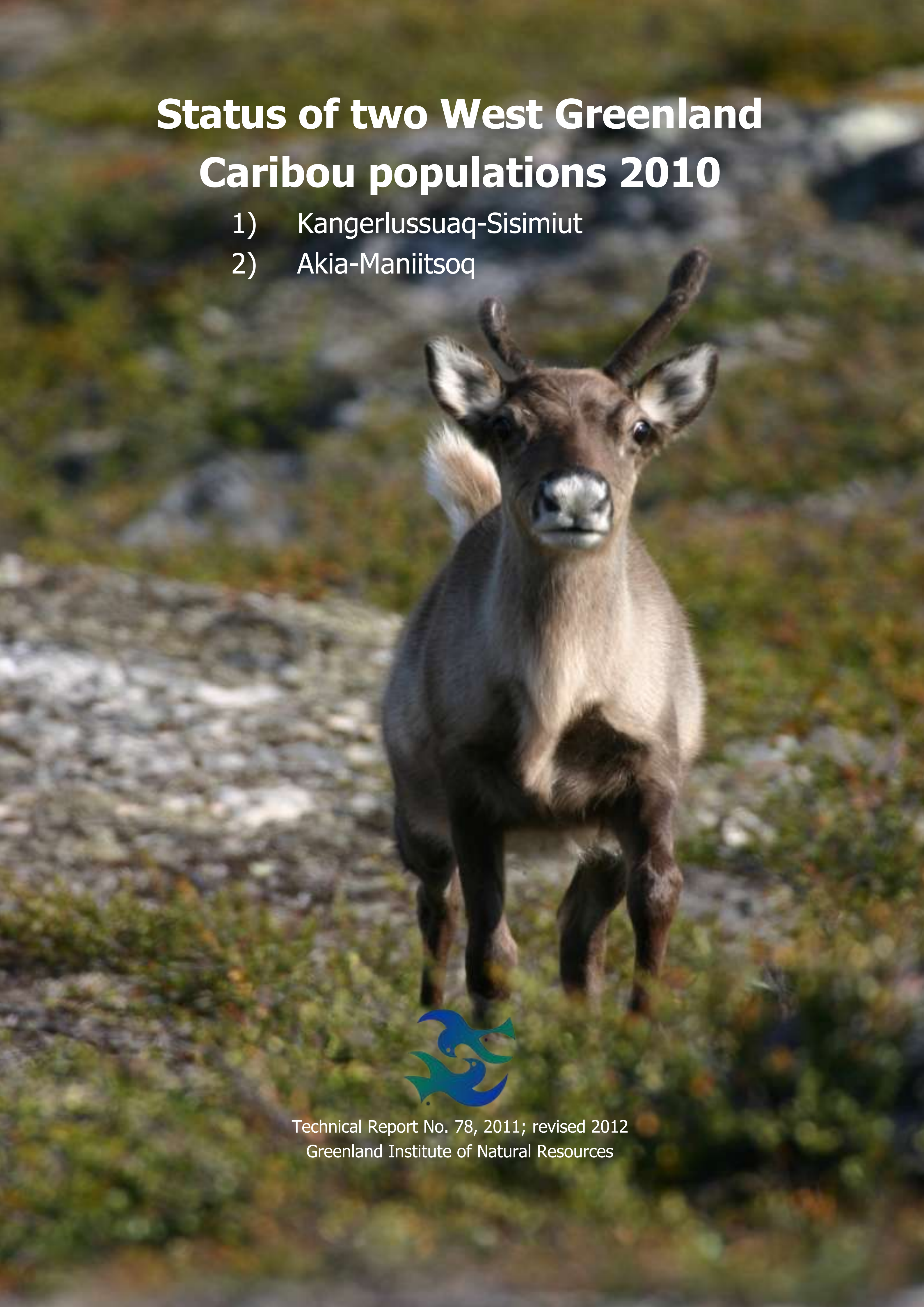
# Status of two West Greenland Caribou populations 2010

1) Kangerlussuaq-Sisimiut
2) Akia-Maniitsoq



Technical Report No. 78, 2011; revised 2012
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# Status of two West Greenland Caribou populations 2010

1) Kangerlussuaq-Sisimiut
2) Akia-Maniitsoq

By

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**Part: I**

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# *Foreword*

Please note the following 2012 revisions to the 2011 text.

a) **In Part I, Results, page 18,** ***Akia-Maniitsoq estimated population size, Central Region*****:** The abundance estimate has been amended to the 'raw' 24,000 caribou with justification provided, and Coefficient of Variance included in Table 4.
b) As per a) appropriate text alterations made in **Summary, page 5, 6 & 8,** and **Discussion, pages 26, 29 & 30.**
c) **Table 5, page 32**: The 2010 Akia-Maniitsoq population estimate is amended.
d) **In Part I, Appendix 5, Table 13:** The redundant (duplicate) pages 71-75 are removed, and thus page numbering changed from Appendix 5 onwards.

## *Summary*

In March 2010 two stocks, Kangerlussuaq-Sisimiut and Akia-Maniitsoq were surveyed by helicopter for abundance and herd structure. Methods and analysis followed Cuyler et al. (2003, 2005).

The estimate for pre-calving population size of Kangerlussuaq-Sisimiut herd of the North region in March 2010 is ca. 98,300 caribou (71,500 – 132,400; 90% CI, CV = 0.19). Caribou density in March 2010 was 6.9 caribou per $km^2$ in the high-density stratum, and 2.5 per $km^2$ in the low-density stratum. Mean group size was 3 ± 2 SD. Late winter calf percentage was 15%, and the recruitment 28 calves per 100 cows. The bull to cow ratio was 0.54. If natural mortality is between 8 and 10% then on a herd this size from 8,000 to 10,000 animals may be expected to die annually.

The estimate for pre-calving population size of Akia-Maniitsoq herd of the Central region in March 2010 is ca. 24,000 caribou (i.e., 23,989, 90% CI 16,667 – 31,311, CV = 0.18). Caribou density in March 2010 was 1.6 caribou per $km^2$ in the high-density stratum, and 1.5 per $km^2$ in the low-density stratum. Mean group size was 5 ± 4 SD. Late winter calf percentage was 14%, and the recruitment 23 calves per 100 cows. The bull to cow ratio was 0.38. If natural mortality is between 8 and 10% then on a herd this size from 1,900 to 2,400 animals may be expected to die annually.

At the recommended caribou density of 1.2 caribou per sq km that probably will not harm the vegetation (Kingsley & Cuyler 2002, Cuyler et al. 2007) the optimal herd size is about 31,200 caribou in the Kangerlussuaq-Sisimiut area and about 18, 400 caribou in Akia-Maniitsoq. In March 2010, Kangerlussuaq-Sisimiut exceeded this number by 67,000 caribou and Akia-Maniitsoq by 5,600. Density remains higher than recommended. Calf recruitment is low. Further, the Akia-Maniitsoq has a highly skewed sex ratio and appears to be declining. All suggest strongly that the range is overloaded with caribou and probably overgrazed (Miller et al. 2005).

Since records began in 1721, West Greenland caribou numbers have cycled naturally between hyper-abundance and scarcity at least twice. In past cycles, the latter was preceded by extended periods of high animal numbers. Given the recent large populations in Kangerlussuaq-Sisimiut and Akia-Maniitsoq, the possibility of a new abrupt crash in caribou number in the foreseeable future cannot be excluded. It can take the better part of a century for caribou numbers to recover.

The challenges ahead for these two herds are several. Climate continues to change and whether the impacts on these two caribou populations will be a net- positive or negative are as yet unknown. Coincidentally, development and infrastructure associated with mining, oil and hydro-power industrial activities are expanding, specifically on the range of the Akia-Maniitsoq caribou population. To promote a better understanding of the current situation and possible outcomes, we should investigate and model the interaction between caribou and their forage / range, simultaneously with modelling the cumulative effects on caribou populations of climate, development and harvests.

## *Naalisagaq*

2010-mi martsimi Kitaani Kangerlussuaq-Sisimiut aamma Akia-Maniitsoq helekopterimik kisitsivigineqarmata tuttoqarfinni taakkunani marlunni tuttut ataatsimoortukkaartullu amerlassusi missingerneqarput. Periaatsini paasissutissanillu misissuinerni tunngavigineqarpoq Cuyler et al. (2003, 2005).

Kangerlussuaq-Sisimiut tuttui amerlassusilerneqarput 98.300-inut (71.500 – 132-400; 90 %) norrinngikkallarneranni, eqimassusiallu allanngorarpoq tuttut pr. km$^2$-imut 2,5-imiit 6,9-mut. Eqimasukkuutaat amerlassusiat agguaqatigiissillugu 3 ±2 SD-uvoq. Norraat ukiup naalernerani 15 %-iupput kulavannit 100-nit amerleriaat norraat 28-iullutik. Angutivissat kulavaallu avissimanerat 0.54-iuvoq. Nalinginnaasumik toqusarneq 8-10%-iutikkaanni taama amerlatigalutik tuttut ukiumut 8.000 10.000-illu akornanni toqusarnissaat ilimagisariaqarpoq.

Akia-Maniitsoq tuttui amerlassusilerneqarput 24.000-inut (23,989, 90% CI 16,667 – 31,311, CV 0.18) norrinngikkallarneranni, eqimassusiat allanngorarpoq tuttut 1,5-imiit 1,6-isarlutik km$^2$-mut. Eqimasukkuutaat amerlassusiat agguaqatigiissillugu 5 ±4 SD-uvoq. Norraat ukiup naalernerani 14 %-iupput, kulavannit 100-nit amerleriaat norraat 23-iullutik. Angutivissat kulavaallu avissimanerat 0.38-iuvoq. Nalinginnaasumik toqusarneq 8-10%-iutikkaanni taama amerlatigalutik tuttut ukiumut 1.900 aamma 2.400-t toqusarnissaat ilimagisariaqarpoq.

Tuttut km$^2$-imi amerlassusissaat inassutigineqartoq, uagut naasoqarnermut akornutaassangatinngisarput 1,2-jusoq (Kingsley & Cuyler 2002, Cuyler et al. 2007) tunngavigalugu tuttut Kangerlussuaq-Sisimiuni 31.200 missaanniittariaqarpoq Akia-Maniitsumilu 18.400 missaanniittariaqarluni. Kangerlussuaq-Sisimiut tuttuisa kisitsit taanna 67.000-inik sinnersimavaat Akia-Maniitsumilu 5.600-inik. Taamaalilluni taakkunani marlunni tuttui assut amerlapput norrartakillutillu. Aaammalumi isumaqarnarpoq Akia-Maniitusp tuttuisa arnavissanut angutivissanullu avissimanerat equngasoq arriitsumillu ikiliartorneqartoq. Pissutsit assigiinngitsut taamaanneranut takussutissaammata nunatat taakkua pineqartut artorsartinneqarsorinarput immaqalu mangiarneqarpallaarlutik (Miller et al. 2005).

1721-imiilli Kalaallit Nunaata kitaata tuttoqarfiisa tuttui namminneerlutik ikilisarlutillu amerlisartut malugineqartalersimapput. Minnerpaamik marloriarlutik ikilerujussuartarsimapput, taamalu ikilerujussuarnissaat sioqqullugu tuttorpassuaqartarsimalluni. Ukiuni qulikkuutaani kingullerni Kangerlussuup-Sisimiut aamma Akia-Maniitsup tuttoqarnerujussuannut tunngatillugu ilisimasat tunngavigalugit tuttut siunissami ungasinngitsumi ikileriapiloorsinnaanerat ilimaginngitsoorneqarsinnaanngilaq. Taamalu pisoqassagaluarpat tuttuneqqinnissaanut ukiut hundritilingajalluinnaat ingerlaqqaartariaqassapput.

Inerliunneqartariaqarpoq tuttoqarfinnut taakkununnga tunngatillugu siunissami unammiugassarpassuaqartoq. Ilisimaneqanngilaq klimap allanngornerisa kingunerisa tuttoqatigiit taakkua ajunngitsumik ajortumilluunniit sunnerumaarneraat. Tamatumalu saniatigut ilimagineqarpoq aatsitassarsiornermut atasumik angallattoqarnerulerumaartoq immaqalu erngup nukinganik nukissiorfiliornermut atasumik aqqutit annertusarneqarumaartut sanaartorfiunerulerumaarlunilu, pingaartumik Akia-Maniitsumi. Massakkut ingerlatsinerup annertunerulerneratigut pissutsit qanoq innerat tamakkualu kingunerisinnaasaat paasinarneruleqqullugit tuttut neriniarfiisalu qanoq ataqatigiinnerat aammalu klimap ataatsimut, suliffissuaqarnikkut ineriartornerup piniarnerullu sunniutigiumaagaat paasiniartariaqarpagut.

# *Resume*


I marts 2010 blev antallet i og flokstrukturen af de to rensdyrbestande Kangerlussuaq-Sisimiut og Akia-Maniitsoq i Vestgrønland estimeret ved en helikopter-optælling. Metoder og analyser var baseret på Cuyler et al. (2003, 2005).

Kangerlussuaq-Sisimiut-bestanden blev estimeret til 98.300 rener (71.500 - 132.400; 90 % KI, CV = 0.19) før kælvning, og tætheden varierede fra 2,5 til 6,9 rener pr. $km^2$. Den gennemsnitlige flokstørrelse var 3 ±2 SD. Kalveandelen i senvinter var 15 %, med en rekruttering på 28 kalve pr. 100 simler. Forholdet mellem bukke og simler var 0,54. Ved en naturlig dødelighed på 8-10 % vil man i en bestand af denne størrelse forvente at se en dødelighed på mellem 8.000 og 10.000 dyr om året.

Akia-Maniitsoq-bestanden blev estimeret til 24.000 rener (23,989, 90% KI 16,667 – 31,311, CV = 0.18) før kælvning, og tætheden varierede fra 1,5 til 1,6 rener pr. km². Den gennemsnitlige flokstørrelse var 5 ±4 SD. Kalveandelen i senvinter var 14 %, med en rekruttering på 23 kalve pr. 100 simler. Forholdet mellem bukke og simler var 0,38. Ved en naturlig dødelighed på 8-10 %, vil man i en bestand af denne størrelse forvente at se en dødelighed på mellem 1.900 og 2.400 dyr om året.

Med en anbefalet tæthed på 1,2 rener pr. km², som vi formoder ikke påvirker vegetationen negativt (Kingsley & Cuyler 2002, Cuyler et al. 2007), burde en optimal bestandsstørrelse ligge på ca. 31.200 rener i Kangerlussuaq-Sisimiut-området og ca. 18.400 rener i Akia-Maniitsoq. Kangerlussuaq-Sisimiut-bestanden overstiger dette med 67.000 rener og Akia-Maniitsoq-bestanden med 5,600 rener. Der er således i begge områder en høj rensdyrtæthed og en lav kalverekruttering. Endvidere ser det ud til, at Akia-Maniitsoq-bestanden har en skæv kønsfordeling og er i tilbagegang. Flere forhold indikerer således, at områderne er overbelastede og muligvis overgræssede (Miller et al. 2005).

Siden 1721 har man observeret naturlige antalsmæssige svingninger i de vestgrønlandske rensdyrbestande. Mindst to gange har bestandene være kraftigt reduceret, mens der forud for dette har været lange perioder med mange dyr. Givet de sidst årtiers viden om høje bestandsantal i Kangerlussuaq-Sisimiut og Akia-Maniitsoq kan man ikke udelukke et nyt styrtdyk i antallet af rensdyr i den nærmeste fremtid. Skulle dette ske, kan det tage næsten hundrede år før bestandene reetableres.

Det må konkluderes at der er mange fremtidige udfordringer for disse to bestande. Det vides ikke om eventuelle klimaeffekter vil påvirke de to bestande positivt eller negativt. Herudover forventes en øgede aktivitet samt en vis udvikling af infrastrukturen i forbindelse med minedrift og evt. etablering af vandkraftværker, specielt i Akia-Maniitsoq-området. For at forbedre forståelsen af den nuværende situation og mulige konsekvenser af de øgede aktiviter, bør vi undersøge samspillet mellem rensdyr og græsningsområderne samt modellerer de kumulative effekter af klima, industriel udvikling og fangst.

## *Introduction*

Helicopter surveys, begun in 2000 and using new methods/design, were the first to document the current large numbers of caribou present in several of the West Greenland populations and the associated high densities, e.g., 4 to 6 caribou per sq km, on the limited range available (Cuyler et al. 2002, 2003, 2004, 2005, 2007). Density above 2 caribou per sq km negatively affects forage quality and quantity, and can lead to overgrazing of the vegetation, which ultimately contributes to population crashes (Helle et al. 1990). In the Yukon and Alaska, densities above 2 caribou per sq km are considered high and result in caribou dispersal which is assumed due to competition for food (Haber & Walters 1980). As there are no large predators and since range degradation could seriously threaten the future health and stability of West Greenland herds, beginning in 2002, an imprecise target density of 1.2 caribou per sq km became a management goal for the West Greenland herds (Kingsley & Cuyler 2002, Cuyler et al. 2007), to be attained by longer hunting seasons, increasing hunting quotas and harvesting more cows and calves.

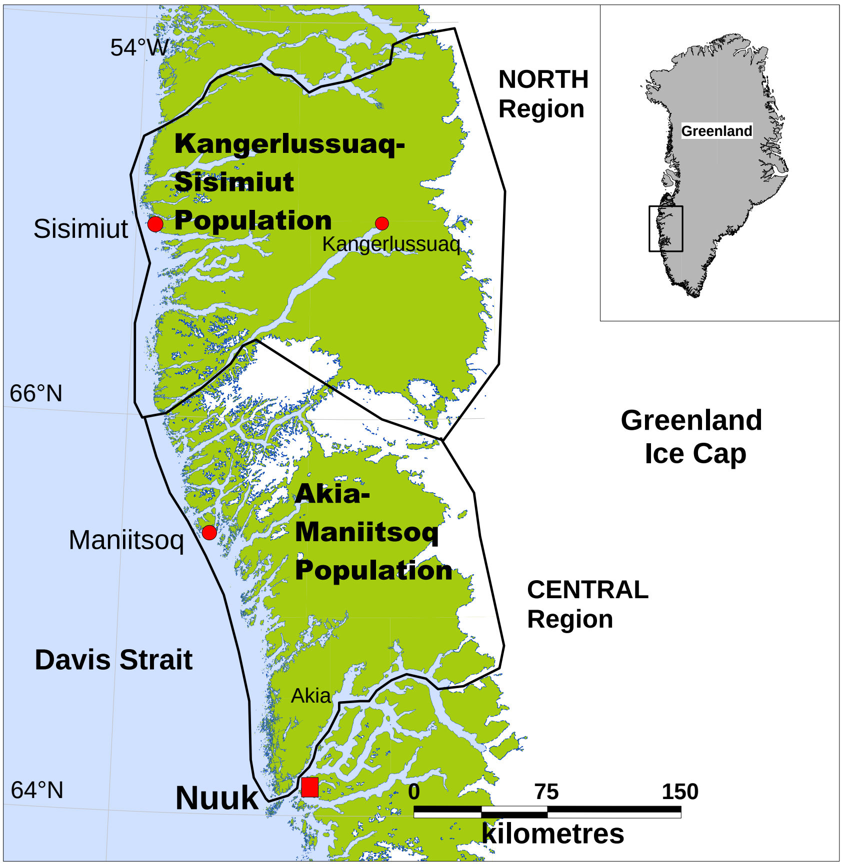


***Figure 1.*** *Locations of the two largest West Greenland caribou populations, Kangerlussuaq-Sisimiut and Akia-Maniitsoq, in the North and Central regions.*

West Greenland's two largest indigenous caribou populations, the Kangerlussuaq-Sisimiut (KS) and the Akia-Maniitsoq (AM) (Figure 1) of the North and Central regions respectively, were last surveyed by helicopter in March 2005. The KS caribou density on preferred range was then almost six times greater than the target density of 1.2 caribou per km$^2$, while the AM was almost three times larger. The 2005 KS abundance was large, ca. 90,500, and either unchanged or increased since 2000 (survey method changes eliminated direct comparison) (Cuyler et al. 2005), however their herd structure was skewed. The bull to cow ratio was below normal and calf recruitment (11%) had declined almost to the natural mortality value (8-10%) where productivity is zero. In contrast, the 2005 AM abundance estimate was ca. 35,800 and was 22.5% below the 2001 estimate of 46,200 caribou (Cuyler et al. 2005). Herd structure suggested that calf recruitment and densities were declining, while the bull to cow ratio was relatively normal (Table 1). Although 2005 herd numbers were high, herd composition for both populations indicated problems, so attempts to reduce abundance continued. Since 2005 management efforts to reduce caribou density included further lengthening hunting seasons, e.g., 1 August to 15 November for sport hunters and to 28 February for commercial hunters, while harvests remained unlimited (no quota). Had the past five years of harvest management strategies, natural factors or other influences reduced caribou abundance and density in the Kangerlussuaq-Sisimiut and Akia-Maniitsoq populations?

***Table 1.*** *Recent late winter herd parameters from aerial and ground surveys of the Kangerlussuaq-Sisimiut and Akia-Maniitsoq stocks in West Greenland (Cuyler et al. 2002, 2003, 2005).*

| Parameter | 1998 | 2000 | 2001 | 2005 |
|---|---|---|---|---|
| **Kangerlussuaq-Sisimiut caribou – (2) North region** | | | | |
| Mean group size ± SD | 2.3 | 2.7 | - | 4.6 ± 3.4 |
| Maximum group size | 10 | 17 | - | 17 |
| Density per sq km | - | 1.2 to 2.8 | - | 2 to 6 |
| Calf percentage | 21 % | 27% | - | 11% |
| Recruitment, Calves / 100 Cows | 48 | 68 | - | 16 |
| Bull to Cow Ratio | 0.86 | 0.83 | - | 0.33 |
| **Akia-Maniitsoq caribou – (3) Central region** | | | | |
| Mean group size ±SD | 6.4 | 3.6 | 3.2 | 4.3 ± 2.9 |
| Maximum group size | 36 | 17 | 18 | 17 |
| Density per sq km | - | - | 1.1 to 4.0 | 1 to 3 |
| Calf percentage | 25% | 20% | 17% | 14% |
| Recruitment, Calves / 100 Cows | 65 | 49 | 31 | 24 |
| Bull to Cow Ratio | 0.92 | 1 | 0.58 | 0.45 |

### *Present surveys*

In March 2010 by helicopter transect survey, we re-examined abundance in the two largest herds in West Greenland, the KS caribou population of the North region, and the AM population of the Central region. This report presents the 2010 late-winter abundance, herd structure and distribution for these two caribou populations.

# Methods

## *Survey design and field methods*

In March 2010 we completed aerial transect surveys for two caribou populations in two regions; Kangerlussuaq-Sisimiut (North region) and Akia-Maniitsoq (Central region). Three observers were in the helicopter. Two counted on the left side and one on the right side. We used manual click-counters to log the number of caribou seen on a specific transect by each observer. Observers included, Greenland Institute of Natural Resources research scientist, Christine Cuyler, and biology assistant Sofie Jeremiassen, ex-commercial hunter Rink Heinrich (Nuuk), and two hunting officers, Hans Mølgaard (Sisimiut) and Magnus Petersen (Nuuk). Detailed descriptions of design and methods applied follow Cuyler et al. (2002, 2003 & 2005). Historical backgrounds for each population are available in Cuyler et al. (2002, 2003 & 2005). In brief, to increase the probability of detecting caribou, we used an AS350 helicopter (OY-HGU) to slowly fly short transects, at an altitude of about 15 m (50 feet), with a narrow strip width (2x 300m), and avoided solar glare. March was again selected for its optimal day length and low variability in caribou group size (Roby & Thing 1985, Thing 1982, Thing & Falk 1990, Ydemann & Pedersen 1999, Cuyler et al. 2002, 2003, 2005 & 2007), which reduces sampling error and aids precision. Further, caribou movement is relatively low in March (Cuyler & Linnell 2004). Our 15 m altitude with the pilot watching the 'zero-line' and notifying us of caribou present, meant that there is no dead zone under the helicopter on these surveys. Photos were taken using a Canon Power Shot A630. Photo size was ca. 500-600 KB.

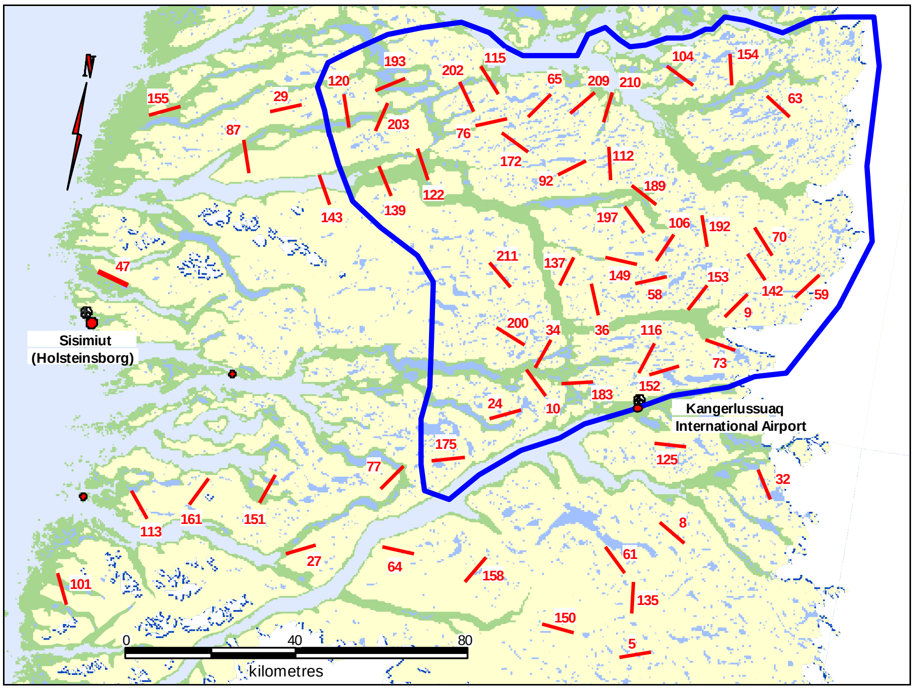


***Figure 2.*** *Transect lines, with ID numbers, and the stratification used for the 2010 aerial survey of the Kangerlussuaq-Sisimiut caribou population in the North region. The area inside blue outline indicates the high caribou density stratum. Elevation above 200 m is shown.*

### *Kangerlussuaq-Sisimiut caribou population (North region)*

The aerial survey of the Kangerlussuaq-Sisimiut herd occurred 03-08 March 2010. The North region encompasses approximately 26,000 km², which includes islands, lakes and rivers, but deletes Ice Caps and glaciers The 60 random transect lines were divided between two strata, one high and one low caribou density stratum (Figure 2). The high-density stratum was 8,000 km², and the low-density stratum 18,000 km². 40 transects were allocated to the high caribou density stratum, and 20 transects were allocated to the low-density stratum. Herd structure and recruitment counts were flown over large areas in both the high and low caribou density strata.

### *Akia-Maniitsoq caribou population (Central region)*

The aerial survey of the Central region occurred 9-13 March 2010. The Central region encompasses approximately 15,362 km², which includes islands, lakes and rivers, but deletes glaciers and ice caps. The 54 random transect lines were divided between 2 strata, one high and one low caribou density stratum (Figure 3). The high-density stratum involved c. 10,037 km², while the low-density stratum encompassed c. 5,325 km². 39 transects were allocated to the high caribou density stratum and 15 transects to the low caribou density stratum. Herd structure and recruitment counts were flown over large areas in both the high and low caribou density strata.

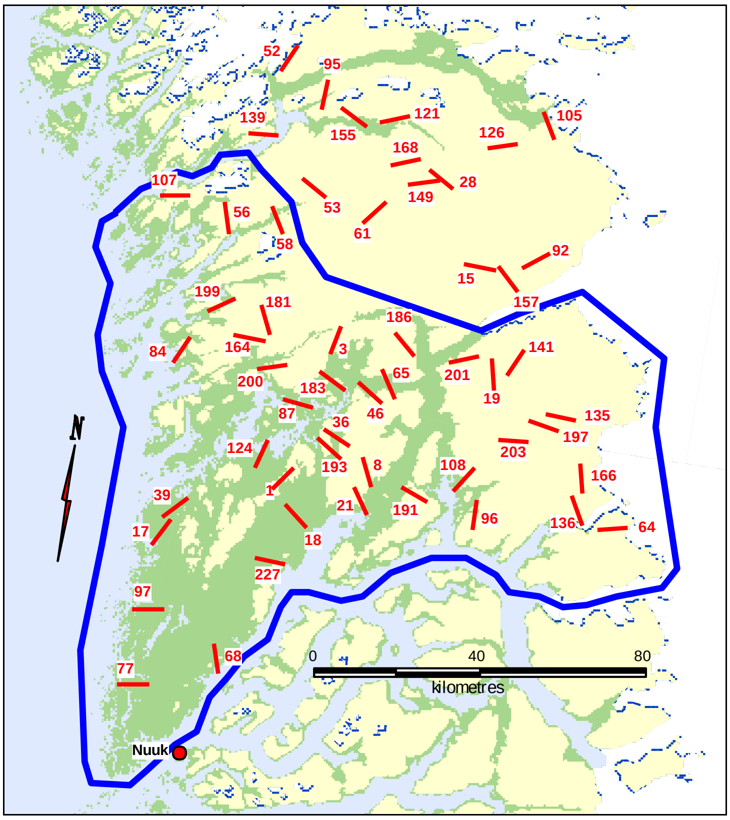


***Figure 3.*** *Transect lines, with ID numbers, and the stratification used for the 2010 aerial survey of the Akia-Maniitsoq caribou population in the Central region. The area inside blue outline indicates the high caribou density stratum. Elevation above 200 m is shown.*

### *Estimating abundance*

Population estimates for the two caribou populations investigated and the minimum number for the missed animals were calculated according to Cuyler et al. (2002, 2003). The standard method when each missed animal is identified follows Pollock & Kendall (1987). At the flight altitude used, 15 m, "dead" ground is common on transects, i.e. terrain features often prevent seeing the entire 300 metre strip width on one or both sides of the helicopter. Caribou may be missed because they are hidden from view. This is a source of negative bias and contributes to under estimating population size.

Alternately, we estimated abundance using the number of collared cows observed, either from transects or from the total observed, in the Lincoln-Petersen estimator as revised by Chapman (1951).

$$\boldsymbol{N} = (((n_1+1)*(n_2+1)) \; / \; m + 1))-1 \qquad (1)$$

$\boldsymbol{N}$ is the animal abundance
$n_1$ is the number of marked animals
$n_2$ is the total number of animals observed (captured)
$m$ is the number of marked animals among the total number of animals observed.

The 95% confidence interval (CI) was calculated as follows:

$$CI = 1.96*SQRT(((n_1 +1)*( n_2 +1)*( n_1 -m)*( n_2 - m))/(( m +1)*( m +1)*( m +2))) \qquad (2)$$

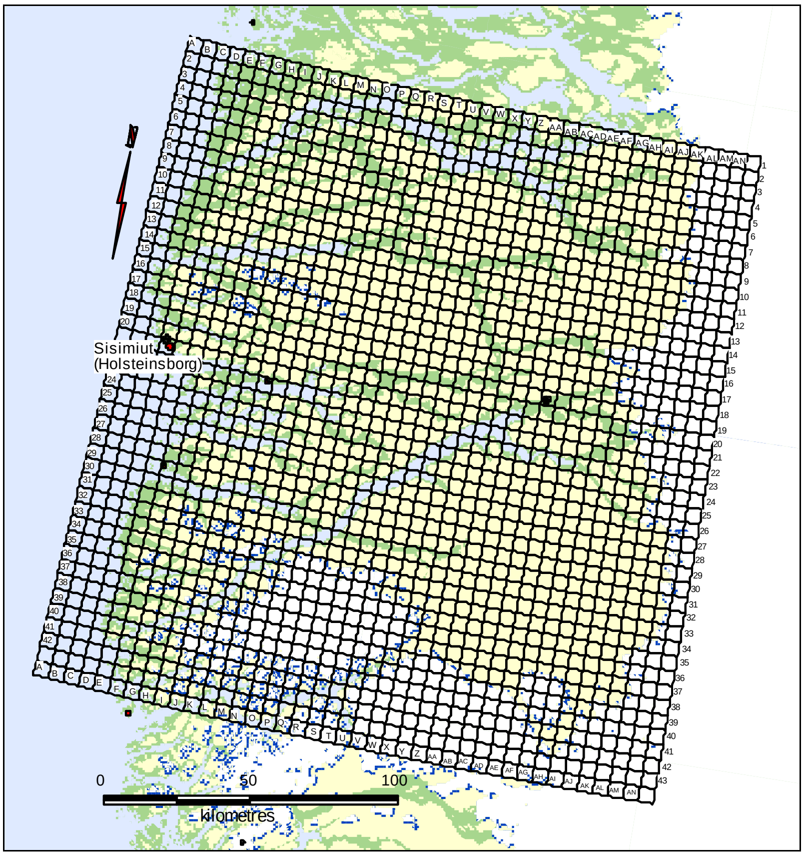


***Figure 4.*** *Grid cell map for charting location of caribou groups sexed and aged for herd structure and calf recruitment, 2010 aerial survey Kangerlussuaq-Sisimiut caribou population, North region. Cells are 5 x 5 km.*

### *Herd structure, calf recruitment & distribution*

To increase the number of caribou seen for sexing and ageing, we flew at altitudes below 30 m (100 feet) when not specifically flying transects. Thus herd structure and recruitment were possible between transects and on refuelling flights, as well as in areas of high caribou density. There were also opportunistic observations while flying a strip-transect. We placed the approximate location of each group observed on a grid cell map for that region (Figure 4 & 5). Female sex was reliably determined by the presence or absence of a vulva and/or urine patch on the rump on both adults and calves. No other method was 100% certain, e.g. antler size, shape, presence or absence, were not used, as the presence and characteristics of antlers on cows or juvenile male caribou is highly variable in West Greenland. Age was determined by body size. 10-month-old calves of both sexes are considerably smaller than all other age classes in late-winter, March. There were two age classes used in subsequent analyses, i.e., calf (≅ 10-months-old) and adult (> 1 year). Calf percentage is the percentage of the total number of caribou sexed and aged. Calf recruitment is the late-winter calf per 100 cow ratio. Group size was based on proximity and group cohesion during possible flight response. Distribution is based on total caribou seen on transects and those observed for herd structure for a given grid cell.

