time the previous was completed and delivered into the municipal offices. This also applied to professional hunters, with one major difference. Professionals were allowed 20 caribou per 'hunter report'. These reports provide information about the caribou killed, e.g., location, sex, age-class and rump fat depth. (Recent analyses have illustrated that where caribou are concerned the last two are unreliable /erroneous. These are recommended deleted from future reports). It has been illegal to bring a caribou carcass aboard your boat before a 'hunter report' for it had been completed. However, control by conservation officers is lacking. Thus, whether professional or recreational, few hunters pickup the mandatory 'hunter reports' from the municipal offices in the first place, and it appears that few complete them and hand them in. Harvest reporting by 'hunter report' is incomplete and does not reflect the total number harvested.

Further, the numbers of caribou removed from a population cannot be obtained from the government's nation-wide *Piniarneq* reporting. *Piniarneq* is based solely on where a hunter lives. Since in any given hunting season hunters may harvest caribou from several populations, the *Piniarneq* database is totally inadequate at providing the number of animals removed from a specific population. It is impossible to allocate which caribou were shot from each population.

Sale of caribou meat

It is a widespread belief among the general public that only professional hunters may legally sell their catch, i.e., meat, fish and birds. The truth is otherwise. It is legal for recreational hunters to sell their catch, including caribou, and even at the local market, albeit only if the local municipal bylaws allow (*Selvstyrets bekendtgørelse nr. 7 af 27 juni 2013 beskyttelse og fangst af vilde rensdyr, §7 Stk. 2: De enkelte kommuner træffer beslutninger vedr. indhandling og salg på "brættet" for fritidsfangere*).

As regards the sale of caribou meat, there is little difference between recreational and professional permits. The same rules apply to both, i.e., *Hjemmestyrets bekendtgørelse nr. 21 af 27 juli 1998 om levnedsmiddelvirksomheder* (chapter 1, §1. Stk. 7). Both may sell their catch directly to the final consumer. There are two main caveats. It is illegal to store meat for later sale or to advertise. Advertising includes all forms for public solicitation, e.g., by newspaper, radio, TV, notice boards, e-mail lists, social media, etc. The 'final consumer' is defined as the person cooking and eating the caribou. Examples of those not a part of this definition would typically include, hotel kitchens, restaurants, hospitals, and grocery stores or chains. These must require that the hunter, professional or recreational, has a certificate for food handling and hygiene before they may buy the game or fish.

In 2013 the Veterinary and Food Safety Board in Greenland (*Veterinær- og Fødevaremyndigheden i Grønland (VFMG)*) began holding courses in food handling and hygiene for the 'primary producers' (hunters) with veterinarians teaching. The course was open for all and called *Certifikatkursus i hygiejne og egenkontrol for primærproducenter af fødevarer*. Since spring 2016 the course will be taught by the Food College Greenland (INUILI; Levnedsmiddel Akademiet Narsaq) in South Greenland. The course is now named: *Hygiejne for primærproducenter*. This course, and others, may be found at the following website: http://www.inuili.gl/da/Kurser/Kurser-2016

The current INUILI curriculum is identical to that offered by VFMG and includes much of *Hjemmestyrets bekendtgørelse nr. 21 af 27 juli 1998 om levnedsmiddelvirksomheder*, with specifically the contents of chapters 10 and 12 being taught. Similar to VFMG's certification, successful completion of the INUILI course permits a primary producer to sell game (e.g. red meat and birds) and fish to hotel kitchens, restaurants and 24-hour care facilities.

VFMG currently teaches another course for primary producers called *Anti mortem fanger kursus*. Designed specifically for hunters of caribou and muskoxen, this course involves an evaluation of individual animals before their being chosen for harvest. The purpose is to meet European Union (EU) standards, which will permit carcass delivery to slaughter facilities that are authorized for meat export to the EU. To date, four persons in Kangerlussuaq (Søndre Strømfjord) and three in Qaqortoq have taken the course and received certificates.

There is an exception to the 'rule' of final consumer. Those hotel kitchens, restaurants and 24-hour care facilities having registered chefs/cooks already authorized in food handling and hygiene may buy directly from professional and recreational hunters without requiring the hunter to possess a certificate in food handling and hygiene.

Appendix 10

Past and recent Greenland caribou population estimates & minimum counts

Table 12. *Population estimates and minimum counts of wild caribou in Greenland, given in order from north to south latitudes*[1].

Caribou Population	Region No.	Region Name	1977 / 78	1993	1994	1995	1996	1999	2000	2001	2002	2005	2006	2010	2012[4]
Inglefield Land	10	-	-	-	-	100	-	2,260	-	-	-	-	-	-	
Olrik Fjord	9	.	-	-	-	-	-	-	-	38*	-	-	-	-	
Nuussuaq Halvø	8	-	170	-	-	400	-	-	-	400	1.164*	-	-	-	
Naternaq	1	Naternaq	100	80	-	271	-	-	-	-	-	-	-	-	
Kangerlussuaq-Sisimiut	2	North	17,900	3,788	7,727	6,196	10,869	-	51,600[3]	-	-	90,464[3]	-	98,300	
Akia-Maniitsoq	3	Central	5,300	3,506	3,080	6,408	6,806	-	-	46,236	-	35,807		24,000	
Ameralik	4	South	-	1,341	1,458	4,553	4,458+	-	-	31,880	-	-	9,680	-	11,700
Qeqertarsuatsiaat	5	South	-					-	-	5,372	-	-	5,224	-	4,800
Qassit	6	Paamiut	-	-	-	-	-	-	196*	-	-	-	-	-	
Neria	7	Paamiut	-	-	181	407	-	-	1,600 (332*)	-	-	-	-	-	
		Total Greenland Approximate Estimate	-	**9,000**	**13,000**	**18,000**	**22,000**	-	-	**140,000[2]**	-	-	**141,000[2a]**	-	**139,000[2b]**

[1]Estimates between 2000 and 2010 were obtained using survey methods and design unlike those employed from 1993 to 1999. Therefore conclusions about trends in population size are inappropriate, because the population size differences between these two time periods are not assumed readily comparable. Similarly the 2012 survey of the South region used new survey methods as compared to the 2000-2010 period.

[2] Rough sum of population estimates obtained in 1999, 2000 and 2001.

[2a] Rough sum of population estimates obtained in 2005 and 2006.

[2b] Rough sum of population estimates obtained in 2010 and 2012.

[3] Kangerlussuaq-Sisimiut estimates from 2000 and 2005 were obtained using somewhat dissimilar methods, i.e. the 2005 survey reduced flight altitude by 85 m, speed by ca. 45 km/hr, and strip width by 400 m. The two estimates are therefore not assumed readily comparable and should not be interpreted as indicating population trend for this population for the time period 2000-2005.

[4] The 2012 estimates may receive an update following a quality-check in autumn 2016.

* Minimum counts.

