

Aerial moose survey in the southwest of hunting zone 22

Survey report – Winters 2021 and 2023



Coordination and drafting

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Sampling method	Stratified random
Dates of the two inventories combined to create the study area	February 10 to March 5, 2021; January 24 to February 17, 2023
Visibility rate (%)	73
Area of study (km ²)	75,666
Habitat area of the subzone (km ²)	69,233
Moose population in the inventoried area (75,666 km ²):	3,944
Corrected winter density (moose/10 km ²)	0.57
Relative error, 90% CI (%)	7.2
Moose population in community territories (Figure 2)	4,130
Theoretical harvest rate* in the study area (%)	7.7
Number of adult males per 100 adult females	43.3
Number of calves per 100 adult females	42.4

* Average of the sport harvest for the permissive year (2021) and the non-permissive year (2022) in the study area + the Guaranteed Levels of Harvesting (GLH) allocated to Cree communities in the study area under the James Bay and Northern Quebec Agreement. The GLH is used in the absence of actual harvest monitoring data from Cree hunters.

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Acknowledgements

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The Cree First Nation of Waswanipi was particularly involved in logistical support for the portion carried out in 2021, notably by managing the clearing of forest roads to allow for the establishment of fuel reserves. The community of Waswanipi also provided lodging and supplies at a camp for a full crew. Steven Blacksmith and his team set up a remote, functional base of operations north of the study area. This contribution was essential to carrying out the work, as the public health restrictions linked to the COVID-19 pandemic in 2021 required the creation of an isolated crew from the community.

Colleagues from the Ministère des Forêts, de la Faune et des Parcs (MFFP) provided highly valued technical, scientific and administrative support. The adaptation of the habitat quality model used for sampling stratification was made possible thanks to the expertise of Catherine Dion, Sophie Dallaire and Christian Dussault. Claude Gagnon's support in geomatics was also instrumental in planning and analyzing the data from this survey. Administrative support was provided by Christina Thibeault and François Landry. Finally, thanks to Maxime Lavoie for reviewing the analyses, to Guillaume Szor and Stéphane Rivard for their insightful advice, and to Jérôme Plourde and Laurent De Vriendt for reviewing the report.

Introduction

The Gouvernement du Québec coordinated an aerial survey of the moose population (*Alces alces*) in hunting zone 22 in logistical and financial collaboration with the Cree Nation Government, the Cree First Nation of Waswanipi and the Cree Trappers' Association. The study area of this survey was covered over two winters, in 2021 and 2023.

In 2021, a small portion of zone 22 was surveyed at the same time as the survey of zone 17. The considerable decline in the moose population then measured in zone 17 (Brodeur et al., 2022) led to a restriction on Indigenous harvest and the suspension of sport hunting in that zone under the James Bay and Northern Quebec Agreement (JBNQA). This finding subsequently motivated a proposal from the Cree Nation Government to continue updating moose demographic data in zone 22. In 2023, a second survey extended the coverage to a sector of zone 22 where hunting pressure appeared to be the highest. This report presents the combination of the two partial surveys of zone 22, carried out complementarily in 2021 and 2023, in order to cover the southwest of zone 22 (Figure 1).

Moose harvest in zone 22 is carried out primarily by Cree hunters who are beneficiaries of the JBNQA. The Act respecting hunting and fishing rights in the James Bay and New Québec territories (D-13.1) provides for “Guaranteed Levels of Harvesting” (GLH), which defines the number of moose that may be harvested exclusively by each of the Indigenous communities that are beneficiaries of the JBNQA. These communities also hold the exclusive right to hunt moose in Category I and II lands, as well as in the Parc national Assinica and the Parc national des Lacs-Albanel-Mistassini-et-Waconichi (Figure 1). Moose supply is therefore protected by legal provisions that reflect the importance of this species for the Cree Nation.

The wildlife management measures set out in Act D-13.1 partly refer to hunting zones. In this regard, the GLH for moose attributed to the Cree beneficiaries of the JBNQA are specific to zones 17 and 22 (Figure 1). In zone 22, the total of the GLH is 872 moose, distributed among 8 Cree communities¹², based on their population, the importance of moose for subsistence, and the proportion of their community territory that overlaps with the hunting zone. These figures come from the study on Cree community harvest levels conducted between 1972 and 1979 (James Bay and Northern Québec Native Harvesting Committee, 1982). Community territories are subdivided into Cree traplines, where wildlife management stewardship is the responsibility of a tallyman. The study area of this survey was defined to provide an estimate of the moose population specific to the community territories of Waswanipi (portion of zone 22), Waskaganish, Eastmain and Nemaska (Figure 2).

Moose is also a sought-after species among non-Indigenous sport hunters in Québec. It is in fact the most popular big-game species. In the province, about 170,000 moose hunting licences are purchased annually ([Hunting licence sales | Gouvernement du Québec \[quebec.ca\] \(in French\)](#)). Hunting zone 22, located in the Nord-du-Québec administrative region, hosts nearly 650 sport hunters annually. Over the five sport hunting seasons preceding this survey (2018 to 2022), the average annual harvest was about 103 moose throughout the zone ([Hunting statistics | Gouvernement du Québec \[quebec.ca\] \(in French\)](#)). Sport hunting pressure in this zone is among the lowest in Québec, mainly because of its remoteness from major urban centres and its limited accessibility.