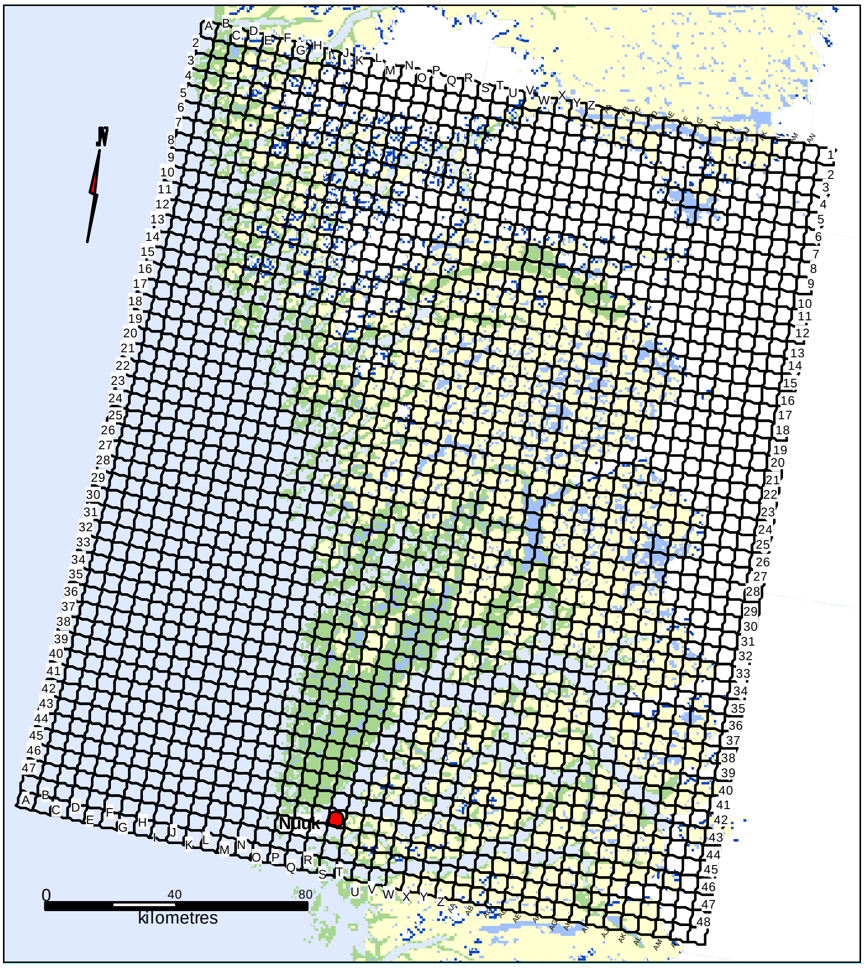


***Figure 5.*** *Grid cell map used for charting location of caribou groups sexed and aged for herd structure and recruitment in 2010 aerial survey of the Akia-Maniitsoq caribou population, Central region. Cells are 5 x 5 km.*

### *Statistical design*

The aerial helicopter survey was designed as a stratified strip-transect count. Each transect had three observers, of which two counted the same strip area, i.e. both counted on the left side of the helicopter. A method to calculate a minimum number for the missed animals was developed. The standard method when each missed animal is identified was as follows Pollock & Kendall (1987). For details see appendices 1, 2 & 3. The correction calculation accounted for different correction factors for each stratum. Since no good method is available which could include the variance of a correction factor, the confidence intervals were instead calculated using a bootstrap method (Effron & Tibshirani 1993).

## *Results*

### *Kangerlussuaq-Sisimiut estimated population size, North Region*

We observed a total of 1429 caribou on the 59 transects. The raw data (Appendix 4) gave an uncorrected preliminary pre-calving population estimate of ca. 98,721 caribou, with densities of ca. 6.8 caribou per sq km in the high-density strata and 2.5 caribou per sq km in the low-density strata. After correction and bootstrapping (Cuyler et al. 2002), the final pre-calving population size estimate for March 2010 became ca. 98,300 (90% CI: 71,500 – 132,400), with densities greater than two and about seven in the low- and high-density strata respectively (Table 2).

***Table 2.*** *Survey information and preliminary raw and corrected population size estimates for Kangerlussuaq-Sisimiut caribou, North region, 03-08 March 2010.*

| Parameter | High-density Stratum | Low-density Stratum | Totals |
|---|---|---|---|
| Area size | 8,000 $km^2$ | 18,000 $km^2$ | 26,000 $km^2$ |
| Number strips | 40 | 19 | 59 |
| Length of each strip | 7.5 km | 7.5 km | |
| Total strip width | 2x 300 m | 2x 300 m | |
| Area covered | 180 $km^2$ | 85.5 $km^2$ | 265.5 $km^2$ |
| % Coverage of North region | 2.3 % | 0.5 % | 1.0 % |
| Flight height | 15 metres | 15 metres | |
| Flight speed (km/hr) | 46 to 65 | 46 to 65 | |
| Total caribou seen (*n*) | 1217 | 212 | 1429 |
| Raw Density (caribou / $km^2$)* | 6.8 | 2.5 | 2 to 7 |
| Raw estimate herd size* | 54,089 | 44,632 | 98,721 |
| **Corrected Density (caribou / $km^2$)**** | **6.9** | **2.5** | **+2 to 7** |
| **Corrected estimate herd size**** | **54,700** | **42,900** | **98,300** |
| **90% Confidence Interval (CI)** | **40,500 – 70,700** | **21,+300 – 73,700** | **71,500 – 132,400** |
| **Coefficient of Variance (CV)** | **0.16** | **0.36** | **0.19** |
| **Standard Error (SE)** | **9100** | **16100** | **18500** |

* From raw data with no correction for missed caribou.

** Herd size estimate after bootstrapping and correction for missed caribou has been made.

### *Kangerlussuaq herd structure & recruitment*

The demographics data collection was thorough with over 1700 caribou sexed and aged in the KS herd (Table 3, Appendix 4). The KS caribou occurred throughout their region, with a mean group size of ca. 3 ±2 SD. Large congregations of animals were not common in the KS herd, where the largest group was 17 caribou. There were about 54 bulls and 28 calves per 100 cows in the KS herd.

***Table 3.*** *Herd Structure for two caribou herds in West Greenland, March 2010.*

| Parameter | Kangerlussuaq-Sisimiut Caribou Population | Akia-Maniitsoq Caribou Population |
|---|---|---|
| Region (Hunting area) | North (2) | Central (3) |
| Time period | 03-08 March 2010 | 09-13 March 2010 |
| Method | Helicopter | Helicopter |
| Total observed | 2215 | 1473 |
| Total sexed & aged (*n*) | 1735 | 1352 |
| Number of groups observed | 752 | 306 |
| Average group size | 2.96 ± 2.14 SD | 4.81 ± 4.14 SD |
| Maximum group size | 17 | 31 |
| Minimum group size | 1 | 1 |
| Bull (> 1 year) | 519 (29.9%) | 317 (23.5%) |
| Cow (> 1 year) | 952 (54.9%) | 840 (62.1%) |
| Calf from 2009 | 264 (15.2%) | 195 (14.4%) |
| Recruitment (calf/100cow) | 27.7 | 23.2 |
| Bull to Cow ratio | 0.54 | 0.38 |

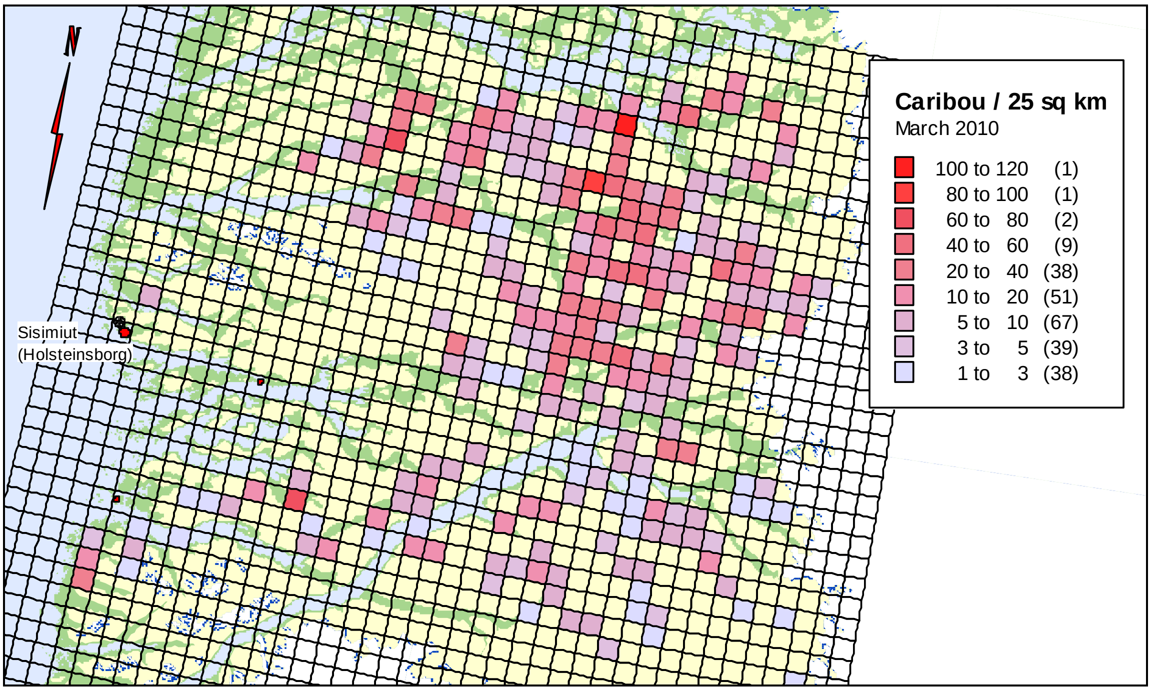


***Figure 6.*** *The March 2010 distribution of the Kangerlussuaq-Sisimiut caribou in the NORTH region, as per the ground covered by the helicopter survey. Data exists only for those cells with colour. Cells are 5 x 5 km.*

*Kangerlussuaq-Sisimiut March 2010 distribution*

High densities of caribou occurred in the deep interior (Figure 6). Several areas north of the Isortoq River, e.g., the Qoorqut, Majoriaq, Kingatsiaq and Saningassoq (Appendix 9) had small groups of caribou everywhere, as did valleys just east and south of the Majoriaq highlands and just east of Saningassoq. Aside from the interior, in one specific grid cell at the Kuuk Akua shore of the inner Nordre Strømfjord we observed 120 caribou. Among these we noticed five emaciated mature bulls (directly under the helicopter) ribs and spine jutting starkly through their fur. The valleys and highlands between and surrounding the Ivnaatqaa-Kangilinaaq areas of Nagssugtuup Nunaa also held many caribou, as did the general area north of Tarajornitsuit, northwest from the Kangerlussuaq Airport, and the valley east of Dye 1.

***Figure 7.*** *Caribou are superbly camouflaged for the "salt & pepper" background of snow and bare vegetation. Conditions like these are a common occurrence. Photos taken March 2010. (Photos: C. Cuyler)*

*Kangerlussuaq-Sisimiut survey weather & conditions*

The survey of the KS herd, North region, used 33 hours and 42 minutes of flying time. It took six days to complete, which included five days flying and one day rest between days four and six, necessary to keep the pilot's hours airborne within safety limits. Similar to the 2000 and 2005 surveys, financial constraints (Appendix 8), which restrict the number of helicopter hours, resulted in area coverage of 2.3% and 0.5% in the high and low density strata respectively. Weather conditions on the first day were sunny and clear. The second day began with sunshine but quickly deteriorated into a low overcast cloud cover, which resulted in a shadow less terrain of no features beyond the vegetation or rocks poking through the snow cover. This was further compounded by occasional fog. The third day was also a dull shadow less overcast with some sunshine mid-day before returning to a featureless overcast. The entire fourth day was sunny and bright. The sixth day we began in the far northwest of the North region, however, there was thick valley & coast fog, which prevented our flying transect T-155. The rest of this final day was bright and sunny. Snow cover was typically patchy and sometimes sparse, creating a "salt & pepper" background, which was optimal camouflage for caribou (Figure 7). Although occasionally up to 99% or as low as 10%, typical snow cover was about 40%, i.e., white snow cover broken by either dark vegetation or bare rock/ground. Snow cover could vary dramatically along a transect line (Part II Appendix 10a, b).

***Akia-Maniitsoq estimated population size, Central Region***

We observed a total of 380 caribou on the 54 transects, (Appendix 5). The raw pre-calving March 2010 population estimate was 23,989 (90% CI: 16,667 – 31,311), with densities of ca. 1.5 – 1.6 caribou/km² for low- and high-density strata. After correction and bootstrapping (Cuyler et al. 2002), the estimate became 31,200 (90% CI: 21,800 – 42,200), with densities of 1.7 & 2.2 for the low- and high-density strata respectively (Table 4). This 'corrected' estimate is inflated and inaccurate because correction is based on caribou missed by the left rear observer compared to left front, and applying that to the right rear observer. The inexperienced left rear observer missed most caribou. The experienced right rear did not. Applying the large correction to the right rear observer was wrong. Thus estimate is ca. 24,000 caribou.

***Table 4.*** *Survey information and raw and corrected population size estimates for Akia-Maniitsoq caribou, Central region, 09-13 March 2010. Raw estimate is more accurate because correction was flawed.*

| Parameter | High-density Stratum | Low-density Stratum | Totals |
|---|---|---|---|
| Area size | 10,037 km² | 5,325 km² | 15,362 km² |
| Number strips | 39 | 15 | 54 |
| Length of each strip | 7.5 km | 7.5 km | |
| Total strip width | 2x 300 m | 2x 300 m | |
| Area covered | 175.5 km² | 67.5 km² | 243 km² |
| % Coverage of Central region | 1.7 % | 1.3 % | 1.6 % |
| Flight height | 15 metres | 15 metres | |
| Flight speed (km/hr) | 46 to 65 | 46 to 65 | |
| Total caribou seen (*n*) | 276 | 104 | 380 |
| **Raw Density (caribou/km²)*** | **1.6** | **1.5** | **1.6** |
| **Raw estimate herd size* with 90% CI** | **15,785** | **8,204** | **23,989 (±7322)** |
| **Coefficient of Variance (CV)** | **0.19** | **0.38** | **0.18** |
| Corrected Density (caribou / km²)** | 2.2 | 1.7 | +2 |
| Corrected estimate herd size** | 21,900 | 9,100 | 31,200 |
| 90% Confidence Interval (CI) | 14,300 – 31,600 | 4,100 – 14,900 | 21,800 – 42,200 |
| Coefficient of Variance (CV) | 0.24 | 0.36 | 0.20 |
| Standard Error (SE) | 5300 | 3300 | 6200 |

* Herd size estimate from raw data with no correction for missed caribou.

** Herd size estimate after bootstrapping and correction for missed caribou has been made.

### *Akia-Maniitsoq herd structure & recruitment*

In March 2010, the demographics data was thorough with over 1300 caribou sexed and aged in the AM herd (Table 4, Appendix 5). The AM mean group size was ca. 5 ±4 SD. There were ca. 38 bulls and 23 calves per 100 cows in the AM herd.

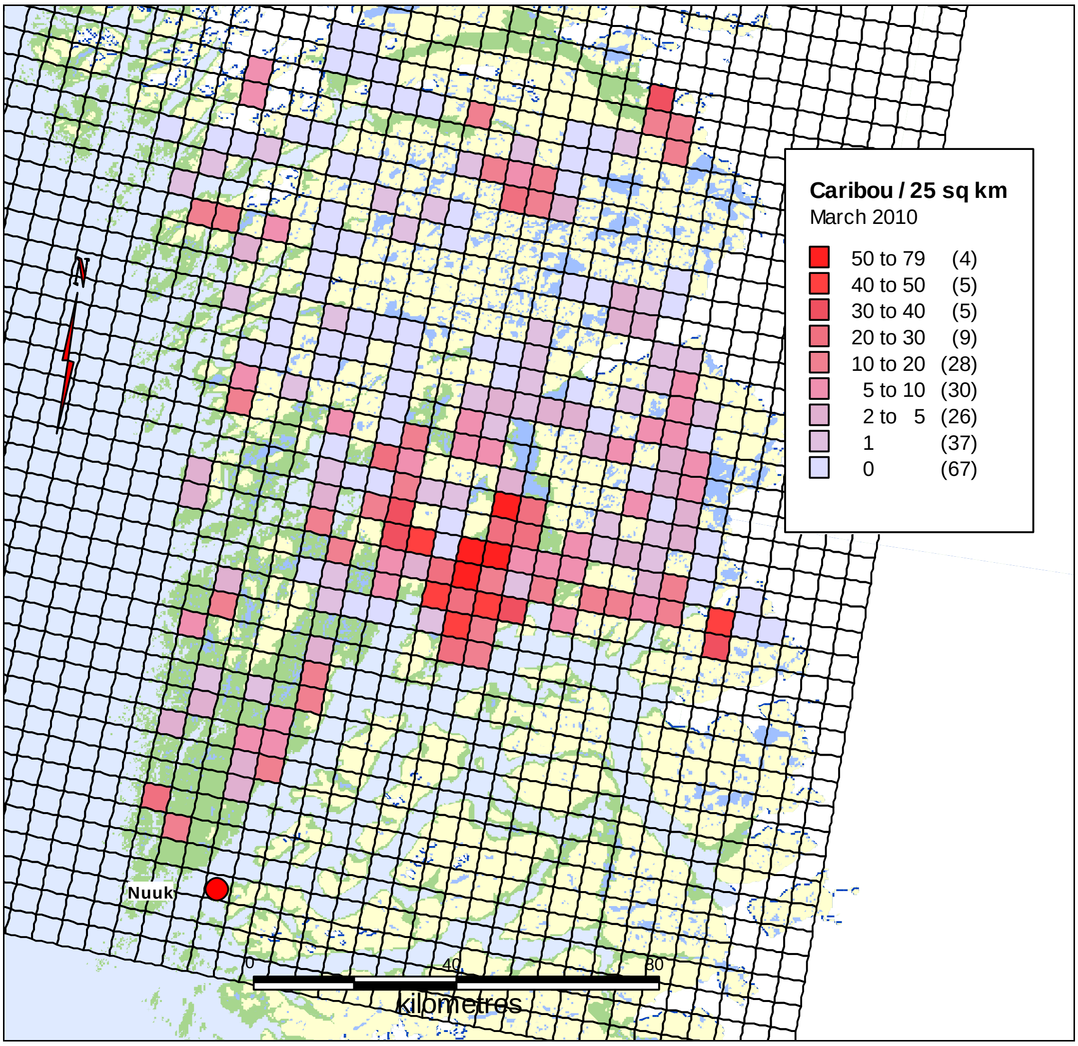


***Figure 8.*** *The March 2010 distribution of the Akia-Maniitsoq caribou in the CENTRAL region, as per the ground covered by the helicopter survey. Data exists only for those cells with colour. Cells are 5 x 5 km.*

### *Akia-Maniitsoq March 2010 distribution*

Unexpectedly, the AM caribou were not evenly distributed in their high density stratum. Few caribou were observed on the Akia-Nordlandet lowlands, previously a preferred winter range. Meanwhile, numerous unusually large groups occurred in Narssarssuaq Valley. The largest group numbered 31 caribou. Several groups would aggregate while fleeing the helicopter to create groups larger than 31, e.g., Figure 11 and Part II Appendix 12. The highest densities of caribou were observed in Narssarssuaq Valley, Ivisartoq and, as on the surveys of 2001 & 2005, in "Eldorado" Valley (Appendix 9). Similar to previous surveys and in the low-caribou density stratum, many caribou were observed on and in area of transects 28 and 149 (which are close together) and transect 105, which is adjacent to the Greenland Ice Cap.

***Akia-Maniitsoq survey weather & conditions***
The survey of Akia-Maniitsoq used 24 hours and 00 minutes of flying time. It took five days to complete, which included four days flying and one day rest between days two and four. The latter was necessary to keep the pilot's hours airborne within safety limits. Fewer hours were needed than for the KS survey because of shorter refuelling distances and a smaller overall region area. Also for the KS survey, we had to "ferry" the helicopter both up to the Kangerlussuaq airport from Nuuk and back again. Similar to the 2001 and 2005 surveys, financial constraints (Appendix 8), which restrict the number of helicopter hours, resulted in area coverage of 1.7% and 1.3% for the high and low density strata respectively. Weather conditions on the first day were predominantly a dull overcast with no shadows. It brightened around mid-day but quickly returned to overcast and the last transects were finished in rain, which further reduced visibility. The second day was sunny and clear, except for local valley fog occurring at the south end of transect 155. It remained bright until late in the afternoon, when it became overcast and dull with no shadows. It rained for the final transects of the second day. The entire fourth day was sunny and bright, although the final transects were flown with deep shadows owing to the low angle of the slowly setting sun. Also there was a layer of new snow on the ground, which made spotting fresh caribou tracks easy. The fifth day began overcast and dull with no shadows, however, the sky cleared by noon and was generally brighter for the rest of the day. Similar to the 2005 survey, in 2010 the Central region had more snow cover relative to the North region. Snow cover in the high-density stratum varied between 10 and 99%, while the typical range was 40 to 80%. As usual, the low-density stratum was almost totally covered in deep snow.

***Akia-Maniitsoq, Satellite collared cows: mark-capture-recapture***
We observed a total of four collared cows. All were in the densely populated Narssarssuaq Valley – Ilulialik Bay area (Appendix 9). At the time of the March 2010 survey collared cows in the AM population numbered a minimum of 14 and a maximum of 24. Two collared cows were among the total 380 caribou observed while flying transects. Four collared cows were among the total 1482 caribou observed. Estimating abundance using the Chapman (1951) estimator and assuming 14 collared cows gives rise to ca. 1900 (95% CI: ±1700) caribou derived from the 380 transect observations and to ca. 4400 (95% CI: ±2900) caribou derived from the 1482 total caribou observed. Similarly if 24 collared cows are assumed, then the results are from ca. 3200 (95% CI: ±2900) to ca. 7400 (95% CI: ±5300) respectively.

One collared cow was in the highlands of transect 191, had an orange Telonics satellite collar and no calf-at-heel. The other was on transect 21 at the southern end in the lowlands at the mouth of the Narssarssuaq Valley. She had an iridium yellow satellite collar, and a male calf-at-heel (Figure 9). Her collar appeared to be up-side-down. Two more collared cows were seen off-transect on 13 March (Figure 10). One cow, in the south-eastern most lowlands of the Narssarssuaq Valley, had an orange Telonics collar and a male calf-at-heel. The other had an orange Telonics collar and no calf-at-heel. She was on the north riverbank of the deep canyon valley found on the east side of the Ilulialik Bay. Orange collars were easier to spot than yellow collars. Neither colour showed well in patchy backgrounds and poor light.

***Figure 9.*** *Caribou cow with yellow-black iridium satellite collar followed by her male calf, 12 March, Akia-Maniitsoq, Central region, observed at the south end of transect number 21, which is at the mouth of the Narssarssuaq Valley as it meets Qugssuk Bay. (Photo: C. Cuyler)*

***Figure 10.*** *Collared caribou cows, 13 March, Akia-Maniitsoq, Central region: on top left caribou cow with orange Telonics satellite collar (male calf not shown), observed on the far eastern side of mouth of the Narssarssuaq Valley; on bottom left a caribou cow with orange Telonics satellite collar (no calf) accompanied by adult male, observed on the north side of canyon valley on the east side of Ilulialik Bay. The collared cow is the animal on lower right. (Photos: C. Cuyler)*

*Unexpected distribution in Akia-Maniitsoq, Central region*

We discovered hundreds of caribou residing on the flats in the northern half of the Narssarssuaq Valley (Figure 11). The groups of caribou were unusually large. As they fled from the helicopter, several groups often coalesced into huge flocks.

***Figure 11.*** *Unusually high numbers of caribou in exceptionally large groups were observed on the flats in the northern portion of Narssarssuaq Valley 12 March 2010, Akia-Maniitsoq, Central region. (Photos: C. Cuyler)*

*Miscellaneous observations*

Spotting caribou was difficult because of the patchy backgrounds, which were a combination of snow and bare vegetation or ground (Figure 7, Part II Appendices 10a, 10b & 13). Poor daylight conditions (Figure 12) exacerbated this. One dead caribou was observed in the AM region, and none in the KS. In the North region only 59 of the 60 transects were flown, owing to thick local valley fog at transect 155.

Although running is common, caribou within the strip width (2x 300 m) of a transect often remained stationary, looking at the helicopter (Figure 12), while some few remained lying down or grazing. In sharp contrast to the experienced observers, new observers could not detect these caribou in the poor light and difficult background cover.

*Figure 12. Three caribou are standing still about 250 m from transect line T-1. They are just left of largest black boulder mid-frame. Photo illustrates poor lighting conditions, under which a new observer was unable to spot these, and many other caribou on the survey. Photo was taken 10 March 2010. (Photo: C. Cuyler)*

We flew over three caribou exclosures (vegetation fenced off / protected from caribou) in the Akia-Nordlandet area of the Central region. All appeared in good condition, i.e., the fencing remained intact and upright (Figure 13).

***Figure 13.*** *Exclosure protecting vegetation from caribou grazing, Niaqornaq area west side Qugssuk Bay, 12 March 2010, Akia-Maniitsoq, Central region. View to the east-north-east into Qugssuk Bay. Of the three Akia-Nordlandet exclosures, the one pictured is that furthest south and closest to the coast. (Photo: C. Cuyler)*

*Unauthorized motor-vehicle use*

The March 2010 Akia-Maniitsoq survey was the first time we observed skidoo and ATV (all terrain vehicle/4-wheel) tracks (Figure 14) in the terrain. Our observations were opportunistic and made only when these occurred in conjunction with our caribou transects. Our survey budget did not permit looking for, or mapping, the extent of skidoo traffic. Skidoo tracks were observed once in the low-density caribou stratum in the north of the Central region. Skidoo tracks were observed two places within the high-density caribou stratum, which is in the south of the Central region. First, skidoo traffic originating from the Olivenite (Serpentine) mine on the north side of Fiskefjord was obvious (Appendix 9). These tracks went in a north easterly direction and penetrated far into the terrain. Secondly, the entire Akia-Nordlandet area appeared heavily used by skidoos, evidenced by the widespread prevalence and extent of skidoo tracks throughout the area, while ATV tracks were seen only on the west shore of Qugssuk Bay.

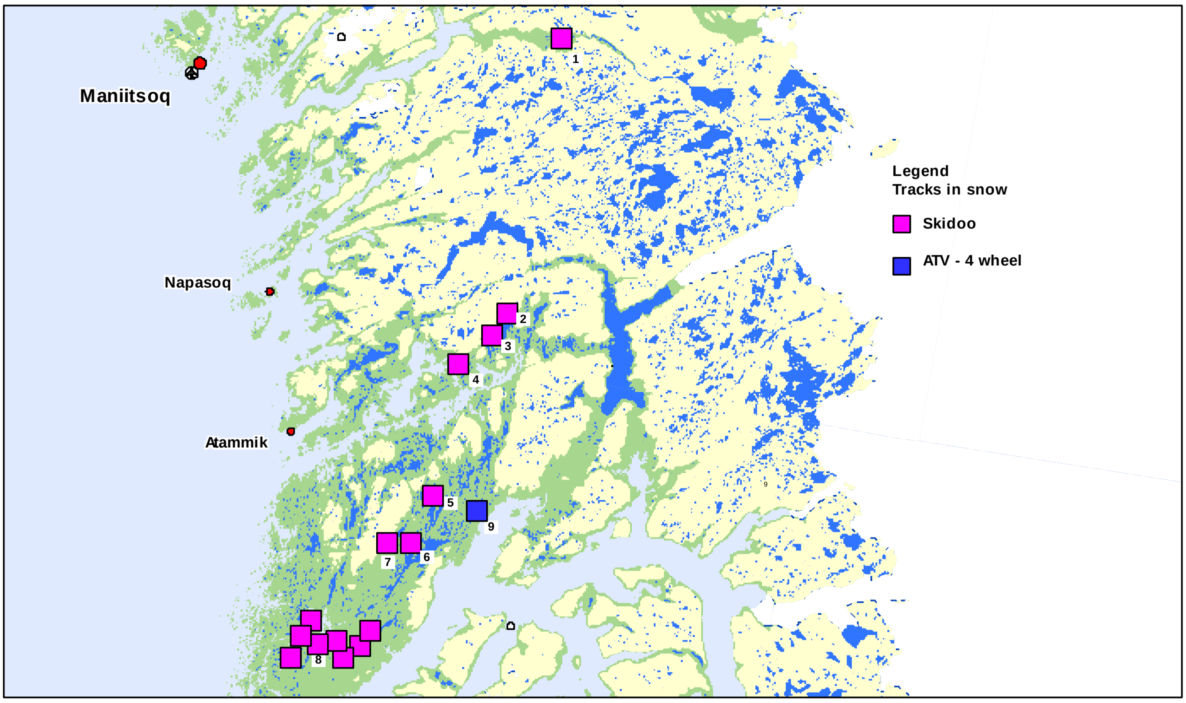


***Figure 14.*** *Skidoo and ATV tracks observed while flying helicopter for caribou survey, Akia-Maniitsoq, Central region, 9-10 March 2010. The ATV's were set ashore on the northwest shore of Qugssuk Bay at Tatsûp Ataa. GPS positions given in order north to south are approximate and given in Degrees, minutes, seconds.*

1. *65°36′ 27.6″ N; 51°21′ 49.9″ W*
2. *65°05′ 43.4″ N; 51°21′ 38.4″ W*
3. *65°03′ 08.1″ N; 51°24′ 08.3″ W*
4. *64°59′ 16.0″ N; 51°31′ 32.3″ W*
5. *64°44′ 28.1″ N; 51°31′ 04.9″ W*
6. *64°38′ 59.1″ N; 51°34′ 11.1″ W*
7. *64°38′ 30.8″ N; 51°40′ 13.4″ W*
8. *64°26′ 47.8″ N; 51°48′ 00.7″ W*
9. *64°43′ 40.1″ N; 51°18′ 55.2″ W*

# *Discussion*

***Kangerlussuaq-Sisimiut population***

The KS caribou abundance appears to have been stable since 2005. At first glance the 2010 mean estimate is 9% higher than the 2005, however, the CI's are too wide on both to permit definite conclusions beyond that the KS is and has been at an extremely high density. The corrected pre-calving March 2010 Kangerlussuaq-Sisimiut population estimate is ca. 98,300 caribou (90% CI: 71,500 – 132,400). Given the often poor weather conditions, patchy snow cover, "salt & pepper" backgrounds, and "dead" ground, caribou may have gone undetected on the transects, which could make this a conservative estimate of KS abundance. This estimate is greater than any previous estimate for the KS population.

On primary winter range KS caribou density is almost 7 caribou per sq km, which is a rise from the 6 caribou per sq km observed in 2005. Although caribou could be numerous at specific localities and given the continued large population size, an increase in mean group size could be expected. However, the 2010 group size of 3 ±2 was less than the 2005, ca. 5 ±3 (Table 1). The 2010 maximum group size was again 17, similar to that observed on the 2000 and 2005 surveys. Although low, the 2010 calf percentage, 15%, and calf recruitment into the population, 28 calves per 100 cows, are better than in 2005 (Tables 1, 4, Figure 15) when they were 11% and 16 respectively. Regardless, today's late winter recruitment is far below the 48 to 68 calves per 100 cows of a decade ago. We are concerned, because at the current very high density of 7 caribou per sq km on core winter range, density dependant effects may express themselves (Miller et al. 2005). For example, natural mortality can increase while growth and fecundity decline, and severe stochastic weather events can reduce recruitment with negative consequences for population stability (Skogland 1985).

Given that the North region is ca. 26,000 sq km, if the recommended density of 1.2 caribou per sq km was attained, then an appropriate KS population size might be ca. 31,200 caribou. The 2010 estimate exceeds this by ca. +67,000 caribou. Even if we assume the KS population is at the lower end of the CI 90%, i.e., 71,500, still this is more than 'double' what is assumed somewhat in balance with range carrying capacity for a sustainable caribou population.

Although annual harvest results per population are unavailable, the total numbers of caribou harvested in Greenland (Table 5) are low relative to the numbers required for KS population reduction even if all of the current harvest applied to just the KS caribou in the North region. Therefore, despite the large quotas in 2000-2001 followed by open harvests from 2002 through 2010 and long hunting seasons, hunting has not been sufficient to reduce the KS caribou population size. In fact, hunting has had no clear affect on KS abundance. This may be because the KS interior is inaccessible to the majority of hunters, and of course that is where the caribou are (Figure 6). The result is that most caribou are out of the range of hunters. After almost a decade of open harvests and long hunting seasons, one could expect that caribou have learned to avoid the coast and shorelines. Caribou numbers are extremely high, but hunters do not see them, with the results that too few animals are harvested.

***Akia-Maniitsoq population***

The AM caribou population appears to be in decline. The raw pre-calving March 2010 estimate is ca. 24,000 caribou (CV = 0.18). This estimate is ca. 11,800 animals less than the 2005 survey estimate, and ½ that of the 2001 survey. Similar to KS results, this AM estimate may be considered a conservative estimate owing to the negative bias of caribou missed as a result of poor light, patchy snow cover, "salt & pepper" backgrounds and "dead" ground. (Note: the 2010 *corrected* AM estimate is not used. It is wrong because an incorrect correction factor inflated the result.)

