Moose Management Areas of the Nunatsiavut Territory:
History and Potential Research Initiatives

DISCUSSION PAPER

LGL LIMITED
environmental research associates

Submitted to

TORNGAT WILDLIFE PLANTS & FISHERIES SECRETARIAT

Torngat Wildlife, Plants and Fisheries Secretariat
217 Hamilton River Road
P.O. Box 2050, Stn. B
Happy Valley-Goose Bay, NL A0P 1E0

LGL Report SA1136
2 May 2012

Moose Management Areas of the Nunatsiavut Territory:
History and Potential Research Initiatives

DISCUSSION PAPER

Prepared by

C. Jones

P.O. Box 954, Stn. C
386 Hamilton River Road
Happy Valley-Goose Bay, NL A0P 1C0

Submitted to

Torngat Wildlife, Plants and Fisheries Secretariat
217 Hamilton River Road
P.O. Box 2050, Stn. B
Happy Valley-Goose Bay, NL A0P 1E0

LGL Report SA1136
2 May 2012

Suggested citation for this report:

Jones, C. 2012. Moose Management Areas of the Nunatsiavut Territory: History and Potential Research Initiatives. LGL Report No. SA1136. Report by LGL Limited, Happy Valley-Goose Bay, NL, prepared for Torngat Wildlife, Plants and Fisheries Secretariat, Happy Valley-Goose Bay, NL. 23 pp.

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS III
LIST OF TABLES IV
LIST OF FIGURES IV
BACKGROUND 1
HISTORICAL DISTRIBUTION 1
REVIEW OF LABRADOR MOOSE MANAGEMENT AREAS 2
ORIGIN OF A MOOSE HARVEST IN NUNATSIAVUT 2
NUNATSIAVUT MOOSE MANAGEMENT AREAS 4
PREVIOUS SURVEYS AND POPULATION ESTIMATES 4
ECOREGION COMPOSITION 7
Lake Melville 7
Coastal Barrens 8
Kingarutuk – Fraser River 8
Mecatina River 8
Smallwood Reservoir – Michikamau 8
Torngat Mountains 9
POTENTIAL RESEARCH INIATIVES 9
POPULATION ESTIMATES AND INDICES 9
Total Count 9
Strip Transect 9
Random Block 10
Geospatial Techniques 10
Mark-Resight Methods 11
Survey Timing 11
Demographic Data 12
Hunter Returns 12
Summary 13
RESEARCH PARTNERSHIPS 16
REFERENCES 21
LITERATURE CITED 21
PERSONAL COMMUNICATIONS 23

LIST OF TABLES

PAGE

Table 1 Summary Parameters of Recent Labrador Moose Surveys, March 2008 5

Table 2 Ecoregion Overlap and Percent Composition within Nunatsiavut Moose Management Areas 7

LIST OF FIGURES

Figure 1 Location of (A) Select Northern Labrador Geographic Features and (B) Labrador Inuit Land Claims Agreement Areas 17

Figure 2 Labrador Moose Management Area Configuration during (A) 2010/2011 and (B) 2011/2012 Hunting Seasons 18

Figure 3 Nunatsiavut Moose Management Area Configuration during (A) 2011/2012 and (B) 2012/2013 Hunting Seasons 19

Figure 4 Overlap of Labrador Inuit Lands (A) and Ecoregion Composition (B) within Nunatsiavut Moose Management Areas 20

LIST OF APPENDICES

APPENDIX A Confidence Intervals and Limits

BACKGROUND

Historical Distribution

Moose (*Alces americanus*) are relatively new to Labrador. The first reported observation occurring near Ashuanipi Lake in 1949 (Harper 1961; Figure 1A). By 1953, moose were resident in an area of southwestern Labrador having originally dispersed from eastern Quebec along sheltered river valleys (Mercer and Kitchen 1968). During the decade between the 1950s and early 1960s the rate of expansion was estimated at approximately 10 kilometers per year (Mercer and Kitchen 1968). In addition to the natural range expansion of moose into Labrador from Quebec, 12 animals (7 cows and 5 bulls) were introduced into southern Labrador (St. Lewis River area) in 1953 from the insular Newfoundland population (itself introduced) (Pimlott and Carberry 1958). Further range extension into interior Labrador may have been facilitated in later years through use of transmission line right-of-ways as travel corridors (Folinsbee 1976). Comparative DNA analyses suggest that the current moose population in Labrador is predominantly the product of natural dispersion from eastern Quebec, as opposed to the 1953 introduction event (Broders et al. 1999). Thus, unlike the insular Newfoundland population, since moose immigrated into Labrador of their own accord they should be considered an indigenous species.

Phillips (1983) documented moose sightings in northern Labrador between Flowers and Fraser rivers spanning 1976 to 1981. Moose were locally known to occur as far north as Nain by 1980. Chubbs and Schaefer (1997) summarized observations of moose or their sign in northern Labrador from 1980 to the mid-1990s to estimate a rate of northern range expansion of eight kilometres (km) per year. In 1995, independent sightings of two animals and indirect evidence (*i.e.* browsing and scat) were obtained as far north as Okak Bay and Hebron Fiord (Chubbs and Schaefer 1997). In recent years, observations of moose scat and tracks have been repeatedly observed in spring at the head of Napaktok Bay (W. Barney, pers. comm.). Collectively, these sightings near the northern tree-line (approximately 58°N latitude), likely represent the furthest possible northward expansion of moose in Labrador (Payette 1993; Chubbs and Schaefer 1997).

Labrador has a relatively low-density moose population with animals primarily associated with select river valleys during winter. Incised river valleys are preferentially selected in late winter as a result of reduced snow accumulations and availability of preferred forage. Density estimates for previous studies (using stratified random block methods) of moose in central and southern Labrador are comparable to similar marginal habitats in northern Quebec and range from 0.013 – 0.168 /km^2 (Chubbs and Schaefer 1997; Barney 2008a; Jones 2008). Estimates derived from large-scale strip transect surveys of central Labrador conducted in 2000 (122,000 km^2) and 2001 (29,900 km^2) reported moose densities of 0.016 and 0.030 /km^2, respectively (Jung et al. 2009). It must be emphasized that the highest densities of moose in Labrador occur in the central interior. Past forestry practices in the area have elevated the succession of willow and birch stands on the landscape and this high quality forage has likely assisted population numbers (Newbury 2007). However, density reductions of ~70% have occurred over the fourteen year period between 1994 and 2008 for Moose Management Areas 53 (MMA53; Muskrat Falls) and MMA54 (Grand Lake) (Chubbs and Schaefer 1997; Barney 2008b; Jones 2008a; Figure 2A). Regardless, central Labrador represents the regional benchmark for moose density with comparative estimates for northern Labrador and coastal areas being typically reduced. With increasing latitude (or altitudinal gradient) moose will be localized in areas with suitable habitat, such as mixedwood stands on south-facing slopes, low-lying valleys, river confluences, and riparian strips dominated by willow (*Salix spp.*), birch (*Betula spp.*), and alder (*Alnus spp.*) communities. Overall, the extent of moose population increase in Labrador is likely restricted by predation, poaching and limited availability of prime habitat (Chubbs and Schaefer 1997; Trimper 1997).

Review of Labrador Moose Management Areas

By 1977, moose populations within central Labrador were deemed to be of sustainable levels to warrant the sanction of an annual licensed hunt (Northland Associates 1980). Prior to 1980, the majority of provincial wildlife moose survey and classification flights were conducted adjacent to the Churchill River and Grand Lake (MMA50 to MMA54; Folinsbee 1976). Boundary delineations for additional Moose Management Areas were based on aerial surveys conducted during spring 1980 in four separate areas beyond central Labrador (Phillips 1983). These new MMAs were established in southern and northern Labrador for the 1984/85 hunting season. Two management areas were created north of Lake Melville, MMA55 (Double Mer) and MMA56 (Kaipokok).

Between 1980 and 2010 only minor changes have occurred within Labrador moose management areas. Noteworthy exceptions include the formation of MMA48 (Wabush) during 1996/97 and MMA85 (Snegamook) during the 1998/99 hunting seasons (Figure 2A). In 2010/11 the hunting season dates for all Labrador MMAs were standardized extending from the second Saturday in September to the second Sunday in March. In general, hunting quotas remained relatively unchanged and dedicated surveys of management areas occurred infrequently. With the exception of MMA53 and MMA54, it is not uncommon for MMAs to have only been systematically surveyed once, if at all, in the past thirty years. Replicate surveys of these areas are of low priority given the sparse occurrence of moose over large expanses of predominately low quality moose habitat (W. Barney, pers. comm.). Typically, moose hunting quotas within Labrador have been set at conservatively low numbers to ensure they fall below assumed levels of recruitment. In absence of periodic surveys, it is more common for local residents of an area (e.g. hunters) to have a sense of regional moose numbers based on anecdotal accounts of observed animals and hunter success rate. For the 2010/2011 hunting season, moose quotas in northern management areas were classified as either sex licenses for MMA55 (25 licenses), MMA56 (5), and MMA85 (10). These harvest levels had remained unchanged for the past thirteen years.

Origin of a Moose Harvest in Nunatsiavut

Four new MMAs were added to northern Labrador for the 2011/2012 moose season (Figure 2B). The selection of these areas was endorsed in a Torngat Wildlife and Plants Co-Management Board (Board) decision submitted to the Province of Newfoundland and Labrador in 2010, following consultation with the Nunatsiavut Government. The management areas include all of the Labrador Inuit Settlement Area (LISA) south of Torngat Mountains National Park (Figure 1B).