¹² The GLH were defined before the creation of Oujé-Bougoumou, when its future residents were mainly located in Mistissini. The GLH of Oujé-Bougoumou is not defined at the time of writing. The community of Whapmagoostui has a GLH of 0 moose due to its location on the margin of the historical range of the species.

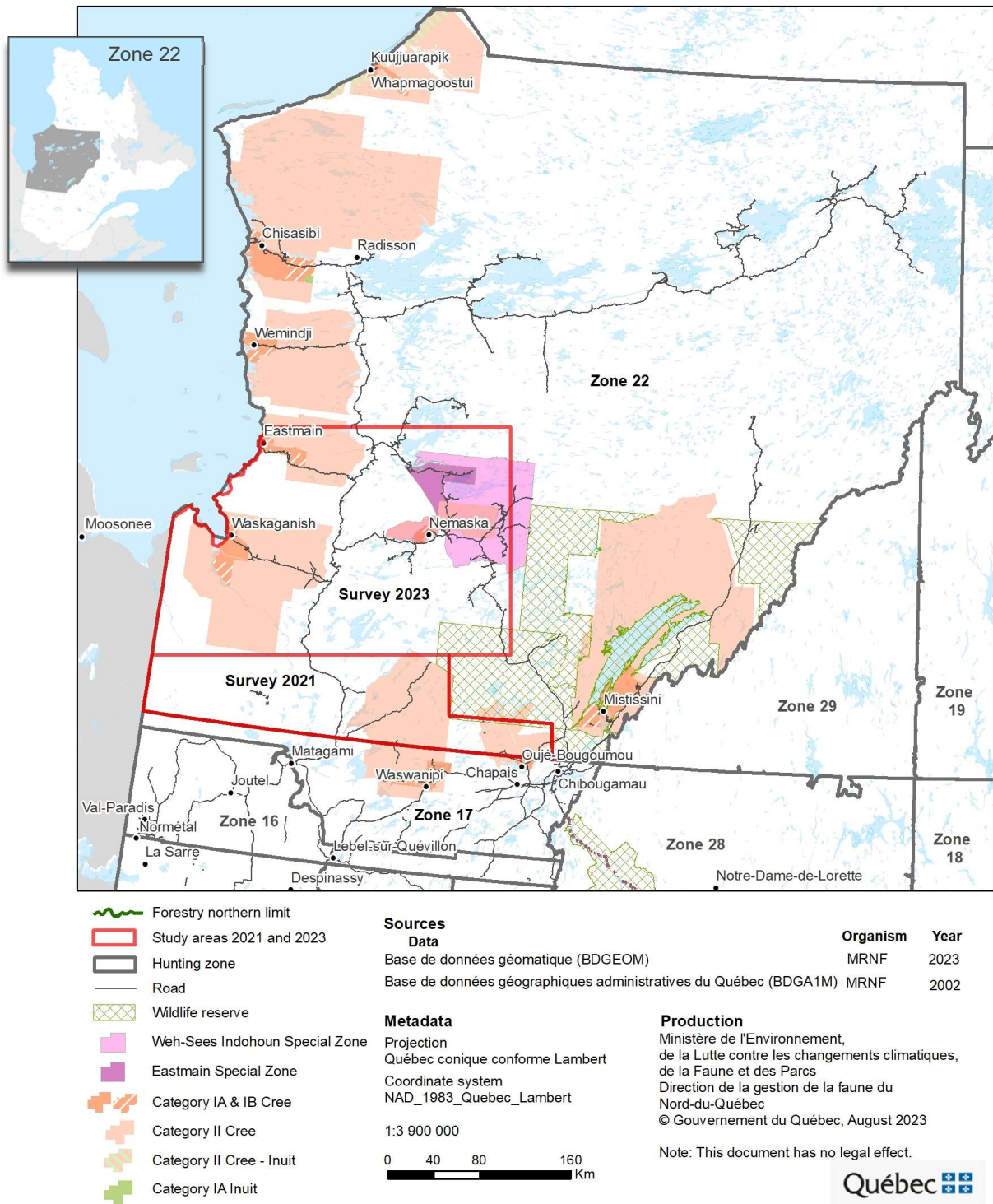
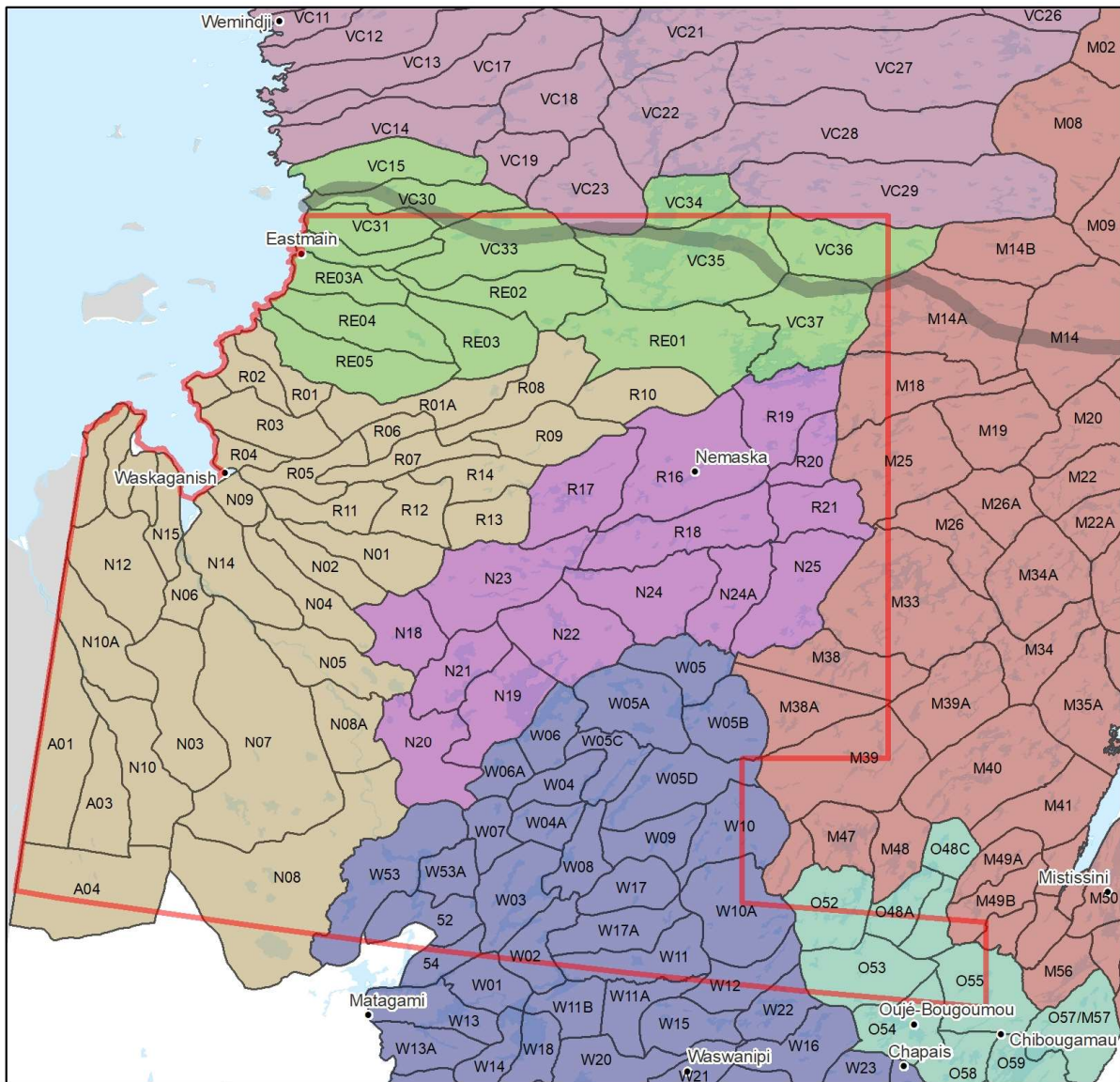