The AM population abundance estimate has decreased by almost 50% since their first helicopter survey in 2001, when numbers were ca. 46,200 (Table 5). Still it remains higher than recommended. Given that the Central region is ca. 15,362 sq km, if the recommended density of 1.2 caribou per sq km was attained then a suitable population size for the range available might be ca. 18,400 caribou. The 2010 AM caribou population estimate exceeds this by ca. 5,600 caribou. In 2001, caribou density on core winter range was four-times the recommended target density, in 2005 was three-times, and in 2010 is approaching the recommended target. The trend is declining numbers of caribou. Hunting is not assumed the primary cause, because the AM interior is relatively inaccessible to hunters, a situation reminiscent of the KS interior, making harvests insufficient, despite the great numbers of hunters, who are well equipped with modern technology and able to patrol large distances of coast and fjord shorelines in speed boats. For several years now there have been unusually long warm autumns lacking frost or snow, without which the caribou remain in the high elevations far from the lowlands or shorelines and therefore beyond the range of hunters.

The decline in the AM population could be an expression of density dependant affects, which arise from intra-specific competition, i.e. between individuals in the same population, when density is high on limited range (Miller et al. 2005). Typical direct effects increase mortality, while delayed effects affect growth and fecundity

(Skogland 1985). The latter is supported by the poor bull to cow ratio in 2010 (Table 4), and additionally by the poor late winter calf recruitment observed in both 2005 and 2010. Density dependant factors may now be playing a major role in the population dynamics of the AM herd.

***Akia-Maniitsoq – Satellite collared cows: capture-mark-recapture estimates***
Extra estimates of abundance were calculated for the AM caribou population based on the observations (recapture) of satellite collared cows using capture-mark-recapture analysis. With 14 collared cows at the time of the March 2010 survey the mark-recapture-estimate varied from 1900 (95% CI: ±1700) to 4400 (95% CI: ±2900) dependent respectively upon the number of caribou observed only on transects, or the total number of caribou seen. If there were 24 collared cows at the time of our survey, then the result was from 3200 (95% CI: ±2900) to 7400 (95% CI: ±5300). Several problems, however, may confound these results and render them unreliable. The random transects of this survey were not designed to deal with capture-mark-recapture data. Although the survey transects are randomly allocated sighting of collared cows was not random. The collared caribou cows were not collared randomly as regards the total Central region. Cows did not have an equal probability of 'recapture' (of being observed) during the aerial survey, because cows do not move randomly in the entire terrain, but will exhibit site fidelity (Cuyler & Linnell, 2004). Also, there was an unusual clumped and large aggregation of caribou present in the Narssarssuaq Valley area. Therefore we flew intensively in this area for herd structure data, and several of the collared caribous where also captured in those areas the year before. The limited and uneven geographical area sampled would thus likely bias the mark-recapture estimate downwards relative to the size of the entire herd. That we observed three of the collared cows in the Narssarssuaq Valley area and fourth next door in Ilulialik Bay supports this and the result may seriously underestimate the population abundance. Given that several core assumptions for capture-mark-recapture analysis are broken and that estimates themselves differ widely, we conclude that this analysis is unsuitable and therefore do not accept the estimates.

***Recruitment***
We consider the current late winter calf recruitment results low for both the KS and AM caribou (28 and 23 respectively) for three reasons. First because calf recruitment was substantially higher before, e.g., the 1998-2000 KS values were 48 to 65 calves per 100 cows respectively, while the 1998 AM value was 65 calves per 100 cows (Figure 15). Secondly, in West Greenland there are no large predators to erode calf numbers. Thirdly, herd studies from North America and Scandinavia report late winter recruitments of 41 calves per 100 cows (Fancy et al. 1994), 20 calves per 100

cows (Dzus 1999) and 22 calves per 100 cows (Parker 1972), and these populations have predators. Further a comparison to the Southampton Island herd, which like Greenland has no predators, shows late winter recruitments varying between 22 and 77 calves per 100 cows (Heard & Ouellet 1994), with 22 considered low.

Poor calf recruitment in the absence of predators suggests an elevated natural mortality among calves and a decreased fecundity of adult females. Independent of climate and genetics, caribou calf mortality increases with high population density and grazing pressure (Valkenburg et al. 2000). Calf recruitment can also be low and variable where winter ranges are overgrazed, or when snow conditions are hard or deep (Heggberget et al. 2002). Snow depth is negligible in the KS dry steppe climate of the North region's inland, which is where winter caribou density is highest. While analysis of current fecundity is pending, we know that high caribou density raises faeces pathogen contamination of the KS summer feeding areas resulting in high calf mortality (Clausen et al. 1980, Thing & Clausen 1980). On the AM winter range, snow depth can be +70cm and snow coverage almost complete. Given the high KS and AM caribou density for the past decade or more, we assume winter ranges are overgrazed and trampled to some extent. The poor calf recruitment supports this. With little replacement occurring in both populations there will be fewer individuals in the next generations. If recruitment does not match mortality then population numbers will decline.

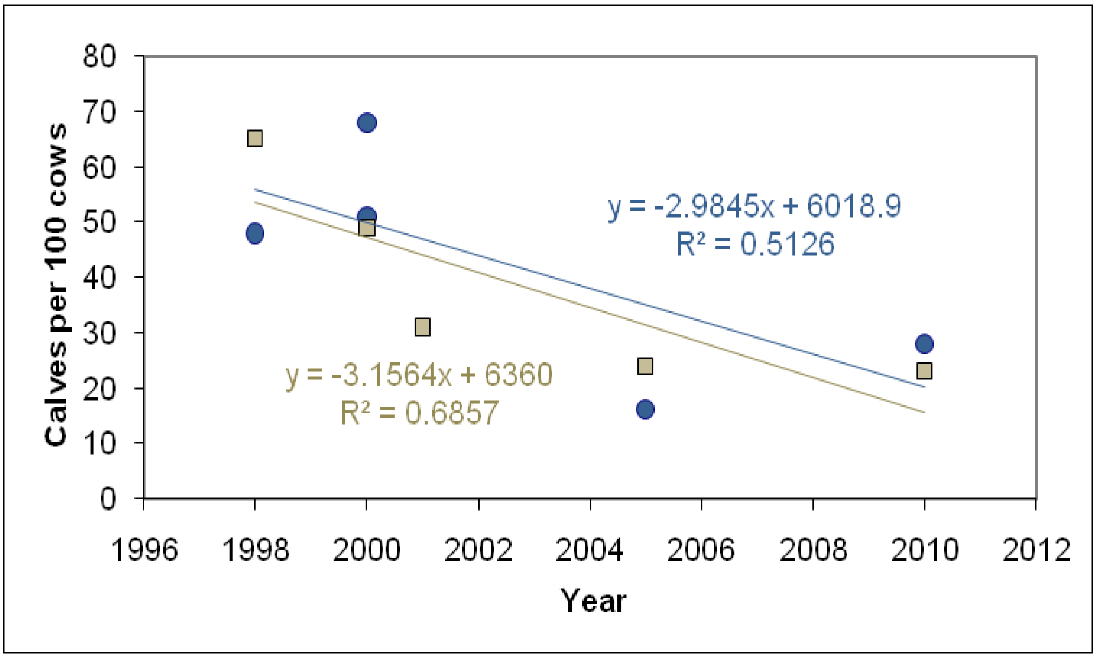


***Figure 15.*** *Late winter (March) calf recruitment for the Kangerlussuaq-Sisimiut (●, p = 0.2) and Akia-Maniitsoq (■, p = 0.08) caribou populations between 1998 and 2010.*

*Bull to Cow ratio*

Although the late winter 2010 bull to cow ratio for KS caribou at 0.54 was fine, the AM ratio was low, 0.38, the lowest recorded for this population. Further, it appears that the AM bull to cow ratio has declined steadily since 1998 (Table 1, Figure 16). We are concerned by this trend. Male skewed harvesting is not suspected as the cause. From 1995 to 1998, the reported harvest was 90% male (Loison et al. 2000), however, the harvest quotas at that time were negligible compared with the total populations. Further, since 2000 the harvest of cows has typically equalled or exceeded males following the Greenland Institute of Natural Resources recommendations for more females (Witting & Cuyler In Press). Post-mating mortality among males may increase when environmental conditions are adverse and population density high, because male rut activity compromises survival by reducing food intake and body condition, e.g., fat reserves, which may not be recovered over the following winter even if winter forage is unlimited (Barboza et al., 2004). We have no reason to suspect environmental conditions, therefore the slow decline in the AM bull to cow ratio suggests that the AM caribou density, although itself declining and now only ca. 1.6 caribou per sq km, is still too high for the current carrying capacity of their range, which condition likely continues to deteriorate. A skewed sex ratio doesn't necessarily limit female reproduction in a polygynous species like caribou (Skogland 1989); however, further skewing of the sex ratio may risk the dynamics and genetics of this population (Ryman et al. 1981, Ginsberg & Milner-Gulland 1994).

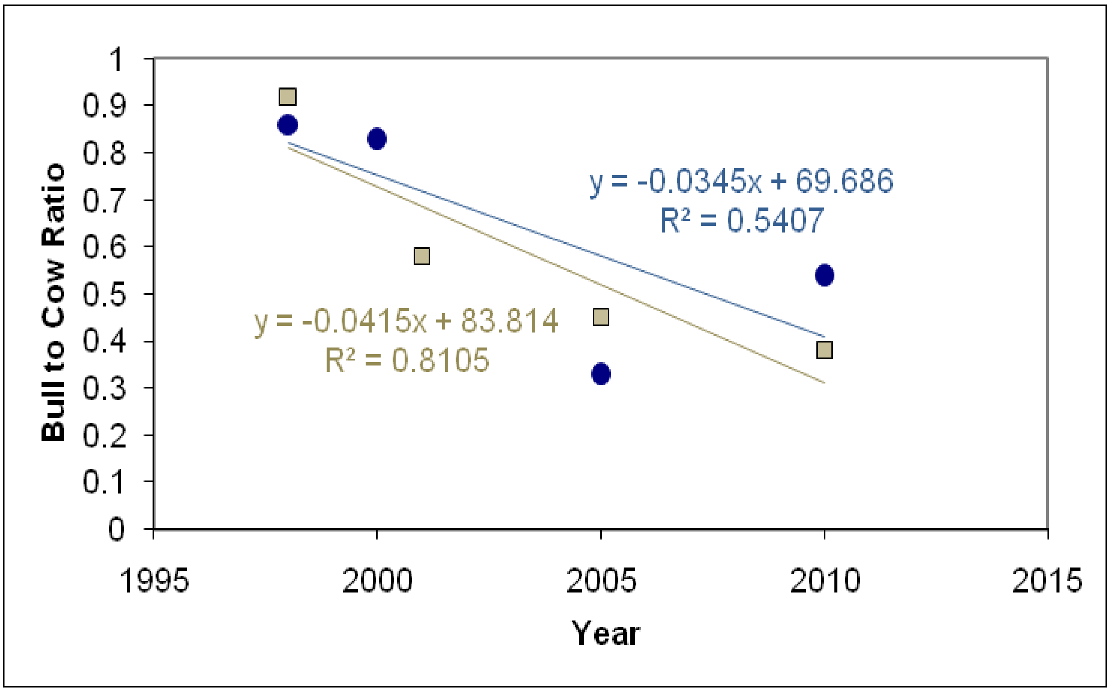


***Figure 16.*** *Late winter (March) bull to cow ratio for the Kangerlussuaq-Sisimiut (●, p = 0.3) and Akia-Maniitsoq (■, p = 0.1) caribou populations between 1998 and 2010.*

### *Annual natural mortality*

Given the general life expectancy of 10 to 12 years (Loison et al. 2000, Cuyler & Østergaard 2005), natural mortality for West Greenland caribou in the 1990's was ca. 8-10%. Stochastic events notwithstanding using a 8-10% natural mortality and 2010 population estimates, results in an expected natural mortality of ca. 7,900 to 9,800 KS caribou each year in the North region. Given KS calf percentages in 2005 and 2010 have been 11% to 15% and the 2010 abundance suggests a stable or marginally increasing population, then the assumed 8-10% annual natural mortality of 8-10,000 animals may describe relatively accurately the annual natural mortality.

Similarly for the Central region, there is an expected natural mortality of ca. 1,900 to 2,400 AM caribou annually. Given the AM calf percentage in 2005 and 2010 has been 14%, and the 2010 abundance suggests a declining population, then the assumed 8-10% annual natural mortality may be too low, or harvests higher than reported.

### *Management implications*

*Caribou overabundance*

Since 1721, natural cycles in abundance of West Greenland caribou have been recorded and twice caribou were almost non-existent (Meldgaard 1986). Scarcity was always preceded by a long period of hyper-abundance. Population estimates (Table 5) suggest that caribou abundance in West Greenland has been over 100,000 animals since 2000. A summary of known harvest statistics (Table 6, Figure 17) suggests that high numbers of caribou may have reached much further into the past, perhaps even back to the 1970's when harvests were often as high as in recent years. Today, there remain far too many KS caribou relative to their range area. To a much lesser extent the same applies to AM caribou. As with previous surveys, once again in 2010 the advised density target, 1.2 caribou per sq km, was not achieved. Optimal herd size was exceeded, and for the KS greatly exceeded. Although our knowledge of carrying capacity on West Greenland ranges remains imperfect, poor calf recruitment and the low AM sex ratio strongly indicate that the range has been overused (Miller et al. 2005). The continued over-abundance of the KS and AM caribou is not likely to promote rejuvenation and regeneration of forage on the range. It is unknown how long current caribou numbers can be supported by what forage remains on the limited range available. The better bull to cow ratio for KS caribou relative to the poor AM ratio, despite much higher KS caribou density, suggests that the KS range can support a higher density of caribou than the AM range. Regardless, we do not assume that the high densities of the past decade are sustainable in the years to come.

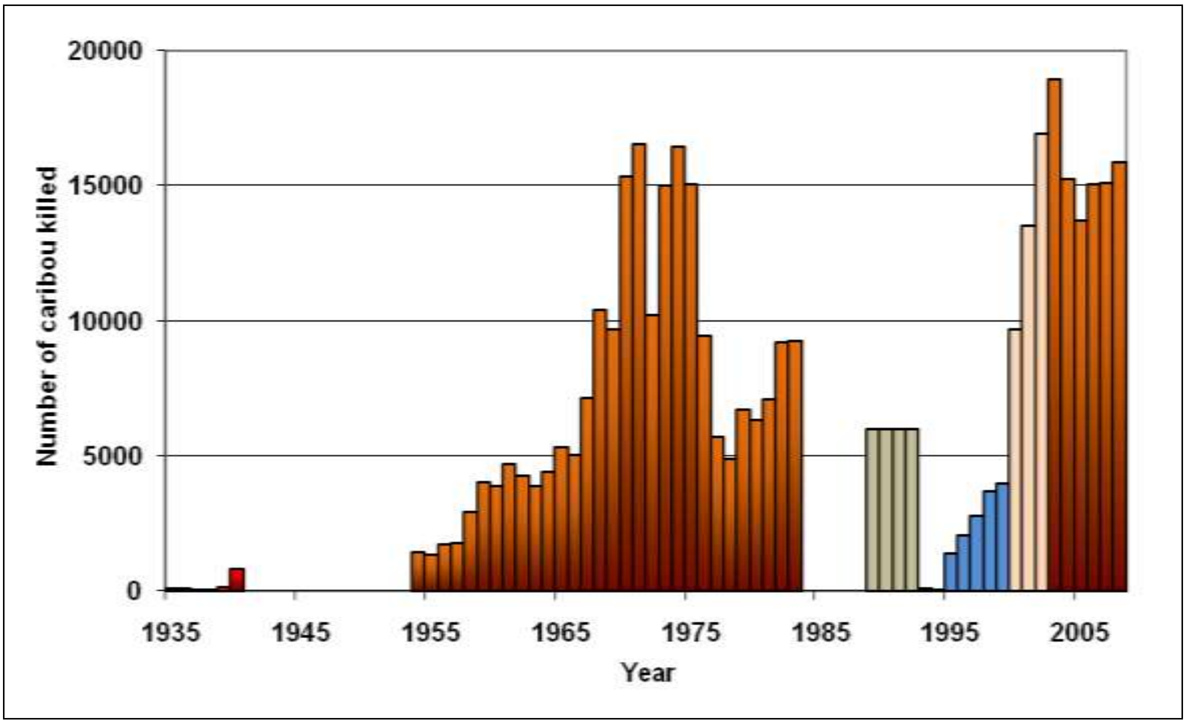


***Figure 17.*** *The total reported caribou harvests in Greenland from 1935 to 2008: Open harvest (■), assumed harvest 1989-1992 (■) (Peter Nielsen pers comm.), restricted quota harvest (■), large quota harvests (■). No records were kept from 1979 to 1995. Hunting was prohibited in 1993 and 1994. Minimal harvest prior to the late 1950's coincided with caribou scarcity. (Anon: Grønlands fangstlister, Piniarneq).*

We can expect that ranges destroyed by overgrazing and trampling eventually result in a decline in caribou number, which may be slow or abrupt depending on circumstances (Miller et al. 2005). For example, density dependent effects can result in slow declines, in contrast to severe stochastic weather events, which can cause abrupt crashes. Freuchen (1911), Degerbøl (1957), Vibe (1967), Roby et al. (1984) and Meldgaard (1986) all recognized the major role of climate and stochastic weather events in reducing caribou number in Greenland. Where the quality and quantity of caribou forage is poor and worsening, then those populations are increasingly vulnerable to catastrophic weather events, which can seriously limit forage availability. One widespread acute thaw-refreeze icing or extreme deep snow event can precipitously and dramatically decimate caribou number across all age classes (Miller 1990, Jacobsen & Wegener 1995). If this happens to the AM or KS herd it will be poor consolation for today's hunters that caribou numbers have always recovered in the past, because it takes the better part of a century to do so (Vibe 1967, Meldgaard 1986).

***Table 5.*** *Population estimates and minimum counts of wild caribou / reindeer in Greenland, given in order from north to south. All population size estimates are approximate[1].*

| Caribou / Reindeer Population | Region No. | Region Name | 1977 / 78 | 1993 | 1994 | 1995 | 1996 | 1999 | 2000 | 2001 | 2002 | 2005 | 2006 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | - |
| Qeqertarsuatsiaat | 5 | South | - | | | | | - | - | 5,372 | - | - | 5,224 | - |
| 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]** | - | - | - | - |

[1]Estimates from 2000 to 2010 were obtained using survey methods and design unlike those employed from 1993 to 1999. Therefore herd size differences between these two time periods are not assumed readily comparable.
[2] Rough sum of population estimates from 1999, 2000 and 2001.
[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 herd for the time period 2000-2005.
* Minimum counts.
Sources: Ydeman & Pedersen 1999, Linnell et al. 2000, Landa et al. 2000, Cuyler et al. 2002, 2003, 2004, 2005, 2007 and current study

Given climate change, there is a real chance of disastrous events occurring. The resilience of the AM and KS caribou populations will depend on those high quality individual animals that survive and able to reproduce, owing to their better body condition and fat reserves than those who die. Marked among-cow differences in quality of survival and reproduction were observed by Weladji et al. (2008). These high quality animals establish the foundation for a caribou recovery following crashes in abundance. The resilience of the AM population may be less than the KS, because of the poor AM sex ratio, i.e., risks to genetics and population dynamics, which could compound the usual negative effects of catastrophic stochastic weather events.

***Table 6.*** *Greenland caribou population estimates, harvest quotas, reported harvest and the percentage by which the quota was filled: Harvest records are from "Piniarneq 2011" published by the Ministry of Fisheries, Hunting & Agriculture, Imaneq 4, P.O. Box 269, 3900 - Nuuk, Greenland.*

| Year | Estimate of total caribou in Greenland | Quota | Reported Harvest (Piniarneq) | Amount of quota filled |
|---|---|---|---|---|
| 1995 | ca. 18,000 | 2,000 | 1,398 | 69.9% |
| 1996 | ca. 22,000 | 2,600 | 2,048 | 78.8% |
| 1997 | | 3,111 | 2,755 | 88.6% |
| 1998 | | 3,680 | 3,692 | 100.3% |
| 1999 | | 4,050 | 3,957 | 97.7% |
| 2000 | | 13,600 | 9,671 | 71.1% |
| 2001 | ca. 140,000 | 24,300 | 13,490 | 55.5% |
| 2002 | | 36,150* | 16,901 | 52.3% |
| 2003 | | Open | 18,951 | - |
| 2004 | | Open | 15,226 | - |
| 2005 | | Open | 13,719 | - |
| 2006 | | Open | 15,057 | - |
| 2007 | | Open | 15,092 | - |
| 2008 | | Open | 15,872 | - |
| 2009 | | Open | Not yet available** | - |

* The 2002 harvest quota was originally set at 32,150 caribou; however, the number of licences permitted exceeded that number by 4,000.

** The 2009 is expected to be similar to harvests since 2001.

Increasing development and industry is another factor affecting caribou, specifically on the once relatively pristine habitat of the AM herd. Substantial increases in infrastructure (e.g., roads, power transmission lines, pipelines, mines, ports and landing strips), creating greater human access and disturbance, as well as fragmentation of the landscape can be expected. Their negative effects on caribou populations in other countries have been widely documented.

Modelling the interaction between caribou and their forage / range as well as the cumulative effects of climate, industrial development and hunter harvest, would give us a better understanding of the current situation and where the West Greenland caribou populations are headed.

*Hunting caribou by skidoo – Pros?*

The past and current high density and abundance of the AM and KS caribou are not likely sustainable under any natural conditions. The majority of AM and KS caribou are primarily distributed in the inaccessible interiors during winter. Local knowledge says this is also true for summer and autumn. Harvesting by hunters can be an effective tool for reducing caribou abundance if the caribou are accessible, as has occurred in the Ameralik caribou population of the South Region (Witting & Cuyler In Press), which topography and indented coastline bring animals close to shorelines. At present, AM and KS caribou harvests are insufficient to reduce population number because on foot it is impossible to reach the majority of animals. The result is the perception among hunters that caribou are few today.

Raising hunter access to caribou would change their perception of caribou numbers and increase harvests. Motorized vehicles, however, are generally prohibited in the terrain beyond the cities and settlements, and require written permission from the Greenland government (Hjemmestyret 1999, 2000). Only commercial hunters are allowed a winter caribou season. Their access to, and harvest of, caribou would be increased if transport by skidoo was approved. Access to caribou by skidoo could promote an efficient effective reduction in AM and KS caribou numbers.

*Hunting caribou by skidoo – Cons?*

A management scheme permitting a winter skidoo harvest of caribou would require several important considerations. Hunters may oppose increasing harvests using skidoos. Skidoo & ATV's disrupted normal winter distribution of the AM caribou. For the first time in 2010, we observed extensive skidoo use over the Akia-Nordlandet area, which is preferred winter range of the AM population (Cuyler & Linnell 2004). Although hunting caribou from skidoo is prohibited (Hjemmestyret 1999b), we received reports that a full-time hunter harvested many caribou by skidoo in the Akia-Nordlandet area during the winter 2010. In contrast to the AM surveys of 2001 and 2005, in 2010 we observed few caribou on this winter range. Instead, incredible numbers and large aggregations of caribou were observed in the adjacent and less 'skidoo' accessible Narssarssuaq Valley. We propose that this skidoo and ATV hunting activity was the principle cause behind the abnormal clumped distribution of AM caribou observed in March 2010. Caribou appeared to have been driven away from their preferred range and crowded into adjacent habitat where their densities could create intra-specific competition for food. If faced with severe stochastic winter weather events, under such conditions the resilience of the AM population could suffer. Further, a clumped caribou distribution jeopardises the abundance surveys as they are presently designed. Our surveys are based upon the normally even distribution of small groups of caribou throughout the high-density stratum. If large aggregations occur and escape the few random transects, this can create problems when estimating abundance.

Skidoo hunting would likely increase the negative energy budget of caribou in winter. We assume skidoo hunting would disrupt the amount of time spent foraging and ruminating by caribou. This would further reduce already low winter food intake and lower the digestibility of what is consumed. Energy uptake would decrease further than observed. Considerable skidoo hunting would substantially increase caribou activity energy costs. The excessive and negative impacts on body condition, fecundity and survival of the remaining caribou are undesirable.

The declining AM population makes difficult the management use of winter skidoo harvesting. If herd size were to suddenly drop in response to a catastrophic weather event or perhaps just unfavourable trends, skidoo hunting could worsen that situation, postponing a future population recovery. Furthermore, the majority of caribou taken in a hunter harvest are likely the most resilient and reproductively valuable individuals, i.e., males and females in their prime, rather than the young, sick or old. Population resilience depends on sex and age structures that favour abundance recovery. Thus because hunters take high quality animals the effect on the entire herd could be greater than the total harvested would suggest.

Current prohibition of skidoo use in the terrain pertains only to the former municipalities of Upernavik, Uummannaq, Sisimiut, Kangerlussuaq and Maniitsoq (Hjemmestyret 1999a, 2000). What is permissible in Nuuk, Ilulissat, Qaanaaq, Paamiut, and Syd- & Østgrønland, is left in question. Still, hunting or transporting caribou by skidoo is illegal everywhere in Greenland (Hjemmestyret 1999b). The government may give dispensation to specific individuals or group for one year at a time (Hjemmestyret 1999a). If the government permits skidoo hunting for caribou in one or more regions, what is to prevent the Greenland populace from assuming that skidoo hunting is allowed in all regions, including species other than caribou? What is to prevent people from assuming skidoo hunting, or just skidoo travel, is permitted for everyone everywhere anytime, and that first obtaining dispensation from NNPAN (*Departementet for Indenrigsanliggender, Natur & Miljø)* is no longer needed to drive a skidoo in the Greenland terrain? It is easy to imagine skidoo hunting evolving into a gigantic management headache.

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# *Appendix 1*

## *Region Stratification & Transect Allocation*

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

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

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

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

Once a simulation was done, the resulting data was analyzed using standard parametric methods, and a confidence interval found. The procedure was repeated for different total numbers of transects. The data was then plotted by taking all the confidence intervals, centering these on their common mean and plotting them against the total number of transects (Figure 18).

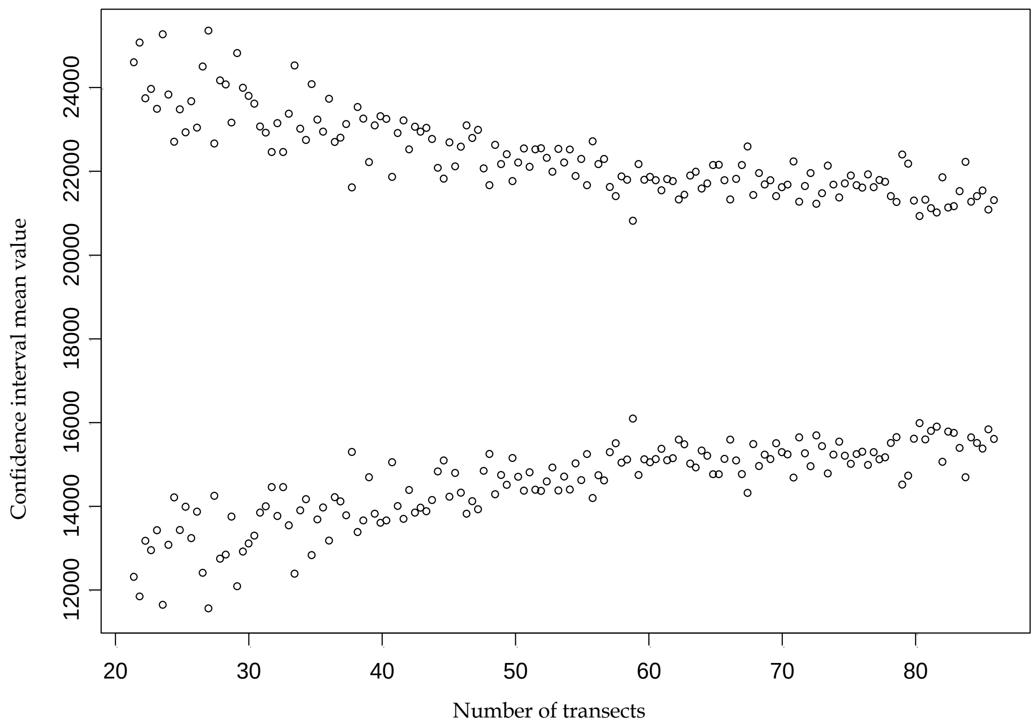


*__Figure 18.__ How many transect lines needed for a relatively accurate and precise survey of the Central region? Simulation of confidence interval mean values versus the number of transects used.*

From the graph it is obvious that an effort smaller than 40 lines will result in a wide confidence interval, whereas a number larger than 60 will be a waste of resources. Note that the picture here is slightly misleading since it takes into account only the width of the confidence interval around the grand mean of the estimates. In reality the means will jump around less for higher sample sizes. For economic reasons the final number of transect lines in 2005, and again in 2010, was set to 54 for the Akia-Maniitsoq herd in the Central region, while 60 transects were again applied for the Kangerlussuaq-Sisimiut herd in the North region.

*Transect allocation*

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

If : $A_i$ is the area of strata i

$d_i$ is the expected density of strata i

then the best allocation is proportional to

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

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

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

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

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

The allocation assumed that the relative densities remained unchanged since last survey of 1996. The stratification was not the same as in the last survey, but was altered based on the observed densities in 1996. The Central and North regions were divided into two strata, a high and low-density strata. On the basis of the above mentioned formulas, in 2005, and again in 2010, the Central region was allocated 15 transects to the low-density area and 39 transects to the high-density area. Similarly the North region was allocated 20 transects to the low-density area and 40 transects to the high-density area.

# Appendix 2

***Survey field method and statistical design***

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

*Field methods – Reducing negative bias: Sightability / Detectability of caribou on transect*

To reduce the negative bias associated with violation of the assumption that all caribou within the strip are observed, the following survey field methods were used.

- Narrow strip width, 300x2 metres,
- Slow flying speed, ca. 46-65 kilometre/hour,
- Low altitudes, 15 metres,
- Sun typically behind observers,
- Short transect length, 7.5 kilometres (better concentration & reduced fatigue),
- Statistical correction for missed caribou.

*Statistical design*

Caribou population estimates can be calculated as follows:

For each stratum we have:

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

Where

$\hat{N}_j$ is the estimated total in the $j^{th}$ strata

$y_i$ is the total number of caribou observed in strip $i$

$A_j$ is the total area of strata $j$

$A_i$ is the area of strip $i$

$\bar{A}$ is the mean area of the strips in the stratum

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

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

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

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

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

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

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

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

# *Appendix 3*

***Increasing the accuracy of aerial counts of caribou in western Greenland.***

Most aerial surveys of animal abundance are negatively biased because animals within the sample unit are overlooked by observers. Various doublecount methods have been developed to generate survey specific correction factors. However, these methods require that observations can be attributed to specific individuals or groups, which is not always possible. We present a simple method for generating a minimum estimate of the number of overlooked animals based on the total number of animals seen by double observers on one side of the aircraft. In addition, we describe aspects of survey design that have been used in caribou *Rangifer tarandus* surveys in West Greenland to further reduce bias.

The extent to which animals are overlooked can be influenced by many factors such as aircraft design, flying speed, flight height, light conditions, vegetation density, topographic complexity, and observer experience/fatigue (Caughley 1974, Samuel et al. 1987, Aastrup & Mosbech 1993). Early attempts to correct for this bias focused on determining a factor from a series of controlled trials, and using this as a blanket correction factor for all further surveys (Caughley 1974, Caughley et al. 1976, Samuel et al. 1987, Pollock & Kendall 1987, Aastrup & Mosbech 1993). However, because conditions vary from survey to survey there have been attempts to develop survey-specific correction factors, especially using the doublecount methodology (Pollock & Kendall 1987, Graham & Bell 1989, Rivest et al. 1995, 1998). In this process, at least one side of the aircraft has two observers. Using the numbers of animals or groups seen by the first observer only, the second observer only, or by both observers it is possible to apply capture-mark-recapture methodology to calculate the number of animals seen by neither observer (Pollock & Kendall 1987). However, this requires that observations from the two observers can be attributed specifically to each animal or group observed. While such results may be achieved using double-track tape recorders (Marsh & Sinclair 1989) or GPS/data logger technology, there are always situations whereby technology fails, is unavailable or cannot be applied practically. We present an extension of the normal doublecount statistics to estimate the correction factor for the proportion of animals unseen using the total number of animals counted by each observer within a given sample strip. In many ways this is similar to the aims of Caughley & Grice (1982), but is designed for species that occur at a higher density.

*Accounting for overlooked animals*

In the cases where there are more than one observer in one side of the aircraft and it is possible to know which animals have been seen or not seen by each observer, it is possible to estimate the probability that a visible animal has been observed. The method is thoroughly discussed in Pollock & Kendall (1987) and will be slightly elaborated upon here. We will use the following nomenclature similar to the one used by Graham & Bell (1989).

$B$ is the number of animals observed by both observers
$S_f$ is the number of animals observed by the front seat observer only
$S_r$ is the number of animals seen by the rear seat observer only
$M$ is the number of animals not seen by either observer
$p_f$ is the probability that a visible animal is seen by the front seat observer
$p_r$ is the probability that a visible animal is seen by the rear seat observer
N is the total number of visible animals in the transects

Then $N = S_f + S_r + B + M$

In a conventional doublecount setup where animals or groups can be individually identified for comparison between observers the following procedure is often used:

B can be estimated as $E(B) = p_f \cdot p_r \cdot N$

Therefore $N = \frac{E(B)}{p_f \cdot p_r}$

In the same manner $S_f$ can be estimated as

$E(S_f) = p_f \cdot (1 - p_r) \cdot N$

By substitution

$$E(S_f) = p_f \cdot (1 - p_r) \cdot \frac{E(B)}{p_f \cdot p_r}$$

$$E(S_f) = (1 - p_r) \cdot \frac{E(B)}{p_r}$$

$$E(S_f) \cdot p_r = E(B) - E(B) \cdot p_r$$

$$(E(S_f) + E(B)) \cdot p_r = E(B)$$

$$p_r = \frac{E(B)}{E(B) + E(S_f)}$$

In the same manner $p_f$ can be estimated as

$$p_f = \frac{E(B)}{E(B)+E(S_r)}$$

Thereby the proportion of animals overlooked by both the front and the rear seat observer is

$$(1-p_f)\cdot(1-p_r)$$

Therefore, the number of observed animals in the left side of the helicopter should be multiplied with

$$\frac{1}{1-(1-p_f)\cdot(1-p_r)} = \frac{1}{1-(1-\frac{B}{B+S_r})\cdot(1-\frac{B}{B+S_f})} = \frac{(B+S_f)\cdot(B+S_r)}{B\cdot(B+S_f+S_r)}$$

or equivalently

$$\hat{N} = (B+S_f+S_r)\cdot\frac{(B+S_f)\cdot(B+S_r)}{B\cdot(B+S_f+S_r)} = \frac{(B+S_f)\cdot(B+S_r)}{B}$$

And, under the assumption that the left and right rear seat observers have the same probability of observing a visible animal, the right side observations should be multiplied by

$$\frac{1}{p_r} = \frac{B+S_f}{B}$$

This method does not take into account the variance in the estimates of $p_f$ and $p_r$. The easiest way to find confidence intervals is to use a bootstrap procedure (Effron & Tibshirani 1993).