Sources: Ydemann & Pedersen 1999, Linnell *et al.* 2000, Landa et al. 2000, Cuyler *et al.* 2002, 2003, 2004, 2005, 2007, 2011 and current study.

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PART II
Photographic record
South region helicopter survey photos 1-12 March 2012

All photographs presented in the five appendices of Part II were taken by Christine Cuyler, and from the left front side of helicopter, which maintained an altitude of ca. 40 m. Distances (m) to caribou, if given, are approximate and estimated from 0-line.

Compass headings given: North (N), South (S), East (E) and West (W).
Appendices 11, 12, 13 and 14 – all photographs were resized to 200KB.
Appendix 15, all photographs presented are unaltered and original size, >6MB.
See Figures 4 to 7 for transect line locations.

All photographs and more are available at full size (>6MB) on the Greenland Institute of Natural Resources server:
F:/40-59/PaFu/42/Landpattedyr/24 Aerial Survey/2012 South/Photo DATA_South Survey 2012

***Figure 18**. Group of 24 Ameralik caribou on the sea ice among islands at the mouth Sermilik Fjord on the north side, view S, 12 March 2012.*

Appendix 11
Ameralik transect line snow conditions & topography

Ameralik South Region: HIGH-density stratum, transects (not all) in order flown

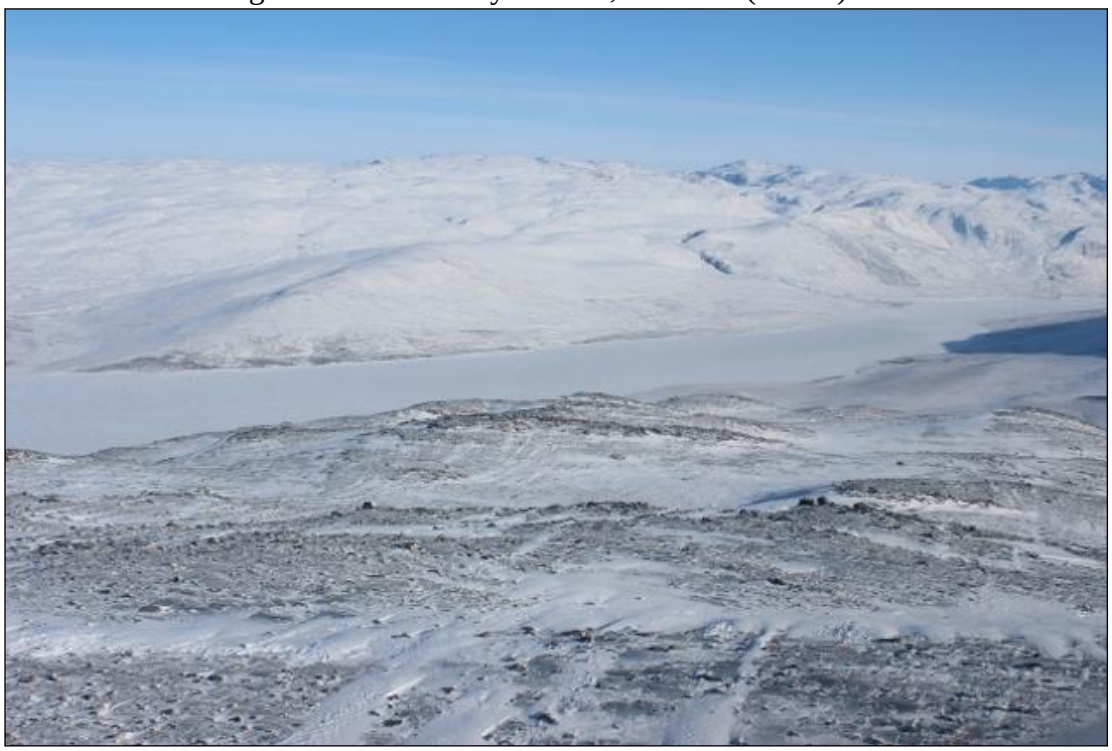

***Figure 19**. Line 45 flying A to B, ca. 35 caribou (not visible) were foraging near lakeshore, view E, 8 March 2012.*

***Figure 20**. Line 45 flying A to B, three (3) caribou centre photo, view NE, 8 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 21**. Line 44 flying B to A, view SW, 8 March 2012.*

***Figure 22**. Line 44 flying B to A, windswept rocky terrain, two (2) caribou ½-way right of centre photo, view SW, 8 March 2012.*

***Figure 23**. Line 43 flying A to B, sunny south-facing rocky slopes where caribou have been foraging extensively, view N, 8 March 2012.*

***Figure 24**. Line 43 flying A to B, sunny south-facing rocky slopes where caribou have been foraging extensively, view NE, 8 March 2012.Backgrounds like these reduce caribou sightability, specifically when the caribou are stationary.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 25**. Line 46 flying A to B, snow cover is minimal, view to NE, 8 March 2012.*

***Figure 26**. Line 46 flying A to B, snow cover is minimal, view to NE, 8 March 2012.*

***Figure 27**. Line 47, near start B-point, flying B to A, landscape windswept, view S, 8 March 2012.*

***Figure 28**. Line 47, flying B to A, four (4) caribou on steep rocky slope just below centre in dark shadow, view NW, 8 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 29**. Line 48, just north of the glacial tongue, three (3) caribou low right of centre, flying B to A, view S, 8 March 2012.*

***Figure 30**. Line 48, at end A-point, shrubs along the river, flying B to A, view S, 8 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 31**. Line 60, first valley used by many caribou, flying A to B, view E, 9 March 2012.*

***Figure 32**. Line 60, second valley also used by many caribou, flying A to B, view E, 9March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 33**. Line 59, one caribou left of centre and tracks, 40 m altitude can be too high when terrain slopes sharply away from the 0-line, flying B to A, view S, 9 March 2012.*

***Figure 34**. Line 59 flying B to A, view SW, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 35**. Line 58, rugged topography of the 0-line ahead, flying A to B, view NE, 9 March 2012.*

***Figure 36**. Line 58, Gyr falcon sited along this slope, flying A to B, view NE, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

Figure 37*. Line 57, top near start B-point windswept rocks, middle 1 caribou & feeding craters, bottom near end A-point, flying B to A, view W on 0-line, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 38**. Line 52, looking at start B-point from Isfjord, flying B to A, view W, 9 March 2012.*

***Figure 39**. Line 52, big valley midway with skidoo track (one of many), flying B to A, view SSW, 9 March 2012.*

***Figure 40**. Line 51, top rugged, descending into big valley, 14 caribou foraging in dark willows right of centre, flying B to A, views W on 0-line, 9 March 2012.*

***Figure 41**. Line 50, plenty of bare ground/rock showing, flying A to B, view NE, 9 March 2012.*

***Figure 42**. Line 50, rocks' colour resembles caribou pelage, flying A to B, view NE, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 43**. Line 56, the 0-line is beside the glacier tongue, flying A to B, view ESE, 9 March 2012.*