Figure 1. Location of the study areas flown over in 2021 and 2023 in the southwest of hunting zone 22 in relation to the Category lands defined under the James Bay and Northern Quebec Agreement and the special wildlife exploitation zones in effect between 2003 and 2017 in the area affected by Hydro-Québec worksites.



- Study area
- Transition black spruce-feathermoss to black spruce-lichen woodlands
- Outside Québec
- Cree traplines
- Wemindji
- Eastmain
- Mistissini
- Nemaska
- Waskaganish
- Waswanipi
- Oujé-Bougoumou

Sources

Data	Organism	Year
Base de données géomatique (BDGEOM)	MRNF	2023
Base de données géographiques administratives du Québec (BDGA1M)	MRNF	2002

Metadata

Projection
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 Coordinate system
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Production

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 Direction de la gestion de la faune du
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Figure 2. Location of the Cree community territories and their traplines in the southwest of hunting zone 22 in relation to the study area and the boundary between the southern black spruce–feathermoss forest and the northern black spruce–lichen woodlands.

The first exploratory work aimed at counting moose and caribou in the southern portion of zone 22 was carried out between 1972 and 1979 (Brassard 1972; Grenier 1974; Morasse 1975; Joly and Brassard 1979). These flights initially sought to specify the distribution of these species, which had previously been based on a compilation of the geographic locations of harvests by sport and Indigenous hunters conducted in 1964. The technical means and objectives of the time resulted in a very low sampling rate and limited the ability to obtain a rigorous estimate of population density. The authors of these survey reports also expressed reservations about the risk of underestimation due to the difficulty of adequately detecting and counting moose under dense forest cover during surveys sometimes carried out solely by DC-3 aircraft. Joly and Brassard (1979) used a helicopter in phase 2 to improve the number of plots counted and revisited earlier work, concluding that moose density in the study area (Figure 3) was 0.31 moose/10 km². The upward adjustment of this estimate, based on the detection rate used in surveys conducted in subsequent decades, indicates that the density would have been 0.42 moose/10 km² in 1979. The great variability in moose habitat quality in this region and the importance of hardwood stands for the species were well known at the time (Audet 1976). However, the sampling rate of the surveys was too low to allow for meaningful stratification. Brassard (1972) reported results by sector in James Bay, noting moose scarcity in some areas of more than 30,000 km², while densities could reach relatively high values of more than 2 moose/10 km² in forest stands of only a few dozen km² where the habitat was suitable. An interpretation of the forest cover and the surveys was mapped (Morasse 1975) to highlight the areas where the best potential was known at the time in the southern portion of hunting zone 22 (Figure 3).