The Labrador Inuit Land Claims Agreement came into effect on December 1, 2005. The Agreement states that Inuit have the right to harvest wildlife and plants for subsistence, social and ceremonial purposes throughout LISA (LILCA 2005). However, for species of conservation and/or management concern, harvest levels by Labrador Inuit within Nunatsiavut are subject to quota restrictions (total allowable harvest levels) established by the Board. The Board also has the authority to suggest modifications to total allowable harvest levels based on new research and information. In addition to its reporting duties to the Nunatsiavut Government, the Board is primarily responsible for recommendations to the Minister (of appropriate federal or provincial jurisdiction) appropriate conservation and management measures for wildlife, plants, and habitat in LISA (LILCA 2005).

In addition to input from Nunatsiavut appointees, the Torngat Wildlife and Plants Co-Management Board began to receive anecdotal reports of increasing moose numbers within the vicinity of Nunatsiavut communities during consultation visits in 2008 (F. Phillips, pers. comm.). In response to requests from beneficiaries to establish a moose hunt on Nunatsiavut lands, the Board submitted a total allowable harvest (TAH) decision of 35 licenses to the provincial Minister of Environment and Conservation in June 2010. A suggested configuration of four proposed moose management areas confined to the LISA boundary was also submitted at this time. The annual license quota was based on a conservative estimate given the local knowledge of the regional moose population. Due to their recent range expansion, moose are not a traditionally hunted game animal and do not have a prominent role in the cultural history of the Labrador Inuit. However, a licensed moose harvest within Nunatsiavut was supported based on the perceived abundance of available animals, the dietary and economic benefits of country foods, and the recent population reduction of the George River caribou herd. During the past few years hunters in northern Labrador have had to travel further to hunt caribou. The decrease in caribou numbers has resulted in the unpredictability of their northerly winter movements.

Provincial approval was granted in April 2011 resulting in the creation of MMA88 (Backway), MMA89 (Rigolet), MMA91 (Postville), and MMA92 (Nain) within Nunatsiavut (Figure 2B). Although these moose management areas are confined within LISA, the definitive legal boundaries are based on geographical landmarks and are described in the provincial *Wild Life Act* and Regulations (2011). Changes to prior moose management areas outside of Nunatsiavut dictated by the new configuration include elimination of MMA55 (Double Mer) and MMA56 (Kaipokok), formation of MMA90 (Mokami), and a minor boundary adjustment to the northeastern corner of MMA85 (Snegamook). These modifications are illustrated in Figure 2. Non-beneficiaries of the Labrador Inuit Land Claims Agreement are required to get permission from the Nunatsiavut Government to pursue any harvesting activities inside Labrador Inuit Lands unless those interests are accommodated under the Agreement. Additional areas outside LISA have been established under Schedule 12-E of LILCA (2005), within which resident Labrador Inuit are able to exercise specific harvesting rights as though it was part of the Settlement Area (Figure 1B). The combined area overlaps portions of MMA53 (Muskrat Falls), MMA54 (Grand Lake), MMA57 (Paradise River), MMA84 (Traverspine), MMA87 (Eagle Plateau), and MMA90 (Mokami). Since the Schedule 12-E areas are subjected to special license requirements and are not considered a distinct moose management area they have not been considered for the purposes of this paper.

In November 2011, the Torngat Wildlife and Plants Co-Management Board submitted a decision to the Province of Newfoundland and Labrador to modify the shared boundary between MMA89 and MMA91, and to change the name of MMA91 (Postville) to MMA91 (Kaipokok). The boundary decision was a result of community consultations that identified Lake Michael, Michael's River, and surrounding areas of historical use as more appropriately allocated within MMA88 (Rigolet). Both decisions were accepted by the Provincial Minister in March 2012. This paper presents the currently accepted MMA boundaries and nomenclature for the 2012/2013 moose hunting season. A comparison of the original configuration for the 2011/2012 hunting season and the revised 2012/2013 Nunatsiavut MMAs are presented in Figure 3. The overlap of Labrador Inuit Lands (LIL) with the current Nunatsiavut MMA configuration is depicted in Figure 4A.

The 35 annual licenses held by Nunatsiavut are for Labrador Inuit beneficiaries and are not available to resident hunters through the provincial big game license draw. All moose licenses are for animals of either sex. They are allocated six per Labrador Inuit community (Nain, Hopedale, Postville, Makkovik, Rigolet) with one license reserved for each of the five community governments. The remaining five licenses are assigned to upper Lake Melville, which includes three for Nunatsiavut beneficiaries who reside outside of LISA, and one each for the two Inuit community corporations. It was envisioned that licenses reserved for each Inuit community government or Inuit community corporation could be used to provide for social or cultural events, community feasts, freezer or food-sharing programs, etc. However, each has the option of declining the license whereby it will go back into the respective pool (J. Goudie, pers. comm.). There are no changes to the original total allowable harvest (TAH) decision of 35 moose licenses for the 2012/2013 hunting season.

NUNATSIAVUT MOOSE MANAGEMENT AREAS

Previous Surveys and Population Estimates

The first systematic surveys to assess population size and demographics for moose in northern Labrador were conducted in spring 1980 (Phillips 1983). Two regions investigated north of Lake Melville included the Kaipokok River drainage basin (2,330 km^2) and an area centered on Double Mer, extending from the lower Sebaskachu River to Tom Luscombe Brook (4,122 km^2). Surveys were flown during 14-27 April, 1980. Parallel strip transects (5 km spacing; 1 km strip width) from a fixed-wing aircraft were initially used to document observations of moose and their sign, and to stratify survey areas based on apparent habitat quality. Subsequent to the initial flights, a helicopter was utilized to thoroughly assess areas identified as productive moose habitat and conduct animal classification.

Results for the Double Mer study area included a population estimate of 61 ± 59 (95% CI; Appendix A) with a minimum count of 32 animals and a mean group size of 1.68 moose per group (Phillips 1983). Population demographic data included an adult (≥ 1 year) bull:cow ratio of 53:47. Calf:cow ratio was 1.33 with calves comprising 37.5% of the total population. Observed twining rate was extremely high at 71%. The population for Kaipokok drainage was estimated at 38 ± 37 (95% CI) with a minimum count of 11 animals and an average group size of 1.22. All animals were classified and included 7 males, and 2 females each with a calf, however sample size was too low for meaningful moose demographics. Both MMA55 (Double Mer) and MMA56 (Kaipokok) were created in 1984 based on the findings of these surveys. Estimated moose densities for Double Mer and Kaipokok were 0.015 and 0.016 /km^2, respectively (Phillips 1983).

The most recent survey for MMA55 was conducted during mid- to late-March 2008. The survey employed a stratified random block design and was a joint project of the Newfoundland and Labrador and Nunatsiavut governments (Torngat Wildlife and Plants Co-Management Board). Estimates indicate a revised moose population of 314 ± 80 (90% CI) or 0.06 /km2 within MMA55 (Table 1; Barney 2008a). A total of 24 animals were classified with no evidence of twinning observed. The sex ratio of adult bulls:cows was 26:74. The percentage of calves in the population was 13.6% and the calf:cow ratio was 0.21 (21 calves per 100 cows). Group size ranged from one to six animals (Barney 2008a). Direct comparisons between the 1980 and 2008 estimates must be treated with caution given the different survey methodologies employed. In general, strip transects result in large confidence limits (Appendix A) for population estimates of moose given that they exhibit preferential habitat selection in winter and are not randomly distributed over the landscape. Phillips (1983) expressed reservations of the density and population estimates for Double Mer and Kaipokok on the basis of the chosen method of habitat stratification. Dalton (1986) was critical of the 1980 estimates "due to a lack of stratification, unequal strata size, unequal sampling effort, and methods which have been show to be highly biased". Although the updated 2008 results suggest a fourfold increase in moose density, it is possible that the 1980 value of 0.015 /km^2 was underestimated.

Table 1 Summary Parameters of Recent Labrador Moose Surveys, March 2008

Parameter	**MMA 53** (Jones 2008)	**MMA 54** (Barney 2008b)	**MMA 55** (Barney 2008a)	**CYA732A** (Jones 2008)
Moose Population Survey				
Survey Method	Stratified Random	Strip Transect	Stratified Random	Stratified Random
Survey Area (km^2)	4,180	3,942	5,366	6,000
Population Size (90% CI)	195 ± 130	85 ± 23	314 ± 80	115 ± 154
Density Estimate (/km^2)	0.047	0.023	0.060	0.023
Moose Classification				
Animals Classified	50	32	22	42
Adult Bull:Cow Ratio	35:65	38:62	26:74	52:48
Calves per 100 Cows	50.0	37.5	21.4	31.3
Percent Calves	22.0	18.8	13.6	11.9

Much information on distribution and anecdotal reports of moose within MMA88 (Backway) could be gained from interviews with hunters from upper Lake Melville, Rigolet and Sandwich Bay that frequent the area. Given its small area and close proximity to airport facilities it is an ideal candidate for a dedicated moose survey to obtain baseline demographic information. The newly revised MMA89 (Rigolet) is ~1,800 km^2 greater than the former configuration of MMA55 (Double Mer). As compared to MMA55, it appears that the only apparent loss of adequate moose habitat is localized to the Sebaskachu River drainage, which is now assigned within MMA90 (Mokami). The 2012 boundary alteration of MMA89 (Rigolet) makes direct comparison of moose density and population size obtained for MMA55 in 2008 difficult. In contrast, the newly revised MMA91 (Kaipokok) is reduced in size from the original configuration (MMA91 [Postville]), but still encompasses an area three and a half times larger than the former MMA56 (Kaipokok). The extensive areas of MMA91 and MMA92 (Nain) will result in challenges for the acquisition of moose information outside the local vicinity of Inuit communities and are virtually impossible to survey in their entirety.