The estimates of $p_f$ and $p_r$ are equivalent to the Petersen estimate. Although this estimate is biased, the bias can be eliminated using Chapman's correction.

$$\hat{N}_{left} = \frac{(B+S_f+1)\cdot(B+S_r+1)}{B+1} - 1$$ (Graham & Bell 1989)

Then $\frac{\hat{N}}{S_r+B}$ will be an estimate of $\frac{1}{p_r}$

Hence the estimate of the number of animals on the right side of the aircraft is

$$\hat{N}_{right} = S_{right} \cdot \frac{(B + S_f + 1) \cdot (B + S_r + 1) - (B + 1)}{(B + 1) \cdot (S_r + B)}$$

However, if we don't know which specific animals or groups have been seen by each observer but have the total number of animals observed within each strip for each observer, then we can calculate maximum values for $p_f$ and $p_r$

If for each strip $i$

$f_i$ is the number of animals seen by the observer in the front seat

$r_i$ is the number of animals seen by the rear seat observer

Then we can define

$$B^* = \sum_i Min(f_i, r_i)$$
$$S_f^* = \sum_i Max(0, f_i - r_i)$$
$$S_r^* = \sum_i Max(0, r_i - f_i)$$

and observe that

$$B^* \geq p_f \cdot p_r \cdot N$$
$$S_f^* \leq p_f \cdot (1 - p_r) \cdot N$$
$$S_r^* \leq p_r \cdot (1 - p_f) \cdot N$$

leading to

$$N \leq \frac{B^*}{p_f \cdot p_r}$$

and

$$S_f^* \leq p_f \cdot (1 - p_r) \cdot N \leq p_f \cdot (1 - p_r) \cdot \frac{B^*}{p_f \cdot p_r}$$

$$p_r \leq \frac{B^*}{B^* + S_f^*}$$

Similarly

$$p_f \leq \frac{B^*}{B^* + S_r^*}$$

Since we here are dealing with maximum values of $p_f$ and $p_r$ the corresponding values for overlooked animals will be minimum values. Accordingly the corrected values for the number of animals seen will still be negatively biased. As this methodology gives a lower bound of the probability of observing a visible animal it is instructive to simulate some observations in order to gauge the effectiveness of the method.

Since we are assuming that for each transect line the number seen by both observers is equal to the lowest number seen, it would be reasonable to assume that the method works best for small observation numbers and large observation probabilities. This assumption can be tested using a simulation study. In this simulation a number of virtual surveys were set up, each with 100 transect strips. For each assumed level of detection probability (0.6; 0.7; 0.8; 0.9) a mean number of animals per strip was chosen between 1 and 10. The number of animals on each transect strip was chosen as a Poisson random variable. The number of animals seen by each observer was then chosen as a binomial random variable. The resulting estimates of the sighting probabilities were then plotted against the mean number of animals per strip. As expected (Figure 19) the estimated detection probabilities tended to be too high, particularly when the number of animals per strip is high.

*Reducing bias through survey design*

The overriding concern with the survey design has been to minimise the number of overlooked animals by flying closer to the ground and concentrating the effort in a narrow strip close to the aircraft. In addition, observer fatigue was minimised by flying many short transect strips, rather than fewer longer strips. It is possible to evaluate the effectiveness of the different experimental protocols by comparing $p_f$ and $p_r$ between years. In addition, it is instructive to see how large a difference accounting for overlooked animals makes in each case (Table 7).

In the 2000 survey (with the higher flight altitude and wider strip) for the Kangerlussuaq-Sisimiut region (Cuyler et al. 2002) there was still a large bias that needed to be corrected. In contrast, the 2001 surveys (lower altitude, narrower strip)

(Cuyler et al. 2003) in the other three regions resulted in a much smaller bias (Table 7).

*Discussion*

The above example clearly supports a wealth of previous studies and demonstrates that failing to take overlooked animals into account during aerial surveys will produce an underestimate (inaccurate) of true population size. While we appear to have been able to reduce bias through improved survey design (lower flight altitude, narrower strip) our methodology provides a simple procedure to establish a survey specific correction factor provided that double observers are available for at least one side of the aircraft. Our approach does not require that observations by the double observers can be attributed to specific groups and is therefore suitable to situations where the technology for such cross-referencing does not exist, or where it is difficult to attribute animals to specific groups.

When our experience is taken together with the experience reported in the scientific literature it would appear that the aerial surveys performed in the 1993-96 period (Linnell et al. 2000) produced severe underestimates of population size. The use of a fixed-wing aircraft rather than helicopter, higher flying speeds and altitudes, wider strip widths and longer transects are all likely to increase the proportion of overlooked animals. In addition their analysis failed to correct for uncounted animals. The resulting conflict over caribou management in Greenland (Linnell et al. 2000) shows the importance of addressing bias in aerial surveys.

Even after applying our correction methodology, the resulting estimate is still an underestimate of true population size. This is because (1) we assume maximum values of $p_f$ and $p_r$ and (2) there will always be animals that are present in the strip but are hidden from both observers by vegetation or topography, i.e. they have a null sighting probability. This effect is most likely to be pronounced in forested areas (Samuel et al. 1987, Rivest et al. 1998). Even though our surveys all occurred on treeless tundra, the topographic complexity may have obscured some caribou from both observers, especially at the lower flying altitudes. The statistical approach presented by Rivest et al. (1998) offers one potential approach to account for the issue should further experiments show that the effect is substantial.

*__Table 7.__ Results of the caribou surveys conducted in four regions of western Greenland (2000-2001), highlighting the differences in sighting probability by the double observers, the effect that correcting for visibility bias has on the estimated population size and the effect of reducing flying height and strip width.*

| Area | Kangerlussuaq-Sisimiut | Akia | Ameralik | Qeqertarsuatsiaat |
|---|---|---|---|---|
| Altitude | 100 m | 17 m | 17 m | 17 m |
| Strip width | 1,000 m | 600 m | 600 m | 600 m |
| $P_f$ | 0.94 | 0.89 | 0.88 | 0.89 |
| $P_r$ | 0.68 | 0.85 | 0.92 | 0.82 |
| 80% CI uncorrected | 36,000-52,800 | 35,000-51,700 | 23,300-37,900 | 2,800-7,900 |
| 80% CI corrected | 42,700-61,500 | 37,000-55,800 | 24,700-39,300 | 2,900-8,200 |

Data from Cuyler et al. 2002, 2003.

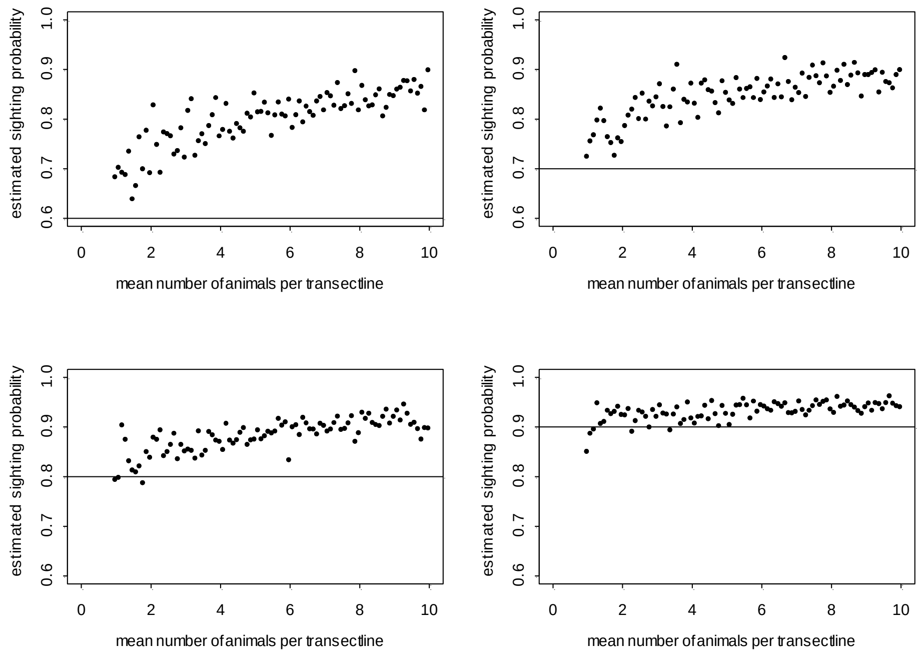


*__Figure 19.__ Simulations of the effects of number of animals encountered per transect strip on the estimated sighting probability (bias adjustment) at four different levels of detection probability (the horizontal line at 0.6, 0.7, 0.8 and 0.9).*

# *Appendix 4*

*Aerial survey 2010 Kangerlussuaq-Sisimiut caribou, North region, West Greenland*

***Table 8.*** *Raw data aerial survey Kangerlussuaq-Sisimiut caribou herd, North region, March 2010. observers: Christine Cuyler (CC), Rink Heinrich (RH), & Hans Mølgaard (HM).*

| Date ddmmyy | Transect number | Density Stratum | Number Caribou observed on transect | | | Rear Seat Observers | |
|---|---|---|---|---|---|---|---|
| | | | Left front (CC) | Left rear | Right rear | Left | Right |
| 03-Mar-10 | 152 | High | 3 | 2 | 8 | RH | HM |
| 03-Mar-10 | 73 | High | 16 | 16 | 5 | RH | HM |
| 03-Mar-10 | 116 | High | 14 | 15 | 15 | RH | HM |
| 03-Mar-10 | 183 | High | 1 | 1 | 6 | RH | HM |
| 03-Mar-10 | 10 | High | 15 | 19 | 2 | RH | HM |
| 03-Mar-10 | 34 | High | 20 | 13 | 15 | RH | HM |
| 03-Mar-10 | 200 | High | 3 | 1 | 4 | RH | HM |
| 03-Mar-10 | 211 | High | 7 | 7 | 7 | RH | HM |
| 03-Mar-10 | 175 | High | 11 | 4 | 2 | RH | HM |
| 03-Mar-10 | 24 | High | 2 | 2 | 2 | RH | HM |
| 03-Mar-10 | 125 | Low | 31 | 33 | 4 | RH | HM |
| 03-Mar-10 | 32 | Low | 0 | 0 | 3 | RH | HM |
| 03-Mar-10 | 8 | Low | 14 | 14 | 4 | RH | HM |
| 04-Mar-10 | 153 | High | 4 | 4 | 2 | RH | HM |
| 04-Mar-10 | 9 | High | 19 | 19 | 6 | RH | HM |
| 04-Mar-10 | 59 | High | 4 | 4 | 5 | RH | HM |
| 04-Mar-10 | 70 | High | 4 | 4 | 3 | RH | HM |
| 04-Mar-10 | 142 | High | 6 | 6 | 7 | RH | HM |
| 04-Mar-10 | 192 | High | 8 | 8 | 7 | RH | HM |
| 04-Mar-10 | 106 | High | 3 | 5 | 6 | RH | HM |
| 04-Mar-10 | 58 | High | 2 | 2 | 11 | RH | HM |
| 04-Mar-10 | 36 | High | 22 | 24 | 19 | HM | RH |
| 04-Mar-10 | 137 | High | 6 | 6 | 12 | HM | RH |
| 05-Mar-10 | 149 | High | 34 | 34 | 49 | HM | RH |
| 05-Mar-10 | 197 | High | 38 | 38 | 9 | HM | RH |
| 05-Mar-10 | 189 | High | 17 | 17 | 14 | HM | RH |
| 05-Mar-10 | 112 | High | 31 | 31 | 67 | HM | RH |
| 05-Mar-10 | 210 | High | 71 | 71 | 68 | HM | RH |
| 05-Mar-10 | 209 | High | 25 | 25 | 4 | HM | RH |
| 05-Mar-10 | 65 | High | 4 | 4 | 3 | HM | RH |
| 05-Mar-10 | 172 | High | 3 | 3 | 0 | HM | RH |
| 05-Mar-10 | 92 | High | 56 | 56 | 55 | HM | RH |
| 06-Mar-10 | 63 | High | 9 | 9 | 10 | HM | RH |
| 06-Mar-10 | 154 | High | 13 | 13 | 9 | HM | RH |
| 06-Mar-10 | 104 | High | 29 | 29 | 25 | HM | RH |
| 06-Mar-10 | 122 | High | 1 | 1 | 5 | RH | HM |
| 06-Mar-10 | 76 | High | 3 | 3 | 0 | RH | HM |
| 06-Mar-10 | 115 | High | 5 | 5 | 6 | RH | HM |
| 06-Mar-10 | 202 | High | 16 | 16 | 4 | RH | HM |
| 06-Mar-10 | 203 | High | 14 | 14 | 58 | RH | HM |
| 06-Mar-10 | 193 | High | 21 | 21 | 68 | RH | HM |
| 06-Mar-10 | 120 | High | 0 | 0 | 17 | RH | HM |
| 06-Mar-10 | 29 | Low | 0 | 0 | 0 | RH | HM |
| 06-Mar-10 | 87 | Low | 0 | 0 | 0 | HM | RH |
| 06-Mar-10 | 143 | Low | 7 | 7 | 2 | HM | RH |
| 06-Mar-10 | 139 | High | 14 | 14 | 19 | HM | RH |
| 08-Mar-10 | 155 | Low | fog | fog | fog | HM | RH |
| 08-Mar-10 | 47 | Low | 5 | 5 | 0 | HM | RH |
| 08-Mar-10 | 101 | Low | 0 | 0 | 0 | HM | RH |
| 08-Mar-10 | 113 | Low | 0 | 0 | 0 | HM | RH |
| 08-Mar-10 | 161 | Low | 0 | 0 | 0 | HM | RH |
| 08-Mar-10 | 151 | Low | 46 | 46 | 28 | HM | RH |
| 08-Mar-10 | 27 | Low | 7 | 7 | 5 | HM | RH |
| 08-Mar-10 | 77 | Low | 3 | 3 | 5 | HM | RH |
| 08-Mar-10 | 64 | Low | 16 | 16 | 6 | HM | RH |
| 08-Mar-10 | 158 | Low | 11 | 11 | 0 | RH | HM |
| 08-Mar-10 | 150 | Low | 4 | 4 | 2 | RH | HM |
| 08-Mar-10 | 5 | Low | 0 | 0 | 0 | RH | HM |
| 08-Mar-10 | 135 | Low | 1 | 1 | 0 | RH | HM |
| 08-Mar-10 | 61 | Low | 0 | 0 | 6 | RH | HM |
| | | **TOTAL** | **1429** (730 left side + 699 right side) | | | | |

***Table 9.*** *Random transects for aerial survey Kangerlussuaq-Sisimiut caribou herd, North region, March 2010.*

| Date ddmmyy | Direction flown | Transect number | Transect start DD mm.m | | Transect end DD mm.m | |
|---|---|---|---|---|---|---|
| | | | Latitude | Longitude | Latitude | Longitude |
| 08-Mar-10 | W-E | 5 | 66º 30.3' | 50º 24.5' | 66º 28.9' | 50º 34.0' |
| 03-Mar-10 | SE-NW | 8 | 66º 44.4' | 50º 20.4' | 66º 46.5' | 50º 29.2' |
| 04-Mar-10 | SW-NE | 9 | 67º 13.0' | 50º 20.4' | 67º 16.4' | 50º 14.4' |
| 03-Mar-10 | SE-NW | 10 | 66º 59.1' | 51º 12.8' | 67º 01.9' | 51º 20.3' |
| 03-Mar-10 | WSW-ENE | 24 | 66º 56.9' | 51º 19.6' | 66º 55.0' | 51º 28.7' |
| 08-Mar-10 | SW-NE | 27 | 66º 35.0' | 52º 14.4' | 66º 33.1' | 52º 23.3' |
| 06-Mar-10 | ENE-WSW | 29 | 67º 26.8' | 52º 59.0' | 67º 28.5' | 52º 49.3' |
| 03-Mar-10 | SE-NW | 32 | 66º 51.7' | 49º 56.0' | 66º 55.1' | 50º 01.7' |
| 03-Mar-10 | SW-NE | 34 | 67º 02.3' | 51º 17.5' | 67º 06.2' | 51º 14.3' |
| 04-Mar-10 | S-N | 36 | 67º 14.2' | 51º 05.3' | 67º 10.5' | 51º 01.3' |
| 08-Mar-10 | ESE-WNW | 47 | 67º 01.5' | 53º 31.1' | 67º 02.4' | 53º 41.2' |
| 04-Mar-10 | NE-SW | 58 | 67º 15.3' | 50º 51.3' | 67º 16.9' | 50º 41.8' |
| 04-Mar-10 | SW-NE | 59 | 67º 17.2' | 49º 59.5' | 67º 20.5' | 49º 53.3' |
| 08-Mar-10 | SE-NW | 61 | 66º 39.4' | 50º 37.2' | 66º 42.1' | 50º 44.8' |
| 06-Mar-10 | SE-NW | 63 | 67º 39.3' | 50º 11.7' | 67º 41.5' | 50º 20.7' |
| 08-Mar-10 | NW-SE | 64 | 66º 36.6' | 51º 53.9' | 66º 36.6' | 51º 43.7' |
| 05-Mar-10 | NE-SW | 65 | 67º 33.1' | 51º 36.5' | 67º 36.5' | 51º 30.4' |
| 04-Mar-10 | SE-NW | 70 | 67º 21.9' | 50º 09.6' | 67º 24.9' | 50º 16.6' |
| 03-Mar-10 | ESE-WNW | 73 | 67º 09.9' | 50º 25.6' | 67º 09.2' | 50º 15.4' |
| 06-Mar-10 | W-E | 76 | 67º 30.7' | 51º 52.5' | 67º 34.1' | 51º 47.2' |
| 08-Mar-10 | SW-NE | 77 | 66º 47.1' | 51º 52.8' | 66º 43.7' | 51º 58.3' |
| 06-Mar-10 | S-N | 87 | 67º 18.8' | 53º 01.6' | 67º 22.6' | 53º 05.2' |
| 05-Mar-10 | SW-NE | 92 | 67º 29.2' | 51º 14.7' | 67º 26.8' | 51º 23.2' |
| 08-Mar-10 | SSE-NNW | 101 | 66º 21.0' | 53º 26.8' | 66º 24.6' | 53º 31.4' |
| 06-Mar-10 | SE-NW | 104 | 67º 40.9' | 50º 45.4' | 67º 42.6' | 50º 55.0' |
| 04-Mar-10 | NE-SW | 106 | 67º 22.4' | 50º 42.1' | 67º 18.6' | 50º 46.3' |
| 05-Mar-10 | S-N | 112 | 67º 27.4' | 51º 06.0' | 67º 31.4' | 51º 08.2' |
| 08-Mar-10 | SE-NW | 113 | 66º 33.7' | 53º 08.1' | 66º 36.6' | 53º 15.1' |
| 06-Mar-10 | SE-NW | 115 | 67º 35.1' | 51º 47.6' | 67º 38.0' | 51º 55.0' |
| 03-Mar-10 | SW-NE | 116 | 67º 04.4' | 50º 44.9' | 67º 08.2' | 50º 41.7' |
| 06-Mar-10 | NNW-SSE | 120 | 67º 27.1' | 52º 33.1' | 67º 30.9' | 52º 36.6' |
| 06-Mar-10 | SSE-NNW | 122 | 67º 26.2' | 52º 09.4' | 67º 22.8' | 52º 03.8' |
| 03-Mar-10 | W-E | 125 | 66º 56.3' | 50º 35.8' | 66º 55.9' | 50º 25.5' |
| 08-Mar-10 | S-N | 135 | 66º 34.5' | 50º 32.9' | 66º 38.5' | 50º 34.3' |
| 04-Mar-10 | SW-NE | 137 | 67º 13.2' | 51º 15.0' | 67º 17.1' | 51º 12.5' |
| 06-Mar-10 | SSE-NNW | 139 | 67º 23.2' | 52º 20.7' | 67º 19.9' | 52º 14.9' |
| 04-Mar-10 | NW-SE | 142 | 67º 18.6' | 50º 10.2' | 67º 21.5' | 50º 17.4' |
| 06-Mar-10 | SSE-NNW | 143 | 67º 20.4' | 52º 38.9' | 67º 17.0' | 52º 33.2' |
| 05-Mar-10 | E-W | 149 | 67º 17.7' | 51º 02.7' | 67º 17.7' | 50º 52.2' |
| 08-Mar-10 | W-E | 150 | 66º 30.9' | 50º 49.8' | 66º 31.0' | 50º 59.9' |
| 08-Mar-10 | SSW-NNE | 151 | 66º 38.6' | 52º 34.9' | 66º 42.5' | 52º 31.9' |
| 03-Mar-10 | WSW-ENE | 152 | 67º 04.3' | 50º 41.5' | 67º 06.2' | 50º 32.3' |
| 04-Mar-10 | SW-NE | 153 | 67º 13.2' | 50º 33.2' | 67º 16.8' | 50º 28.2' |
| 06-Mar-10 | S-N | 154 | 67º 41.9' | 50º 32.8' | 67º 45.8' | 50º 35.2' |
| 08-Mar-10 | ENE-WSW | 155 | 67º 22.9' | 53º 37.2' | 67º 24.8' | 53º 27.9' |
| 08-Mar-10 | SW-NE | 158 | 66º 34.4' | 51º 26.5' | 66º 37.8' | 51º 21.0' |
| 08-Mar-10 | SSW-NNE | 161 | 66º 36.5' | 52º 56.1' | 66º 40.3' | 52º 52.3' |
| 05-Mar-10 | NW-SE | 172 | 67º 30.5' | 51º 43.6' | 67º 28.7' | 51º 34.1' |
| 03-Mar-10 | WSW-ENE | 175 | 66º 48.3' | 51º 44.0' | 66º 49.6' | 51º 34.3' |
| 03-Mar-10 | ENE-WSW | 183 | 67º 01.1' | 51º 08.6' | 67º 02.2' | 50º 58.6' |
| 05-Mar-10 | SE-NW | 189 | 67º 25.4' | 50º 49.5' | 67º 27.2' | 50º 58.9' |
| 04-Mar-10 | SE-NW | 192 | 67º 21.4' | 50º 30.8' | 67º 25.5' | 50º 34.3' |
| 06-Mar-10 | SW-NE | 193 | 67º 32.3' | 52º 27.0' | 67º 34.7' | 52º 18.5' |
| 05-Mar-10 | SE-NW | 197 | 67º 21.8' | 50º 51.6' | 67º 24.3' | 50º 59.8' |
| 03-Mar-10 | SE-NW | 200 | 67º 04.9' | 51º 22.7' | 67º 06.4' | 51º 32.4' |
| 06-Mar-10 | NW-SE | 202 | 67º 35.5' | 52º 00.8' | 67º 32.4' | 51º 54.0' |
| 06-Mar-10 | SW-NE | 203 | 67º 31.2' | 52º 22.1' | 67º 27.3' | 52º 24.4' |
| 05-Mar-10 | NE-SW | 209 | 67º 34.6' | 51º 22.8' | 67º 37.9' | 51º 16.4' |
| 05-Mar-10 | SSW-NNE | 210 | 67º 34.3' | 51º 11.7' | 67º 38.3' | 51º 10.7' |
| 03-Mar-10 | SE-NW | 211 | 67º 11.6' | 51º 30.9' | 67º 14.2' | 51º 38.9' |

.