***Figure 44**. Line 56, poor snow cover and rocky terrain, flying A to B, view NE, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 45**. Line 55 flying A to B, view NE, 9 March 2012.*

***Figure 46**. Line 55, caribou tracks & foraging on this slope, mother with calf in upper right quadrant centre, flying A to B, view E on 0-line, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

Figure 47*. Line 54, near start B-point little snow many rocks, flying B to A, view SW, 9 March 2012.*

Figure 48*. Line 54 flying B to A, view SSW, 9 March 2012.*

Ameralik South Region: HI-density stratum, transects (not all) in order flown

***Figure 49**. Line 49, Austmannadalen valley's slopes drop away sharply from 0-line making sighting the many caribou among the willows difficult, flying B to A, view SW, 9 March 2012.*

***Figure 50**. Line 49 Austmannadalen's south-facing slopes and valley bottom were well foraged by caribou, six caribou just up from centre, flying B to A, view backwards SE, 9 March 2012.*

Ameralik South Region: LOW-density, transects (not all) in order flown

Figure 51. *Line 37 near B-point, views first N and then E on 0-line, 3 March 2012.Beyond beyond B-point the high density stratum began.*

Ameralik South Region: LOW-density, transects (not all) in order flown

Figure 52. *Line 34, view along 0-line looking E, 3 March 2012. Above the snow poor valley just E of B-point and south of east end of the Kangerdluarssungûp tasersuap lake; Below the uplands close to A-point.*

Ameralik South Region: LOW-density, transects (not all) in order flown

***Figure 53**. Line 42 flying B to A, rocky terrain has little snow cover, view W, 8 March 2012.*

***Figure 54**. Line 42 flying B to A, view SW, 8 March 2012.*

***Figure 55**. Line 41 flying B to A, on the windswept rocks three (3) caribou are standing, view W, 8 March 2012.*

***Figure 56**. Line 41 flying B to A, cow & calf standing up & right of centre, view SW, 8 March 2012.*

Ameralik South Region: LOW-density, transects (not all) in order flown

***Figure 57**. Line 40 flying B to A, view WSW, 8 March 2012.*

***Figure 58**. Line 40 flying B to A, view SW, 8 March 2012.*

Ameralik South Region: LOW-density, transects (not all) in order flown

***Figure 59**. Line 62, approaching start A-point on the jagged mountain peak on the right, flying A to B, view E, 12 March 2012.*

***Figure 60**. Line 62 flying A to B, view ENE, 12 March 2012.*

Ameralik South Region: LOW-density, transects (not all) in order flown

***Figure 61**. Line 39 flying B to A, view NW across the 0-line, 12 March 2012.*

***Figure 62**. Line 39 flying B to A, view W along 0-line, 12 March 2012.*

***Figure 63**. Line 38 flying B to A, windswept rocky highlands gave way to windswept coast, views W along 0-line, 12 March 2012.*

Appendix 12
Qeqertarsuatsiaat (QEQ) transect line snow conditions & topography
QEQ South Region: HIGH-density stratum, transects (not all) in order flown

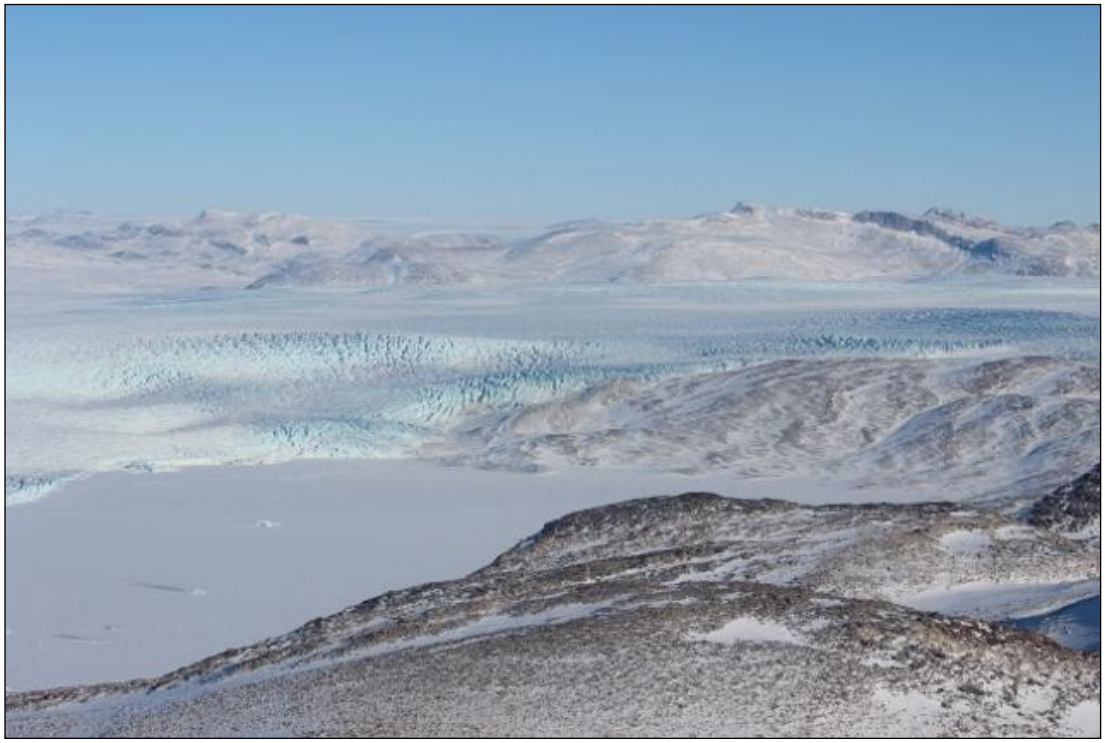

Figure 64. *Line 13, view N from the line as approach B-end point, 2 March 2012.*

Figure 65. *Line 13 near B-end, view NNE, 2 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

Figure 66. *Contrasting conditions between B-ends of lines 13 & 14, view NNW to line 14, which runs on the far side and almost parallel to the lake, 2 March 2012.*

Figure 67. *Line 16 flying B to A, view W, 2 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 68**. Line 16 flying B to A, view SW, 2 March 2012.*

***Figure 69**. Line 19 flying B to A, taken at start B-point, view W, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 70**. Line 19 flying B to A, view SW, 7 March 2012.*

***Figure 71**. Line 18 at start A-point, flying A to B, view E, 7 March 2012. High angled slopes as depicted here, confound estimating distances to the caribou, specifically for observer(s) on the down-slope side where the terrain rapidly falls away.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 72**. Line 18 flying A to B, view NE, 7 March 2012.*

***Figure 73**. Line 17 start B-point, flying B to A, view WSW, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 74**. Line 17 flying B to A, approaching A-point, view WSW, 7 March 2012.*