Present scientific knowledge of moose within the Kaipokok River/Postville area is still based on the initial 1980 provincial government census of MMA56. The majority of information on moose distribution and abundance in northern Labrador has been gained from component studies for environmental assessments of low-level flight training and their subsequent mitigation and monitoring reports (RRCS 1989; DND 1994; JWEL 1997). For example, MMA85 (Snegamook) located immediately west of MMA56 was never systematically surveyed by the provincial government (G. Luther, pers. comm.). This zone was created for the 1998/99 hunting season after results of March 1997 surveys found relatively high moose densities at the western inflow constrictions of the Shipiskan and Kanairiktok rivers at Shipiskan and Snegamook lakes, respectively (JWEL 1997). Flight closures at these localized areas were recommended for low level military aircraft operating out of CFB 5 Wing Goose Bay after moose densities of 1.7 (Snegamook) and 0.95 /km^2 (Shipiskan) were recorded in 10.5 km^2 sample blocks (JWEL 1997).

Primary river valleys within MMA91 include the Kaipokok River watershed and lower reaches of the Kanairiktok and Adlatok rivers. The most recent survey conducted near this latitude of northern Labrador was performed in late-March 2008 over a 6,000 km^2 area centered on the confluence of the Shipiskan and Kanairiktok rivers. A stratified random block survey was performed by LGL Limited for the Institute of Monitoring and Research (IEMR) to assess distribution and moose demographics in an area prescribed for potential supersonic military aircraft training (CYA732A; Jones 2008). The estimated population size was 115 moose or 0.019 /km^2. Based on a minimum observed count of forty-two moose within the study area, the 90% confidence limits were 42 to 269 animals. All forty-two moose observed in the study area were classified by age and sex. The ratio of adult bulls:cows was 52:48 and the percentage of calves and yearlings in the population was 11.9% and 9.5%, respectively. The calf:cow ratio was 0.31 and no adult females were observed with twin calves. Average group size was 1.8 moose per group.

A component study documenting moose habitat use and distribution was not prepared for the Voisey's Bay EIS. The low density moose population was not considered a Valued Ecosystem Component (VEC) that would be affected by the large-scale mining project (VBNC 1997). Similarly, dedicated baseline moose surveys were not deemed necessary for Aurora Energy's proposed Michelin Project uranium mining operation (near Postville) given the infrequent occurrence of moose within the proposed footprint (L. Evans, pers. comm.). However, information on incidental moose sightings have been documented during baseline studies for other species (notably caribou) for these large-scale mining activities in northern Labrador. For example, during dedicated Harlequin Duck waterfowl surveys conducted in June 2010 for Aurora Energy, a total of eight moose were observed on the mainstem of Big River (L. Evans, pers. comm.). Additional incidental moose observation were obtained during Harlequin Duck replicate surveys in 2008 and 2009 on nine river stretches originally inventoried for the Voisey's Bay EIS. Moose observed during these waterfowl surveys are biased toward females with calves that favor isolated islands as an antipredator strategy during the parturition period (Stephens and Peterson 1984; Addison et al. 1993). Three moose were observed on Ikadlivik Brook in 2008 (Jones and Goudie 2008). In 2009, four separate moose were observed each on Anaktalik, Ikadlivik, Kogluktokoluk, and Igluvigaluk brooks (Jones and Goudie 2009).

Ecoregion Composition

The four MMAs within the Nunatsiavut territory encompass the Boreal Shield, Taiga Shield, and Arctic Cordillera ecozones, comprising eight distinct ecoregions (Figure 3B). An ecoregion is defined as a component part of an ecozone characterized by distinctive regional ecological factors, including climatic, physiography, vegetation, soil, water, fauna, and land use (ESWG 1995). A summary table of the ecoregion overlap within the four Nunatsiavut MMAs is presented in Table 1. The majority of the two southern moose management areas (MMA88 and MMA89) lie within the Lake Melville ecoregion characterized by some of the most productive forests in Labrador. MMA91 contains a more diverse assemblage of ecoregions than the other management areas. It is primarily defined by the Smallwood Reservoir –Michikamau ecoregion typified by rolling plains with numerous lakes and isolated rugged hills. MMA92 is dominated by the Kingarutuk – Fraser River ecoregion which generally contains half of its land cover as bare rock and tundra.

Table 2 Ecoregion Overlap and Percent Composition within Nunatsiavut Moose Management Areas

ECOZONE	ECOREGION	**MMA 88** Backway		**MMA 89** Rigolet		**MMA 91** Kaipokok		**MMA 92** Nain	
		km^2	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**
Boreal Shield	Lake Melville	1,232.4	61.9	4,285.1	59.6	49.8	0.3	–	–
	Paradise River	6.3	0.3	–	–	–	–	–	–
Taiga Shield	Coastal Barrens	628.1	31.5	574.9	8.0	4,068.5	21.7	3,270.9	10.1
	Eagle Plateau	49.7	2.5	–	–	–	–	–	–
	Kingarutuk - Fraser River	75.5	3.8	–	–	4,025.7	21.4	19,941.9	61.8
	Mecatina River	–	–	1,641.7	22.8	1,753.5	9.3	–	–
	Smallwood - Michikamau	–	–	693.1	9.6	8,867.7	47.3	–	–
Arctic Cordillera	Torngat Mountains	–	–	–	–	–	–	9,070.4	28.1
	TOTAL S	**1992.0**	**100**	**7,194.8**	**100**	**18,765.2**	**100**	**32,283.2**	**100**

General descriptions of the climate, primary geomorphological features, and vegetation communities for the main ecoregions within the MMAs are presented below (*from* ESWG 1995):

Lake Melville

A narrow extension of the boreal forest into the Taiga Shield ecozone surrounding Lake Melville in southeastern Labrador. It comprises all of Melville Plain and portions of river valleys entering the plain from Mecatina and Hamilton plateaus. It is basically an irregular lowland much dissected by river valleys. The ecoregion is characterized by a perhumid high-boreal ecoclimate. Elevations are generally close to sea level, to about 300 m asl, although a few hills reach about 500 m asl. Rock outcrops are common. Its mixed forests are dominated by productive, closed stands of balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), white birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*).

Coastal Barrens

This ecoregion forms a coastal strip of exposed headlands, sheltered inlets, and islands from Napaktok Bay south to the Strait of Belle Isle. It is classified as having an Atlantic low subarctic climate. Steep-sided, rounded mountains with deeply incised U-shaped valleys and fjords extending well inland along the Labrador Sea coast are common. A low, closed to open white spruce (*Picea glauca*) forest with a moss understory is generally found on moist, sheltered, upper and lower valley slopes. However, coastal heath dominates the ecoregion along headlands and ridges. Cliff summits are mostly exposed bedrock with mosses and lichens limited to small cracks and sheltered lee slopes. Frequent forest fires commonly reduce woodlands to scrubland dominated by alder, dwarf birch, and Labrador tea (*Rhododendron groenlandicum*). Salt marshes or plateau bogs are common on large marine terraces.

Kingarutuk – Fraser River

This ecoregion encompasses the southern continental tundra covering the George Plateau and several other mountainous outcrops, including the Mealy Mountains, south of Lake Melville. It is classified as having a high subarctic ecoclimate. Hummocky and drumlinized upper surfaces are covered by discontinuous, boulder, sandy morainal veneers. Continuous vegetation occurs only in depressions where snow accumulates and provides moisture throughout the growing season. Bare rock and tundra, and alpine heath of lichens, mosses, and sedges, each comprise about 50% of the upper surfaces. White birch/willow thickets growing on less stable scree frequently form a transition zone between tundra and very open spruce forests. Dwarf, open black spruce, dwarf mixed evergreen deciduous shrubs, and moss are dominant on bogs and poorly drained sites.

Mecatina River

This major part of this ecoregion spans the southern Labrador border with Quebec and extends northwest to the southern boundary of the Smallwood Reservoir. Two smaller but separate areas of the ecoregion lie north and west of Lake Melville. The ecoregion is classified as having a low subarctic ecoclimate. The terrain is rough and undulating and rises to elevations of about 215-600 m asl. Fluvioglacial deposits are sporadically distributed in the form of eskers and river terraces. The predominant vegetation includes low, open and sometimes closed cover patches of black spruce with an understory of dwarf birch, Labrador tea, lichens, and mosses. The forests are transitional, both to tundra and alpine tundra vegetative communities to the north, and to the closed cover of typical coniferous boreal forests to the south. Black spruce is the climatic climax species in this ecoregion, trembling aspen reaches its northern limit, and balsam fir is restricted to rare sites of medium-textured materials.

Smallwood Reservoir – Michikamau

The largest part of this ecoregion lies east and south of the Smallwood Reservoir, spanning the Labrador-Quebec boundary in southwestern Labrador. The second part extends across central Labrador from the Smallwood Reservoir in the west to Postville near the Coastal Barrens ecoregion. The general aspect of the region is that of a rolling plain with numerous lakes and isolated rugged hills that stand about 150 m above the surrounding surface. The ecoregion is classified as having a low subarctic ecoclimate. Its open coniferous forests are transitional, both to tundra and alpine tundra vegetation communities to the north, and to the closed cover of typical coniferous boreal forests to the south. Open stands of lichen – black/white spruce woodland with an understory of feather moss, are dominant.

Torngat Mountains

Located in northernmost Labrador, this ecoregion is classified as having a low arctic ecoclimate. It is composed of massive Archean granitic rocks, that form steep-sided, rounded mountains with deeply incises valleys and fjords along the Labrador Sea coast. Glaciation has sculpted cirques, deep U-shaped valleys, and fjords. Land cover is composed of a sparse layer of lichen, moss, arctic sedge, grass, and patches of mixed evergreen and deciduous shrubs on sheltered, south-facing slopes. Unvegetated rock and tundra (alpine heath made up of lichens, mosses, and sedges) each comprise about 50% of upland surfaces. White birch/willow thickets growing on less stable scree frequently form a transition zone between tundra and very open spruce forests. Arctic black spruce with mixed evergreen and deciduous shrubs, and underlain by moss, is dominant on bogs and poorly drained sites.