***Table 10.*** *Raw data aerial survey herd structure Kangerlussuaq-Sisimiut caribou herd, North region, March 2010.*

| Date ddmmyy | Grid Cell | Transect # | Group Size | Unknown Sex / Age | Bull (>1 year) | Cow (>1 year) | Calves (<1 year) |
|---|---|---|---|---|---|---|---|
| 03-Mar-10 | | 24 | 2 | | 0 | 2 | |
| 03-Mar-10 | | 24 | 2 | | 0 | 1 | 1 |
| 03-Mar-10 | | 175 | 4 | | 0 | 3 | 1 |
| 03-Mar-10 | | 175 | 4 | | 0 | 4 | |
| 03-Mar-10 | Y-20 | | 3 | | 0 | 2 | 1 |
| 03-Mar-10 | Y-20 | | 2 | | 1 | 1 | |
| 03-Mar-10 | AA-20 | | 4 | | 4 | 0 | |
| 03-Mar-10 | AB-19 | | 2 | | 2 | 0 | |
| 03-Mar-10 | | 125 | 2 | | 0 | 1 | 1 |
| 03-Mar-10 | | 125 | 4 | | 0 | 3 | 1 |
| 03-Mar-10 | AI-23 | | 1 | | 0 | 0 | 1 |
| 03-Mar-10 | AK-24 | | 1 | | 0 | 1 | |
| 03-Mar-10 | AK-24 | | 2 | | 0 | 1 | 1 |
| 03-Mar-10 | AG-26 | | 3 | | 1 | 2 | 0 |
| 03-Mar-10 | | 8 | 1 | | 0 | 1 | 0 |
| 03-Mar-10 | | 8 | 5 | | 0 | 5 | 0 |
| 03-Mar-10 | | 8 | 3 | | 0 | 3 | 0 |
| 03-Mar-10 | | 8 | 5 | | 0 | 5 | 0 |
| 03-Mar-10 | AD-25 | | 2 | | 0 | 2 | |
| 03-Mar-10 | AD-25 | | 3 | | 0 | 3 | |
| 03-Mar-10 | AD-24 | | 4 | | 0 | 3 | 1 |
| 03-Mar-10 | AD-24 | | 2 | | 0 | 2 | |
| 03-Mar-10 | AD-24 | | 1 | | 0 | 1 | |
| 03-Mar-10 | AD-24 | | 2 | | 2 | 0 | |
| 03-Mar-10 | AD-24 | | 5 | | 3 | 2 | |
| 03-Mar-10 | AC-24 | | 2 | | 1 | 1 | |
| 03-Mar-10 | AC-23 | | 1 | | 1 | 0 | |
| 03-Mar-10 | AA-23 | | 4 | | 4 | 0 | |
| 03-Mar-10 | AH-23 | | 2 | 2 | 0 | 0 | |
| 03-Mar-10 | AD-20 | | 4 | 4 | 0 | 0 | |
| 03-Mar-10 | AD-20 | | 2 | 2 | 0 | 0 | |
| 03-Mar-10 | T-20 | | 7 | 7 | 0 | 0 | |
| 03-Mar-10 | T-18 | | 3 | 3 | 0 | 0 | |
| 03-Mar-10 | W-34 | | 2 | | 0 | 1 | 1 |
| 03-Mar-10 | Z-22 | | 2 | | 2 | 0 | |
| 04-Mar-10 | AC-19 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AD-18 | | 2 | | 2 | 0 | |
| 04-Mar-10 | AD-17 | | 3 | | 3 | 0 | |
| 04-Mar-10 | AD-16 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AD-16 | | 3 | | 1 | 2 | |
| 04-Mar-10 | AD-15 | | 11 | | 2 | 6 | 3 |
| 04-Mar-10 | | 153 | 1 | | 0 | 1 | |
| 04-Mar-10 | | 153 | 2 | | 0 | 2 | |
| 04-Mar-10 | | 153 | 1 | | 0 | 0 | 1 |
| 04-Mar-10 | AF-14 | | 4 | | 0 | 4 | |
| 04-Mar-10 | AF-14 | | 1 | | 0 | 1 | |
| 04-Mar-10 | AF-14 | | 6 | | 1 | 3 | 2 |
| 04-Mar-10 | AF-14 | | 3 | | 3 | 0 | |
| 04-Mar-10 | AF-14 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AF-14 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AF-14 | | 3 | | 3 | 0 | |
| 04-Mar-10 | AF-13 | | 3 | | 3 | 0 | |
| 04-Mar-10 | AF-13 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AE-14 | | 5 | 5 | 0 | 0 | |
| 04-Mar-10 | AE-14 | | 7 | 7 | 0 | 0 | |
| 04-Mar-10 | AF-15 | | 4 | 4 | 0 | 0 | |
| 04-Mar-10 | AF-15 | | 3 | | 3 | 0 | |
| 04-Mar-10 | | 9 | 4 | | 3 | 1 | |
| 04-Mar-10 | | 9 | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | | 9 | 2 | | 0 | 2 | |
| 04-Mar-10 | | 9 | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | | 9 | 4 | | 1 | 0 | 1 |
| 04-Mar-10 | | 9 | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | | 9 | 1 | | 0 | 1 | |
| 04-Mar-10 | AG-13 | | 4 | | 2 | 1 | |
| 04-Mar-10 | AG-13 | | 2 | | 0 | 2 | |
| 04-Mar-10 | AH-13 | | 2 | | 0 | 0 | 2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 04-Mar-10 | AH-13 | | 2 | | 0 | 2 | |
| 04-Mar-10 | AI-14 | | 4 | | 2 | 1 | 1 |
| 04-Mar-10 | AI-14 | | 2 | | 0 | 2 | |
| 04-Mar-10 | AI-14 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AI-14 | | 3 | | 3 | 0 | |
| 04-Mar-10 | | 59 | 4 | | 0 | 3 | 1 |
| 04-Mar-10 | AI-12 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AI-12 | | 3 | | 0 | 3 | |
| 04-Mar-10 | AI-12 | | 2 | | 0 | 2 | |
| 04-Mar-10 | AI-12 | | 8 | | 2 | 5 | 1 |
| 04-Mar-10 | | 70 | 4 | | 2 | 2 | |
| 04-Mar-10 | AG-10 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AG-11 | | 4 | | 1 | 3 | |
| 04-Mar-10 | AG-11 | | 4 | | 4 | 0 | |
| 04-Mar-10 | AG-11 | | 2 | | 1 | 1 | |
| 04-Mar-10 | AG-11 | | 3 | | 1 | 2 | |
| 04-Mar-10 | AG-11 | | 3 | | 0 | 3 | |
| 04-Mar-10 | AG-11 | | 1 | | 0 | 1 | |
| 04-Mar-10 | AG-11 | | 4 | | 1 | 3 | |
| 04-Mar-10 | AG-11 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AG-11 | | 4 | | 2 | 2 | |
| 04-Mar-10 | AG-11 | | 1 | | 0 | 1 | |
| 04-Mar-10 | | 142 | 6 | | 0 | 5 | 1 |
| 04-Mar-10 | AF-12 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AF-12 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AF-12 | | 1 | | 0 | 1 | |
| 04-Mar-10 | AF-12 | | 4 | | 1 | 3 | |
| 04-Mar-10 | AF-12 | | 5 | | 2 | 3 | |
| 04-Mar-10 | AE-12 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AE-12 | | 12 | | 4 | 8 | |
| 04-Mar-10 | AE-12 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AE-12 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AE-12 | | 10 | | 2 | 7 | 1 |
| 04-Mar-10 | AE-12 | | 9 | | 4 | 4 | 1 |
| 04-Mar-10 | AE-12 | | 7 | | 1 | 5 | 1 |
| 04-Mar-10 | | 192 | 5 | | 1 | 4 | |
| 04-Mar-10 | AD-11 | | 2 | | 0 | 2 | |
| 04-Mar-10 | AD-11 | | 2 | | 1 | 1 | |
| 04-Mar-10 | AD-11 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AD-11 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AC-12 | 106 | 1 | | 1 | 0 | |
| 04-Mar-10 | AC-12 | 106 | 2 | | 0 | 2 | |
| 04-Mar-10 | AB-14 | 58 | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AB-14 | 58 | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AB-14 | | 3 | | 3 | 0 | |
| 04-Mar-10 | AB-14 | | 4 | | 1 | 2 | 1 |
| 04-Mar-10 | AC-19 | | 3 | | 0 | 1 | 2 |
| 04-Mar-10 | AC-19 | | 4 | | 1 | 2 | 1 |
| 04-Mar-10 | AC-18 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AB-17 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AB-17 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AA-17 | | 6 | | 2 | 4 | |
| 04-Mar-10 | AA-18 | | 2 | | 2 | 0 | |
| 04-Mar-10 | X-18 | | 3 | | 0 | 3 | |
| 04-Mar-10 | X-18 | | 6 | | 0 | 6 | |
| 04-Mar-10 | X-18 | | 3 | | 0 | 3 | |
| 04-Mar-10 | Y-17 | | 1 | | 1 | 0 | |
| 04-Mar-10 | Y-17 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | Y-17 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | Y-17 | | 4 | | 1 | 2 | 1 |
| 04-Mar-10 | Y-17 | | 9 | | 0 | 8 | |
| 04-Mar-10 | Y-17 | | 2 | | 2 | 0 | |
| 04-Mar-10 | Y-17 | | 4 | | 0 | 4 | |
| 04-Mar-10 | Z-16 | | 3 | | 3 | 0 | |
| 04-Mar-10 | AA-15 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AA-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | AA-15 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AA-15 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | Z-15 | 36 | 1 | | 0 | 0 | 1 |
| 04-Mar-10 | Z-15 | 36 | 1 | | 1 | 0 | |
| 04-Mar-10 | Z-15 | 36 | 2 | | 2 | 0 | |
| 04-Mar-10 | Z-15 | 36 | 2 | | 0 | 1 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 04-Mar-10 | Z-15 | 36 | 2 | | 0 | 2 | |
| 04-Mar-10 | Z-15 | | 5 | | 0 | 5 | |
| 04-Mar-10 | Z-15 | | 4 | | 0 | 3 | 1 |
| 04-Mar-10 | Z-15 | | 6 | | 1 | 4 | 1 |
| 04-Mar-10 | Z-15 | | 6 | | 5 | 1 | |
| 04-Mar-10 | Z-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | Z-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | Z-15 | | 1 | | 1 | 0 | |
| 04-Mar-10 | Z-15 | | 5 | | 1 | 4 | |
| 04-Mar-10 | Z-15 | | 2 | | 0 | 2 | |
| 04-Mar-10 | Y-15 | | 2 | | 0 | 2 | |
| 04-Mar-10 | Y-15 | | 2 | | 0 | 2 | |
| 04-Mar-10 | Y-15 | | 13 | | 0 | 10 | 3 |
| 04-Mar-10 | Y-15 | | 5 | | 1 | 4 | |
| 04-Mar-10 | Y-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | | 137 | 1 | | 0 | 1 | |
| 04-Mar-10 | X-15 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | X-15 | | 3 | | 0 | 1 | 2 |
| 04-Mar-10 | X-15 | | 2 | | 0 | 0 | 2 |
| 04-Mar-10 | X-15 | | 3 | | 0 | 3 | |
| 04-Mar-10 | X-15 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | X-15 | | 3 | | 3 | 0 | |
| 04-Mar-10 | X-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | X-15 | | 4 | | 2 | 2 | |
| 04-Mar-10 | X-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | X-15 | | 1 | | 0 | 1 | |
| 04-Mar-10 | X-15 | | 1 | | 1 | 0 | |
| 04-Mar-10 | X-16 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | X-16 | | 2 | | 2 | 0 | |
| 04-Mar-10 | X-16 | | 4 | | 3 | 1 | |
| 04-Mar-10 | X-16 | | 1 | | 0 | 0 | 1 |
| 04-Mar-10 | Y-16 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | Y-16 | | 4 | | 2 | 2 | |
| 04-Mar-10 | Y-16 | | 3 | 3 | 0 | 0 | |
| 04-Mar-10 | Y-16 | | 3 | | 1 | 2 | |
| 04-Mar-10 | Y-16 | | 3 | | 0 | 3 | |
| 04-Mar-10 | Y-16 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | Y-16 | | 4 | | 0 | 1 | 1 |
| 04-Mar-10 | Y-16 | | 2 | | 0 | 2 | |
| 04-Mar-10 | Z-17 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | Z-17 | | 3 | | 0 | 3 | |
| 04-Mar-10 | Z-17 | | 1 | | 0 | 1 | |
| 04-Mar-10 | Z-17 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | Z-17 | | 4 | | 1 | 3 | |
| 04-Mar-10 | Z-17 | | 12 | | 3 | 9 | |
| 04-Mar-10 | Z-17 | | 5 | | 1 | 4 | |
| 04-Mar-10 | Z-17 | | 3 | | 1 | 1 | 1 |
| 04-Mar-10 | Z-17 | | 3 | | 1 | 1 | |
| 04-Mar-10 | Z-17 | | 4 | | 2 | 2 | |
| 04-Mar-10 | AA-17 | | 6 | | 4 | 2 | |
| 04-Mar-10 | AA-17 | | 2 | | 2 | 0 | |
| 04-Mar-10 | AA-17 | | 4 | | 1 | 3 | |
| 04-Mar-10 | AA-17 | | 1 | | 1 | 0 | |
| 04-Mar-10 | AA-17 | | 4 | | 2 | 1 | 1 |
| 04-Mar-10 | AA-17 | | 2 | | 0 | 1 | 1 |
| 04-Mar-10 | AA-17 | | 6 | | 1 | 3 | 2 |
| 04-Mar-10 | AA-17 | | 2 | | 0 | 2 | |
| 04-Mar-10 | AA-17 | | 3 | | 2 | 1 | |
| 04-Mar-10 | AA-17 | | 4 | | 2 | 2 | |
| 04-Mar-10 | AA-17 | | 5 | | 2 | 3 | |
| 04-Mar-10 | AA-17 | | 5 | | 1 | 3 | 1 |
| 04-Mar-10 | AA-18 | | 5 | | 1 | 3 | 1 |
| 04-Mar-10 | AA-18 | | 5 | | 1 | 4 | |
| 04-Mar-10 | AA-18 | | 5 | | 3 | 1 | 1 |
| 04-Mar-10 | AB-18 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AB-18 | | 3 | | 0 | 2 | 1 |
| 04-Mar-10 | AB-18 | | 4 | | 0 | 3 | 1 |
| 05-Mar-10 | AB-19 | | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | AA-20 | | 4 | | 4 | 0 | |
| 05-Mar-10 | AB-17 | | 1 | | 1 | 0 | |
| 05-Mar-10 | | 149 | 3 | 3 | 0 | 0 | |
| 05-Mar-10 | Z-13 + AA-13 | | 13 | 13 | 0 | 0 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 05-Mar-10 | AB-12 | 197 | 5 | | 2 | 3 | |
| 05-Mar-10 | AA-11 | 197 | 1 | | 1 | 0 | |
| 05-Mar-10 | AA-11 | 197 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | AA-11 | 197 | 1 | | 0 | 1 | |
| 05-Mar-10 | AA-10 | | 5 | | 2 | 3 | |
| 05-Mar-10 | AA-10 | | 4 | | 2 | 2 | |
| 05-Mar-10 | AA-10 | | 1 | | 0 | 1 | |
| 05-Mar-10 | AA-10 | | 2 | | 1 | 1 | |
| 05-Mar-10 | AA-10 | | 1 | | 0 | 1 | |
| 05-Mar-10 | AA-10 | | 4 | | 2 | 1 | 1 |
| 05-Mar-10 | AA-10 | | 2 | | 2 | 0 | |
| 05-Mar-10 | AA-10 | | 1 | | 1 | 0 | |
| 05-Mar-10 | AB-10 | | 10 | | 3 | 6 | 1 |
| 05-Mar-10 | AB-10 | | 4 | | 2 | 2 | |
| 05-Mar-10 | AB-10 | | 3 | | 0 | 3 | |
| 05-Mar-10 | AB-10 | | 2 | | 0 | 2 | |
| 05-Mar-10 | | 189 | 3 | | 2 | 1 | |
| 05-Mar-10 | AA-9 | 189 | 2 | | 1 | 1 | |
| 05-Mar-10 | AA-9 | 189 | 5 | | 1 | 4 | |
| 05-Mar-10 | | 112 | 3 | | 2 | 1 | |
| 05-Mar-10 | | 112 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | | 112 | 3 | | 1 | 1 | 1 |
| 05-Mar-10 | | 112 | 3 | | 1 | 2 | |
| 05-Mar-10 | | 112 | 3 | | 0 | 2 | 1 |
| 05-Mar-10 | | 112 | 3 | | 1 | 1 | 1 |
| 05-Mar-10 | | 112 | 4 | | 0 | 4 | |
| 05-Mar-10 | Y-8 | | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | Y-8 | | 3 | | 3 | 0 | |
| 05-Mar-10 | Y-7 | | 6 | | 3 | 3 | |
| 05-Mar-10 | Y-7 | | 1 | | 1 | 0 | |
| 05-Mar-10 | Y-7 | | 3 | | 0 | 2 | 1 |
| 05-Mar-10 | Y-7 | | 1 | | 1 | 0 | |
| 05-Mar-10 | Y-7 | | 4 | | 2 | 2 | |
| 05-Mar-10 | Y-7 | | 6 | | 0 | 3 | 3 |
| 05-Mar-10 | | 210 | 1 | | 1 | 0 | |
| 05-Mar-10 | | 210 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | | 210 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | | 210 | 1 | | 1 | 0 | |
| 05-Mar-10 | X-6 | 209 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | X-6 | 209 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | X-6 | 209 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | W-7 | 209 | 4 | | 4 | 0 | |
| 05-Mar-10 | | 65 | 1 | | 1 | 0 | |
| 05-Mar-10 | | 65 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | | 65 | 2 | | 1 | 1 | |
| 05-Mar-10 | | 65 | 1 | | 1 | 0 | |
| 05-Mar-10 | | 65 | 1 | | 1 | 0 | |
| 05-Mar-10 | U-7 | | 4 | | 3 | 1 | |
| 05-Mar-10 | U-7 | | 6 | | 3 | 3 | |
| 05-Mar-10 | U-7 | | 4 | 4 | 0 | 0 | |
| 05-Mar-10 | U-7 | | 4 | | 2 | 2 | |
| 05-Mar-10 | U-8 | | 1 | | 0 | 1 | |
| 05-Mar-10 | U-8 | | 1 | | 0 | 1 | |
| 05-Mar-10 | V-9 | | 2 | | 0 | 2 | |
| 05-Mar-10 | V-9 | | 1 | | 0 | 1 | |
| 05-Mar-10 | W-9 | | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | W-9 | | 4 | | 0 | 3 | 1 |
| 05-Mar-10 | W-9 | | 1 | | 0 | 1 | |
| 05-Mar-10 | W-9 | | 1 | | 0 | 1 | |
| 05-Mar-10 | W-10 | | 6 | | 1 | 4 | 1 |
| 05-Mar-10 | W-10 | | 1 | | 0 | 1 | |
| 05-Mar-10 | | 92 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | | 92 | 2 | | 1 | 1 | |
| 05-Mar-10 | | 92 | 11 | | 1 | 10 | |
| 05-Mar-10 | | 92 | 2 | | 0 | 1 | 1 |
| 05-Mar-10 | | 92 | 5 | | 0 | 4 | 1 |
| 05-Mar-10 | | 92 | 5 | | 1 | 4 | |
| 05-Mar-10 | | 92 | 3 | | 0 | 3 | |
| 05-Mar-10 | X-9 | | 6 | | 1 | 5 | |
| 05-Mar-10 | X-9 | | 4 | | 0 | 3 | 1 |
| 05-Mar-10 | X-9 | | 1 | | 0 | 1 | |
| 05-Mar-10 | X-9 | | 4 | | 0 | 3 | 1 |

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|---|---|---|---|---|---|---|---|
| 05-Mar-10 | X-9 | | 5 | | 0 | 5 | |
| 05-Mar-10 | X-9 | | 3 | | 0 | 3 | |
| 05-Mar-10 | | 172 | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-14 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-14 | | 4 | | 2 | 1 | 1 |
| 06-Mar-10 | AB-14 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-14 | | 2 | | 2 | 0 | |
| 06-Mar-10 | AB-14 | | 2 | | 1 | 1 | |
| 06-Mar-10 | AB-14 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-14 | | 2 | | 0 | 2 | |
| 06-Mar-10 | AB-14 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-14 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AB-14 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-14 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-13 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AB-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AB-13 | | 3 | | 1 | 2 | |
| 06-Mar-10 | AB-13 | | 5 | | 1 | 3 | 1 |
| 06-Mar-10 | AB-13 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | AB-13 | | 2 | | 1 | 1 | |
| 06-Mar-10 | AB-12 | | 3 | | 2 | 0 | 1 |
| 06-Mar-10 | AB-12 | | 1 | | 0 | 0 | 1 |
| 06-Mar-10 | AA-12 | | 3 | | 1 | 2 | |
| 06-Mar-10 | AA-12 | | 3 | | 0 | 3 | |
| 06-Mar-10 | AA-12 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AA-12 | | 3 | | 0 | 3 | |
| 06-Mar-10 | AA-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AA-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AA-13 | | 3 | | 2 | 1 | |
| 06-Mar-10 | AA-13 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AA-13 | | 2 | | 0 | 2 | |
| 06-Mar-10 | AA-13 | | 4 | | 1 | 3 | |
| 06-Mar-10 | Z-13 | | 3 | | 0 | 3 | |
| 06-Mar-10 | Z-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Z-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Z-13 | | 3 | | 0 | 3 | |
| 06-Mar-10 | Y-13 | | 2 | | 0 | 2 | |
| 06-Mar-10 | Y-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-13 | | 3 | | 0 | 3 | |
| 06-Mar-10 | Y-13 | | 2 | | 1 | 1 | |
| 06-Mar-10 | Y-13 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | Y-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-13 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | Y-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | X-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | X-13 | | 2 | | 1 | 1 | |
| 06-Mar-10 | X-13 | | 1 | | 0 | 1 | |
| 06-Mar-10 | X-13 | | 2 | | 2 | 0 | |
| 06-Mar-10 | X-13 | | 2 | | 0 | 2 | |
| 06-Mar-10 | X-13 | | 4 | | 0 | 3 | 1 |
| 06-Mar-10 | X-13 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | X-13 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | X-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | X-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | X-13 | | 3 | | 3 | 0 | |
| 06-Mar-10 | X-13 | | 2 | | 2 | 0 | |
| 06-Mar-10 | X-12 | | 1 | | 0 | 0 | 1 |
| 06-Mar-10 | X-12 | | 1 | | 0 | 1 | |
| 06-Mar-10 | X-12 | | 1 | | 1 | 0 | |
| 06-Mar-10 | X-11 | | 1 | | 0 | 1 | |
| 06-Mar-10 | X-11 | | 3 | | 3 | 0 | |
| 06-Mar-10 | X-11 | | 4 | | 2 | 2 | |
| 06-Mar-10 | X-11 | | 4 | | 1 | 3 | |
| 06-Mar-10 | X-11 | | 3 | | 2 | 1 | |
| 06-Mar-10 | X-11 | | 2 | | 1 | 1 | |
| 06-Mar-10 | Y-11 | | 10 | | 5 | 5 | |
| 06-Mar-10 | Y-11 | | 7 | | 2 | 5 | |
| 06-Mar-10 | Y-11 | | 5 | | 0 | 3 | 2 |
| 06-Mar-10 | Y-12 | | 7 | | 2 | 5 | |

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|---|---|---|---|---|---|---|---|
| 06-Mar-10 | Y-12 | | 3 | | 2 | 1 | |
| 06-Mar-10 | Y-11 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-11 | | 2 | | 0 | 2 | |
| 06-Mar-10 | Y-11 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-11 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-11 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-11 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-11 | | 2 | | 2 | 0 | |
| 06-Mar-10 | Y-11 | | 6 | | 5 | 1 | |
| 06-Mar-10 | Y-11 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-11 | | 3 | | 3 | 0 | |
| 06-Mar-10 | Z-11 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | Z-11 | | 4 | | 0 | 4 | |
| 06-Mar-10 | Z-11 | | 7 | | 4 | 2 | 1 |
| 06-Mar-10 | Z-11 | | 2 | | 2 | 0 | |
| 06-Mar-10 | Z-11 | | 3 | | 3 | 0 | |
| 06-Mar-10 | Z-11 | | 6 | | 0 | 3 | 3 |
| 06-Mar-10 | Z-10 | | 4 | | 1 | 2 | 1 |
| 06-Mar-10 | Z-10 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Z-10 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Z-10 | | 4 | | 1 | 3 | |
| 06-Mar-10 | Z-10 | | 10 | | 5 | 4 | 1 |
| 06-Mar-10 | Z-10 | | 2 | | 2 | 0 | |
| 06-Mar-10 | Z-10 | | 4 | | 1 | 3 | |
| 06-Mar-10 | Z-10 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Z-10 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Z-10 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Z-10 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AA-10 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AA-10 | | 1 | | 0 | 1 | |
| 06-Mar-10 | AA-10 | | 1 | | 0 | 0 | 1 |
| 06-Mar-10 | AA-10 | | 2 | | 0 | 2 | |
| 06-Mar-10 | AA-10 | | 2 | | 2 | 0 | |
| 06-Mar-10 | AB-10 | | 6 | | 6 | 0 | |
| 06-Mar-10 | AB-10 | | 1 | | 1 | 0 | |
| 06-Mar-10 | AB-10 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AB-9 | | 3 | | 1 | 2 | |
| 06-Mar-10 | AB-9 | | 5 | | 2 | 3 | |
| 06-Mar-10 | AB-9 | | 3 | | 2 | 1 | |
| 06-Mar-10 | AB-9 | | 7 | | 2 | 5 | |
| 06-Mar-10 | AB-9 | | 4 | | 0 | 2 | 2 |
| 06-Mar-10 | AB-9 | | 4 | | 1 | 2 | 1 |
| 06-Mar-10 | AC-9 | | 1 | | 1 | 0 | |
| 06-Mar-10 | AC-9 | | 3 | | 2 | 0 | 1 |
| 06-Mar-10 | AC-8 | | 4 | | 1 | 3 | |
| 06-Mar-10 | AC-8 | | 1 | | 1 | 0 | |
| 06-Mar-10 | AD-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AD-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AE-7 | | 4 | | 0 | 3 | 1 |
| 06-Mar-10 | AE-7 | | 5 | | 0 | 4 | 1 |
| 06-Mar-10 | AF-7 | | 2 | | 0 | 2 | |
| 06-Mar-10 | AF-7 | | 6 | | 1 | 5 | |
| 06-Mar-10 | AF-7 | | 6 | | 1 | 3 | 2 |
| 06-Mar-10 | AG-5 | | 8 | | 1 | 7 | |
| 06-Mar-10 | AG-5 | | 1 | | 0 | 1 | |
| 06-Mar-10 | | 63 | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AF-4 | | 5 | | 1 | 4 | |
| 06-Mar-10 | AF-4 | | 2 | | 1 | 1 | |
| 06-Mar-10 | AF-4 | | 1 | | 1 | 0 | |
| 06-Mar-10 | AF-4 | | 1 | | 0 | 0 | 1 |
| 06-Mar-10 | AF-4 | | 2 | | 2 | 0 | |
| 06-Mar-10 | AF-4 | | 2 | | 0 | 2 | |
| 06-Mar-10 | AF-4 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | AF-4 | | 5 | | 2 | 2 | 1 |
| 06-Mar-10 | AF-4 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AF-4 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AF-4 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AF-4 | | 4 | | 2 | 1 | 1 |
| 06-Mar-10 | AF-4 | | 4 | | 0 | 4 | |
| 06-Mar-10 | AD-3 | 154 | 2 | | 0 | 2 | |
| 06-Mar-10 | AD-3 | 154 | 2 | | 2 | 0 | |
| 06-Mar-10 | AD-3 | 154 | 1 | | 1 | 0 | |

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|---|---|---|---|---|---|---|---|
| 06-Mar-10 | AD-3 | 154 | 4 | | 1 | 2 | 1 |
| 06-Mar-10 | AD-3 | 154 | 5 | | 1 | 3 | 1 |
| 06-Mar-10 | AD-3 | 154 | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | AD-3 | | 2 | | 2 | 0 | |
| 06-Mar-10 | AD-3 | | 8 | | 3 | 4 | 1 |
| 06-Mar-10 | AC-4 | | 8 | | 0 | 5 | 3 |
| 06-Mar-10 | AC-4 | | 4 | | 1 | 3 | |
| 06-Mar-10 | AC-4 | | 4 | | 1 | 2 | 1 |
| 06-Mar-10 | AC-4 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | AC-4 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | AC-4 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AC-4 | | 6 | | 4 | 2 | |
| 06-Mar-10 | AC-4 | | 5 | | 1 | 2 | 2 |
| 06-Mar-10 | AC-4 | | 2 | | 0 | 2 | |
| 06-Mar-10 | AC-4 | | 1 | | 0 | 1 | |
| 06-Mar-10 | | 104 | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | | 104 | 2 | | 0 | 0 | 2 |
| 06-Mar-10 | | 104 | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | | 104 | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | | 104 | 2 | | 2 | 0 | |
| 06-Mar-10 | AA-4 | | 3 | | 0 | 1 | 2 |
| 06-Mar-10 | AA-4 | | 3 | | 2 | 1 | |
| 06-Mar-10 | AA-5 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | AA-5 | | 3 | | 3 | 0 | |
| 06-Mar-10 | AA-5 | | 4 | | 3 | 1 | |
| 06-Mar-10 | AA-5 | | 4 | | 0 | 3 | 1 |
| 06-Mar-10 | Y-5 | | 5 | | 5 | 0 | |
| 06-Mar-10 | Y-5 | | 4 | | 2 | 1 | 1 |
| 06-Mar-10 | Y-6 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-6 | | 3 | | 2 | 0 | 1 |
| 06-Mar-10 | Y-6 | | 3 | | 0 | 0 | 3 |
| 06-Mar-10 | Y-6 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-6 | | 5 | | 1 | 4 | |
| 06-Mar-10 | Y-6 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-6 | | 1 | | 0 | 0 | 1 |
| 06-Mar-10 | Y-7 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | Y-7 | | 5 | | 3 | 2 | |
| 06-Mar-10 | Y-7 | | 3 | | 2 | 1 | |
| 06-Mar-10 | Y-7 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-7 | | 1 | | 0 | 0 | 1 |
| 06-Mar-10 | Y-7 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-7 | | 3 | | 3 | 0 | |
| 06-Mar-10 | Y-7 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-7 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Y-8 | | 4 | | 0 | 2 | 2 |
| 06-Mar-10 | Y-8 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | Y-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-8 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | Y-8 | | 3 | | 1 | 2 | |
| 06-Mar-10 | Y-8 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-8 | | 4 | | 2 | 2 | |
| 06-Mar-10 | Y-8 | | 2 | | 0 | 2 | |
| 06-Mar-10 | Y-8 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Y-8 | | 3 | | 1 | 2 | |
| 06-Mar-10 | Y-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-8 | | 2 | | 2 | 0 | |
| 06-Mar-10 | Y-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Y-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | X-17 | | 2 | | 0 | 2 | |
| 06-Mar-10 | X-17 | | 1 | | 1 | 0 | |
| 06-Mar-10 | X-17 | | 1 | | 1 | 0 | |
| 06-Mar-10 | X-16 | | 4 | | 0 | 2 | 2 |
| 06-Mar-10 | X-16 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | X-16 | | 3 | | 1 | 2 | |
| 06-Mar-10 | V-16 | | 1 | | 0 | 1 | |
| 06-Mar-10 | V-16 | | 3 | | 0 | 3 | |
| 06-Mar-10 | V-16 | | 1 | | 1 | 0 | |
| 06-Mar-10 | U-15 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | U-15 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | U-15 | | 3 | | 0 | 3 | |
| 06-Mar-10 | U-15 | | 4 | | 0 | 4 | |
| 06-Mar-10 | U-15 | | 3 | | 0 | 3 | |

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|---|---|---|---|---|---|---|---|
| 06-Mar-10 | U-15 | | 1 | | 1 | 0 | |
| 06-Mar-10 | U-15 | | 3 | | 1 | 2 | |
| 06-Mar-10 | T-14 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | T-14 | | 2 | | 0 | 2 | |
| 06-Mar-10 | T-14 | | 2 | | 0 | 2 | |
| 06-Mar-10 | T-13 | | 1 | | 1 | 0 | |
| 06-Mar-10 | T-13 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | | 122 | 1 | | 1 | 0 | |
| 06-Mar-10 | Q-10 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | Q-10 | | 1 | | 0 | 1 | |
| 06-Mar-10 | Q-10 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Q-9 | | 4 | | 3 | 1 | |
| 06-Mar-10 | Q-9 | | 1 | | 1 | 0 | |
| 06-Mar-10 | Q-9 | | 5 | | 3 | 2 | |
| 06-Mar-10 | Q-9 | | 7 | | 1 | 4 | 1 |
| 06-Mar-10 | Q-9 | | 3 | | 0 | 3 | |
| 06-Mar-10 | R-9 | | 5 | | 2 | 2 | 1 |
| 06-Mar-10 | R-9 | | 2 | | 1 | 1 | |
| 06-Mar-10 | R-9 | | 1 | | 1 | 0 | |
| 06-Mar-10 | R-9 | | 5 | | 2 | 3 | |
| 06-Mar-10 | R-9 | | 1 | | 1 | 0 | |
| 06-Mar-10 | R-9 | | 1 | | 0 | 1 | |
| 06-Mar-10 | R-9 | | 3 | | 0 | 3 | |
| 06-Mar-10 | R-9 | | 2 | | 1 | 1 | |
| 06-Mar-10 | R-9 | | 3 | | 3 | 0 | |
| 06-Mar-10 | R-9 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | R-9 | | 1 | | 0 | 1 | |
| 06-Mar-10 | S-8 | | 3 | | 0 | 3 | |
| 06-Mar-10 | S-6 | 115 | 3 | | 3 | 0 | |
| 06-Mar-10 | S-6 | 115 | 2 | | 1 | 1 | |
| 06-Mar-10 | R-6 | | 2 | | 2 | 0 | |
| 06-Mar-10 | S-7 | | 12 | | 9 | 3 | |
| 06-Mar-10 | R-8 | | 4 | | 2 | 2 | |
| 06-Mar-10 | R-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | R-8 | | 4 | | 1 | 3 | |
| 06-Mar-10 | R-8 | | 1 | | 0 | 1 | |
| 06-Mar-10 | R-8 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | Q-8 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | Q-8 | | 3 | | 0 | 3 | |
| 06-Mar-10 | Q-8 | | 2 | | 0 | 2 | |
| 06-Mar-10 | Q-8 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | N-8 | | 2 | | 2 | 0 | |
| 06-Mar-10 | N-8 | | 11 | | 2 | 7 | 2 |
| 06-Mar-10 | N-8 | | 11 | | 5 | 6 | |
| 06-Mar-10 | N-8 | | 2 | | 1 | 1 | |
| 06-Mar-10 | O-7 | | 6 | | 3 | 3 | |
| 06-Mar-10 | O-7 | | 4 | | 4 | 0 | |
| 06-Mar-10 | O-7 | | 3 | | 3 | 0 | |
| 06-Mar-10 | O-7 | | 13 | | 6 | 5 | 2 |
| 06-Mar-10 | O-7 | | 3 | | 1 | 1 | 1 |
| 06-Mar-10 | O-7 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | N-7 | | 5 | | 1 | 2 | 2 |
| 06-Mar-10 | M-10 | | 4 | | 1 | 3 | |
| 06-Mar-10 | M-10 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | M-10 | | 3 | | 0 | 2 | 1 |
| 06-Mar-10 | M-10 | | 3 | | 0 | 3 | |
| 06-Mar-10 | M-10 | | 17 | | 6 | 7 | 4 |
| 06-Mar-10 | L-10 | | 4 | | 0 | 3 | 1 |
| 06-Mar-10 | L-10 | | 5 | | 2 | 3 | |
| 06-Mar-10 | K-10 | | 2 | | 0 | 2 | |
| 06-Mar-10 | J-11 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | J-11 | | 5 | 5 | 0 | 0 | |
| 06-Mar-10 | J-11 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | J-11 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | M-13 | 143 | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | N-13 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | N-13 | | 8 | 8 | 0 | 0 | |
| 06-Mar-10 | N-13 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | N-13 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | 0-13 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | 0-13 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | O-12 | | 1 | 1 | 0 | 0 | |

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|---|---|---|---|---|---|---|---|
| 06-Mar-10 | O-12 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | P-12 | | 2 | | 0 | 1 | 1 |
| 06-Mar-10 | | 138 | 3 | | 2 | 1 | |
| 06-Mar-10 | O-11 | | 15 | 15 | 0 | 0 | |
| 06-Mar-10 | O-11 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | P-12 | | 8 | 8 | 0 | 0 | |
| 06-Mar-10 | P-12 | | 4 | 4 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 7 | 7 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 10 | 10 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | Q-12 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | R-12 | | 4 | 4 | 0 | 0 | |
| 06-Mar-10 | R-12 | | 9 | 9 | 0 | 0 | |
| 06-Mar-10 | R-12 | | 5 | 5 | 0 | 0 | |
| 06-Mar-10 | R-12 | | 8 | 8 | 0 | 0 | |
| 06-Mar-10 | S-12 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | T-13 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | T-13 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | U-15 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | U-15 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | U-15 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | U-15 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | V-16 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | V-16 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | V-16 | | 7 | 7 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 2 | 2 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 1 | 1 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 3 | 3 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 4 | 4 | 0 | 0 | |
| 06-Mar-10 | W-16 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | U-19 | | 1 | | 1 | 0 | |
| 08-Mar-10 | T-19 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | T-19 | | 1 | | 0 | 0 | 1 |
| 08-Mar-10 | S-19 | | 1 | | 1 | 0 | |
| 08-Mar-10 | S-19 | | 1 | | 0 | 0 | 1 |
| 08-Mar-10 | S-19 | | 5 | 5 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | S-18 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 5 | 5 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | S-18 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 3 | | 0 | 1 | 1 |
| 08-Mar-10 | S-18 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | S-18 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | R-17 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | R-17 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | R-17 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | P-15 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | O-15 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | N-14 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | D-11 | 47 | 5 | | 5 | 0 | |
| 08-Mar-10 | D-31 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | D-32 | | 3 | | 1 | 1 | 1 |
| 08-Mar-10 | D-32 | | 4 | 4 | 0 | 0 | |
| 08-Mar-10 | D-32 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | D-32 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | D-33 | | 6 | 6 | 0 | 0 | |
| 08-Mar-10 | D-33 | | 1 | 1 | 0 | 0 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 08-Mar-10 | D-33 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | D-33 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | D-33 | | 5 | 5 | 0 | 0 | |
| 08-Mar-10 | D-33 | | 7 | 7 | 0 | 0 | |
| 08-Mar-10 | D-33 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | F-32 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | F-30 + 31 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | F-30 + 31 | | 9 | 9 | 0 | 0 | |
| 08-Mar-10 | H-28 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | I-28 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | J-28 | | 6 | 6 | 0 | 0 | |
| 08-Mar-10 | K-27 | | 8 | 8 | 0 | 0 | |
| 08-Mar-10 | K-27 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | | 151 | 4 | | 0 | 3 | 1 |
| 08-Mar-10 | M-26 | | 6 | | 0 | 3 | 3 |
| 08-Mar-10 | N-28 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | N-29 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | N-29 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | N-29 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | Q-28 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | Q-27 | | 6 | 6 | 0 | 0 | |
| 08-Mar-10 | Q-27 | | 4 | 4 | 0 | 0 | |
| 08-Mar-10 | R-26 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | R-26 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | R-26 | | 1 | | 0 | 1 | |
| 08-Mar-10 | R-26 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | R-26 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | S-24 | | 2 | | 2 | 0 | |
| 08-Mar-10 | S-24 | | 2 | | 2 | 0 | |
| 08-Mar-10 | S-24 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | S-24 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | S-25 | | 9 | 9 | 0 | 0 | |
| 08-Mar-10 | S-25 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | S-25 | | 4 | 4 | 0 | 0 | |
| 08-Mar-10 | S-25 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | S-26 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | S-26 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | S-26 | | 4 | 4 | 0 | 0 | |
| 08-Mar-10 | S-28 | 64 | 1 | | 0 | 0 | 1 |
| 08-Mar-10 | T-28 | | 3 | | 1 | 1 | 1 |
| 08-Mar-10 | T-28 | | 3 | | 1 | 1 | 1 |
| 08-Mar-10 | T-28 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | T-28 | 64 | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | W-26 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | W-26 | | 4 | 4 | 0 | 0 | |
| 08-Mar-10 | W-26 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | W-26 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | W-26 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | X-26 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | X-25 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | X-25 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | X-25 | | 6 | 6 | 0 | 0 | |
| 08-Mar-10 | X-25 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | X-25 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | Y-25 | | 4 | 4 | 0 | 0 | |
| 08-Mar-10 | Y-25 | | 5 | 5 | 0 | 0 | |
| 08-Mar-10 | Y-25 | | 7 | 7 | 0 | 0 | |
| 08-Mar-10 | Z-24 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | Z-24 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | Z-23 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | AB-26 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | Y-30 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | | 158 | 3 | | 0 | 3 | |
| 08-Mar-10 | X-28 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | X-28 | | 2 | | 2 | 0 | |
| 08-Mar-10 | Y-28 | | 3 | | 0 | 2 | 1 |
| 08-Mar-10 | Y-28 | | 3 | | 2 | 1 | |
| 08-Mar-10 | Y-28 | | 2 | | 1 | 1 | |
| 08-Mar-10 | Y-28 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | Y-28 | | 2 | | 2 | 0 | |
| 08-Mar-10 | Y-27 | | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | Y-27 | | 5 | | 0 | 5 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 08-Mar-10 | Y-27 | | 2 | | 0 | 2 | |
| 08-Mar-10 | Z-28 | | 8 | 8 | 0 | 0 | |
| 08-Mar-10 | Z-29 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | Z-29 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | Z-29 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | AA-30 | | 5 | 5 | 0 | 0 | |
| 08-Mar-10 | AB-30 | 150 | 2 | | 0 | 1 | 1 |
| 08-Mar-10 | AC-31 | | 3 | 3 | 0 | 0 | |
| 08-Mar-10 | AE-30 | | 2 | | 2 | 0 | |
| 08-Mar-10 | AE-29 | | 3 | | 0 | 1 | 1 |
| 08-Mar-10 | AE-29 | | 1 | 1 | 0 | 0 | |
| 08-Mar-10 | AD-29 | | 1 | | 0 | 1 | |
| 08-Mar-10 | AD-27 | | 6 | 6 | 0 | 0 | |
| 08-Mar-10 | AC-25 | | 2 | 2 | 0 | 0 | |
| 08-Mar-10 | AC-24 | | 2 | 2 | 0 | 0 | |
| 09-Mar-10 | AB-21 | | 5 | 5 | 0 | 0 | |
| 09-Mar-10 | AB-22 | | 5 | 5 | 0 | 0 | |
| 09-Mar-10 | AB-22 | | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | AC-22 | | 2 | 2 | 0 | 0 | |
| 09-Mar-10 | AC-22 | | 2 | 2 | 0 | 0 | |
| 09-Mar-10 | AE-24 | | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | AF-24 | | 1 | 1 | 0 | 0 | |
| 09-Mar-10 | AF-24 | | 5 | 5 | 0 | 0 | |
| 09-Mar-10 | AF-24 | | 1 | 1 | 0 | 0 | |
| 09-Mar-10 | AG-26 | | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | AG-26 | | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | AG-26 | | 2 | 2 | 0 | 0 | |
| 09-Mar-10 | AG-26 | | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | AH-27 | | 3 | 3 | 0 | 0 | |
| 09-Mar-10 | AH-27 | | 3 | 3 | 0 | 0 | |
| 09-Mar-10 | AH-27 | | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | AH-27 | | 1 | | 1 | 0 | |
| 09-Mar-10 | AI-28 | | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | AK-28 | | 1 | 1 | 0 | 0 | |
| 09-Mar-10 | AL-31 | | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | AI-37 | | 2 | 2 | 0 | 0 | |
| 09-Mar-10 | AI-37 | | 2 | | 0 | 1 | 1 |
| | | **TOTALS** | **2215** | **480** | **519** | **952** | **264** |
| | | | | **Unknown** | **Bull** | **Cow** | **Calf** |
| | | | | **Total sexed & aged** | | **1735** | |