***Figure 75**. Line 28 just after start B-point, flying B to A, view W, 7 March 2012. Gorge in background was steep sided and deep. Maintaining the 40m altitude above ground requires skillful piloting of the helicopter, specifically when ambient wind direction and velocity can change abruptly.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 76**. Line 28 flying B to A, view NW down and out the gorge to fjord, 7 March 2012.*

***Figure 77**. Line 28 flying B to A, approaching A-point, view SW, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 78**. Line 7 flying B to A, rocky outcrops were typical, view WSW, 7 March 2012.*

***Figure 79**. Line 3 near start A-point, flying A to B, view SE, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 80**. Line 3, large and small boulders scattered everywhere were typical for much of this transect line, and reduced caribou sightability, flying A to B, view ESE, 7 March 2012.*

***Figure 81**. Line 2, start at B-point, flying B to A, view NW, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 82**. Line 2 at A-point end, view S across the 'flats', 7 March 2012.*

***Figure 83**. Line 1, just east of B-point end, view N across the 'flats' from the Frederikshåb Isblink, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 84**. Line 10, flying B to A, at start B-point, view SW, 7 March 2012. Terrain drops sharply away from the 0-line on left side of helicopter.*

***Figure 85**. Line 10 flying B to A, view SW, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 86**. Line 22, solar glare as flying B to A, close to start B-point, view SW, 7 March 2012.*

***Figure 87**. Line 22, solar glare as flying B to A, close to end A-point, view SW, 7 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

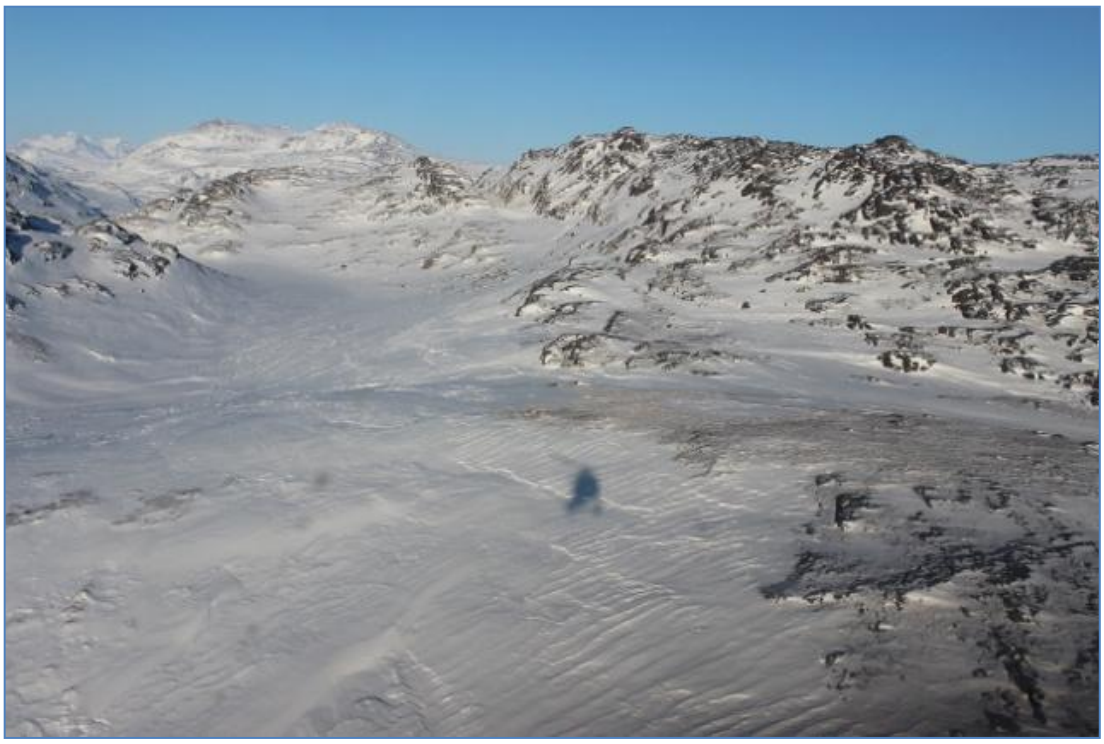

***Figure 88**. Line 24 flying A to B, close to the start A-point, view NE, 7 March 2012.*

***Figure 89**. Line 24, flying A to B, view ENE, 7 March 2012. There were many feeding craters ca. 14 caribou (not visible) foraging along these south-facing rocky ridges that have little snow cover.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 90**. Line 24 flying A to B, top view NE, bottom view SE, 7 March 2012. Large glacial erratics (boulders) above, and rugged terrain below, reduce caribou sightability.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

Figure 91*. Line 27 flying B to A, top view W, mid and bottom views SW, 7 March 2012. Sun-in-eyes required polarized sunglasses & plus dark shadows reduced caribou sightability.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