POTENTIAL RESEARCH INIATIVES

Population Estimates and Indices

Moose population size can be assessed in three basic ways: total (complete) counts, sample estimates and indices (Timmermann and Buss 2007). Total counts are beneficial for small-scale study areas but are impractical to inventory wide-ranging moose populations over multiple survey days. Sample estimates involve surveying a subset of the population and extrapolating the resultant survey data, based on statistical methods, to generate a population estimate. Historically, sample estimates of moose populations in Labrador have been conducted by strip transect or stratified random block aerial survey methodologies. In other areas of North America with higher moose numbers, ancillary information of moose demographic trend data has been utilized by wildlife management agencies as an index of moose population health during years between systematic survey estimates.

Total Count

Total counts are performed for well defined geographic areas such as river valley segments or predefined sampling units (SUs). They cannot be conducted for large-scale investigative studies of entire moose management areas. Essentially, a total count is assumed when surveying SUs during stratified random block surveys (when correction factors are not applied). Flight transects within SUs are of varying distances apart to provide complete coverage. All ungulate tracks need to be followed to determine if a moose is within the SU boundary and located animals should be georeferenced to determine if they lie in or outside the SU.

Strip Transect

These surveys employ a transect of fixed width, whereby only animals within a defined survey area (strip) are counted. The strip width is typically 250-500 m, but may vary with vegetation cover. Transects may be arranged in either a systematic or random pattern.

Strip transects provide the best results when animals are randomly distributed over large tracts of homogeneous habitat. Discrepancies in land cover type may result in large variations in the number of animals counted per transect. Animals which have a tendency to aggregate (e.g. caribou) can also cause large variations in the density estimate per transect, reducing overall survey precision (Garton et al. 2005).

Random Block

Simple random block surveys assume there is an equal likelihood of observing an animal over the entire study area. In reality, animals tend to show preference for habitat types that contain optimal quality and access to resources for food availability, shelter, rearing of young, etc. The precision of a population estimate can be improved by adequate stratification of sampling units prior to the survey. Inventory procedures to estimate moose number in northern ecosystems are well developed and thoroughly described by Gasaway et al. (1986).

The wide availability of free remote-sensing data products has permitted the stratification of potential study areas in the office which can greatly assist project planning and financial constraints. Jones (2008) used ArcGIS software (Esri, Redlands, CA) to stratify landscapes into 'high' and 'low' value moose habitat (strata), then further subdivided the study area into SUs of 4 km^2 cell size. Each SU represented a potential survey plot and was referenced to the 1:50,000 UTM grid network (NAD27; 1000 m). Following completion of the stratification exercise, sample blocks were randomly selected (without replacement) within each stratum and transferred to 1:50,000 NTS map sheets.

Recent independent moose surveys of MMA53 and MMA55 both based desktop stratification of SUs on Earth Observation for Sustainable Development of Forests (EOSD) data scenes and found the landcover stratification adequately predicted moose distribution in central Labrador (Barney 2008a; Jones 2008). However, Jones (2008) found that the EOSD land cover mapping data was not applicable for northern regions of Labrador and had to utilize additional remotely sensed data sources to stratify a separate study area on the Kanairiktok River (CYA732A; 54.5°N latitude). The EOSD land cover classification failed to adequately represent the vegetation of taiga regions and inconsistencies were discovered in remote areas dominated by sparsely stocked unmerchantable timber.

Ideally, a fixed-wing reconnaissance flight should be performed prior to the survey to test the validity of the GIS-based stratification exercise. Such a flight could also serve to locate pockets of caribou (and/or their tracks) that may overlap selected survey SUs within the proposed moose study area. These SUs would need to be omitted and replaced before conducting the helicopter-based stratified random block survey.

Geospatial Techniques

This geospatial method is gaining preference over the Gasaway technique (Gasaway et al. 1986) due to more flexible assumptions and has been utilized to estimate moose densities in Alaska, Yukon and Northwest Territories (VerHoef 2002; Kellie and DeLong 2006; Larter 2009). Major differences over the Gasaway approach are the ability to incorporate larger survey areas, sample unit boundaries are delineated by latitude and longitude graticles, sightability correction factors are unnecessary, and the analyses employ a spatial statistical model (Larter 2009). Geospatial methods are also more cost effective in the long-term as it permits sampling the same project area at a lower intensity more frequently to obtain a better understanding of population trend (Ver Hoef 2008). In contrast, Gasaway and other plot-based methods such as strip counts are known to be expensive and time consuming when the population is sparsely distributed over a large area (Ward et al. 2000).

In general, geospatial techniques have been used to assess populations in areas of high moose density (Alaska) and its use is likely not adequate, nor economically feasible to enumerate the low density population of Labrador. The geospatial approach has been utilized to estimate a low density moose population in the Dehcho administrative region of southwestern Northwest Territories (~150,000 km^2; Larter 2009). The region was separated into two study areas of approximately 23,000 km^2 (Mackenzie River valley) and 9,500 km^2 (Liard River valley). Density estimates were found to be 0.044 and 0.049 moose /km^2, respectively. Costs and logistic effort were deemed prohibitive to replicate annual large-scale surveys. However, annual classification monitoring flights were replicated at reduced cost, over a smaller area, given that the selected subset chosen adequately represented the original sample units used in the initial baseline survey (Larter 2009).

Mark-Resight Methods

Radio-collared animals within a population represent a marked subset that can be utilized in conjunction with systematic distribution survey methodology (e.g. strip transect) to calculate a mark-resight population estimate. The required variables include the number of marked (radio-collared) animals, total number of animals sighted, and number of marked animals sighted during the entire survey. Two algorithms commonly applied to closed populations include the Lincoln-Petersen Estimator and the Joint Hypergeometric Maximum Liklihood Estimator (White and Garrott 1990).

Population estimates and mortality information generated from telemetry studies are usually an ancillary benefit of having radio-collared animals in the study population. Radio-collars are primarily deployed to address specific research questions such as spatial and temporal use of home range and specific life-history habitat requirements. For animals that aggregate into clusters (e.g. caribou), radio-collars can facilitate classification surveys, such that demographic information is typically gained from multiple animals associated with each collared individual. Unfortunately, since moose exhibit a less clumped distribution than other ungulates, radio-collared programs for moose tend to be restricted to detailed habitat and/or resource utilization studies as opposed to facilitating physical relocation by a study observer.

Survey Timing

Aerial surveys for moose in Labrador should be conducted during mid- to late-winter. Adequate survey conditions are usually present in March but timing is more dependent on snow conditions, temperature, and ability to perform a continuous survey with limited weather delays. Surveys should be conducted within a short time frame (3-5 days) after a fresh snowfall to erase prior tracks. Clear or lightly overcast survey conditions with minimal winds are preferred. Moose detection and survey accuracy are increased by using multiple observers (including those sighted by the pilot). Timing of moose surveys also need to take into account the temporal movement patterns of the George River Caribou Herd in northern Labrador. A dedicated moose survey could potentially be compromised by a large scale movement of caribou through the study area (or a high concentration of tracks within selected survey SUs).

Generally, in early winter moose select for food, and are found in regenerating forest cutovers (≥ 6-8 years following timber harvest) and burns (≥ 10-12 years following wildfire) when these habitats are available. In mid-winter, when temperatures are extremely low and wind chill is high, moose often select small sheltered patches near a food supply. Mixedwood and deciduous south-facing slopes are also a preferred habitat at this time. In late winter moose tend to concentrate in river valleys and show preference for areas with a high mature conifer component to the forest cover, since these areas exhibit reduced snow depth and crusting compared to open habitats. This selection tends to facilitate escape following disturbance and is likely a predator avoidance strategy (Stephens and Peterson 1984). A common exception to this case are cow-calf groups, which often spend the entire winter in mature mixed stands, possibly because the calf is affected by snow depths which would inhibit movement in more open areas. In these localized areas moose tracks tend to form deep 'trenches' as they are repeatedly used as travel corridors between high quality forage patches. Dussault et al. (2005) found snow depths over 60 cm act as a limiting factor to population growth, as they decrease food availability and increase energy expenditure on calf movements.

Demographic Data

Successful moose management depends on adequate knowledge of population dynamics. Due to the lack of quality data for Labrador moose populations, managers have generally been conservative in their harvest management strategies and quota allotment. The age and sex ratio of the population is an essential parameter used for management of big game populations. Population structure may be estimated by aerial classification surveys. Historically, Labrador moose classification flights have been paired with winter population surveys to take advantage of locating sparsely distributed animals by track identification. Helicopters are often preferred because they tend to provide more accurate data than fixed-wing aircraft due to their greater manoeuvrability and inherent visibility.

The ratio of adult cows to calves can be used as a measure of production and potential recruitment. Numerous factors influence cow:calf ratios, including age of first breeding by females, predation of neonates, timing of survey (effective calf survival) and sightability of females with calves. Levels of recruitment and proportion of males in the population (i.e. adult bull:cow ratio) are important trend data parameters that can be monitored over time. Detection of significant or consistent changes in these demographic parameters can be indicative of population increases or decreases. Adequate sample sizes of (assumed) randomly distributed classified animals are required to draw conclusions and extrapolate to the total population. This has been problematic for previous Labrador moose investigations given that moose tend to occupy habitats that hinder visual observation, are generally much less gregarious than other big game animals, and populations exist at low densities and are spread out over large areas of remote landscape.