# *Appendix 5*

## *Aerial survey 2010 Akia-Maniitsoq caribou, Central region, West Greenland*

***Table 11.*** *Raw data aerial survey Akia-Maniitsoq caribou herd, Central region, March 2010. Observers: Christine Cuyler (CC), Hans Mølgaard (HM), Sofie Jeremiassen (SJ), Magnus Petersen (MP) & Rink Heinrich (RH).*

| Date dd.mm.yy | Transect number | Density Stratum | Number Caribou observed on transect | | | Rear Seat Observers | |
|---|---|---|---|---|---|---|---|
| | | | Left front (CC) | Left rear | Right rear | Left | Right |
| 09.03.10 | 105 | Low | 17 | 17 | 15 | HM | RH |
| 09.03.10 | 126 | Low | 1 | 1 | 0 | HM | RH |
| 09.03.10 | 168 | Low | 11 | 11 | 6 | HM | RH |
| 09.03.10 | 53 | Low | 0 | 0 | 1 | HM | RH |
| 09.03.10 | 139 | Low | 0 | 0 | 0 | HM | RH |
| 09.03.10 | 107 | High | 9 | 9 | 24 | HM | RH |
| 09.03.10 | 84 | High | 4 | 4 | 6 | HM | RH |
| 09.03.10 | 39 | High | 8 | 8 | 6 | HM | RH |
| 09.03.10 | 17 | High | 6 | 6 | 0 | HM | RH |
| 09.03.10 | 97 | High | 2 | 2 | 0 | HM | RH |
| 09.03.10 | 68 | High | 3 | 3 | 3 | HM | RH |
| 09.03.10 | 77 | High | 10 | 10 | 0 | MP | HM |
| 10.03.10 | 227 | High | 0 | 0 | 2 | MP | HM |
| 10.03.10 | 124 | High | 3 | 3 | 9 | MP | HM |
| 10.03.10 | 87 | High | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 200 | High | 2 | 0 | 4 | MP | HM |
| 10.03.10 | 164 | High | 0 | 0 | 1 | MP | HM |
| 10.03.10 | 181 | High | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 199 | High | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 58 | High | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 52 | Low | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 95 | Low | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 155 | Low | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 121 | Low | 6 | 3 | 4 | MP | HM |
| 10.03.10 | 28 | Low | 3 | 3 | 9 | MP | HM |
| 10.03.10 | 149 | Low | 17 | 10 | 8 | MP | HM |
| 10.03.10 | 61 | Low | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 56 | High | 2 | 2 | 4 | MP | HM |
| 10.03.10 | 3 | High | 0 | 0 | 0 | MP | HM |
| 10.03.10 | 183 | High | 4 | 4 | 10 | MP | HM |
| 10.03.10 | 1 | High | 7 | 2 | 11 | MP | HM |
| 10.03.10 | 18 | High | 0 | 0 | 0 | MP | HM |
| 12.03.10 | 96 | High | 7 | 0 | 4 | SJ | HM |
| 12.03.10 | 64 | High | 0 | 0 | 0 | SJ | HM |
| 12.03.10 | 136 | High | 0 | 0 | 0 | SJ | HM |
| 12.03.10 | 166 | High | 0 | 0 | 0 | SJ | HM |
| 12.03.10 | 108 | High | 1 | 1 | 11 | SJ | HM |
| 12.03.10 | 191 | High | 7 | 3 | 20 | SJ | HM |
| 12.03.10 | 36 | High | 7 | 3 | 9 | SJ | HM |
| 12.03.10 | 193 | High | 11 | 4 | 12 | SJ | HM |
| 12.03.10 | 21 | High | 16 | 4 | 9 | SJ | HM |
| 12.03.10 | 8 | High | 0 | 0 | 0 | SJ | HM |
| 12.03.10 | 46 | High | 0 | 0 | 0 | SJ | HM |
| 12.03.10 | 65 | High | 3 | 0 | 2 | SJ | HM |
| 12.03.10 | 186 | High | 2 | 0 | 0 | SJ | HM |
| 12.03.10 | 201 | High | 0 | 0 | 0 | SJ | HM |
| 13.03.10 | 203 | High | 1 | 0 | 6 | SJ | HM |
| 13.03.10 | 197 | High | 0 | 0 | 0 | SJ | HM |
| 13.03.10 | 135 | High | 0 | 0 | 6 | SJ | HM |
| 13.03.10 | 141 | High | 0 | 0 | 2 | SJ | HM |
| 13.03.10 | 19 | High | 0 | 0 | 0 | SJ | HM |
| 13.03.10 | 15 | Low | 0 | 0 | 0 | SJ | HM |
| 13.03.10 | 157 | Low | 4 | 0 | 0 | SJ | HM |
| 13.03.10 | 92 | Low | 2 | 2 | 0 | SJ | HM |
| **TOTAL** | | | **380** (176 left side + 204 right side) | | | | |

***Table 12.*** *Random transects aerial survey Akia-Maniitsoq caribou herd, Central region, March 2010.*

| Date ddmmyy | Direction flown | Transect number | Transect start | | Transect end | |
|---|---|---|---|---|---|---|
| | | | Latitude | Longitude | Latitude | Longitude |
| 10-Mar-10 | NE-SW | 1 | 64º 47.14' | 51º 32.91' | 64º 50.49' | 51º 27.56' |
| 10-Mar-10 | N-S | 3 | 65º 09.80' | 51º 21.80' | 65º 05.79' | 51º 22.96' |
| 12-Mar-10 | SE-NW | 8 | 64º 49.86' | 51º 03.41' | 64º 53.51' | 51º 07.52' |
| 13-Mar-10 | W-E | 15 | 65º 20.68' | 50º 47.81' | 65º 20.52' | 50º 38.12' |
| 09-Mar-10 | N-S | 17 | 64º 36.97' | 52º 04.81' | 64º 40.68' | 52º 01.00' |
| 10-Mar-10 | NW-SE | 18 | 64º 43.05' | 51º 20.32' | 64º 45.39' | 51º 28.05' |
| 13-Mar-10 | SSE-NNW | 19 | 65º 09.15' | 50º 34.45' | 65º 05.24' | 50º 31.98' |
| 12-Mar-10 | NW-SE | 21 | 64º 46.09' | 51º 02.62' | 64º 49.33' | 51º 08.32' |
| 10-Mar-10 | NW-SE | 28 | 65º 30.11' | 50º 55.63' | 65º 31.96' | 51º 04.32' |
| 12-Mar-10 | SE-NW | 36 | 64º 54.46' | 51º 11.98' | 64º 56.09' | 51º 20.72' |
| 09-Mar-10 | N-S | 39 | 64º 40.85' | 52º 03.31' | 64º 43.95' | 51º 57.21' |
| 12-Mar-10 | NW-SE | 46 | 65º 02.89' | 51º 12.83' | 65º 00.80' | 51º 04.61' |
| 10-Mar-10 | SSW-NNE | 52 | 65º 40.79' | 51º 56.24' | 65º 44.54' | 51º 52.55' |
| 09-Mar-10 | SE-NW | 53 | 65º 27.61' | 51º 42.92' | 65º 25.81' | 51º 34.19' |
| 10-Mar-10 | SSE-NNW | 56 | 65º 18.61' | 52º 01.44' | 65º 22.37' | 52º 05.01' |
| 10-Mar-10 | SSE-NNW | 58 | 65º 19.84' | 51º 44.91' | 65º 23.29' | 51º 49.99' |
| 10-Mar-10 | NE-SW | 61 | 65º 23.39' | 51º 21.39' | 65º 26.66' | 51º 15.66' |
| 12-Mar-10 | SW-NE | 64 | 64º 50.56' | 49º 43.96' | 64º 49.53' | 49º 53.16' |
| 12-Mar-10 | SE-NW | 65 | 65º 01.78' | 51º 01.07' | 65º 05.11' | 51º 06.50' |
| 09-Mar-10 | N-S | 68 | 64º 22.11' | 51º 37.73' | 64º 25.95' | 51º 40.69' |
| 09-Mar-10 | E-W | 77 | 64º 18.99' | 51º 57.18' | 64º 18.11' | 52º 06.29' |
| 09-Mar-10 | N-S | 84 | 65º 00.67' | 52º 10.06' | 65º 04.40' | 52º 06.31' |
| 10-Mar-10 | W-E | 87 | 64º 58.55' | 51º 25.42' | 64º58.78' | 51º 34.97' |
| 13-Mar-10 | SW-NE | 92 | 65º 21.48' | 50º 30.04' | 65º 24.06' | 50º 22.56' |
| 10-Mar-10 | N-S | 95 | 65º 36.87' | 51º 40.90' | 65º 40.92' | 51º 41.22' |
| 12-Mar-10 | S-N | 96 | 64º 46.69' | 50º 30.23' | 64º 50.72' | 50º 31.05' |
| 09-Mar-10 | E-W | 97 | 64º 28.06' | 52º 06.60' | 64º 29.03' | 51º 57.48' |
| 09-Mar-10 | NNW-SSE | 105 | 65º 38.69' | 50º 27.48' | 65º 42.25' | 50º 32.19' |
| 09-Mar-10 | W-E | 107 | 65º 21.66' | 52º 24.97' | 65º 22.37' | 52º 15.41' |
| 12-Mar-10 | NE-SW | 108 | 64º 51.34' | 50º 38.18' | 64º 54.72' | 50º 32.96' |
| 10-Mar-10 | SW-NE | 121 | 65º 38.27' | 51º 13.44' | 65º 36.60' | 51º 22.38' |
| 10-Mar-10 | S-N | 124 | 64º 49.51' | 51º 38.92' | 64º 53.44' | 51º 36.66' |
| 09-Mar-10 | NE-SW | 126 | 65º 37.47' | 50º 38.29' | 65º 36.02' | 50º 47.44' |
| 13-Mar-10 | W-E | 135 | 65º 03.43' | 50º 14.72' | 65º 03.25' | 50º 05.14' |
| 12-Mar-10 | SE-NW | 136 | 64º 53.40' | 50º 02.64' | 64º 49.88' | 49º 57.96' |
| 09-Mar-10 | E-W | 139 | 65º 31.92' | 52º 02.11' | 65º 32.39' | 51º 52.40' |
| 13-Mar-10 | NE-SW | 141 | 65º 07.52' | 50º 28.98' | 65º 11.23' | 50º 25.13' |
| 10-Mar-10 | NE-SW | 149 | 65º 29.47' | 51º 09.85' | 65º 30.74' | 51º 00.58' |
| 10-Mar-10 | NW-SE | 155 | 65º 35.85' | 51º 26.31' | 65º 37.49' | 51º 35.26' |
| 13-Mar-10 | NW-SE | 157 | 65º 21.24' | 50º 37.14' | 65º 18.50' | 50º 30.00' |
| 10-Mar-10 | E-W | 164 | 65º 05.72' | 51º 43.85' | 65º 05.81' | 51º 53.45' |
| 12-Mar-10 | SSE-NNW | 166 | 64º 57.85' | 50º 01.89' | 64º 53.92' | 49º 59.59' |
| 09-Mar-10 | NE-SW | 168 | 65º 31.49' | 51º 16.54' | 65º 33.14' | 51º 07.62' |
| 10-Mar-10 | SE-NW | 181 | 65º 10.39' | 51º 47.28' | 65º 06.81' | 51º 42.78' |
| 10-Mar-10 | NW-SE | 183 | 65º 03.25' | 51º 25.54' | 65º 01.64' | 51º 16.74' |
| 12-Mar-10 | SE-NW | 186 | 65º 10.27' | 51º 04.97' | 65º 07.62' | 50º 57.69' |
| 12-Mar-10 | E-W | 191 | 64º 50.56' | 50º 54.21' | 64º 49.24' | 50º 45.21' |
| 12-Mar-10 | NW-SE | 193 | 64º 54.99' | 51º 21.95' | 64º 52.77' | 51º 13.97' |
| 13-Mar-10 | W-E | 197 | 65º 02.10' | 50º 19.68' | 65º 01.59' | 50º 10.18' |
| 10-Mar-10 | NE-SW | 199 | 65º 08.02' | 52º 02.68' | 65º 10.53' | 51º 55.12' |
| 10-Mar-10 | E-W | 200 | 65º 02.04' | 51º 44.44' | 65º 03.51' | 51º 35.50' |
| 12-Mar-10 | SW-NE | 201 | 65º 09.10' | 50º 38.21' | 65º 07.59' | 50º 47.14' |
| 13-Mar-10 | W-E | 203 | 64º 58.96' | 50º 27.64' | 64º 59.29' | 50º 18.10' |
| 10-Mar-10 | W-E | 227 | 64º 37.95' | 51º 24.53' | 64º 38.00' | 51º 33.97' |

***Table 13.*** *Raw data aerial survey herd structure Akia-Maniitsoq caribou herd, Central region, March 2010.*

| Date ddmmyy | Grid Cell | Transect # | Group Size | Unknown Sex / Age | Bull (>1 year) | Cow (>1 year) | Calves (<1 year) |
|---|---|---|---|---|---|---|---|
| 09-Mar-10 | AD12 | | 5 | 5 | 0 | 0 | |
| 09-Mar-10 | AD12 | | 7 | 7 | 0 | 0 | |
| 09-Mar-10 | AD12 | | 8 | 8 | 0 | 0 | |
| 09-Mar-10 | AD12 | | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | AD12 | | 8 | 8 | 0 | 0 | |
| 09-Mar-10 | AD13 | 105 | 5 | | 0 | 5 | |
| 09-Mar-10 | AD13 | 105 | 1 | | 0 | 1 | |
| 09-Mar-10 | AE13 | 105 | 5 | | 1 | 4 | |
| 09-Mar-10 | AE13 | 105 | 3 | | 3 | 0 | |
| 09-Mar-10 | AE14 | 105 | 5 | | 0 | 4 | 1 |
| 09-Mar-10 | AD13 | | 6 | 6 | 0 | 0 | |
| 09-Mar-10 | Z15 | | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | Z16 | | 2 | 2 | 0 | 0 | |
| 09-Mar-10 | Y15 | | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | Y16 | | 5 | | 0 | 5 | |
| 09-Mar-10 | X16 | 168 | 4 | 4 | 0 | 0 | |
| 09-Mar-10 | X16 | 168 | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | X16 | 168 | 3 | | 0 | 3 | |
| 09-Mar-10 | O17 | | 1 | | 0 | 1 | |
| 09-Mar-10 | M20 | 107 | 5 | | 0 | 3 | 2 |
| 09-Mar-10 | M20 | 107 | 4 | | 1 | 4 | |
| 09-Mar-10 | N20 | 107 | 2 | | 0 | 2 | |
| 09-Mar-10 | N20 | 107 | 7 | | 1 | 5 | 1 |
| 09-Mar-10 | N20 | 107 | 9 | | 5 | 4 | |
| 09-Mar-10 | N20 | 107 | 9 | | 3 | 4 | 2 |
| 09-Mar-10 | O21 | | 3 | 3 | 0 | 0 | |
| 09-Mar-10 | O26 & P26 | | 5 | | 1 | 3 | 1 |
| 09-Mar-10 | O27-28 | 84 | 3 | | 2 | 1 | |
| 09-Mar-10 | O27-28 | 84 | 2 | | 0 | 2 | |
| 09-Mar-10 | O30 | | 3 | | 0 | 3 | |
| 09-Mar-10 | O31 | | 1 | | 0 | 0 | 1 |
| 09-Mar-10 | O31 | | 2 | | 0 | 2 | |
| 09-Mar-10 | P32 | | 7 | | 3 | 3 | 1 |
| 09-Mar-10 | P33 | | 4 | | 0 | 2 | 2 |
| 09-Mar-10 | Q34-P35 | 39 | 6 | 6 | 0 | 0 | |
| 09-Mar-10 | Q34 | | 3 | | 0 | 2 | 1 |
| 09-Mar-10 | Q35 | | 7 | | 0 | 5 | 2 |
| 09-Mar-10 | Q35 | | 2 | | 2 | 0 | |
| 09-Mar-10 | P35 | | 3 | | 0 | 2 | 1 |
| 09-Mar-10 | P35-36 | 17 | 4 | | 0 | 4 | |
| 09-Mar-10 | P36 | 17 | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | Q39 | | 4 | | 3 | 1 | |
| 09-Mar-10 | P40 | 97 | 2 | | 0 | 0 | 2 |
| 09-Mar-10 | R40 | | 2 | | 0 | 1 | 1 |
| 09-Mar-10 | S40 | | 1 | 1 | 0 | 0 | |
| 09-Mar-10 | S40 | | 5 | | 2 | 3 | |
| 09-Mar-10 | P43 | 77 | 10 | 10 | 3 | 5 | 2 |
| 09-Mar-10 | Q44 | | 8 | | 2 | 4 | 2 |
| 09-Mar-10 | Q44 | | 3 | | 0 | 3 | |
| 10-Mar-10 | S42 | | 4 | | 0 | 2 | 2 |
| 10-Mar-10 | U36 | 227 | 2 | | 2 | 0 | |
| 10-Mar-10 | T32 | 124 | 1 | | 1 | 0 | |
| 10-Mar-10 | T31 | 124 | 2 | | 0 | 2 | |
| 10-Mar-10 | T31 | 124 | 2 | | 1 | 1 | |
| 10-Mar-10 | T30 | | 2 | | 2 | 0 | |
| 10-Mar-10 | V28 | | 3 | | 0 | 3 | |
| 10-Mar-10 | V28 | | 2 | | 0 | 2 | |
| 10-Mar-10 | V28 | | 4 | | 0 | 3 | 1 |
| 10-Mar-10 | V28 | | 2 | | 0 | 1 | 1 |
| 10-Mar-10 | V28 | | 6 | | 2 | 4 | |
| 10-Mar-10 | U27 | | 2 | | 0 | 2 | |
| 10-Mar-10 | U27 | | 1 | | 0 | 1 | |
| 10-Mar-10 | U27 | | 2 | | 1 | 1 | |
| 10-Mar-10 | T27 | 200 | 2 | | 1 | 1 | |
| 10-Mar-10 | T27 | 200 | 4 | | 0 | 4 | |
| 10-Mar-10 | N14 | | 10 | | 4 | 5 | 1 |
| 10-Mar-10 | W14 | 121 | 3 | | 1 | 2 | |
| 10-Mar-10 | W14 | 121 | 3 | | 2 | 1 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10-Mar-10 | Y16 | 28 | 4 | | 0 | 3 | 1 |
| 10-Mar-10 | Z16 | 28 | 3 | | 0 | 3 | |
| 10-Mar-10 | Z17 | 28 | 2 | | 0 | 2 | |
| 10-Mar-10 | AA17 | 28 | 1 | | 1 | 0 | |
| 10-Mar-10 | AA17 | 28 | 2 | | 0 | 1 | 1 |
| 10-Mar-10 | Z17 | 149 | 2 | | 2 | 0 | |
| 10-Mar-10 | Z17 | 149 | 4 | | 1 | 3 | |
| 10-Mar-10 | Y17 | 149 | 3 | | 0 | 2 | 1 |
| 10-Mar-10 | Y17 | 149 | 5 | | 1 | 3 | 1 |
| 10-Mar-10 | P21 | 56 | 2 | | 0 | 1 | 1 |
| 10-Mar-10 | P20 | 56 | 4 | | 0 | 4 | |
| 10-Mar-10 | W27 | 183 | 4 | | 0 | 4 | |
| 10-Mar-10 | U32 | 1 | 4 | 4 | 0 | 0 | |
| 10-Mar-10 | U32 | 1 | 3 | | 0 | 2 | 1 |
| 10-Mar-10 | U33 | 1 | 4 | | 0 | 4 | |
| 10-Mar-10 | T39 | | 5 | | 0 | 4 | 1 |
| 10-Mar-10 | U39 | | 3 | | 1 | 2 | |
| 12-Mar-10 | T41 | | 8 | | 4 | 3 | 1 |
| 12-Mar-10 | T41 | | 4 | | 4 | 0 | |
| 12-Mar-10 | U38 | | 3 | | 0 | 1 | 2 |
| 12-Mar-10 | U38 | | 2 | | 2 | 0 | |
| 12-Mar-10 | U38 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | U38 | | 6 | | 0 | 5 | 1 |
| 12-Mar-10 | U38 | | 2 | | 0 | 2 | |
| 12-Mar-10 | U37 | | 4 | | 0 | 2 | 2 |
| 12-Mar-10 | U37 | | 4 | | 4 | 0 | |
| 12-Mar-10 | U37 | | 1 | | 1 | 0 | |
| 12-Mar-10 | U37 | | 5 | | 4 | 1 | |
| 12-Mar-10 | U37 | | 3 | | 1 | 2 | |
| 12-Mar-10 | Z35 | | 3 | | 1 | 1 | 1 |
| 12-Mar-10 | Z35 | | 3 | | 1 | 2 | |
| 12-Mar-10 | Z35 | | 9 | | 2 | 5 | 2 |
| 12-Mar-10 | Z35 | | 7 | | 2 | 3 | 2 |
| 12-Mar-10 | AA35 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AA35 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AA34 | | 4 | | 3 | 1 | |
| 12-Mar-10 | AA34 | | 4 | | 4 | 0 | |
| 12-Mar-10 | AB34 | | 7 | | 6 | 1 | |
| 12-Mar-10 | AB34 | | 8 | | 4 | 2 | 2 |
| 12-Mar-10 | AD32 | | 7 | | 3 | 2 | 2 |
| 12-Mar-10 | AE32 | | 4 | | 0 | 3 | 1 |
| 12-Mar-10 | AF32 | | 9 | | 2 | 5 | 2 |
| 12-Mar-10 | AF32 | | 1 | | 0 | 1 | |
| 12-Mar-10 | AG32 | | 5 | | 0 | 5 | |
| 12-Mar-10 | AG32 | | 3 | | 1 | 2 | |
| 12-Mar-10 | AH32 | | 3 | | 1 | 2 | |
| 12-Mar-10 | AH32 | | 16 | | 5 | 8 | 3 |
| 12-Mar-10 | AJ33 | | 5 | | 0 | 3 | 2 |
| 12-Mar-10 | AJ33 | | 2 | | 0 | 2 | |
| 12-Mar-10 | AJ33 | | 4 | | 2 | 0 | 2 |
| 12-Mar-10 | AJ33 | | 4 | | 4 | 0 | |
| 12-Mar-10 | AJ33 | | 2 | | 0 | 2 | |
| 12-Mar-10 | AJ33 | | 2 | | 0 | 2 | |
| 12-Mar-10 | AJ33 | | 7 | | 3 | 4 | |
| 12-Mar-10 | AJ33 | | 2 | | 1 | 1 | |
| 12-Mar-10 | AJ33 | | 3 | | 0 | 2 | 1 |
| 12-Mar-10 | AJ33 | | 5 | | 1 | 4 | |
| 12-Mar-10 | AJ32 | | 2 | | 1 | 1 | |
| 12-Mar-10 | AJ32 | | 5 | | 1 | 4 | |
| 12-Mar-10 | AJ32 | | 4 | | 0 | 4 | |
| 12-Mar-10 | AJ32 | | 4 | | 0 | 3 | 1 |
| 12-Mar-10 | AJ32 | | 3 | | 1 | 1 | 1 |
| 12-Mar-10 | AJ32 | | 7 | | 2 | 3 | 2 |
| 12-Mar-10 | AJ32 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AJ32 | | 3 | | 2 | 1 | |
| 12-Mar-10 | AJ32 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AJ32 | | 2 | | 1 | 1 | |
| 12-Mar-10 | AJ32 | | 6 | | 3 | 2 | 1 |
| 12-Mar-10 | AJ32 | | 7 | | 3 | 3 | 1 |
| 12-Mar-10 | AH29 | | 4 | | 0 | 4 | |
| 12-Mar-10 | AH29 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AF30 | | 2 | | 0 | 2 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12-Mar-10 | AD30 | 108 | 1 | | 0 | 1 | |
| 12-Mar-10 | AC31 | 108 | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AC32 | | 18 | 18 | 0 | 0 | |
| 12-Mar-10 | AB34 | | 16 | 16 | 0 | 0 | |
| 12-Mar-10 | AA34 | | 4 | 4 | 0 | 0 | |
| 12-Mar-10 | Y34 | | 6 | | 2 | 3 | 1 |
| 12-Mar-10 | Y34 | | 7 | | 2 | 3 | 2 |
| 12-Mar-10 | Y34 | | 2 | | 0 | 2 | |
| 12-Mar-10 | Z34 | | 10 | | 4 | 4 | 2 |
| 12-Mar-10 | Z34 | | 2 | | 0 | 2 | |
| 12-Mar-10 | Z34 | | 10 | | 1 | 9 | |
| 12-Mar-10 | Z34 | | 3 | | 0 | 1 | 2 |
| 12-Mar-10 | AB32 | 191 | 3 | | 1 | 2 | |
| 12-Mar-10 | AA32 | 191 | 6 | | 6 | 0 | |
| 12-Mar-10 | AA32 | 191 | 8 | | 2 | 4 | 2 |
| 12-Mar-10 | AA32 | 191 | 2 | | 0 | 2 | |
| 12-Mar-10 | AA32 | 191 | 8 | | 0 | 6 | 2 |
| 12-Mar-10 | AA32 | 191 | 7 | | 1 | 4 | 2 |
| 12-Mar-10 | AA31 | 191 | 11 | | 1 | 8 | 2 |
| 12-Mar-10 | AA31 | 191 | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AA31 | 191 | 6 | | 2 | 4 | |
| 12-Mar-10 | AB31 | | 2 | | 0 | 2 | |
| 12-Mar-10 | AB31 | | 7 | | 3 | 4 | |
| 12-Mar-10 | AB31 | | 7 | | 1 | 6 | |
| 12-Mar-10 | AB31 | | 2 | | 1 | 1 | |
| 12-Mar-10 | AB31 | | 2 | | 0 | 0 | 2 |
| 12-Mar-10 | AB30 | | 2 | | 0 | 2 | |
| 12-Mar-10 | AB30 | | 3 | | 1 | 0 | 2 |
| 12-Mar-10 | AB30 | | 10 | | 4 | 6 | |
| 12-Mar-10 | AB30 | | 24 | | 3 | 21 | |
| 12-Mar-10 | AB30 | | 7 | | 1 | 5 | 1 |
| 12-Mar-10 | AB29 | | 6 | | 0 | 3 | 3 |
| 12-Mar-10 | AA29 | | 6 | | 1 | 4 | 1 |
| 12-Mar-10 | AA29 | | 15 | | 2 | 10 | 3 |
| 12-Mar-10 | AA29 | | 4 | | 1 | 1 | 2 |
| 12-Mar-10 | AA29 | | 9 | | 0 | 7 | 2 |
| 12-Mar-10 | AA29 | | 31 | | 7 | 19 | 5 |
| 12-Mar-10 | AA29 | | 5 | | 0 | 5 | |
| 12-Mar-10 | AA29 | | 16 | | 1 | 15 | |
| 12-Mar-10 | AA30 | | 4 | | 0 | 4 | |
| 12-Mar-10 | AA30 | | 5 | | 1 | 3 | 1 |
| 12-Mar-10 | AA30 | | 16 | | 3 | 11 | 2 |
| 12-Mar-10 | AA30 | | 6 | | 0 | 5 | 1 |
| 12-Mar-10 | AA30 | | 3 | | 0 | 2 | 1 |
| 12-Mar-10 | AA30 | | 20 | | 4 | 16 | |
| 12-Mar-10 | AA30 | | 3 | | 0 | 3 | |
| 12-Mar-10 | AA30 | | 3 | | 1 | 1 | 1 |
| 12-Mar-10 | AA30 | | 27 | | 9 | 17 | 1 |
| 12-Mar-10 | AA30 | | 9 | | 1 | 5 | 3 |
| 12-Mar-10 | AA31 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AA31 | | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | AA31 | | 4 | | 1 | 3 | |
| 12-Mar-10 | AA31 | | 5 | | 0 | 3 | 2 |
| 12-Mar-10 | AA31 | | 3 | | 1 | 1 | 1 |
| 12-Mar-10 | AA31 | | 7 | | 0 | 5 | 2 |
| 12-Mar-10 | Z29 | | 8 | | 1 | 5 | 2 |
| 12-Mar-10 | X30, W29-30 | 36 | 2 | | 1 | 1 | |
| 12-Mar-10 | X30, W29-30 | 36 | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | X30, W29-30 | 36 | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | W30 | | 1 | | 0 | 1 | |
| 12-Mar-10 | W30 | | 2 | | 0 | 2 | |
| 12-Mar-10 | W30 | | 1 | | 0 | 1 | |
| 12-Mar-10 | W30 | | 7 | | 3 | 4 | |
| 12-Mar-10 | W30 | | 6 | | 2 | 4 | |
| 12-Mar-10 | W30 | | 6 | | 1 | 5 | |
| 12-Mar-10 | W30 | | 15 | | 5 | 8 | 2 |
| 12-Mar-10 | W30 | | 7 | | 3 | 4 | |
| 12-Mar-10 | W30 | | 11 | | 3 | 6 | 2 |
| 12-Mar-10 | W30 | | 2 | | 1 | 1 | |
| 12-Mar-10 | W31 | | 4 | | 3 | 1 | |
| 12-Mar-10 | W31 | | 4 | | 2 | 2 | |
| 12-Mar-10 | W31 | | 1 | | 0 | 1 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12-Mar-10 | W31 | | 1 | | 0 | 1 | |
| 12-Mar-10 | W31 | | 21 | | 5 | 16 | |
| 12-Mar-10 | W31 | | 15 | | 3 | 12 | |
| 12-Mar-10 | W32 | | 4 | | 1 | 3 | |
| 12-Mar-10 | W32 | | 2 | | 1 | 1 | |
| 12-Mar-10 | W32 | | 2 | | 2 | 0 | |
| 12-Mar-10 | W32 | | 3 | | 1 | 1 | 1 |
| 12-Mar-10 | X32 | | 3 | | 1 | 1 | 1 |
| 12-Mar-10 | Y33 | 21 | 9 | | 1 | 7 | 1 |
| 12-Mar-10 | Y33 | 21 | 2 | | 0 | 1 | 1 |
| 12-Mar-10 | Y33 | 21 | 10 | | 1 | 8 | 1 |
| 12-Mar-10 | Y33 | 21 | 4 | | 2 | 2 | |
| 12-Mar-10 | Y34 | | 2 | | 2 | 0 | |
| 12-Mar-10 | Z33 | | 4 | | 0 | 3 | 1 |
| 12-Mar-10 | Z33 | | 4 | | 1 | 1 | 2 |
| 12-Mar-10 | Y30 | | 6 | | 2 | 3 | 1 |
| 12-Mar-10 | X30 | | 3 | | 0 | 3 | |
| 12-Mar-10 | W30 | | 3 | | 0 | 2 | 1 |
| 12-Mar-10 | W30 | | 1 | | 1 | 0 | |
| 12-Mar-10 | W29 | | 4 | | 0 | 4 | |
| 12-Mar-10 | W29 | | 3 | | 0 | 3 | |
| 12-Mar-10 | W28 | | 2 | | 1 | 1 | |
| 12-Mar-10 | W28 | | 7 | | 4 | 3 | |
| 12-Mar-10 | AB25 | | 2 | 2 | 0 | 0 | |
| 12-Mar-10 | AC25 | | 6 | 6 | 0 | 0 | |
| 13-Mar-10 | Y36 | | 3 | | 0 | 1 | 2 |
| 13-Mar-10 | Y35 | | 10 | | 1 | 5 | 4 |
| 13-Mar-10 | Y35 | | 4 | | 2 | 2 | |
| 13-Mar-10 | Z34 | | 12 | | 3 | 7 | 2 |
| 13-Mar-10 | Z34 | | 3 | | 0 | 2 | 1 |
| 13-Mar-10 | Z34 | | 5 | | 2 | 3 | |
| 13-Mar-10 | Z34 | | 3 | | 0 | 2 | 1 |
| 13-Mar-10 | Z33 | | 5 | | 0 | 3 | 2 |
| 13-Mar-10 | Z33 | | 2 | | 0 | 2 | |
| 13-Mar-10 | AA33 | | 9 | | 4 | 3 | 2 |
| 13-Mar-10 | AA33 | | 6 | 6 | 0 | 0 | |
| 13-Mar-10 | AA33 | | 1 | | 1 | 0 | |
| 13-Mar-10 | AA32 | | 8 | | 1 | 4 | 3 |
| 13-Mar-10 | AA32 | | 8 | | 1 | 5 | 2 |
| 13-Mar-10 | AA32 | | 4 | | 0 | 2 | 2 |
| 13-Mar-10 | AA32 | | 4 | | 0 | 4 | |
| 13-Mar-10 | AB31 | | 3 | | 0 | 3 | |
| 13-Mar-10 | AB31 | | 7 | | 2 | 5 | |
| 13-Mar-10 | AB31 | | 3 | | 1 | 2 | |
| 13-Mar-10 | AB31 | | 4 | | 0 | 2 | 2 |
| 13-Mar-10 | AB30 | | 6 | | 0 | 5 | 1 |
| 13-Mar-10 | AB30 | | 2 | | 0 | 1 | 1 |
| 13-Mar-10 | AB30 | | 10 | | 0 | 9 | 1 |
| 13-Mar-10 | AB29 | | 2 | | 0 | 1 | 1 |
| 13-Mar-10 | AB29 | | 2 | | 0 | 2 | |
| 13-Mar-10 | AB29 | | 5 | | 0 | 4 | 1 |
| 13-Mar-10 | AC29 | | 6 | | 2 | 4 | |
| 13-Mar-10 | AC29 | | 6 | | 1 | 5 | |
| 13-Mar-10 | AC30 | | 3 | | 1 | 1 | 1 |
| 13-Mar-10 | AC30 | | 3 | | 1 | 2 | |
| 13-Mar-10 | AC30 | | 4 | | 2 | 2 | |
| 13-Mar-10 | AC31 | | 1 | | 0 | 0 | 1 |
| 13-Mar-10 | AD31 | | 6 | | 4 | 2 | |
| 13-Mar-10 | AD32 | | 3 | | 3 | 0 | |
| 13-Mar-10 | AE29 | | 1 | | 0 | 1 | |
| 13-Mar-10 | AE28 | 203 | 2 | | 0 | 1 | 1 |
| 13-Mar-10 | AE28 | 203 | 1 | | 1 | 0 | |
| 13-Mar-10 | AH28 | | 2 | | 0 | 1 | 1 |
| 13-Mar-10 | AH28 | | 4 | | 0 | 3 | 1 |
| 13-Mar-10 | AH27 | | 6 | | 1 | 5 | |
| 13-Mar-10 | AH27 | | 3 | | 0 | 3 | |
| 13-Mar-10 | AG25 | | 3 | | 1 | 2 | |
| 13-Mar-10 | AG25 | | 2 | | 1 | 1 | |
| 13-Mar-10 | AF25 | | 4 | | 0 | 3 | 1 |
| 13-Mar-10 | AF25 | | 6 | | 1 | 4 | 1 |
| 13-Mar-10 | AF24 | | 3 | | 1 | 2 | |
| 13-Mar-10 | AE26 | | 9 | | 1 | 5 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13-Mar-10 | Y26 | | 1 | | 1 | 0 | |
| 13-Mar-10 | Y26 | | 2 | | 2 | 0 | |
| 13-Mar-10 | Y27 | | 2 | | 0 | 2 | |
| 13-Mar-10 | Y27 | | 2 | | 0 | 2 | |
| 13-Mar-10 | X27 | | 1 | | 0 | 1 | |
| 13-Mar-10 | X27 | | 2 | | 0 | 2 | |
| 13-Mar-10 | X27 | | 3 | | 1 | 2 | |
| 13-Mar-10 | X27 | | 1 | | 1 | 0 | |
| 13-Mar-10 | X27 | | 1 | | 0 | 1 | |
| 13-Mar-10 | X33 & Y33 | | 6 | | 0 | 5 | 1 |
| 13-Mar-10 | X33 & Y33 | | 20 | | 5 | 15 | |
| 13-Mar-10 | X33 & Y33 | | 15 | | 6 | 7 | 2 |
| 13-Mar-10 | AA28 | | 3 | | 0 | 2 | 1 |
| 13-Mar-10 | AC20 | 157 | 8 | | 0 | 8 | |
| 13-Mar-10 | AE21 | | 3 | | 1 | 2 | |
| 13-Mar-10 | AG23 | | 6 | | 1 | 3 | 2 |
| 13-Mar-10 | AG24 | | 4 | | 1 | 2 | 1 |
| 13-Mar-10 | AF31 & AG31 | | 2 | | 0 | 2 | |
| 13-Mar-10 | AE31 | | 2 | | 0 | 2 | 1 |
| 13-Mar-10 | AE32 | | 1 | | 0 | 1 | |
| 13-Mar-10 | AE32 | | 1 | | 1 | 0 | |
| 13-Mar-10 | AD33 | | 7 | 3 | 0 | 2 | 2 |
| **TOTALS** | | | **1473** | **121** | **317** | **840** | **195** |
| | | | | **Unknown** | **Bull** | **Cow** | **Calf** |
| | | | | **Total sexed & aged** | **1352** | | |