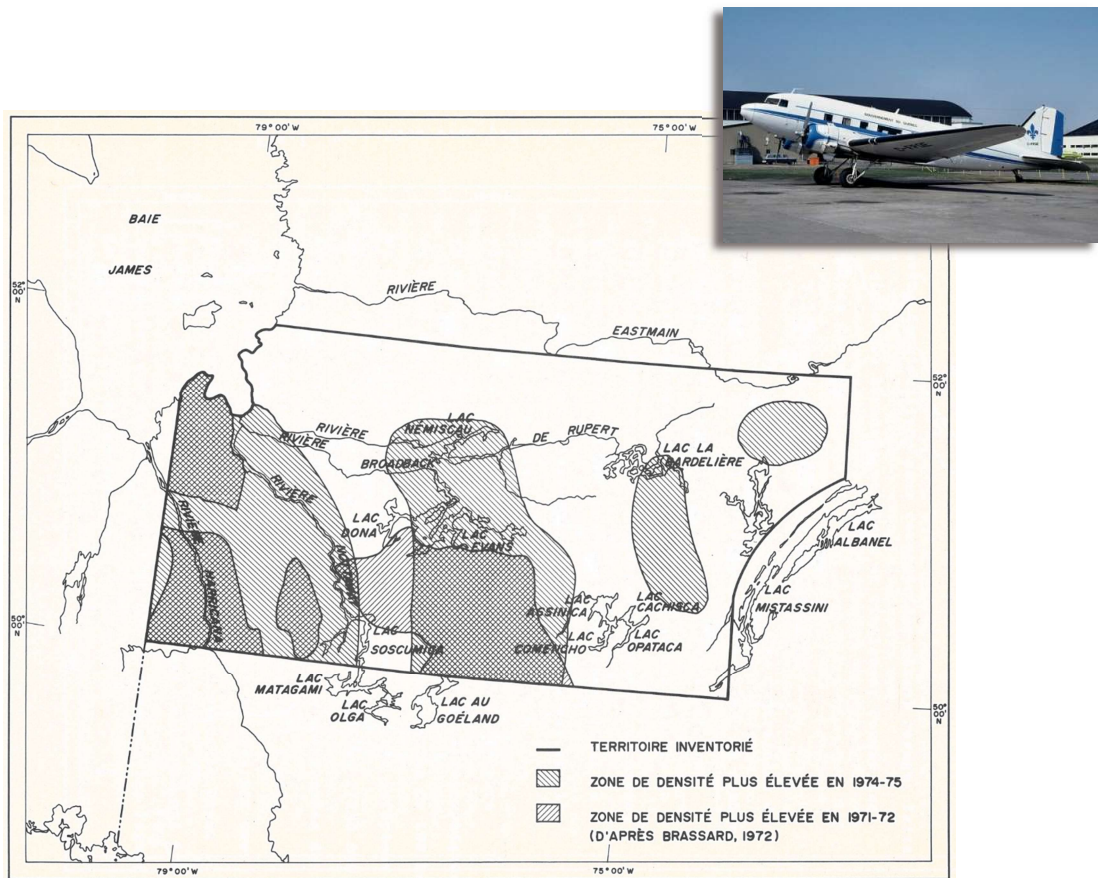


Figure 3. Interpretation of forest cover suitable for moose and of the results of aerial inventories carried out in 1972, 1974 and 1975 in a study area corresponding approximately to the portion of zone 22 within the moss-dominated spruce forest. Taken from Morasse (1975) and reproduced by Joly and Brassard (1979), who obtained an average density of 0.31 moose/10 km² during the 1979 survey of this study area. Inset: the DC-3 aircraft of the Gouvernement du Québec used, among other things, for big game inventories in the 1960s (Service aérien gouvernemental, <https://www.avionslegendaires.net>).