Hunter Returns

The establishment of Nunatsiavut MMAs was based on a simplified approach of confining management area boundaries within the confines of LISA. Although this eases the distribution of hunter/license allocation, the large size will complicate survey design and general moose management. It is assumed that the majority of allocated moose will be harvested within close proximity to Inuit communities, neighboring waterways, and around areas adjacent to cabins, etc. The community of Nain is the sole settlement within MMA92 (Nain), an area that occupies 32,283 km^2, extending as far north as Saglek Bay.

Moose are not a traditionally harvested food component of the Inuit diet. The 2011/2012 hunting season was the initial harvest year for the four Nunatsiavut MMAs. The season extends from 1 September to 31 March, annually. In comparison, the provincial hunting season for Labrador MMAs administered by the

NL Wildlife Division is defined open from the second Saturday in September to the second Sunday in March. The 35 total licenses were drawn on 28 October 2011 from a total pool of roughly 150 applications for the initial moose hunting season in Nunatsiavut (J. Goudie, pers. comm.). The first licensed kill was taken in MMA92 (Nain) on 16 November 2011. It is important to note that MMA quotas (total allowable harvests) were not based on potential hunting pressure but from a conservative approach given local knowledge of the regional moose population.

Given the small allotment of annual licenses, all hunters should be contacted by telephone following the end of each moose season to verify whether they harvested an animal. Additionally, a short questionnaire should be provided with each license that is to be returned to the Nunatsiavut Government, Wildlife Manager following the successful harvest of an animal, or at the end of the moose hunting season. Collection of hunter return data is important information given that these quotas are based on presumed conservative numbers as opposed to values based on scientific data obtained from population demographics. Suggested individual harvest statistics include (in order of importance): hunter success rate, age and sex of harvest, general location of where animal(s) were harvested, hunter effort (as measured by days hunted per animal harvested), number of moose seen per day, time and economic expenditures (i.e. transportation mileage, etc.). By far the most important postseason variable to obtain is annual hunter success rate (kills per license) which can be used as indicator of moose abundance (Chubbs and Schaefer 1997).

Moose jaw bones are sometimes collected to obtain age structure demographics for a population. For large moose populations with high hunting pressure (large quota allotments) obtaining accurate age data is absolutely essential to monitor age cohort structure of the harvest, and presumably, the population. The primary incisor is the standard tooth collected for cementum analyses and is usually prepared and aged by wildlife laboratory technicians (e.g. Matson’s Lab, Milltown, MT). Collection of moose jawbones is not essential for management of moose within Nunatsiavut, based on the small sample size (5-6 per year) potentially available per MMA.

Summary

Labrador moose populations exist at low densities, encompass an extensive area, and consequently are difficult and expensive to enumerate with a high degree of accuracy and repeat precision. Comparing historical population estimates (densities) for moose in Labrador has been complicated by (1) the lack of an adopted standardized survey methodology and (2) the long duration between consecutive surveys. This problem is confounded when subsequent surveys are conducted more than a decade(s) apart and employ varying methodologies. As such, the four Nunatsiavut MMAs should be managed similarly so that future survey estimates of population density and/or demographic parameters are comparable over time within (1) individual MMAs and (2) among other MMAs within LISA.

The four newly created MMAs within Nunatsiavut represent a total area of 60,235 km^2 (Table 2). The two largest MMAs (Nain and Kaipokok) account for 85% of the total area. Analyses of ecoregion composition for individual MMAs represent coarse habitat associations that may be predictive of moose suitability. It can be assumed that high barren elevations, dominant tundra-alpine heath vegetation cover and the high subarctic ecoclimate of the Kingarutuk-Fraser River and Torngat Mountains ecoregions would be indicative of landscapes avoided by moose. MMA91 (Kaipokok) has a total area of 18,765 km^2, of which 14,740 km^2 would be considered possible moose habitat. MMA92 (Nain) has a total area of 32,282 km^2, of which 3,271 km^2 is considered possible moose habitat. Accurate stratification of MMAs is required to omit as much undesirable moose habitat as possible from survey effort.

A desktop habitat stratification exercise should be performed to determine the amount of effective moose habitat within each MMA. This task should be completed at finer scales to more accurately determine the total potential area capable of supporting moose. For example, additional GIS layers and data sources of high resolution satellite imagery, vegetation coverage, forest fire age, digital elevation models, etc. may result in potential areas of localized high quality moose habitat near Nunatsiavut communities (where the majority of hunting pressure will occur). These areas along the Labrador coastline are presently described by the Coastal Barrens ecoregion. Revised area calculations of MMAs are necessary to sufficiently plan potential survey effort, estimate budgetary costs of systematic moose research study options, and finalize selection of optimal survey methodology. Such an exercise should occur prior to the start of dedicated moose surveys or classifications flights within Nunatsiavut MMAs.

The selection of survey frequency and methods adopted by wildlife management agencies are largely dictated by costs. A cost-benefit analysis needs to be conducted in order to evaluate potential moose research and management objectives based on realistic fiscal constraints. Chosen methodologies should be evaluated based on economics as opposed to scientific robustness. The Nunatsiavut MMAs are large areas and costs are likely to be prohibitive for randomly sampled grid-based survey methods. For example, both the Gasaway method and geospatial techniques may not be economically feasible since random selection of SUs may result in large transit times to sample low-density habitat. This scenario greatly highlights the need to develop a detailed GIS-based land cover stratification which would omit those areas within Nunatsiavut MMAs that have extremely low probability of moose utilization (e.g. areas of high elevation). With such a tool, we gain more adaptability to survey methodologies. Stratification would also facilitate classification flights to assess population demographic parameters.

In order to ensure hunting quota sizes are sustainable we ideally require an accurate estimate of how many animals are in the population. Alternatively, demographic data obtained from moose classification flights can be used as indicative of population growth. It should be mentioned that a high degree of money and effort could be spent to conduct systematic population surveys with very little return. The nature of the sparsely distributed northern Labrador moose population results in having to accept wide ranging confidence intervals of population estimates. The population range may be so great that insufficient information exists for which to evaluate management decisions. Similarly, there exists the possibility of expending a lot of resources to obtain high survey accuracy and precision that may only result in an increase or decrease of 1-2 hunting licenses per MMA. If results of the cost-benefit analysis preclude the option to conduct rigorous dedicated stratified moose surveys, the focus should be an emphasis on productivity patterns (e.g. recruitment) as opposed to total population size.

A comparable situation exists in mainland Nova Scotia which has an estimated 1,000 – 1,200 animals distributed over approximately 43,000 km^2. In October 2003, moose on mainland Nova Scotia were listed as Endangered under the *Nova Scotia Endangered Species Act* (NSDNR 2007). Aerial surveys are recommended under the provincial Recovery Plan but the large area combined with mild winter weather over parts of the range has prevented systematic stratified surveys (P. MacDonald, pers. comm.). Recent research objectives have shifted from assessing total population size to productivity parameters indicative of population health. Supplementary information is collected from pellet counts along established transects to provide the ability to detect changes in moose abundance over time.

MMA88 (Backway) and MMA89 (Rigolet) are each of optimal size to generate separate systematic estimates of moose density. In fact, even if these two areas were amalgamated into a single management unit (9,187 km^2), it would still be half the area of MMA91 (Kaipokok) and of comparable size to other MMAs within Labrador (the average area of the sixteen MMAs outside of LISA is approximately 7,400 km^2). A future decision to combine MMA88 and MMA89 may be beneficial given their close proximity to Rigolet, comparable ecoregion composition, and reduction in administrative tasks associated with harvest management. If such a merger were to occur it should happen prior to conducting initial surveys (or surveys could be structured to account for this possibility).

Public consultation sessions within Inuit communities may provide supplemental spatial data which could be incorporated into the land cover stratification product. Specific questions may include where and when moose occur on the surrounding landscape (varying scales), hunting locations and areas deemed important for moose (e.g. wintering yards). Documentation of these oral surveys/questionnaires could be georeferenced and stored in GIS to create a land use atlas. Traditional knowledge on high quality habitat and historical moose observations over the past 30 years could potentially be obtained. Over time hunter location data may depict patterns of analyzed trends in moose harvests per MMA. Reporting of moose sightings within LISA and input of harvest data/statistics by hunters could be facilitated by permitting entry though either the Nunatsiavut and/or Torngat Secretariat website(s).

A dedicated moose telemetry program funded by the Torngat Secretariat would be feasible if it was restricted to a single MMA. Ideally MMA89 (Rigolet) would be the candidate area given its proximity to helicopter charter companies in Goose Bay. Its location would reduce transit time/costs since helicopters will be required to deploy collars and perform subsequent classification flights. The collaring program should deploy collars on female moose so that additional parturition and calf survival rates could be followed annually. Initial collar deployment would ensure that captured animals were adequately dispersed throughout the study area and each represented an independent sample. As a result of their solitary tendencies, group size associated with individual collars will be low (likely 1-4 animals) and variable over the course of the year. Animals could be relocated during subsequent telemetry flights to obtain updated population demographics. An adequate sample of classified animals (not all necessarily collared) is required to extrapolate the sample estimate to the entire population. Since collared animals act as a marked sample, opportunities will also exist to utilize radio-collared moose to facilitate population survey estimates and obtain information on mortality rates and possible cause of death (e.g. natural, predation, or hunting-related). An estimate of the rate of mortality for the population is an important parameter for management purposes. Depending on collar model there is an option to collect large volumes of detailed spatial data for each animal. Resultant GPS locations of moose position over time could be utilized to assess home range size, detailed movement analyses, habitat preference and resource selection functions.