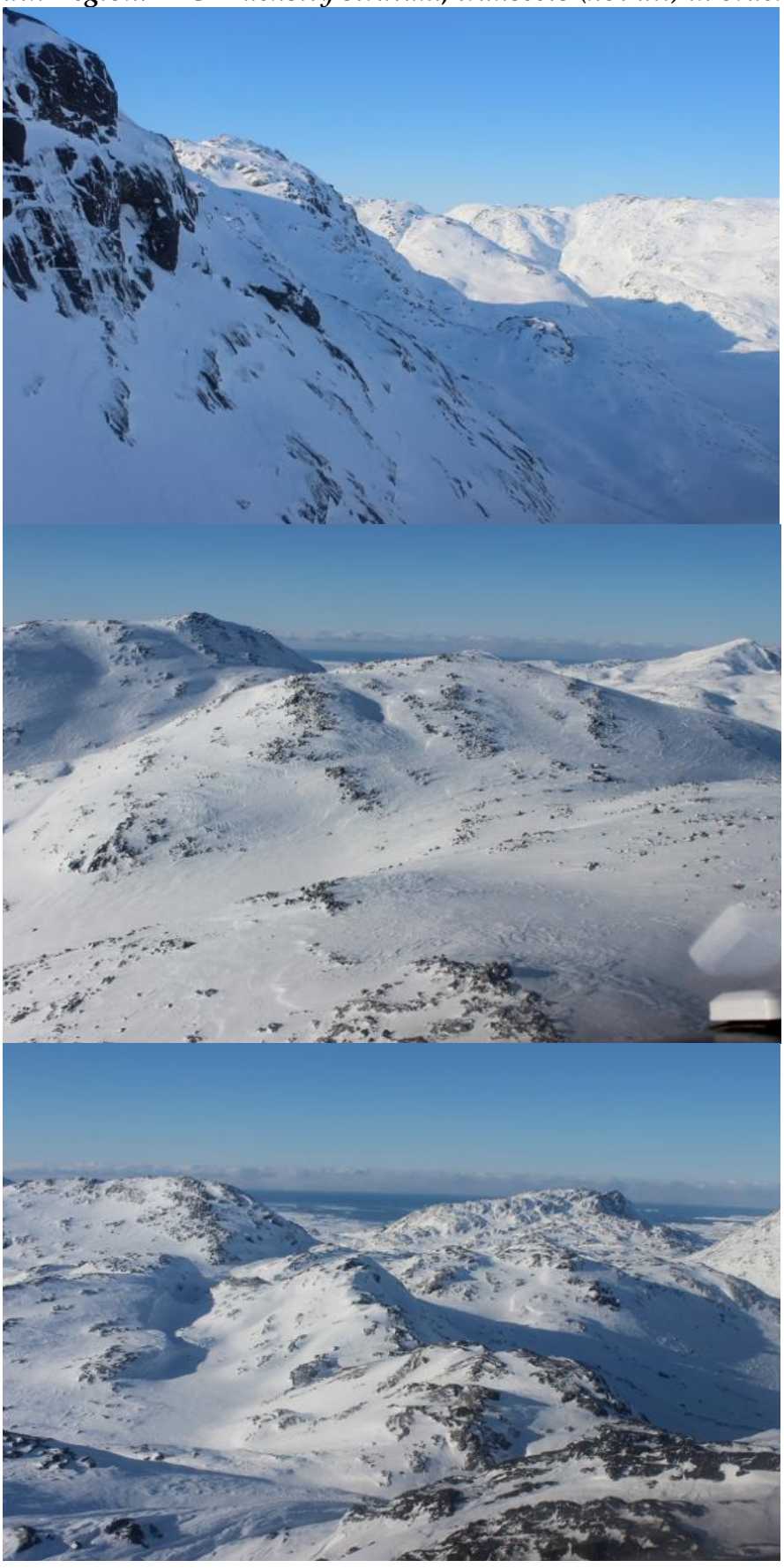

***Figure 92**. Line 32 flying B to A, views to SW, 8 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 93**. Line 31 flying B to A, view directly W on 0-line, 8 March 2012.*

***Figure 94**. Line 31 flying B to A, two (2) caribou on near ridge centre photo, view S, 8 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 95**. Line 29 just after start A-point, flying A to B, 9 caribou centre, view N, 8 March 2012.*

***Figure 96**. Line 29, flying A to B, view E, 8 March 2012.*

QEQ South Region: HIGH-density stratum, transects (not all) in order flown

***Figure 97**. Line 30, flying A to B, view E along 0-line, 8 March 2012.*

***Figure 98**. Line 30, flying A to B, view S from 0-line, 8 caribou and tracks, 8 March 2012.*

QEQ South region: LOW-density stratum, transects (not all) in order flown

***Figure 99**. Line 4 flying B to A, view WNW, 7 March 2012.*

***Figure 100**. Line 4 flying B to A, view WNW, 7 March 2012.*

QEQ South region: LOW-density stratum, transects (not all) in order flown.

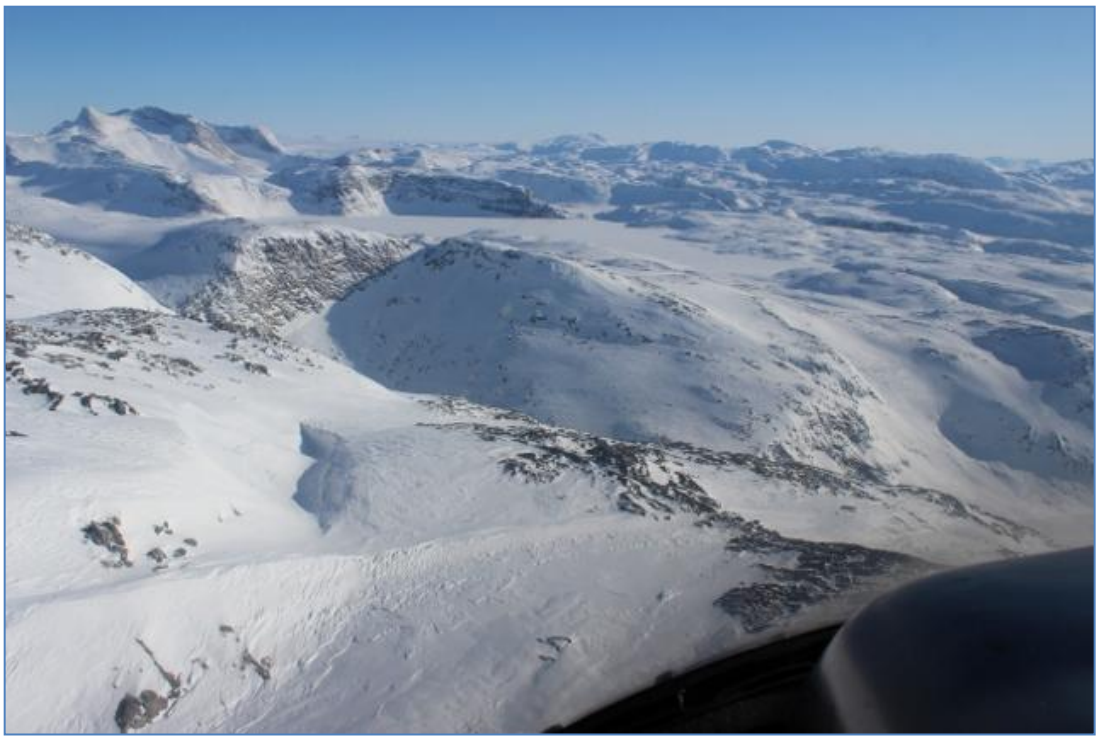

Figure 101. *Line 5 flying A to B, view SE, 7 March 2012.*

Figure 102. *Line 5, approaching end –point, flying A to B, view SE, 7 March 2012.*

QEQ South region: LOW-density stratum, transects (not all) in order flown

***Figure 103**. Line 6 flying B to A, view WNW, 7 March 2012.*

***Figure 104**. Line 6, flying B to A, nearing end A-point, 2 caribou feeding on steep slope (right of centre photo), view WNW, 7 March 2012.*

Appendix 13
Caribou feeding craters in snow, 1-12 March 2016.

Preferred foraging was on south-facing slopes or on flats and valley bottoms. Mountainside slope angle reflects actual, because camera was held horizontal.