In 1991, the Ministère du Loisir, de la Chasse et de la Pêche, in partnership with Hydro-Québec, carried out the first survey of hunting zone 22. The average density of 0.26 moose/10 km² (± 0.1 ; 90% CI) was the lowest recorded at that time in the province (Maltais et al. 1993). This study was based on a sample of plots distributed throughout hunting zone 22 (Figure 4). The considerable effort of 144 surveyed plots nevertheless represented coverage of less than 3% of the 338,000 km² surface area of the hunting zone. The low sampling rate and the influence of habitat potential variability resulted in a wide confidence interval ($\pm 39\%$; 90% CI). Sampling had initially been stratified according to the density of Cree Indigenous harvest, regardless of habitat type. The results did not support the validity of this stratification approach, since more moose had been observed in areas presumed to be of poor quality, where Cree harvest was lowest. Consequently, only the average density was calculated for the entire zone. About forty of the plots were located in the black spruce–lichen woodlands. This habitat contains a few islands of mixedwood and hardwood forest, highly suitable for moose, and few areas of intermediate quality. In general, the lichen-dominated spruce forest is of poor quality for moose and more suitable for forest-dwelling and migratory caribou. In the southwest portion of the zone, a specific analysis of a subsample of 34 plots conducted for Hydro-Québec (Figures 4 and 6; Sector 2) demonstrated the best potential for moose in the moss-dominated spruce forest. A density of 0.42 moose/10 km² (± 0.09 ; 90% CI) was measured there. At that time, the population trend in the southern part of the zone was considered stable when compared to partial estimates made in the 1970s (Figure 3).

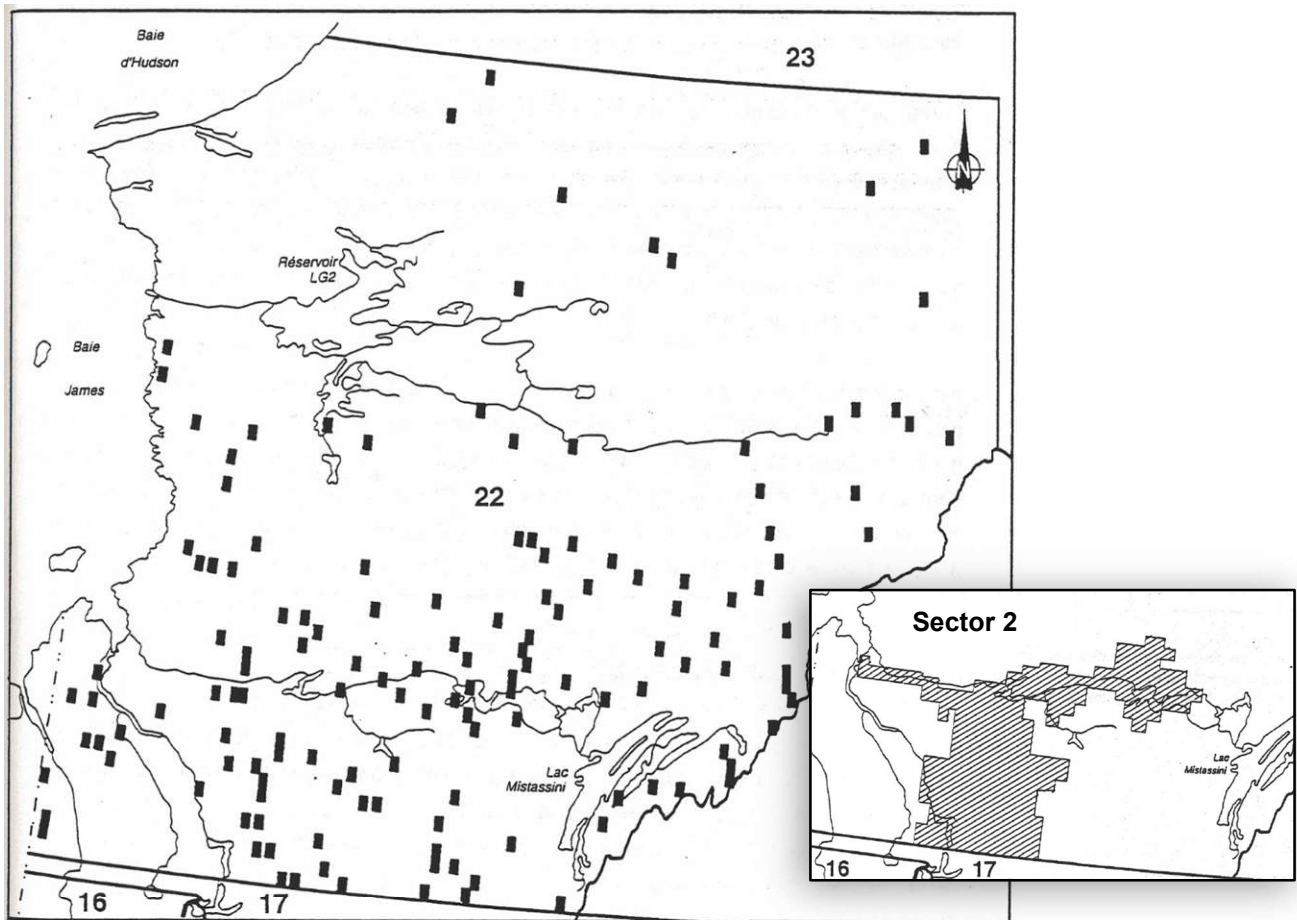


Figure 4. Distribution of the 144 plots of 60 km² (black rectangles) flown over in 1991 during the moose survey conducted throughout hunting zone 22 by the Gouvernement du Québec and Hydro-Québec. Sector 2, located in the southwest portion of the zone, contained 34 of the 144 plots. Adapted from Maltais et al. (1993).