If a decision has to be made between a small-scale collaring program (< 8 collared animals) or the potential to conduct a population survey within an MMA, the survey should be favoured. A more economical use of research funds would be to perform a stratified random block survey of MMA89 and/or MMA88 (Backway). This would provide a population (density) estimate with a statistically generated confidence interval and demographic data obtained from classified animals during the survey. These parameters, in addition to robust land cover stratification for the four Nunatsiavut MMAs, could be applied to all MMAs to assist regional moose management decisions. Even though the survey option lacks the opportunity to collect high accuracy GPS records, it is accepted that detailed spatial analyses would provide little information relevant to the large-scale moose management needs required by the Nunatsiavut Government.

Research Partnerships

The establishment of a moose collaring program would be assisted if it were possible to arrange a partnership between the Torngat Secretariat and industry or academic institutions. Both Vale's Voisey's Bay site (within MMA92) and Aurora Energy's proposed Michelin Project (within MMA91) could serve as potential partners. Presently both Vale and Aurora Energy have no plans to conduct dedicated telemetry programs individually. Moose densities are too low to be of concern from an overall operation perspective. Additionally moose are not considered a 'nuisance' animal and companies have no government requirement for monitoring/mitigation measures since moose is not a federally or provincially listed species. Additional resource extraction projects in future may provide opportunities for numerous partners to cost-share moose telemetry studies.

Long-term climate change studies are presently being conducted by the Labrador Highlands Research Group (Memorial University) in areas of the Mealy, Red Wine, and Torngat mountains. Although their study sites are not located within LISA, their resultant findings are applicable to potential habitat shifts of alpine communities and potential tree-line migration within Nunatsiavut. Future moose dispersal in northern Labrador may potentially be increased as a result of projected altitudinal gradient shifts and degree of habitat change associated with climate change. There exists little opportunity to partner for moose studies but they may be able to provide information of incidental moose observations from marginal alpine habitat.

Opportunities to partner with provincial wildlife may exist for potential surveys of Nunatsiavut MMAs. The NL Wildlife Division was previously engaged in a large-scale study to assess the predator-prey dynamics of the wolf-moose-caribou system within Labrador. It is unknown what the status of this program is at present. They have been radio-collaring wolves in recent years which may lead to findings applicable to moose within Nunatsiavut MMAs.

Over the past 15 years, there have been numerous Labrador organizations working in isolation to generate GIS mapping products for their specific needs. The creation of a successful land cover stratification to facilitate selection of moose population survey methodology is dependent on high quality input data sources. One current product that may be beneficial for this exercise is the 'Labrador Nature Atlas' in production by Nature Conservancy Canada. The information was assembled with the goal of assisting organizations in making wise and sustainable land use planning and resource management decisions.

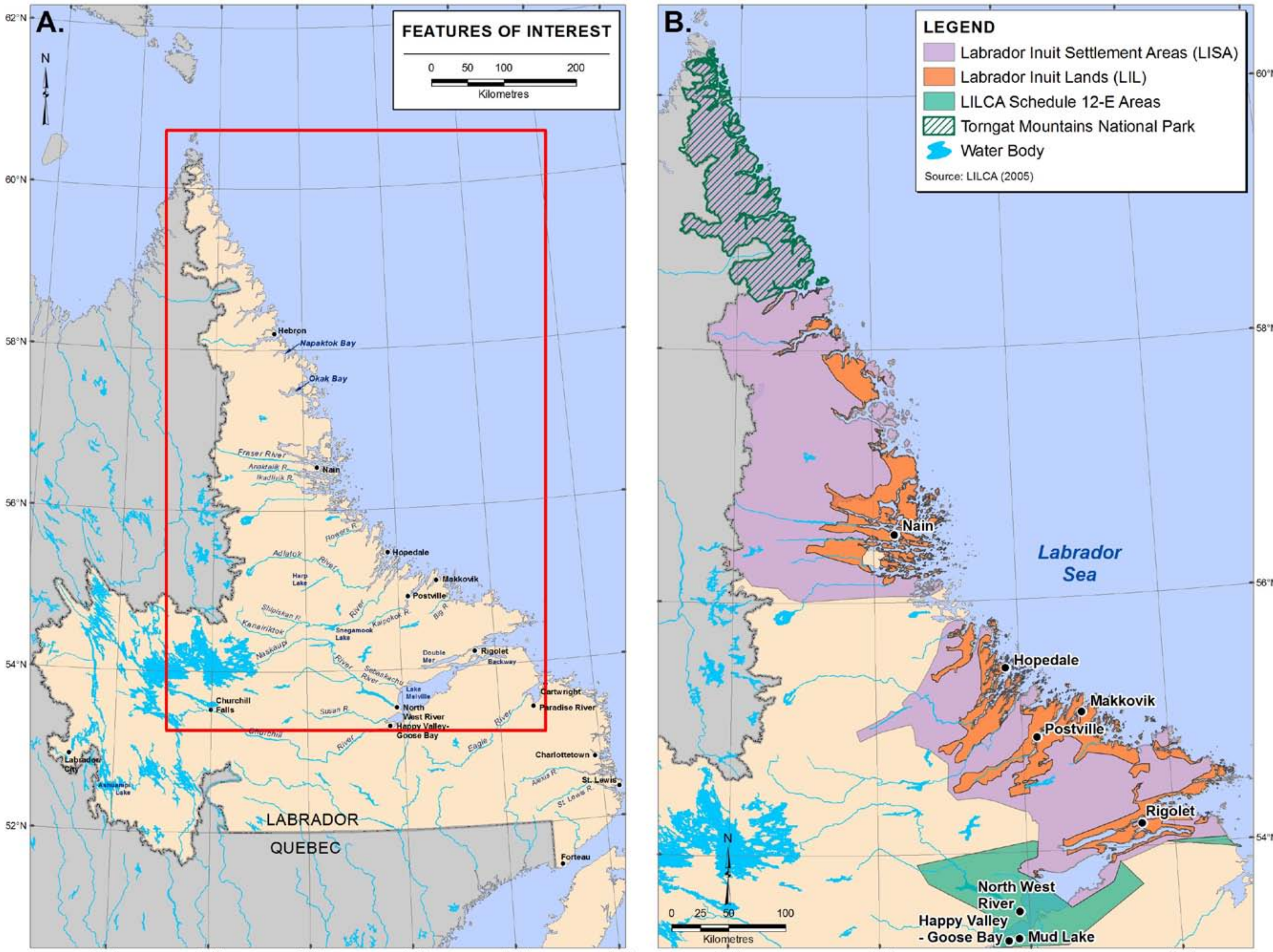

Figure 1 Location of (A) Select Northern Labrador Geographic Features and (B) Labrador Inuit Land Claims Agreement Areas

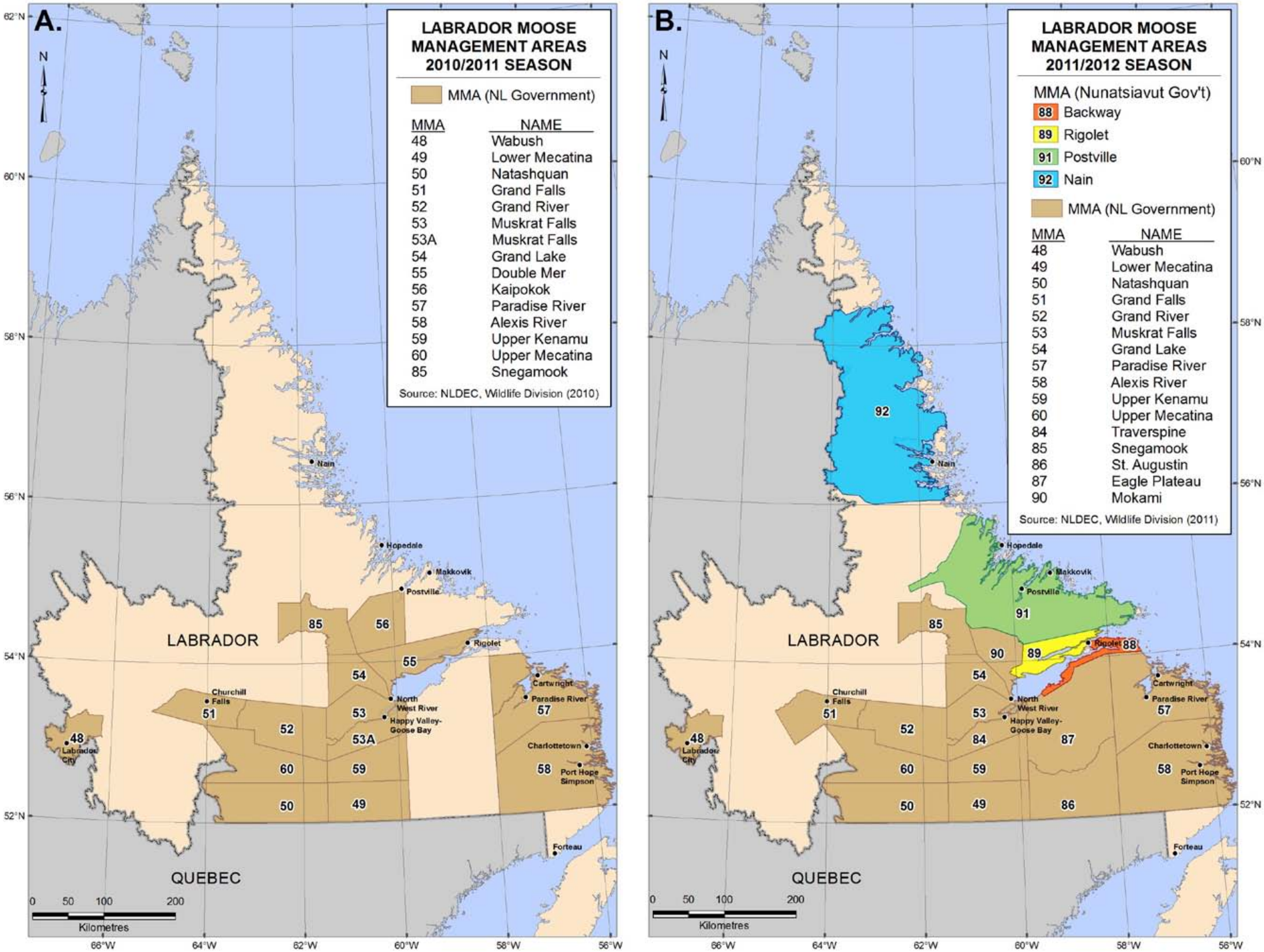

Figure 2 Labrador Moose Management Area Configuration during (A) 2010/2011 and (B) 2011/2012 Hunting Seasons