Figure 105. *Caribou feeding craters in the snow on south-facing slopes in the Ameralik LOW-density stratum along eastern portion of line 37, 3 March.*

Caribou feeding craters: Ameralik LOW-density stratum

Figure 106. *Caribou feeding craters in the snow on south-facing slopes in the Ameralik LOW-density stratum along eastern portion of line 37, 3 March. In top photo, three caribou can be seen at the bottom centre.*

Caribou feeding craters: Ameralik LOW-density stratum

Figure 107. *Caribou feeding craters in the snow on south-facing slopes in the Ameralik LOW-density stratum along eastern portion of line 37, 3 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure xx. *Line 44, caribou feeding craters, Ameralik HIGH density stratum, 8 March.*

Figure 108. *Line 43, caribou feeding craters along rocky slope of lake shore, Ameralik HIGH density stratum, 8 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 109. *Line 42, caribou feeding craters over entire slope, four (4) caribou right of centre, Ameralik HIGH density stratum, 8 March.*

Figure 110. *Line 48, caribou feeding craters, Ameralik HIGH density stratum, 8 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 111. *Nunatarsuaq, line 60, caribou feeding craters over entire sunny slope, five (5) caribou centre, six (6) caribou upper left but still in sunlight, Ameralik HIGH density stratum, 9 March.*

Figure 112. *Nunatarsuaq, line 60, caribou feeding craters throughout rocky rough terrain, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 113. *Nunatarsuaq, line 60, mother with calf centre, feeding over entire rocky area, Ameralik HIGH density stratum, 9 March.*

Figure 114. *Nunatarsuaq, line 60, caribou feeding craters over most of valley bottom and south facing slopes, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 115. *Nunatarsuaq, line 60, caribou feeding craters over entire slope, two (2) caribou, one up left of centre, the other just above flat snow in lower right quadrant, Ameralik HIGH density stratum, 9 March.*

Figure 116. *Nunatarsuaq, line 60, foraging spots cover entire slope, four (4)caribou in a line, 2 at centre, then 1 left and 1 right of centre, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 117. *Nunatarsuaq, line 59, caribou feeding craters spread out over valley, four (4) caribou bottom right, Ameralik HIGH density stratum, 9 March.*

Figure 118. *Nunatarsuaq, line 58, caribou feeding craters spread out over valley, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 119. *Nunatarsuaq, line 58, caribou feeding craters spread across steep slope, Ameralik HIGH density stratum, 9 March.*

Figure 120. *Nunatarsuaq, line 58, caribou feeding craters spread across rocky slope, seven (7) caribou centre (4 cows + 3 calves), Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 121. *Nunatarsuaq, line 58 at eastern end, mother with calf, centre, have foraged over much of this slope, Ameralik HIGH density stratum, 9 March.*

Figure 122. *Nunatarsuaq, line 57, four (4) caribou, lower right of centre, have foraged valley bottom, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 123. *Line 51, caribou have foraged much of this steep slope, Ameralik HIGH density stratum, 9 March.*

Figure 124. *Line 51, caribou feeding craters and foraging around rocks, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 125. *Line 50, caribou have foraged much of this steep slope, Ameralik HIGH density stratum, 9 March.*

Figure 126. *Line 50, caribou in rocky slope right of centre, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

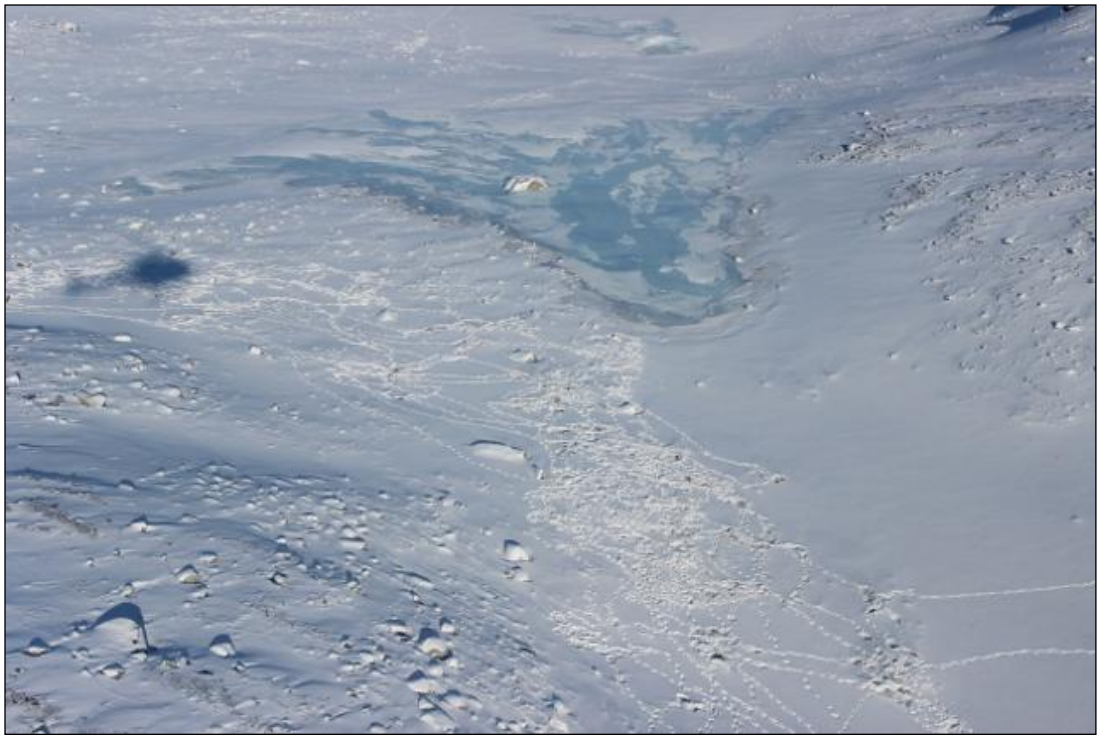

Figure 127. *Line 50, caribou have foraged much of this steep slope, Ameralik HIGH density stratum, 9 March.*

Figure 128. *Line 50, caribou have foraged much of this steep slope, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Ameralik HIGH-density stratum

Figure 129. *Line 50, caribou have foraged much of this rocky slope, Ameralik HIGH density stratum, 9 March.*

Figure 130. *Austmannadalen valley bottom and slopes, line 49, shrubs are abundant and the caribou forage extensively among them. Six (6) caribou appear centre photo, Ameralik HIGH density stratum, 9 March.*

Caribou feeding craters: Qeqertarsuatsiaat

Figure 131. *Line 4, caribou feeding craters on very steep slopes with six caribou left of helicopter shadow centre photo, QEQ Low density stratum, 7 March.*

Figure 132. *Line 30, caribou feeding craters, very steep slopes, QEQ High density stratum, 7 March.*

Appendix 14
Sun in one's eyes & fog/icing of helicopter windows 2012

Despite polarized sunglasses solar glare could reduce caribou sightability, as did window fog/icing.