# *Appendix 6*

## *Logistics Tips & Recommendations*

*Budgets*

- The total cost of the 2010 survey was 1,007,341 Danish kroner (ca. $200,900 USA). Total helicopter time was 57 hours and 42 minutes, which included 33 hours and 42 minutes in the KS caribou survey (NORTH region) and 24 hours for the AM caribou survey (CENTRAL region).
- There are no salaries included in the above total cost, only per diem, travel and accommodation for the participants.
- In West Greenland the AS350 helicopter used in 2010 caribou surveys cost 17,100 Danish kroner ($3,280 USA) per hour.
- When preparing a helicopter survey budget, the hourly cost of the helicopter is only one item. There are several expensive taxes added on after the hourly rate. In 2010 these included:
  - Start tax /start afgift, 52 Danish kroner per start
  - Handling tax, 624 Danish kroner per handling
  - Passenger tax / passagerafgift, 141 Danish kroner per person per flight
  - Openings tax / *åbningsafgift*, minimum 3900 Danish kroner for first minute beyond normal closing time (you pay three hours minimum).
- During the 2010 surveys there were 19 handling, 57 passenger, and 19 start taxes. **Each refueling is a handling tax and the passenger and start taxes apply to each flight**, i.e., if you take off and land 3 times in one day, that counts as 3 flights for that day and is taxed accordingly.

*Airport rules for helicopters & pilots*

- Position reporting for safety reasons – Pilots must report / call-in by radio every 30 minutes. Therefore a satellite telephone in the helicopter is necessary to call-in from the low altitudes employed during caribou surveys. Radio contact is impossible at the 15 m flight altitude used. Without radio contact, the pilot must drop what he's doing and gain altitude until contact is made. This wastes survey time and money.
- Position reporting for safety reasons – Pilot may avoid the 30 minute reporting rule and extend it to up to three hours, by reporting an operations area around a single GPS position. This activity area has a radius of 10 nautical miles (18.5 km) around that point, for a diameter of 20 nautical miles (37 km). Therefore, before flying give the pilot a map with several suitable GPS mid-points ploted / written out. (1 nautical mile = 1.852 km)

- Unless you want to pay the expensive "openings tax", you must be finished refuelling helicopter 15 minutes before airport closes, therefore arrive for refuelling 45 minutes before closing. If the pilot agrees to it, you can cut this time to 30 minutes before closing, but you still have to refuel and depart 15 minutes before closing.
- Pilot maximum 50 flying hours per week.
- Pilot maximum 7 flying hours per day. Safety considerations would suggest that less than 7 hours is better when flying the low slow transects used in the caribou surveys.
- Initiating a flight is NOT permitted if flight time needed will exceed the above two points.
- All airports are closed for Sundays and holidays, unless your project is willing to pay to keep them open. The cost to keep an airport open is minimum 3900 Danish kroner for the first minute after closing time (pay minimum first three hours), or 4500to cover the first hour, extra hours cost more. There are exceptions when the airports are open on Sundays (special cargo or unscheduled flights), so always check the day before.

*Refuelling*

- The AS350 helicopter we used normally flies for about 2 hours and 45 minutes before needing to refuel, when there are three passengers and a pilot onboard. If flight speed is slow or there are fewer persons on board, you may be able to fly more that 3 hours. For every added passenger (weight), the helicopter will use up fuel faster. Regardless, the pilot <u>must</u> return to an airport or fuel depot with a substantial reserve in tanks!
- Refueling at airports is <u>not</u> always possible between 09:00 and 17:00, Monday to Friday, specifically at Sisimiut airport, which can close early, e.g. 14:00, and possibly also at Maniitsoq. Telephone on the specific day to obtain update on whether refueling is possible and when. Refueling at airports takes about 30 minutes and you must depart 15 minutes before the airport closes or you will be charged an expensive "openings tax" (*åbningsafgift*).
- Refueling at the heliports is only possible if fuel barrels are already there, the pilot has manual pumping gear onboard, and we have permission to use the fuel. Ask if there are fuel barrels available for use.
- One barrel (200 litres) of fuel = One hour flying.
- In addition to heliports, you can set out private fuel depots. If placed strategically in the terrain, private fuel depots can reduce the need for time-consuming ferry flights for refueling at airports / heliports. Although delivery and pick-up can be done by helicopter ferry, the cheapest way to

establish a private depot is to transport barrels by boat the previous summer. Find a location hidden from 'fuel thieves' and with a landing area for a helicopter. Things to keep in mind:

- Full fuel barrels must be stored on their side, with the sealed opening side down / closest to the ground. Thus the seal's gasket is kept moist by the fuel, will not dry out and leak air, which spoils the fuel.
- All empty barrels must be removed the following summer, when pick-up by boat is possible.
- Greenland has strong storm winds, and empty barrels can be blown into the sea or across the tundra. This has happened. Therefore until empty barrels can be retrieved the following summer, they must be kept immovable (roped together or weighted).

- Refueling at heliports or fuel depots should take abut 15-20 minutes, however, it may take up to two hours if conditions are adverse, e.g.:
  - Make sure there is a manual fuel pump on board
  - Make sure the manual fuel pump functions

*Transect key-in to helicopter GPS*

- Lableling transects correctly before you are in the air, saves times and money. Key-in your transect end points by labelling them with the transect number and finish that label by denoting the southernmost transect end with the letter "a" and the northernmost with "b". This makes it possible for you to know which end is which and thus direct the pilot to a specific end of a transect. Most transects will be flown from south to north, however, there are times you will fly transects north to south. Being able to say to the pilot, "next transect is 210 and we'll start from 210b", i.e., fly the transect from north to south, gives clear instruction of where you want the pilot to fly.
- Transect numbers are sometimes duplicated between regions/herds. If surveying two herds consequetively (as in this report) you can avoid confusion by also using a letter in front of one of the herd's set of transect numbers, e.g., add "K" for Kangerlussuaq-Sisimiut giving K210.
- Key-in your transect start and end points into the helicopter GPS together with the pilot. You read out the position, while the pilot keys-in the points and calls back the numbers to you as he punches them in. This is the quickest and least boring method to get the points correctly into the helicopter GPS, and gives a good check proceedure that the points are correct.
- Start and end GPS points keyed-in by only the pilot should always be checked prior to takeoff. If pilot can print-out his transect points, then compare with your own, and pick out discrepancies prior to take-off.

- If possible check from helicopter GPS that all transects entered have length 7.5 km. This can illuminate any key-in mistakes if lenght if over long or too short.
- Check that all transects are actually in helicopter GPS. The number of data points may exceed memory of helicopter GPS, which caused all the first transects entered to be erased in 2005. In 2010 the capacity of the helicopter GPS was 1000 waypoints. This exceeded our needs.
- Always carry your original print-out of transect start and end points with you in helicopter for consultation in case the above still does not catch all human errors, or because points inexplicably go missing. Although it means costly delay, with the print-out you can give the pilot the numbers he needs on the spot.
- Entering GPS points for the start and finish of the transects may be done while the helicopter is docked inside the Nuuk airport hangar, because on the roof of the hangar there is a GPS antennae, which broadcasts into the hangar.
- Entering GPS points for the transect is NOT possible inside the hangar in Kangerlussuaq. There is NO antennae on the roof and you cannot punch in GPS points while parked inside the "warm" hangar. You must be out in the cold on the tarmac.
- When out flying for the transects, not all pilots realize that one needs to plot in both the "A" and "B" end points for the transect before you reach the transect. This way I can check if the pilot is flying to the correct start point and the pilot can "see" the transect, which helps him to orient correctly for approaching and ultimately for flying each transect. Make sure you go over this with the pilots before flying. In 2006 the helicopter had an advanced GPS "map" unit to the right of the pilot in the cockpit, but not in 2010. In 2010 the pilot had to rely on only the standard GPS on the dashboard. Several times I had to keep him from overflying the transect before starting.
- To allow comparison among surveys, the transects must be repeated with accuracy. Because pilots do not know the terrain, and often do not know where they are on a map, the project leader must at all times know where the helicoter is  in the terrain, and where the start point of the next transect is. The reason is simple, pilots may inadvertently overfly transects assuming the transect start is at the other 'end' of the transect. Pilots may also overfly start points, because it is difficult to find these with standard GPS and the typical time delay on positions received from the satellite. Advice from the project leader to the pilot, e.g., "the transect starts on the far side of that valley to the left, next to the river", are necessary to ensure that transects are found and flown properly. Inadvertent overflying prior to actually flying the transect for survey can frighten caribou off the transect line before it is flown.

*Photo data retrieval*

- Record the exact start and stop time of each transect line.
- Record the exact start and stop time of each departure, arrival and refueling.
- You can coordinate photos with locations if you ensure the clock time on your camera is the same as your watch / GPS used during the survey.
- There are hundreds of photos taken during a survey. Before each transect, write the transect number onto your notepaper and photograph this prior to beginning taking photos on that specific transect.
- If doing a photos series of a specific route or area, then write a short note (describing name of the area etc) to yourself on the notepaper and photograph this at the start and finish of the series.

*Miscellaneous*

- Book the time period for helicopter use well in advance (minimum two months). If the survey is to occur in March, then booking in October of the previous year is best. Since 2010 you can pre-book the pilot and helicopter of your choice. Check as to whether AirGreenland has other plans for their helicopter or pilot during the time period for the intended survey. One year, AirGreenland neglected to inform us that their pilot was obliged to participate in an AirGreenland pilots training course. This interrupted the survey when weather was optimal.
- Adjust distance of rear seats from the windows: The rear seat observers can have a better sitting position if the one or two middle seats are removed, which permits the two window seats to be moved (they are attached only by velcro) towards the centre of the helicopter. This leaves the rear seat observers more room to turn and sit comfortably while looking out the rear window(s). Otherwise their nose is brushing the window and there is no room to turn a body sideways in the seat. A crink in the neck can be avoided.
- Have with you paper copies of the grid cell maps, with the transects drawn in over the grid cells. You can pencil in your route flown, as you fly, and thus keep track of where you are at all times for recording grid cell ID for herd structure observations. (Otherwise mistakes occur easily as looking up and out of helicopter, hurriedly at the map and then writing down something.) The charting of the course removes that opening for errors.
- Bring non-scratch cloths, which are approved by AirGreenland Helicopter Charter department to wipe condensation off the inside of the helicopter’s windows. Most pilots do not care what you use, while others get upset.

# Appendix 7

### *List of terms*

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

*Annual* – occurring, or done every year.

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

*Body condition* – pertaining to amount of fat present, i.e. plenty of fat equals excellent body condition.

*Bootstrapping* – statistical tool to arrive at confidence intervals without knowledge of the distribution of the parameter in question.

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

*Criteria* – standards set on which judgement can be made, i.e. the sex or age of a caribou.

*Density* – the number of caribou per square kilometre of land area.

*Estimate* – a calculation as to the likely or approximate size of the caribou population.

*Fecundity* – related to fertility and is the potential level of reproductive performance of a population, which is usually much greater than the realised reproduction (fertility). However, fecundity and fertility are often used inconsistently and even interchangeably in the literature.

*Fertility* – of a population is the number of live births over a time period, usually a year, e.g. the number of live births per female, or the number of female young born per female. To calculate fertility we need to know the average litter size, average number of litters produced per time interval (year) and the sex ratio at birth (Caughley 1977).

*Fertility index* – see also under *recruitment*. Ratio of calves to females or calves to adults.

*Herd* – see also under *population*. Greenlandic caribou seldom or never aggregate into large coherent groups. Group size typically stays under 4 animals, with groups scattered throughout a large area.

*Herd structure* – this is the sex and age distribution of the animals within a given population/herd.

*Logistics* – the obtaining, distribution, maintenance and replacement of field equipment and personnel.

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

*Natural mortality* – all mortality due to factors other than hunting (disease, accident, starvation, predation, parasites, etc.).

*Net recruitment* – or rate of increase of the herd is determined by subtracting the adult mortality rate from the gross recruitment.

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

*Population status* – states a wildlife species' occurrence and abundance, i.e. where and how many.

*Population analysis* – attempts to determine herd structure (sex & age) and the forces controlling the composition of the population/herd.

*Population dynamics* – in any analysis of herd structure and status the parameters are seldom if ever static, therefore the term population *dynamics*.

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

*Range* – the extent of the land area on which the caribou wander and graze. The land area used during foraging/calving/rutting by the caribou, e.g. summer and winter ranges. The word is often synonymous with pasture or habitat; however, the term range brings vegetation to mind rather than for example topography.

*Recruitment* – see also under *fertility index*. The late winter (March) value for calves/100 cows, which indicates the increment in caribou number for a specific population from one year to the next.

*Sightability* or *Detectability* – the probability of actually seeing a caribou present within the transect strip flown.

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

*Strata* – (plural of stratum) in this report refers to the division of the North region according to caribou density present.

*Terrain* – refers to the land or ground, usually in conjunction with a description of topography, e.g. rough terrain, mountainous terrain, etc.

*Variance* – statistical term for the amount of variation in measurements. Variance is the expected square deviance regardless of the distribution. Its square root is standard deviation (SD). Note: variance is distribution independent, and is simply the expected square deviation.

# *Appendix 8*

***Observer comments regarding "can anyone be a good caribou observer"?***
***(In English)***

**Piniarnermik Aalisarnermillu Nakkutilliisut**
**Hunting and Fishing Officer**
**Sisimiut**

Sisimiut, April 2010

Christine Cuyler
Greenland Institute of Natural Resources
Box 570, 3900 NUUK, Greenland

**Re: Many believe they are best at seeing caribou, the truth is otherwise.**

As an experienced caribou and muskoxen counter, I can tell many stories. In the old days, specifically from 1990 to 1996 we flew in fixed-wing aircraft. The high speeds and altitudes, which were often extreme, made it frustrating at times to be a caribou counter. But the new survey system [since 2000], which is not without possible further improvements, has been an enormously good experience for me.

Today we count by helicopter, at low altitude and a fine low speed; even stops are possible if needed. However, I have noticed over time that when there is a new 1st time observer on board (e.g., Greenland commercial hunters or hunting officers), that just the same they have big problems detecting the caribou, especially in spring-like landscapes that are a blend of snow cover and bare ground, or when the caribou remain standing still just looking up at the helicopter in wonder as it flies past at low speed. The [observation strip width of] 300 metres out to either side is not a great distance, but especially in stone/boulder filled areas it can be enormously difficult to make any caribou among the stones. Many times I had to look and point out caribou to the observer sitting on the opposite side [of the helicopter]. Caribou were not being detected by the 1st time observer. Everything depends on that the observer for that side MUST SEE the caribou present, and they should see the animals.

When one sits in the helicopter as a counter, one does not in any way shape or form have time to think about one's own health or feelings, or to fight against air-sickness and make "the pilot queasy from the smell of your vomit". These are not easy-going normal passenger route flights. One must be 100% concentrated and on-point for the entire flying of a transect. One must constantly look forward, to the sides and to the rear, because of where the sunlight is coming from, or because cloud cover makes for poor light conditions in a complex terrain. The landscape can be such that the flying mimics the feeling of sailing in deep slow waves on the sea, given that the flight altitude must be strictly kept.

Over the two decades I have been an observer on caribou surveys, there have been several new observers, which included experienced caribou hunters who believe they are the absolute best at seeing / detecting caribou. Our experience shows that they are often disappointed in themselves, and are very quiet and thoughtful when the flying is completed.

Therefore, not just anyone can be a good caribou counter / observer.

Yours truly,
Hans Mølgaard

Hunting and Fishing Officer, Sisimiut
Tel: 866338, Cell phone: 528554, fax: 866339
E-mail: jagtfisk@greennet.gl

14 April, 2011

In connection with caribou surveys by helicopter, I would like to say that it can be enormously difficult to detect the animals because they are well camouflaged. Further, the weather can be a deciding factor, for example overcast conditions [causing no shadows] can make it hard to see the caribou. The helicopter surveys have a 300 metre transect width [to either side for total of 600m]. This is not a great distance, but still it can be very tough to see caribou because of the weather regardless of whether the observer has excellent eyesight. The caribou is a terrestrial mammal and therefore they are also extremely well camouflaged.

It can be problematic when there is direct sunshine, which is why it is very important to have the correct sun glasses on, so that you can see what you are supposed to be observing.

We often observe caribou standing completely still, which can make them near impossible to see unless the observer has a good knowledge of the terrain and the animals.

I would also like to say that caribou observers must be comfortable being helicopter passengers during survey flying. Not only must one endure many hours flying, but specifically the 'zigzag' flying.

Thus I send these short comments.

Yours truly,
Rink Heinrich

---

***Spotting / detecting caribou?***

Daylight and snow ground cover conditions during surveys can make it difficult to detect caribou (Appendix 10a, b). This underscores the necessity of excellent observers experienced in detecting most, if not always all, of the caribou within the strip width of a survey transect, if the survey is to accurately reflect actual caribou abundance. All observers, even excellent ones, miss some animals some of the time (hence the correction factor). In contrast, failure to detect many of the caribou that are actually within the strip width of survey transects, as may occur with inexperienced, or experienced yet inadequate, observers, will underestimate herd number. Further, it is commonly and erroneously assumed that caribou will run when the helicopter passes 15 m overhead. Although most will flee, others often remain stationary. Some look at the helicopter, while a few remain lying down or grazing. Movement cannot be the only key for locating animals present. The ability to spot the shape or colouring of a stationary caribou is necessary, regardless of the degree of camouflage against the varied backgrounds or in white-out shadowless conditions. Clearly, detecting caribou would be difficult to impossible if it were not for the helicopter survey's low flight altitude, low speed, and narrow strip width combined with experienced excellent observers. Current survey design promotes spotting caribou despite the typically imperfect circumstances. One more thing, observers must be completely untroubled by air-sickness (despite G-forces during somewhat aerobatic flying when collecting herd structure observations), because an air-sick observer is unable to concentrate and detect caribou.

*Yours truly,*
*Christine Cuyler*

*(In Danish)*

**Piniarnermik Aalisarnermillu Nakkutilliisut**
**Jagt og Fiskeribetjent**
**Sisimiut**

Sisimiut april 2010

Christine Cuyler
Pinngortitaleriffik Grønlands Naturinstitut
Box 570, 3900 NUUK

**Vedr.: Mange tror at de er allerbedste til at se rensdyr, sandheden er noget andet.**

Jeg kan fortælle så meget, som en snart gammel / rutineret rensdyr/moskustæller. I gamle dage især i den første halvdel af 1990-erne flyver vi med fastvinget fly, og hastighed*en* er høj, samt flyvehøjden kan blive enormt høj, og det kan i nogle tilfælde blive frustrerende at være tæller. Men dette system [ny siden 2000], der i sig selv ikke er den bedste metode, har været enormt god øvelse for mig.

I dag tæller vi med helikopter i lav højde og meget fin lav hastighed og kan dog stoppe op hvis det skulle være. Men jeg har i tiderne lagt mærke til, at når der er nye 1.gangstællere med [f.eks., erhvervsfanger, jagtbetjente], så har de alligevel store problemer med at se dyrene, især når landskabet er så forårsagtigt med blandede sne og sneløs, og dyrene blot kan finde på stå stille og bare kikke beundringsfuldt på helikopteren, der i lav hastighed flyver forbi. 300 meter ud til siderne er ikke langt, men især når der er stenfyldt område, kan det være enormt svært at skelne dyr og sten, og jeg må mange gange kikke og udpege dyrene i min modsatte side, der alligevel i sidste ende ikke ses af 1.gangstællere, der er i denne side, som SKAL SE og bør kunne se dyrene.

Når man sidder i maskinen som tæller, har man ikke på nogen måde tid til at tænke på sin helbred og velbefindende eller kæmpe mod sin luftsyge, og gøre "piloten utilfreds på grund bræklugt", det er jo ikke nogen almindelig fin flyvnings passagerrute man flyver på. Men man skal så længe transekten følges, være 100% oppe på mærkerne, og kikke både fremad og til siderne og dog bagud, da det kommer meget an på hvor man har sollyset fra, eller at der er overskyet og ret dårlig belysning. Landskabet kan jo være så kopieret, at flyvningen føles som om man sejler i store dybe langsomme bølger på havet, da flyvehøjden skal følges.

I mange år jeg har været tæller har vi nogen gange haft nye tællere med, såsom erfarne rensdyrjægere, der tror at de er allerbedste til at se dyrene, men vi oplever at de bliver skuffede af sig selv, og er meget tavse og betænkningsfulde når flyvningen er forbi.

Så det er ikke bare at sætte sig for enhver og begynde som tæller.

Med venlig hilsen
Hans Mølgaard

Aalisarnermik Piniarnermillu Nakkutilliisoq
Jagt og Fiskeri betjent, Sisimiut
Tlf.: 866338 mobil 528554 fax 866339
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14. april 2011

I forbindelse med rensdyrtælling med helikopter, kan jeg fortælle, at det kan være meget svært, at se dyrene med det blotte øje, fordi de er velkamuflerede, ligesom vejret er en afgørende faktor, eksempelvis når der er overskyet og det er svært, at se dyrene af den grund.
Ved rensdyrtælling med helikopter er 300 meter ikke langt, men det kan være meget svært, at se pga. vejret, uanset om man har et godt syn, i og med at rensdyr er landpattedyr, og derfor er de også meget velkamuflerede.

Det kan være meget svært ved høj sol, hvorfor det er meget vigtigt, at have de rigtige solbriller på, for at kunne se det man skal observere.

Tit og ofte observer vi rensdyr, der står fuldstændig stille, hvilket kan være umuligt at se, hvis ikke man har et godt kendskab til terrænet og dyrene.

Jeg skal også sige, at man skal være fortrolige med, at være passager i helikopterflyvningen, og at det er vigtigt, at kunne modstå at flyve i flere timer, eksempelvis når man flyver i sik-sak.

Hvilket jeg hermed sender som en kort kommentar.

Venlig hilsen
Rink Heinrich

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### *At se rensdyr?*

Observation af rensdyr kan besværliggøres af dårlige lysforhold og snedække (Appendiks 10a, b). Dette understreger nødvendigheden af gode erfarne observatører, som kan se om ikke alle så dog de fleste af de tilstedeværende rensdyr på en transekt. Alle observatører, også de rigtigt gode, overser nogle dyr, hvorfor der inkorporeres en korrektionsfaktor i forbindelse med analyse af tælledata . Hvis observatører, med et dårligt overblik, ikke evner at se mange af de rensdyr, der er på transekten vil det resultere i et underestimat af bestandsstørrelsen. Mange har den fejlagtige opfattelse, at rensdyr altid løber når helikopteren flyver 15 m over dem, men faktisk står de ofte stille. Nogle kigger på helikopteren, mens nogle bliver liggende. Bevægelser kan derfor ikke bruges som den eneste måde at se rensdyrene på. For at få gode bestandsestimater skal observatørerne således evne at kunne se facon og farvetegning af et tilstedeværende rensdyr, uanset graden af camouflage i tæt snefog og når himmel og jord synes at gå i et. Endvidere er det vigtigt at helikopteren flyver lavt og langsomt samt at transekten ikke er for bred. Den nuværende tællemetodik fremmer opsporing af rensdyr på trods af typiske besværlige omstændigheder. Det er desuden vigtigt at observatørerne ikke bliver luftsyge (som følge af de G-kræfter som til tider kan forekomme i helikopteren) fordi det ødelægger koncentrationen og evnen til at se rensdyrene.

.

*Med venlig hilsen*
*Christine Cuyler*

*(In Greenlandic)*

**Piniarnermik Aalisarnermillu Nakkutilliisut**
**Sisimiut**

Sisimiut, apriili 2010

Christine Cuyler
Pinngortitaleriffik
Boks 570, 3900 NUUK

**Inuppassuit isumaqartarput tuttunut tappinnerpaajullutik, eqqortorli allarluinnaavoq.**

Utoqqaliarsaalersutut sungiussilluarsimasutullu tuttunik umimmannillu kisitsisartutut oqaluttuassaanga. Ingammik qagaanerusoq 1990-kkut affaasa siullianni timmisartunit suluusalinnit sukkasoorujussuarmik timmisunit aamma portusoorujussuakkoortunit kisitsisarpugut, kisitsisuullunilu ilaannikkut erloqinartartorujussuusarpoq. Taamatulli kisitseriaaseq (2000-imili nutaajusoq) pitsaanerpaajunngitsorli uannut sungiusaataasimaqaaq.

Ullumikkut pukkitsunnguamiit sukkavallaaratalu timmilluta qulimiguulimmit kisitsisarpugut, ilaanneeriarlutalu pisariaqartinneqaraangat silaannarmi uninngasinnaasarluta. Piffissalli ingerlanerani kisitseqataaqqaartunik ilaqaraangatta (assersuutigalugu inuussutissarsiutigalugu piniartunik, piniarnermik nakkutilliisunik) uumasut takunissaat ajornartorsiutigisaraat maluginiartarsimavara, ingammik nuna upernaarpalaartillugu aputitaqarlunilu aputitaqanngitsortaqaraangat uumasullu alutorinnippasillutik uneqqissaarlutik qulimiguulimmik sukkaatsunnguamik timmisumik isiginnaaraangata. Sanimut meterit 300-t isorartunngilaq, ingammillu nuna ujarattaqarpallaartillugu uumasut ujaqqallu immikkoortikkuminaattartorujussuusarput, akuttunngitsumillu kisitseqataaqqaartup tungaanut qineqattaartariaqartarpunga uumasunillu tikkuartuullugit. Tamakku tassaasussaagaluarput kisitseqataaqqaartup illua´tunginni issiasup takusasSAI.

Qulimiguulimmiilluni kisitsilluni peqqissuseq iluarusunnerlu eqqarsaatigineqarsinnaanngillat imaluunniit meriannguneq akiorniarneqarsinnaananilu ”timmisartortarmut meriaarsunni pillugu naammagittaalliorfissaanani”, tassami nalinginnaasumik ilaasunik angallassilluni aqqutikkut timmisoqarneq ajormat. Timminerli tamaat tamakkiisumik malinnaaniartoqartariaqartarpoq aammalu siumut, sanimut tunummullu qinertariaqartarluni, apeqqutaalluni seqineq sumi inissisimanersoq imaluunniit nuianersoq qaamanerluunniit pitsaavallaanngninnersoq. Nuna ima qutaarluutigisinnaasarpoq allaat timmisartorneq allaaneq ajorluni imaq akuttusoorsuarnik portusuunik itinneraartoq aqqutigalugu, tassami timminermi nunap ilusaa malillugu timmisoqartussaammat.

Ukiorpassuarni kisitsisartutut kisitseqataasunik soorlu tuttunnianik misilittagartuunik uumasunut tappinnersaasorisunik ilaqartarsimavunga, kisianni qulimiguulimmik timmilluni kisitsineq naammassigaangat tamakku imminnut pakatsisittarput nipaatsorujussuusarlutillu. Taamaattumik kinaluunniit  imaaliallaannarluni kisitsisartunngorsinnaanngilaq.

Inussiarnersumik inuulluaqqusillunga
Hans Mølgaard

Aalisarnermik Piniarnermillu Nakkutilliisoq
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Tuttunik kisitsinermi quliguulimmik timminermi oqaatigisinnaavara tuttut takujuminaassinnaaneri silap isikkivia apeqqutaasaqaaq aammalu silap qaamanera apeqqutaasarluni soorlu sila qulisimatillugu tuttullu nunamut ilassuunera apeqqutaasarluni isikkivillu iseriatsillugu assut tuttut takujuminaattaqaat.Tuttunik kisitsinermi qulimiguulimmik timmitilluni 300,meterit isorartunngikkaluarput kisiannili silap pissusaa apeqqutaalluni takunninniarneq ilungersornartaqaaq qanorluunniit tappitsigigaluaraanni tassami tuttut nunamiuupput aammalu nunamut assut assingusuullutit.

Seqinnarissumi seqernup tungaanut sammitilluni assut ilungersunartarpoq qinerneq taamaattumik pitsaasunik seqinersiuteqarnissaq assut pisariaqartarpoq misissukkanik takunnissagaanni.

Ilaatigut tuttut uninngaqqissaartut naammattoortarpagut nunamut uumasunullu ilisimasaqanngikkaanni takuneq ajornarunartaqaat.

Aammalu oqaatigissavara qulimiguullinnut sungiussisimalluartariaqarneq tiimillu arlallit timmineq akiorsinnaasariaqarlugu pingaaruteqarpoq,makkununnga eqqarsaatigalugu tuttunik suussusiinik misissuigaangatta sangoriataarneq ammukariataarneq imak oqaatigilluaannaraanni zikzak-erluni.

Taamatut naatsunnguamik ilanngussilaarlunga oqaaseqalaarpunga.

Inuss.Inuullu.
Rink Heinrich

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***Tuttut takullugit ?***

Tuttut takuniarnerat qaamalluannginnermit aputeqarneranillu akornusersorneqarsinnaavoq (Appendiks 10a, b). Tamatuma takutippaa misilittagaqarluartunik suleqateqartariaqarneq tuttunik tamanik imaluunniit tuttunik kisitsiviusumiittunik takunnilertorsinnaasunik. Misissuisut tamarmik, tappinnerpaanut allaat, takunngitsuisarput, taamaattumik kisitsinermi paasisat misissorneqarneranni takunngitsuugaasimasussat naatsorsuinermut ilaatinneqartarput. Kisitsisut qinerfiluttumi tuttut kisitsiviusumiittut qassiunerat takusinnaanngippassuk tamatuma kingunerissavaa tuttut ikinaarlugit amerlassusiliineq. Amerlasuut isumaqartarput tuttut timmisartumit 15 m qulaanneqartut tamarmik qimaalersartut, akuttunngeqisumilli uninngalluaannartarput. Ilaasa helikopteri nakkuterussaartarpaat ilatik aqupisimaannartut. Taamaattumik tuttut angalanissaat kisiat toqqammavigalugu tuttusiortoqarsinnaanngilaq. Kisitsinerit ajunngitsumik inerneqassappata kisitsisut tuttut ilusaat qalipaataallu ilisarisinnaasariaqarpaat qanorluunniit persoralaami qinerfiluttumilu najukkaminnut ilassuutsigigaluarpata. Pingaartuuvortaaq helikopterip pukkitsunnguulluni arriitsumillu timminissaa aammalu nunatap kisitsiviusup silippallaannginnissaa. Kisitseriaatsip ullumikkut atorneqartup tuttusiorneq pitsanngorsarpaa naak ajornartortsiutaasartunik naapitaqartoqartaraluartoq. Pingaartuuvortaaq kisitsisut timmisartorlutik merianngusartuunnginnissaat (nukiit G-mik pineqartartut helikopterimi malunnartarmata) merianngusummi kisitsisut eqqarsaataat allamut sangoqqajaalersarput tuttunillu takunnissinnaanerat akornuserneqartarluni.