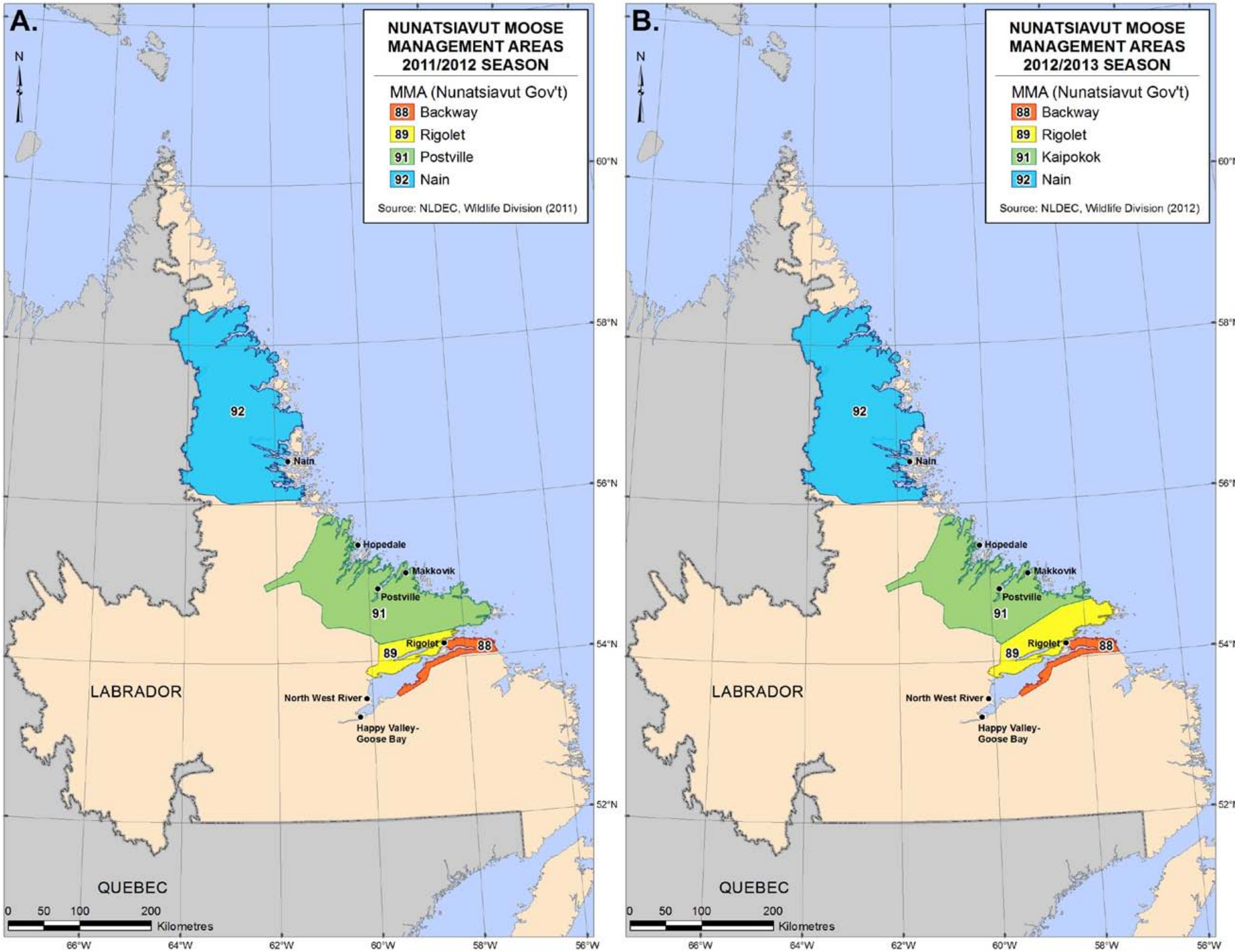

Figure 3 Nunatsiavut Moose Management Area Configuration during (A) 2011/2012 and (B) 2012/2013 Hunting Seasons

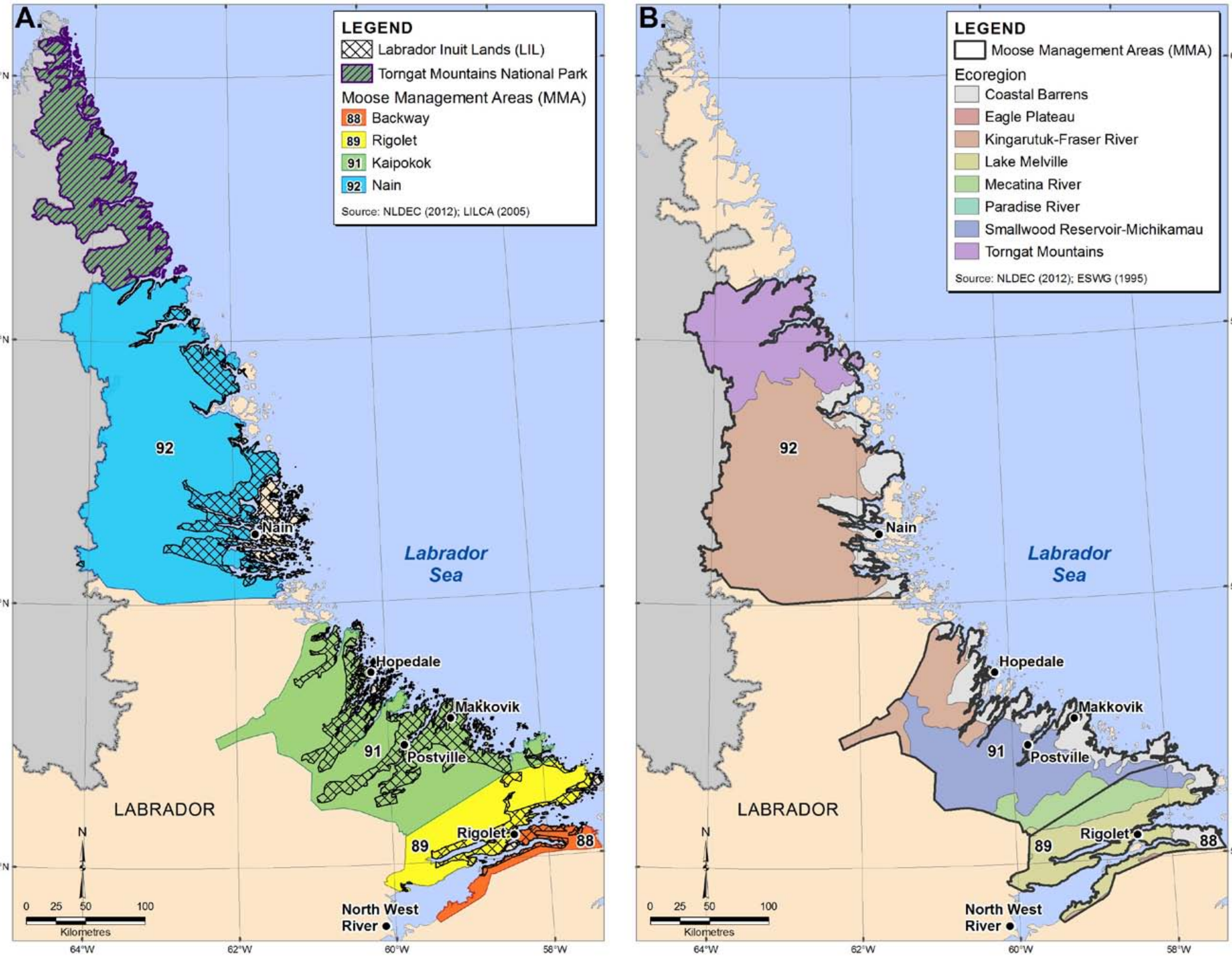

Figure 4 Overlap of Labrador Inuit Lands (A) and Ecoregion Composition (B) within Nunatsiavut Moose Management Areas

REFERENCES

Literature Cited

Addison, E.M., R.F. McLaughlin, D.J.H. Fraser, and M.E. Buss. 1993. Observations of pre- and post-partum behaviour of moose in central Ontario. *Alces* 29:27-33.

Barney, W. 2008a. Moose Population and Density Estimate Survey MMA55 – Double Mer, Labrador. Newfoundland and Labrador Wildlife Division, Corner Brook, NL

Barney, W. 2008b. Moose Population and Density Estimate Survey MMA54 – Grand Lake, Labrador. Newfoundland and Labrador Wildlife Division, Corner Brook, NL

Broders, H.G., S.P. Mahoney, W.A. Montevecchi, and W.S. Davidson. 1999. Population genetic structure and the effect of founder events on the genetic variability of moose, *Alces alces*, in Canada. *Molecular Ecology* 8: 1309-1315.

Chubbs, T.E. and J.A. Schaefer. 1997. Population growth of moose, *Alces alces*, in Labrador. *Canadian Field-Naturalist* 111: 238-242.

Dalton, W.J. 1986. Moose census in Labrador on management areas 51, 52, 53 and 54, February 27 – March 25, 1986. . Project No. 4403. Newfoundland and Labrador Wildlife Division, Goose Bay, NL.