Figure 133. *Solar glare looking into the Naujat Kuat south of line 37B-point, view S, 3 March.*

Figure 134. *Sun in one's eyes on line 2 below Grædefjord, view S, 7 March.*

Sun in one's eyes & window fog/icing reduce caribou sightability

Figure 135. *Despite our best efforts window fog was fast forming and could obscure vision and reduce caribou sightability. There are two caribou just left of centre in this foggy photo. One is visible, the other less so.*

Figure 136. *The combination of dark shadows and window icing could reduce caribou sightability. There are three caribou in the shadow centre photo. If not detected now, once behind the iced window they would not likely be seen.*

Sun in one's eyes & window fog/icing reduce caribou sightability

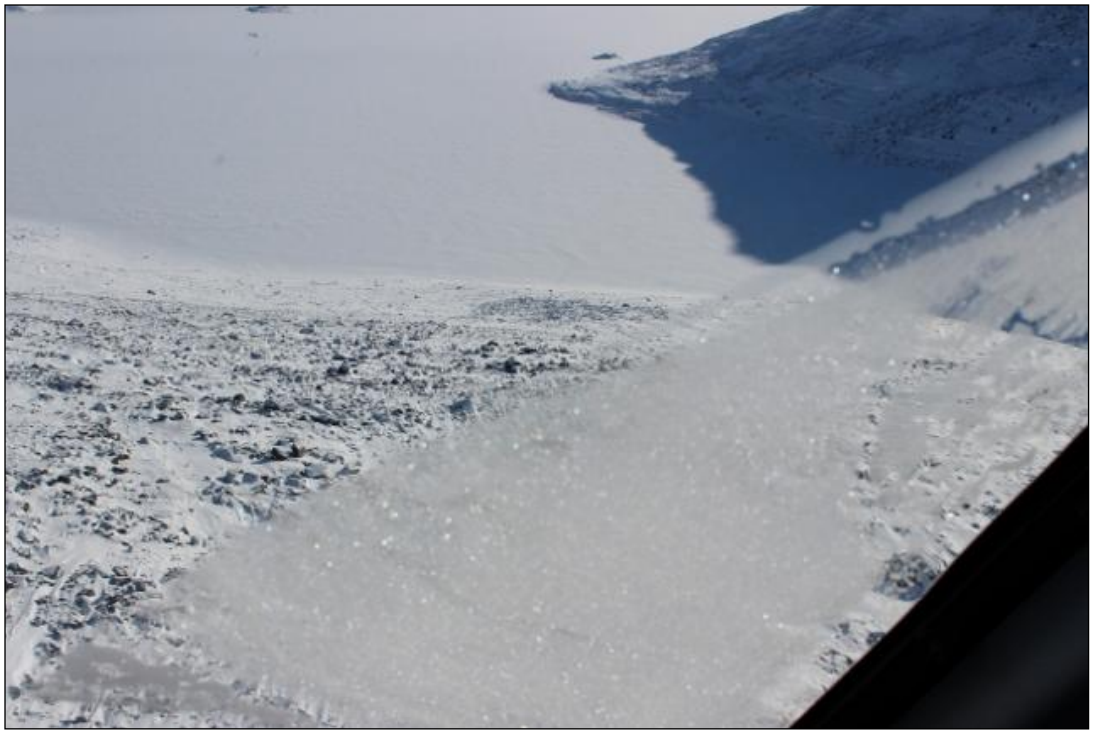

Figure 137. *A clear example of window icing obscuring observer viewing of the terrain.*

Figure 138. *Window icing with markings where recently removed. There are three caribou at little to the right of centre photo entering the last small snow patch under the top of the hill in the foreground, 8 March.*

Appendix 15
How difficult is it to spot caribou?

Small group size (median 3) combined with transect conditions and topography make caribou sightability typically poor. Further, not all flee the helicopter but remain stationary. All photographs are original size, ≥ 6MB.

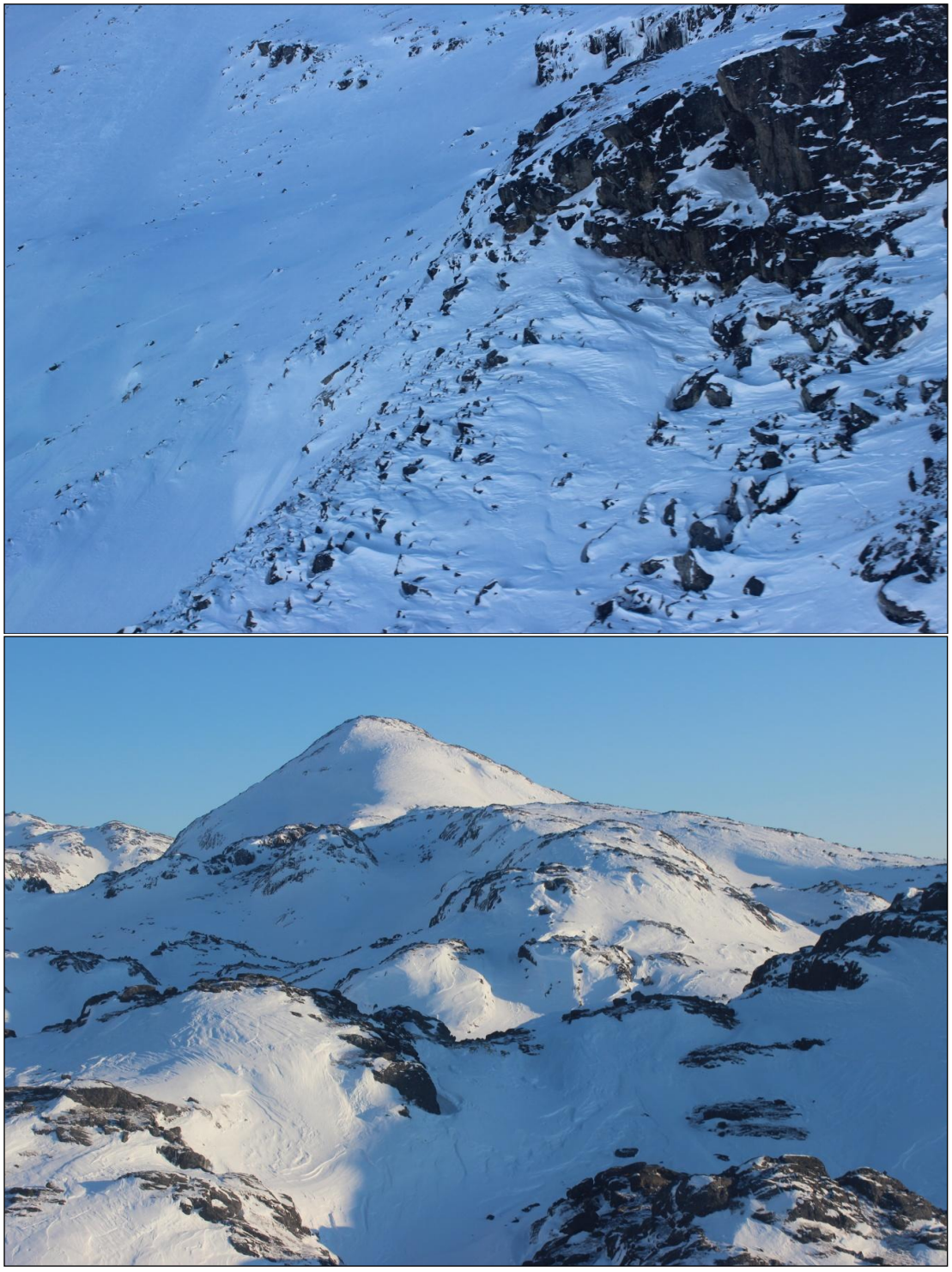

Figure 139. *Dark shadows can make caribou difficult to detect, above are two caribou in lower left on line 6, and below are six at centre photo on line 27, 7 March.*

How difficult to spot a caribou?