Following the 1991 survey, an independent study commissioned by the Grand Council of the Crees concluded that the management measures proposed by the Ministère du Loisir, de la Chasse et de la Pêche in zone 22 were appropriate (Messier 1993). The author noted, however, that the vast size of the zone requires taking into account disparities in moose demographics related to habitat differences, particularly those associated with the climatic gradient. The planning of a specific survey in the black spruce–feathermoss forest of the southwest portion of the zone is therefore consistent with this recommendation. Sector 2, flown over in 1991, is largely represented by the study area of the present survey (Figure 6). The population trend for moose calculated following the present survey is therefore interpreted in relation to the estimate of Sector 2 from 1991.

The Plan de gestion de l'original 2012-2019 aimed to increase moose density to 0.6 moose/10 km² in hunting zone 22 (Lefort and Massé [eds.], 2015). Moose management in zone 22 is carried out according to the recommendations of the Hunting, Fishing and Trapping Coordinating Committee (HFTCC), particularly with respect to hunting rules. Harvest potential is mainly assessed based on aerial survey results, indicators derived from monitoring sport harvest, and the stewardship of Cree tallymen. The HFTCC also has the authority to set the maximum harvest limit for beneficiary and non-beneficiary hunters under the JBNQA in zone 22. To date, the HFTCC has not had to establish a moose harvest quota for zone 22, since the provisions of the provincial management plan and the stewardship of Indigenous harvest by Cree tallymen were sufficient to maintain a harvest level considered sustainable.

In zone 22, moose share certain habitats with forest-dwelling and migratory caribou. Previous aerial big game inventories therefore aimed to count both caribou and moose. Caribou monitoring programs are now specific to the forest-dwelling and migratory ecotypes and planned at the population scale. Over the past two decades, the migratory caribou of the Leaf River herd frequented the study area of this moose survey. This population, however, has abandoned the area due to the reduced amplitude of its migrations (Taillon et al. 2016). This moose survey nevertheless overlaps with the ranges of the Detour, Assinica and Nottaway forest-dwelling caribou populations (Szor and Gingras 2022, 2024; Szor et al. 2023) (Figure 5). Knowledge acquisition work carried out north of these better-defined populations has demonstrated the existence of smaller herds distributed across a landscape fragmented by a high recurrence of fires (Szor and Gingras 2020).

Since 1999, the exploitation rules governing sport hunting activities for moose have alternated between permissive years, when harvest of individuals from all segments is authorized, and restrictive years, when only male and calf harvest is permitted. This alternating principle was in effect, except in special exploitation zones defined around the Hydro-Québec Eastmain-1 and Eastmain 1-A–Sarcelle–Rupert construction sites. Thus, between 2003 and 2017, sport hunting for moose was prohibited in the Eastmain special zone and limited to males and calves in the Weh-Sees Indohoun special zone (Figure 1). At the time of writing this report, the provincial moose management plan is being reissued, and the results of this survey will contribute to revising the management rules for zone 22.

Objectives of the survey

To update the estimate of moose population density in the southwest of hunting zone 22 and to characterize the demographic parameters of this population as well as its harvest rate from hunting.