Department of National Defence (DND). 1994. EIS: Military Flight Training – an Environmental Impact Statement on Military Flying Activities in Labrador and Quebec. Project Management Office Goose Bay, National Defence Headquarters, Ottawa, ON.

Dussault, C., J.-P. Ouellet, R. Courtois, J. Huot, L. Breton, and H. Jolicoeur. 2005. Linking moose habitat selection to limiting factors. *Ecography* 28: 619-628.

Ecological Stratification Working Group. 1995. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada. Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull.

Folinsbee, J. 1976. Distribution of moose in Labrador. Project No. 76M-5. Newfoundland and Labrador Wildlife Division, Goose Bay, NL.

Garton, E.O., J.T. Ratti, and J.H. Giudice. 2005. Research and experimental design. Pages 43-71 *In* C.E. Braun (ed.). Techniques For Wildlife Investigations and Management, 6th Edition. The Wildlife Society, Bethesda, MD.

Gasaway, W.C., S.D. Dubois, D.J. Reed, and S.J. Harbor. 1986. Estimating moose population parameters from aerial surveys. Biological Papers of the University of Alaska, No 22. 108 pp.

Harper, F.C. 1961. Land and fresh-water mammals of the Ungava Peninsula. University of Kansas, Musuem of Natural History, Miscellaneous Publication No. 27. 178 pp.

Jacques Whitford Environment Limited (JWEL). 1997. Distribution of wintering moose within the low-level training area of Labrador and northeastern Québec, 1997. Unpublished report prepared for PMO Goose Bay, National Defence Headquarters, Ottawa, ON.

Jones, C. 2008. Late-Winter Aerial Surveys for Moose in Central Labrador, March 2008, Final Report. Unpublished report prepared for Institute for Environmental Monitoring and Research, Happy Valley-Goose Bay, NL. 25 pp.

Jones, C. and I. Goudie. 2008. Surveys for Monitoring Trends of Harlequin Duck in Labrador and Newfoundland, 2008: Final Report. Unpublished report prepared for Institute for Environmental Monitoring and Research, Happy Valley-Goose Bay, NL. 24 pp.

Jones, C. and I. Goudie. 2009. Harlequin Duck Population Surveys in Labrador and Northern Newfoundland. Unpublished report prepared for Institute for Environmental Monitoring and Research, Happy Valley-Goose Bay, NL. 8 pp.

Jung, T.S., T.E. Chubbs, C.G. Jones, F.R. Phillips, and R.D. Otto. 2009. Winter habitat associations of a low-density moose (*Alces americanus*) population in central Labrador. *Northeast Naturalist* 16: 471-480.

Kellie, K.A. and R.A. DeLong. 2006. Geospatial survey operations manual. Alaska Department of Fish and Game. Fairbanks, AK.

Labrador Inuit Land Claims Agreement (LILCA). 2005. (Online). Land claims agreement between the Inuit of Labrador and Her Majesty the Queen in Right of Newfoundland and Labrador and Her Majesty the Queen in Right of Canada. (Online). Government of Newfoundland and Labrador, St. John's, NL. Available: http://www.laa.gov.nl.ca/laa/land_claims/agreement.html [November 18, 2011].

Larter, N.C. 2009. A program to monitor moose populations in the Dehcho Region, Northwest Territories, Canada. *Alces* 45: 89-99.

Mercer, W.E. and D.A. Kitchen. 1968. A preliminary report on the extension of moose range in the Labrador Peninsula. Pages 62-81 *In* 5th North American Moose Conference and Workshop. Alaska Department of Fish and Game. Memorial University of Newfoundland, St. John's, NL.

Newbury, T.L., Simon, N.P.P., and T.E. Chubbs. 2007. Moose, *Alces alces*, winter browse use in central Labrador. *Canadian Field-Naturalist* 121: 359-363.

Northland Associates Limited. 1980. Lower Churchill Development: Wildlife Studies. Unpublished report prepared for Lower Churchill Development Corporation, St. John's, NL.

Nova Scotia Department of Natural Resources (NSDNR). 2007. Recovery Plan for Moose (*Alces alces Americana*) in mainland Nova Scotia.

Payette, S. 1993. The range limit of boreal tree species in Quebec-Labrador: and ecological and palaeoecological interpretation. *Review of Palaeobotany and Palynology* 79: 7-30.

Phillips, F. 1983. Aerial moose census in selected areas of Labrador, 7 April – 2 May, 1980. Project No. 4402. Newfoundland and Labrador Wildlife Division, Goose Bay, NL.

Pimlott, D.H. and W.J. Carberry. 1958. North American moose transplantations and handling techniques. *Journal of Wildlife Management* 22:51-62.

Renewable Resources Consulting Services Limited (RRCS). 1989. Late Winter Aerial Surveys of Woodland Caribou and Moose in Labrador and Northeastern Quebec. Goose Bay EIS: Technical Report 4-B. Department of National Defence, Ottawa, ON. 22 pp.

Stephens, P.W. and R.O. Peterson. 1984. Wolf-avoidance strategies of moose. *Holarctic Ecology* 7:239-244.

Timmerman, H.R. and M.E. Buss. 2007. Population and harvest management. Pages 559-616 *In* A.W. Franzmann and C.C. Schwartz (eds.). Ecology and Management of the North American Moose, 2nd Edition. University Press of Colorado, Boulder, CO.

Trimper, P.G., E.A. Young, and T.E. Chubbs. 1996. Distribution of wintering moose (*Alces alces*) in river valleys of south-central Labrador and northeastern Québec. *Alces* 32: 1-9.

Ver Hoef, J.M. 2008. Spatial methods for plot-based sampling of wildlife populations. *Environmental and Ecological Statistics* 15: 3-13.

Ver Hoef, J.M. 2002. Sampling and geostatistics for spatial data. *Ecoscience* 9:152-161.

Voisey's Bay Nickel Company Limited (VBNC). 1997. Voisey's Bay Mine/Mill Project: Environmental Impact Statement. Volume 3: Biophysical Assessment. St. John's, NL.

Ward, R.M.P., W.C. Gasaway, and M.M. Dehn. 2000. Precision of moose density estimates derived from stratification survey data. *Alces* 36: 197-203.

White, G.C. and R.A. Garrott. 1990. Analyses of Wildlife Radio-Tracking Data. Academic Press, San Diego, CA. 383 pp.

Wild Life Act, Consolidated Newfoundland and Labrador Regulation 94/11: Open Season Big Game Moose Hunting Order, Labrador, 2011-2012. (Online). St. John's: Environment and Conservation, 2011. Available: http://www.assembly.nl.ca/Legislation/sr/Regulations/rc110094.htm. [November 16, 2011].

Personal Communications

Barney, W. Senior Wildlife Biologist – Habitat, Game and Fur Management, Newfoundland and Labrador Department of Environment and Conservation: Wildlife Division, Corner Brook, NL. Telephone/E-mail correspondence, November 18, 2011.

Luther, G. Biometrician – Research Section, Newfoundland and Labrador Department of Environment and Conservation: Wildlife Division, Corner Brook, NL. Telephone correspondence, November 18, 2011.

Phillips, F. Board Member (Federal Appointee), Torngat Wildlife and Plants Co-Management Board, Happy Valley-Goose Bay, NL. Telephone correspondence, April 4, 2011.

Evans, L. Environmental Affairs Manager, Aurora Energy, St. John's, NL. Telephone/E-mail correspondence, November 16, 2011.

MacDonald, P. Large Mammal Biologist, Nova Scotia Department of Natural Resources: Wildlife Division, Kentville, NS. Telephone correspondence, November 25, 2011.

Marks, C. Computer Systems Analyst, GIS Habitat – GIS Support Unit, Newfoundland and Labrador Department of Environment and Conservation: Wildlife Division, Corner Brook, NL. Telephone/E-mail correspondence, December 14, 2011.

Goudie, J. Wildlife Manager, Nunatsiavut Department of Lands and Natural Resources, Postville, NL. Telephone correspondence, November 16, 2011.

APPENDIX A

Two important components for consideration during the development of survey sampling methodology are *accuracy* and *precision* of the resultant findings. Accuracy refers to how close the estimated value, obtained from the population subset, is from the true population value. Precision refers to the degree of closeness between subsequent population estimates (following the same methodology). Thus, it is possible for multiple population estimates to be precise but inaccurate. These inaccuracies are generally a result of bias(es) introduced into the sampling methodology.

CONFIDENCE INTERVALS

Confidence levels of 90, 95, and 99% are commonly reported in survey results. Selection of a confidence level begins with deciding how certain one wants to be that the true population value is included in the Confidence Interval (CI). The higher the degree of confidence, the wider the resulting CI has to be in order to contain the true value. A 95% CI means that if identical survey methods were repeated multiple times, 95 out of 100 replications would contain the true population value.

Confidence Intervals are essentially a measure of how reliable a population estimate is. The range of a CI is dependent on (1) the number of observations and (2) the spread in the data. The number of observations (or survey effort) can be controlled but the inherent variance in the survey data cannot. Unfortunately, it is not always possible to maximize survey effort in an effort to increase accuracy. As population surveys are expensive to conduct for large areas, there is always a trade-off with cost.

CONFIDENCE LIMITS

The confidence limits are the range of a Confidence Interval made up of a lower and upper limit (boundaries).

For example, the moose population estimate of the Double Mer area in 1980 was 61 ± 59 (95% CI; Phillips 1983). In other words:

> We can be 95% certain that the true population value for moose in the 1980 Double Mer survey area is between the interval of 61 ± 59, or 32 to 120 animals. Here we know the lower limit should be 32 given that there was a total of 32 animals observed during the survey (minimum count).