Figure 140. *Caribou are difficult to see in dark shadowed areas despite snow cover, above on line 47 are four caribou approaching top of ridge ahead, below on line 48 are two caribou centre photo, one standing, one lying, 8 March.*

How difficult to spot a caribou?

Figure 141. *At the edge between dark shadows and sunlight spotting caribou can be difficult. This was on line 46. Above are two caribou at centre photo, below are two caribou at left low centre just in front of the shadow, 8 March.*

How difficult to spot a caribou?

Figure 142. *Willows backgrounds on line 45 make group of 13 caribou and another pair invisible (upper centre and left upper centre respectively) although both were well within 500 m of the helicopter, 8 March.*

Figure 143. *The 'Salt & Pepper' background in the valley on line 45 renders 12 caribou (centre right) and another group of three (centre photo) invisible, although they are <1 km of the helicopter, 8 March.*

How difficult to spot a caribou?

Figure 144. *Even bright sunshine is of little help for spotting the three groups of caribou in this rocky terrain on line 24. There are eight just to the right and below centre. Three are below the 2nd rocky outcrop above and somewhat to the right. The final three are beyond that outcrop on the snow and to the right again. All groups were within 500 m of the helicopter and relatively stationary, 7 March.*

Figure 145. *Rocky terrain on line 30 hides two groups. Six caribou are at low centre, and another 11 are far right of centre, 8 March.*

How difficult to spot a caribou?

Figure 146. *The topography of the region is rough. Caribou present on the transect lines must be detected early before they disappear from sight. On line 27 a group of three caribou are vanishing over the rocky ridge at right of centre photo, 7 March.*

Figure 147. *Again on line 27, the rocky terrain hides one caribou among the rocks ca. ½ way right of centre, 7 March. It is standing still and looking over its shoulder at the helicopter.*

How difficult to spot a caribou?

Figure 148. *Single caribou that stand without moving are not easily detected, whether in mountainous terrain line 22 above, or on flats line 45 below, 7-8 March. Both these caribou are almost centre photo.*

How difficult to spot a caribou?

Figure 149. *Conditions like these promote observer fatigue and lack of concentration. There are two caribou in each photo, 8 March. Both images are from line 44. In photo above, they are just over centre. In the photo below, they are slightly left of centre.*

How difficult to spot a caribou?

Figure 150. *Conditions like these on line 60 make detecting caribou difficult. In the above photos, there are five (5) caribou a smidgen left of centre among rocks, below is a cow with calf. They are also a smidgen left of centre near the big boulder, 9 March.*

How difficult to spot a caribou?

Figure 151. *This rocky slope on line 60 has been well foraged. There are two (2) caribou, one just above centre and the other, which remained stationary as we flew past, is in lower right just above 'flat' relatively untouched snow, 9 March.*

Figure 152. *This is a well foraged rocky slope on line 60. There are four (4) caribou strung out in a line mid-photo, two are at centre, one is ahead to the right and one lags behind to left, 9 March.*

How difficult to spot a caribou?

Figure 153. *There are four (4) caribou centre photo among the rocks at the top of the slope they had been foraging, line 59, 9 March.*

Figure 154. *Seven (7) caribou are just below the top of the ridge ½-way right of centre, 9 March.*

How difficult to spot a caribou?

Figure 155. *Sun in one's eyes makes sighting the 11 caribou difficult, line 52, 9 March. The 11 caribou are in a line on the hill just a smidgen right of centre photo.*

Figure 156. *Sun in one's eyes makes it difficult to sight the 2 caribou, mother & calf, which had foraged this rocky slope and were up in the dark shadow under the flare, line 54, 9 March.*

How difficult to spot a caribou?

Figure 157. *Austmannadalen, even sparse willows hide the two (2) caribou well, a smidgen up and right of centre. These remained stationary as we flew past, line 49, 9 March.*

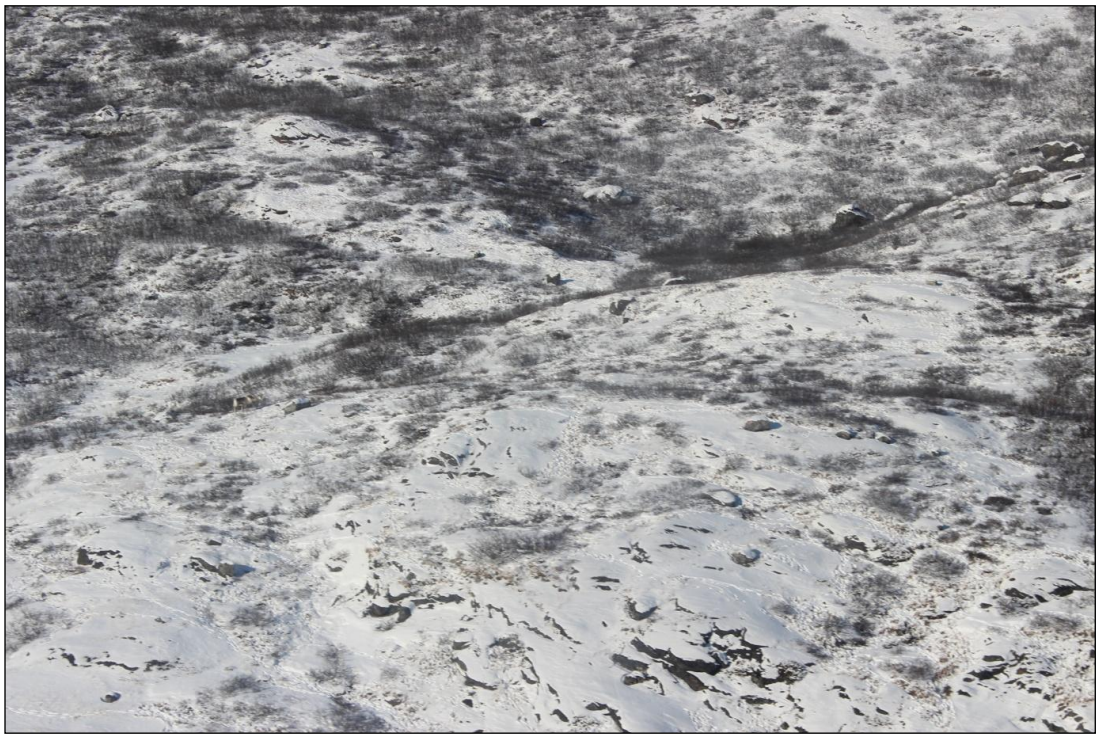

Figure 158. *Austmannadalen willows hide the two (2) caribou well, a cow with calf ½-way to left of centre. These remained stationary as we flew past, line 49, 9 March.*

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