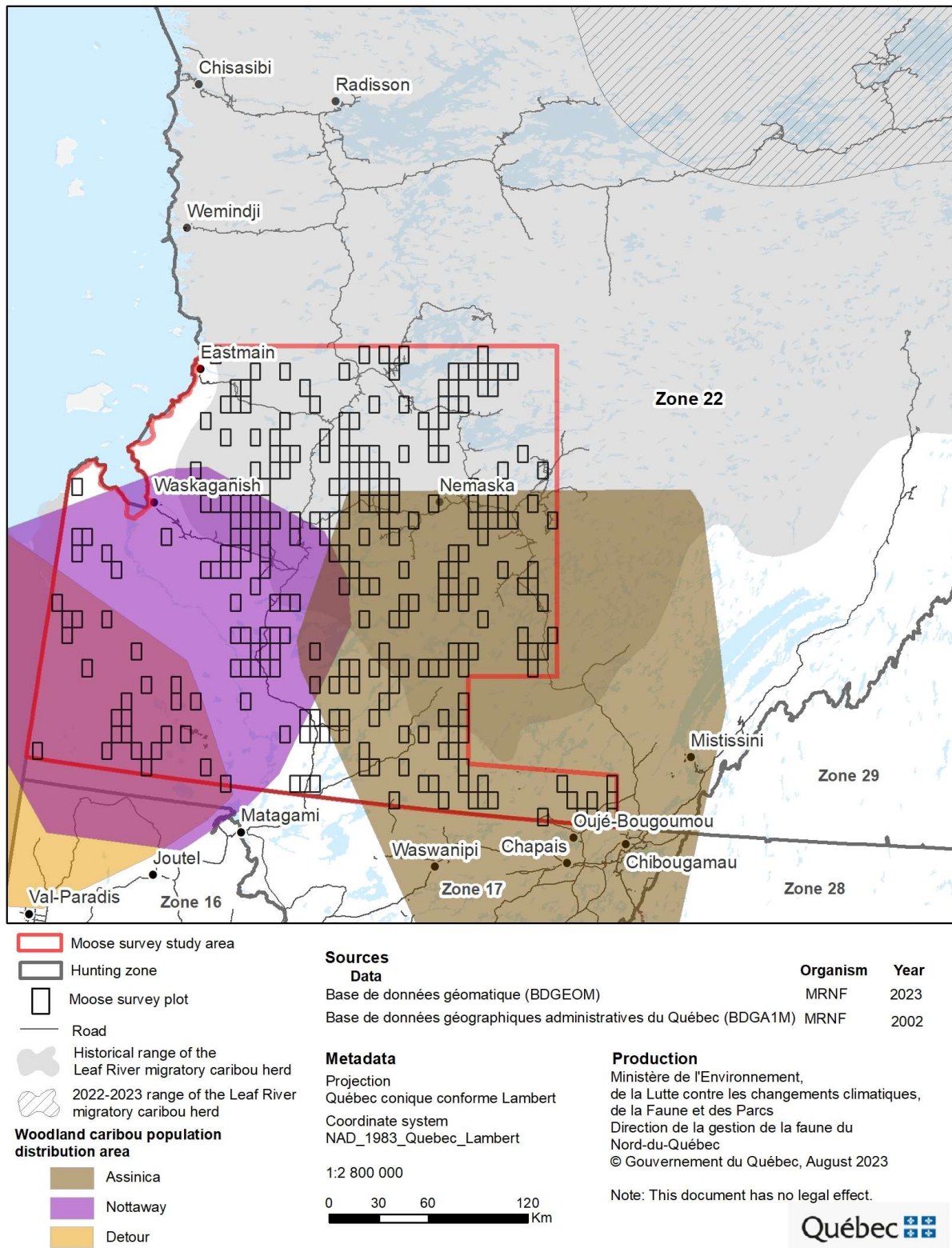


Figure 5. The study area of the moose survey, historically frequented by migratory caribou, overlaps with the range of three forest-dwelling caribou populations and was located more than 100 km from the range of the Leaf River migratory caribou herd. The 274 survey plots are laid out and flown over according to the protocol specific to moose counting.

Methodology

Hunting zone 22 is the largest in Québec, with an area of 339,252 km²; it is located in the Nord-du-Québec administrative region. This survey covered 75,666 km² of the southwest portion of the zone, representing 22% of its surface area. Moose habitat is defined as the portion of the territory that excludes major water bodies (hydrographic layer at 1:250K scale), as well as urbanized and unproductive areas. This portion of potential moose habitat totals 69,233 km² within the study area. It should be noted that the moose densities presented in this report are expressed in relation to the surface area of moose habitat and not to the total area of the study zone.

Stratified random sampling was applied to this survey because of the large size of the study area and the heterogeneity of habitat quality; this method is specified in the survey standards used by the Gouvernement du Québec (Courtois et al. 1991; Courtois et al. 1996).

The sampling plan was based on 274 plots of 60 km² each, designed to sub-sample the territory concerned by the survey. It was built using ArcMap 10.4 software. Eligible plots for random selection had a minimum of 45 km² (75% of their surface area) within the study area and had to contain at least 30 km² of habitat (50% of their surface area). The selection of plots to be surveyed in the field was carried out randomly.

A stratification of the territory was performed using a Habitat Quality Index (HQI), which indicates habitat potential in 1-km² hexagonal areas. An HQI initially designed for the balsam fir–white birch bioclimatic domain (Dussault et al. 2006) was adapted to the black spruce–feathermoss forest. To do so, the weighting of mixedwood, hardwood and shrub stands was adjusted to substitute certain species preferred by moose in the balsam fir–white birch forest that are not available in the black spruce–feathermoss forest (MELCCFP, unpublished data). The average value of the 1-km² HQI hexagons that overlap, in whole or in part, with a plot was used for stratifying the plots eligible for random selection. Three preliminary strata (low, medium and high) were defined, each representing about one-third of the study area.

The distribution of the number of plots to be flown over by stratum was initially carried out arbitrarily in order to favour a greater number of plots of good-quality habitat. This approach was inspired by the basic principle of Neyman allocation, whereby the sampling rate must be adjusted according to the expected variance of the result. The survey plan (Figure 6) therefore included more plots in good- and medium-quality habitat, where moose numbers were expected to be more variable than in poor-quality habitats that would contain few or no moose.

The usefulness of stratification is confirmed only if the number of moose counted is influenced by HQI value. Since it was unknown whether the observations would corroborate our predictions, the possibility of stratification in the density analysis was reassessed after the survey was completed. The arbitrary HQI thresholds of the three preliminarily defined strata were adjusted a posteriori based on this relationship.