*Inussiarnersumik inuulluarit*
*Christine Cuyler*

# Appendix 9

## *Place Names*


*Figure 20.* *Place names used when describing locations in the Kangerlussuaq-Sisimiut caribou survey in the North Region, March 2010.*

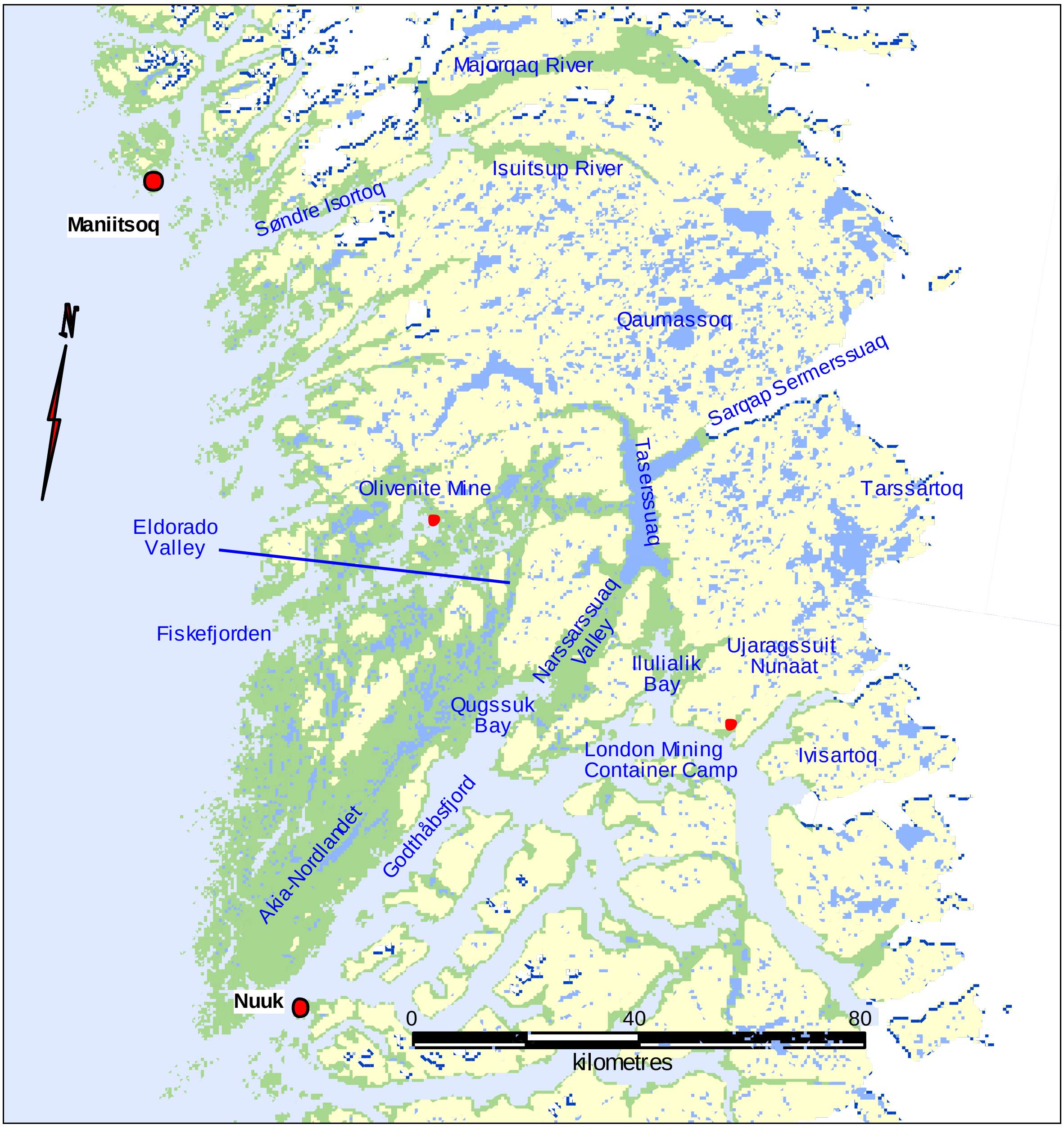


***Figure 21.*** *Place names used when describing locations in the Akia-Maniitsoq caribou survey, Central Region, March 2010.*

## *Part II: Appendix 10*

***A) Kangerlussuaq-Sisimiut caribou herd (KS), North region***

*Photographs taken during the helicopter survey, 3-8 March 2010*

*Compass headings: North (N), South (S), East (E) and West (W).*

***North region: High-density stratum, transects in the order flown***

***Figure 22.*** *Transect 15, view towards ENE, 3 March 2010. Photo by: C. Cuyler.*

***Figure 23.*** *Transect 73 ,view towards NW, 3 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 24.*** *Transect 183, view to the W, 3 March 2010. Photo by: C. Cuyler.*

***Figure 25.*** *Transect 10, view to the NW, 3 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 26.*** *Transect 34, view to the NE, 3 March 2010. Photo by: C. Cuyler.*

***Figure 27.*** *Transect 200, view to the NW, 3 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 28.*** *Transect 211, view to the NW, 3 March 2010. Photo by: C. Cuyler.*

***Figure 29.*** *Transect 175, view to the NW from west end, 3 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 30.*** *Transect 24, view to the ENE, 3 March 2010. Photo by: C. Cuyler.*

***Figure 31.*** *Transect 153, view to the NE, 4 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 32.*** *Transect 9, view NE, 4 March 2010. Photo by: C. Cuyler.*

***Figure 33.*** *Transect 59, view to the NE, 4 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 34.*** *Transect 70, poor light, view NNW, 4 March 2010. Photo by: C. Cuyler.*

***Figure 35.*** *Transect 142, poor light, view to the SSE, 4 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 36.*** *Transect 192, view NNW, valley dunes in poor light, 4 March 2010. Photo by: C. Cuyler.*

***Figure 37.*** *Transect 106, view to the SW, poor light & foggy, 4 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 38.*** *Transect 58, view to the W, poor light & foggy, 4 March 2010. Photo by: C. Cuyler.*

***Figure 39.*** *Transect 36, view to the NNW, poor light & foggy, 4 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 40.*** *Transect 137, view to the NNW, poor light & foggy, 4 March 2010. Photo by: C. Cuyler.*

***Figure 41.*** *Transect 149, poor light, view to SW, 5 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 42.*** *Transect 197, view to WNW, 1 caribou in highlands, 5 March 2010. Photo by: C. Cuyler.*

***Figure 43.*** *Transect 197, view to E in valley at N end transect, 5 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 44.*** *Transect 189, view to the NW, 5 March 2010. Photo by: C. Cuyler.*

***Figure 45.*** *Transect 112, four caribou, view to the NW, 5 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 46.*** *Transect 210, view to the N, 5 March 2010. Photo by: C. Cuyler.*

***Figure 47.*** *Transect 209, one caribou standing still & looking at us, view to the E, 5 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 48.*** *Transect 65, one caribou running away (follow tracks) view to the SE, 5 March 2010. Photo by: C. Cuyler.*

***Figure 49.*** *Transect 172, view to the NE, 5 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 50.*** *Transect 92, view to the NW, 5 March 2010. Photo by: C. Cuyler.*

***Figure 51.*** *Transect 122, view to the NW, 6 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 52.*** *Transect 76, view to the ENE, 6 March 2010. Photo by: C. Cuyler.*

***Figure 53.*** *Transect 115, view to the WSW, 6 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 54.*** *Transect 202, view to the NE, 6 March 2010. Photo by: C. Cuyler.*

***Figure 55.*** *Transect 203, view to the NW, 6 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 56.*** *Transect 193, view to the NNW, 6 March 2010. Photo by: C. Cuyler.*

***Figure 57.*** *Transect 120, view to the SE, 6 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: High-density stratum, transects in the order flown.***

***Figure 58.*** *Transect 139, wide Isortoq River valley covered in windblown loess dirt, view to the NW, 6 March 2010. Photo by: C. Cuyler.*

*KS Herd North region: Low-density stratum, transects in the order flown*

***Figure 59.*** *Transect 125, view to the E, 3 March 2010. Photo by: C. Cuyler.*

***Figure 60.*** *Transect 32, view NW as nearing north end, 3 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure 61.*** *Transect 8, view to the NW, 3 March 2010. Photo by: C. Cuyler.*

***Figure 62.*** *Transect 29, view to the SE, 6 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure 63.*** *Transect 87, view to the WNW, 6 March 2010. Photo by: C. Cuyler.*

***Figure 64.*** *Transect 143, open fjord at the N end of Transect, view to the SE, 6 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure 65.*** *Transect 155, thick fog in lowlands prevented flying this line, view SE, 8 March 2010. Photo by: C. Cuyler.*

***Figure 66.*** *Transect 47,E end of line, view WNW, 8 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure 67.*** *Transect 101 view WNW, 8 March 2010. Photo by: C. Cuyler.*

***Figure 68.*** *Transect 113, S end line, view NW, 8 March 2010. Photo by: C. Cuyler.*

*KS Herd North region: Low-density stratum, transects in the order flown*

***Figure 69.*** *Transect 161, S end of line, view NE to Dye 1 station, 8 March 2010. Photo by: C. Cuyler.*

***Figure 70.*** *Transect 151, S end of line, view NE, 8 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure 71.*** *Transect 27, S end of line, view ENE, 8 March 2010. Photo by: C. Cuyler.*

***Figure 72.*** *Transect 77, view N, 8 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure73.*** *Transect 64, view E, 8 March 2010. Photo by: C. Cuyler.*

***Figure 74.*** *Transect 150, view E, 8 March 2010. Photo by: C. Cuyler.*

***KS Herd North region: Low-density stratum, transects in the order flown***

***Figure 75.*** *Transect 5, view NE, 8 March 2010. Photo by: C. Cuyler.*

***Figure 76.*** *Transect 135, view N, 8 March 2010. Photo by: C. Cuyler.*

*KS Herd North region: Low-density stratum, transects in the order flown*

***Figure 77.*** *Transect 61, poor light, view NW, 8 March 2010. Photo by: C. Cuyler.*

## Appendix 10

***B) Akia-Maniitsoq caribou herd (AM), Central region***

*Photographs taken during the helicopter survey, 9-13 March 2010*

*Compass headings: North (N), South (S), East (E) and West (W).*

***Central Region: High-density stratum, transects in the order flown.***

***Figure 78.*** *Transect 107, view NE, 9 March 2010. Photo by: C. Cuyler.*

***Figure 79.*** *Transect 84 marks on windshield shown up by view to the sun; view SSW, 9 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 80.*** *Transect 39, view SSW, 9 March 2010. Photo by: C. Cuyler.*

***Figure 81.*** *Transect 17, view SSW, 9 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 82.*** *Transect 97, rain on windshield, view SW, 9 March 2010. Photo by: C. Cuyler.*

***Figure 83.*** *Transect 68, view ESE, 9 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

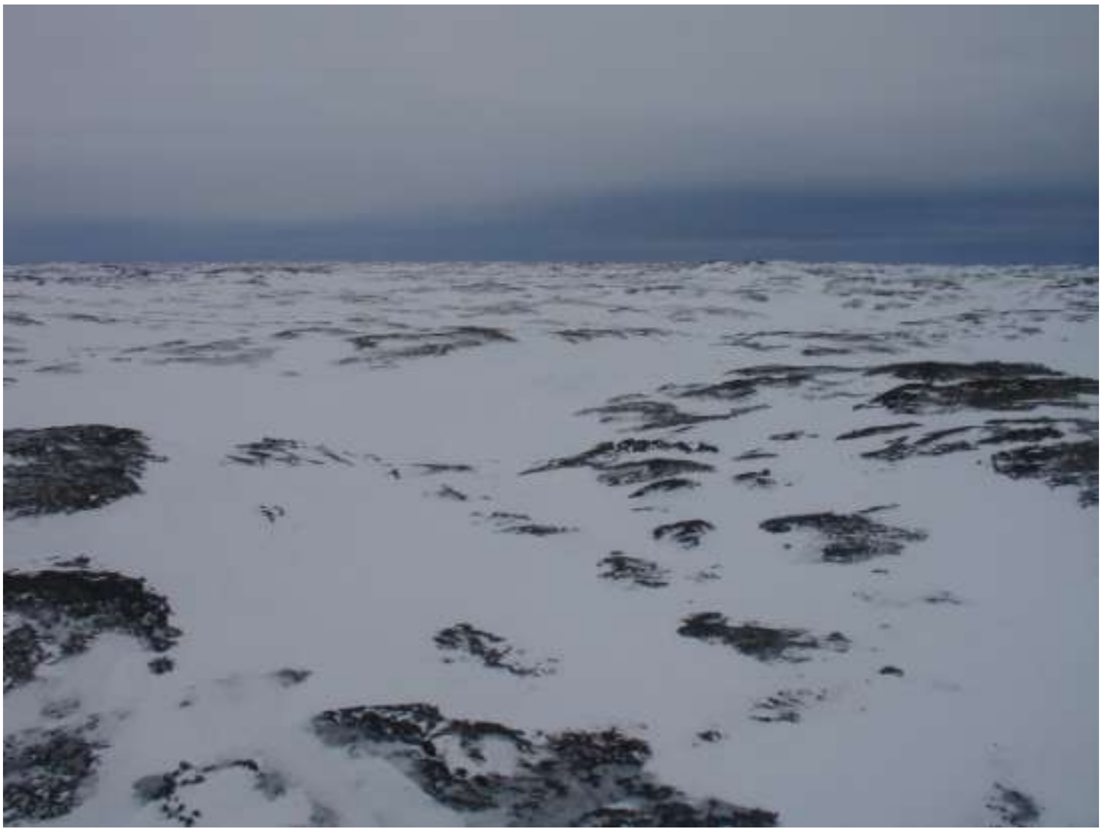

***Figure 84.*** *Transect 77, Akia lowlands, view SW, 9 March 2010. Photo by: C. Cuyler.*

***Figure 85.*** *Transect 227, view ENE, 10 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

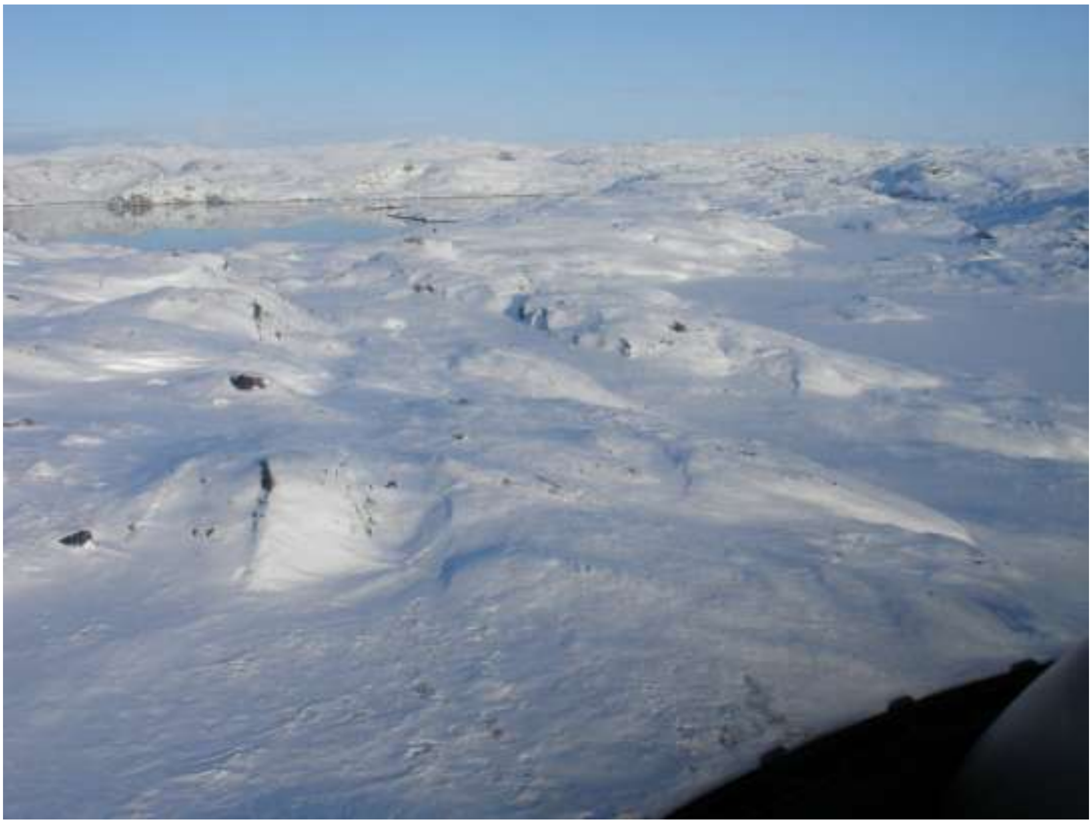

***Figure 86.*** *Transect 124, Fiskefjord in background, view N, 10 March 2010. Photo by: C. Cuyler.*

***Figure 87.*** *Transect 87, which is just E of Olive mine, view ENE, 10 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 88.*** *Transect 200, view WSW, 10 March 2010. Photo by: C. Cuyler.*

***Figure 89.*** *Transect 164, view W, 10 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 90.*** *Transect 181, view NW, 10 March 2010. Photo by: C. Cuyler.*

***Figure 91.*** *Transect 199, view SSW, 10 March 2010. Photo by: C. Cuyler.*

*AM herd, Central region: High-density stratum, transects in the order flown.*

***Figure 92.*** *Transect 58, in river bottom, view NW, 10 March 2010. Photo by: C. Cuyler.*

***Figure 93.*** *Transect 56, view NW, 10 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 94.*** *Transect 3, poor light, view SSE, 10 March 2010. Photo by: C. Cuyler.*

***Figure 95.*** *Transect 183, view ESE, 10 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 96.*** *Transect 1, poor light, view S, 10 March 2010. Photo by: C. Cuyler.*

***Figure 97.*** *Transect 18, poor light, view ESE, 10 March 2010d. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 98.*** *Transect 96, note the snow cover and elevation changes ahead on this transect line, view to the N, 12 March 2010. Photo by: C. Cuyler.*

***Figure 99.*** *Transect 64, the E end at Ice Cap, view E, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

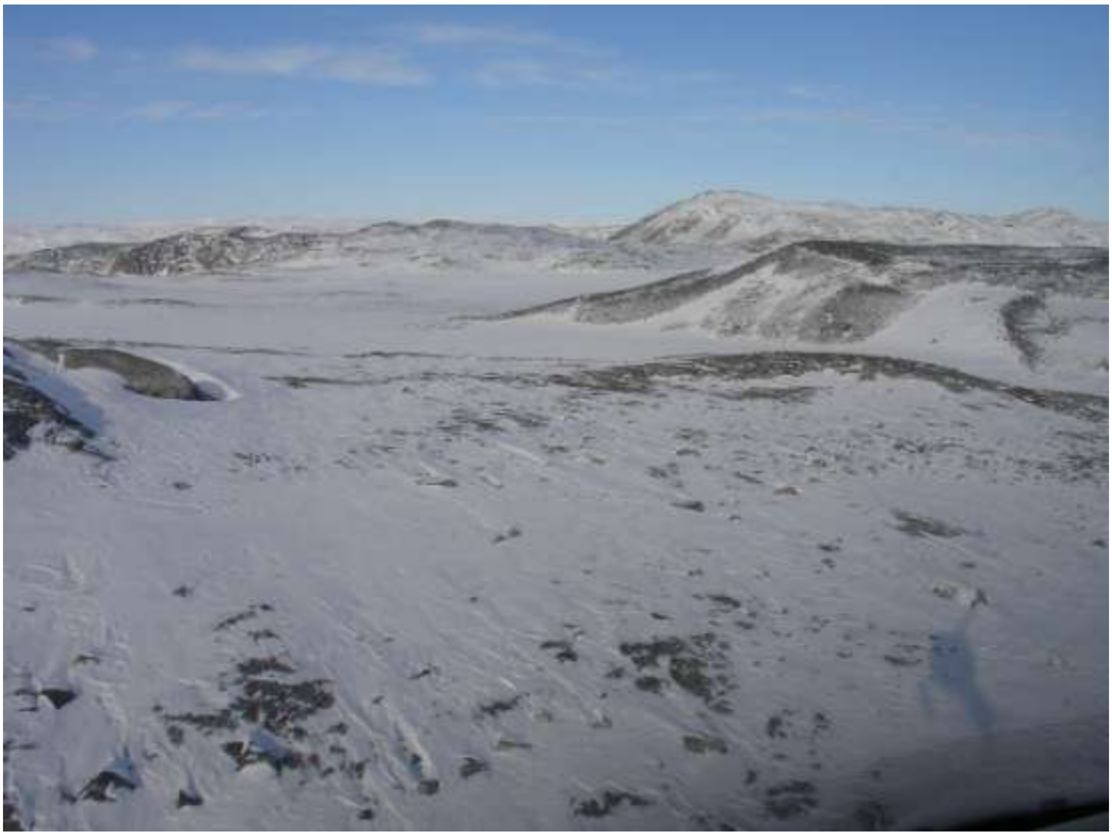

***Figure 100.*** *Transect 136, view NW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 101.*** *Transect 166, view NW, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 102.*** *Transect 108, Ilulialik fjord & Bird Mountain in background, view SSW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 103.*** *Transect 191, E end, view W, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 104.*** *Transect 36, "Eldorado", view NW along zero line, 12 March 2010. Photo by: C. Cuyler.*

***Figure 105.*** *Transect 193, "Eldorado", view SE along zero line, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 106.*** *Transect 21, Narssarssuaq Valley in background, view SE, 12 March 2010. Photo by: C. Cuyler.*

***Figure 107.*** *Transect 8, view NW, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 108.*** *Transect 46, view SE, 12 March 2010. Photo by: C. Cuyler.*

***Figure 109.*** *Transect 65, view NW, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 110.*** *Transect 186, poor light, view NW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 111.*** *Transect 201, poor light, view NE, 12 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 112.*** *Transect 203, poor light, view NE, 13 March 2010. Photo by: C. Cuyler.*

***Figure 113.*** *Transect 197, poor light, view E, 13 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 114.*** *Transect 135, poor light, view ENE, 13 March 2010. Photo by: C. Cuyler.*

***Figure 115.*** *Transect 141, poor light, view S, 13 March 2010. Photo by: C. Cuyler.*

***AM herd, Central region: High-density stratum, transects in the order flown.***

***Figure 116.*** *Transect 19, poor light, view NNW, 13 March 2010. Photo by: C. Cuyler.*

*AM herd Central region: Low-density stratum, transects in the order flown*

***Figure 116.*** *Transect line 105, view to the SSE, 9 March. Photo by: C. Cuyler.*

***Figure 117.*** *Transect line 126, poor light, view to the SW, 9 March. Photo by: C. Cuyler.*

***AM herd Central region: Low-density stratum, transects in the order flown***

***Figure 118.*** *Transect line 168, poor light, view to the SE, 9 March. Photo by: C. Cuyler.*

***Figure 119.*** *Transect line 53, poor light, view to the WSW, 9 March. Photo by: C. Cuyler.*

***AM herd Central region: Low-density stratum, transects in the order flown***

***Figure 120.*** *Transect line 139, poor light, unable to see 300 metres to left of helicopter, which is an example of dead ground, view to the W, 9 March. Photo by: C. Cuyler.*

***Figure 121.*** *Transect line 52, view to NW, 10 March. Photo by: C. Cuyler.*

***AM herd Central region: Low-density stratum, transects in the order flown***

***Figure 122.*** *Transect line 95, view to S, 10 March. Photo by: C. Cuyler.*

***Figure 123.*** *Transect line 155, view to SE with line ending in fog, 10 March. Photo by: C. Cuyler.*

*AM herd Central region: Low-density stratum, transects in the order flown*

***Figure 124.*** *Transect line 121, view to NE, 10 March. Photo by: C. Cuyler.*

***Figure 125.*** *Transect line 28, view to NE, 10 March. Photo by: C. Cuyler.*

***AM herd Central region: Low-density stratum, transects in the order flown***

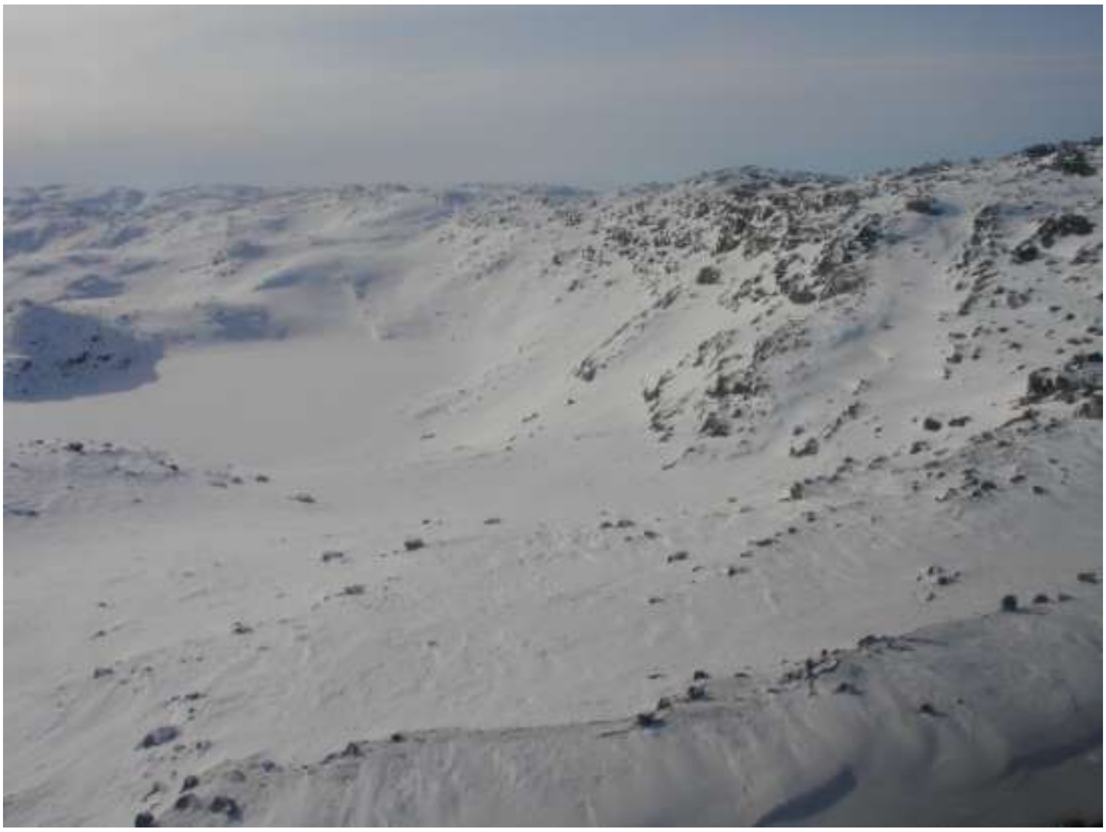

***Figure 126.*** *Transect line 149, view SW, 10 March. Photo by: C. Cuyler.*

***Figure 127.*** *Transect line 61, view to SW, 10 March. Photo by: C. Cuyler.*

*AM herd Central region: Low-density stratum, transects in the order flown*

***Figure 128.*** *Transect 15, view NE, 13 March 2010. Photo by: C. Cuyler.*

***Figure 129.*** *Transect 157, view SE, 13 March 2010. Photo by: C. Cuyler.*

*AM herd Central region: Low-density stratum, transects in the order flown*

***Figure 130.*** *Transect 96, view NE, 13 March 2010. Photo by: C. Cuyler.*

## *Appendix 11*

***Satellite collared caribou cows: Photographs taken during the Akia-Maniitsoq helicopter survey, 9-13 March 2010***

**Figure 131.** *Caribou cow wearing a yellow-black iridium satellite collar with her male calf, at the south end of transect 21, which is at the mouth of the Narssarssuaq Valley as it meets Qugsuk Bay/Fjord. 12 March 2010. Top original photo from 15 m altitude & Bottom: cropped. Photo by: C. Cuyler.*

***Figure 132.*** *Caribou cow with orange Telonics satellite collar. An antlered juvenile male (age < 3 years) is to her left. Her calf is just below two more caribou in the upper left of this photo, which was taken at the mouth of the Narssarssuaq Valley as it meets Qugsuk Bay, 13 March 2010. Flight height was ca. 15 m. Photo by: C. Cuyler.*

***Figure 133.*** *Two caribou ca. 100 m (upper centre); one to the left and to the right a cow (blends into background) with an orange Telonics satellite collar, Ilulialik, 13 March 2010. Photo by: C. Cuyler.*

## *Appendix 12*

***Caribou aggregation in the Narssarssuaq Valley, Central Region***
***Photographs taken during the helicopter survey, 9-13 March 2010***

***Figure 134.*** *Minimum 31 caribou within < 1 km of helicopter, 12 March 2010, north end of Narssarssuaq Valley, view NE. Photo by: C. Cuyler.*

***Figure 135.*** *Group of 5 & 12 caribou, and minimum 25 more in far background, 12 March 2010, north end of Narssarssuaq Valley, view NW. Photo by: C. Cuyler.*

**Figure 136.** *On the left are same group of 12 from figure 135, plus six more to their right, and minimum 35 in far background, 12 March 2010, north end of Narssarssuaq Valley. Photo by: C. Cuyler.*

**Figure 137.** *This is the same far background as figure 136, however, now a minimum of 40 caribou, 12 March 2010, north end of Narssarssuaq Valley, view NW. Photo by: C. Cuyler.*

***Figure 138.*** *Closer yet again to the same animals as in figure 137, and now a minimum of 50 caribou within 700 m, 12 March 2010, north end of Narssarssuaq Valley, view to north. Photo by: C. Cuyler.*

***Figure 139.*** *Closer yet again to the same animals as in figure 138, and now a minimum of 58 caribou within 700 m, 12 March 2010, north end of Narssarssuaq Valley, view north. Photo by: C. Cuyler.*

***Figure 140.*** *Closer yet again, this time only with a portion of the animals from figure 139, and now there are a minimum of 48 caribou within 300 m, 12 March 2010, north end of Narssarssuaq Valley, view NW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 141.*** *In this frame there are a minimum of 61 caribou within 300 m, 12 March 2010, north end of Narssarssuaq Valley, view SW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 142.*** *Closer and in this frame there are a minimum of 68 caribou within 300 m, 12 March 2010, north end of Narssarssuaq Valley, view SW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 143.*** *Closer to the caribou and in this frame there are a minimum of 74 caribou within 300 m, 12 March 2010, north end of Narssarssuaq Valley, view SSW, 12 March 2010. Photo by: C. Cuyler.*

***Figure 144.*** *Closer to the same caribou in this frame, there are minimum 78 caribou within 200 m, 12 March 2010, north end of Narssarssuaq Valley, view south, 12 March 2010. Photo by: C. Cuyler.*

***Figure 145.*** *Large group of 15 caribou, followed by three, while in the upper right on the ridge are two more caribou, 13 March 2010, at the southern mouth of the Narssarssuaq Valley where is meets Qugsuk Bay. Photo by: C. Cuyler.*

# *Appendix 13*

***How difficult is it to spot caribou?***

*Unaltered photographs were taken from ca. 15 m height above ground.*
*Distances are approximate and in metres from the transect's "zero-line" on the ground.*

***Figure 146.*** *Four caribou <50 m, transect 1, Akia-Maniitsoq, 10 Mar 2010. Photo by: C. Cuyler.*

***Figure 147.*** *Five caribou ca. 75 m, transect 18, Akia-Maniitsoq, 10 March 2010. Photo by: C. Cuyler.*

***Figure 148.*** *Three caribou just standing, ca. 25 m, transect 18, Akia-Maniitsoq, March 2010. Photo by: C. Cuyler.*

***Figure 149.*** *Seven caribou ca. 200 m distant, on north shore Godthåbsfjord, Akia-Maniitsoq, 12 March 2010. Photo by: C. Cuyler.*

***Figure 150.*** *Three caribou on ridge ca. 175 m distant. transect 191, Akia-Maniitsoq, 12 March 2010. Photo by: C. Cuyler.*

***Figure 151.*** *One caribou ca. 200 m distant, on transect 36, Eldorado valley bottom. Akia-Maniitsoq, 12 March 2010. Photo by: C. Cuyler.*

***Figure 152.*** *Nine caribou easy to see, < 150 m, at the south end of transect 21. View is to the SSW out towards Qugsuk Bay in the background. Akia-Maniitsoq, 12 March 2010. Photo by: C. Cuyler.*

***Figure 153.*** *Three caribou < 100 m, at mouth of the Narssarssuaq Valley to Qugsuk Bay, Akia-Maniitsoq, 13 March 2010. Photo by: C. Cuyler.*

***Figure 154.*** *Four caribou < 25 m, Ilulialik, 13 March 2010. Photo by: C. Cuyler.*

***Figure 155.*** *Four caribou < 15 m, Ilulialik, 13 March 2010. Photo by: C. Cuyler.*

***Figure 156.*** *One caribou < 100 m, flight height ca. 50 m, 13 March 2010. Photo by: C. Cuyler.*

***Figure 157.*** *One caribou < 200 m, 13 March 2010. Photo by: C. Cuyler.*

***Figure 158.*** *Three caribou < 50 m, Narssarssuaq Valley SE side, 12 March 2010.*
*Photo by: C. Cuyler.*