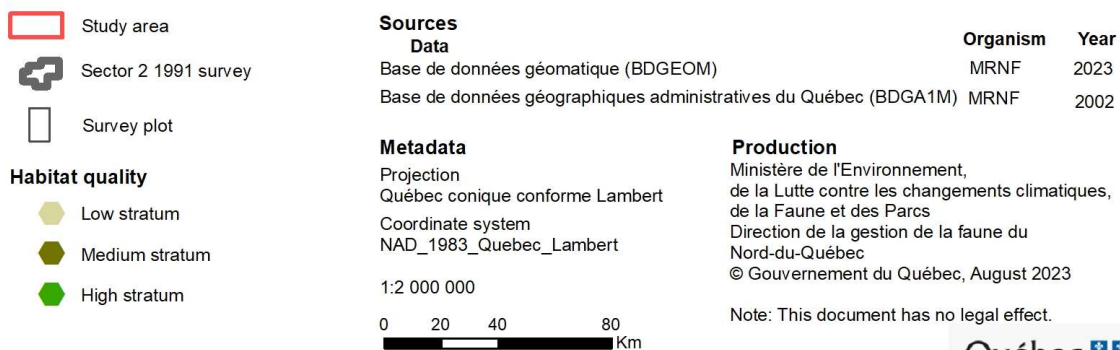
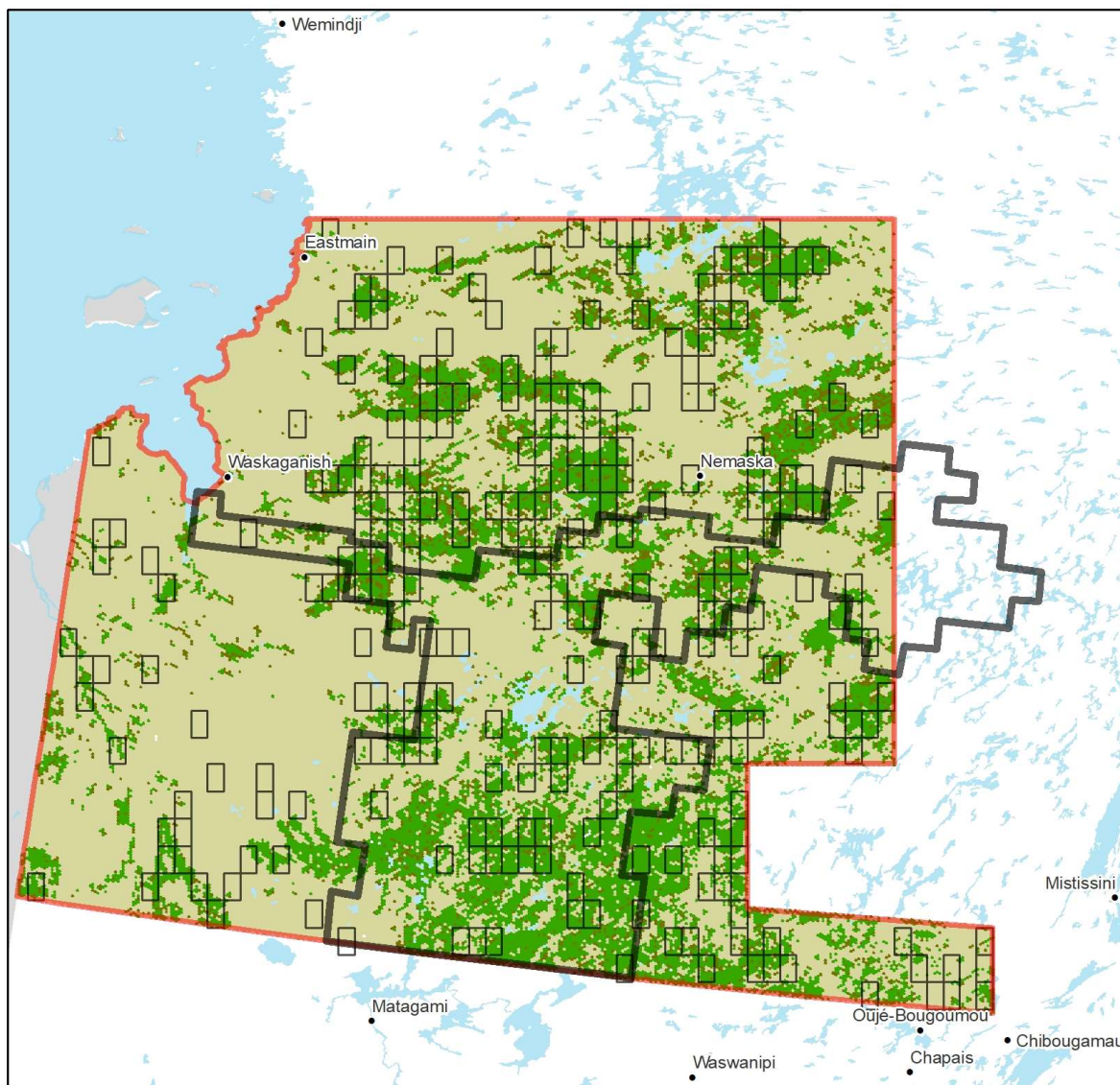


Figure 6. Location of 60-km² survey plots in relation to the 1-km² hexagons of the Habitat Quality Index (HQI), classified according to the three density strata derived from the analysis of survey results. The 1991 survey results for Sector 2 were used for comparison to assess population trends in the southern portion of zone 22. The habitat quality profile of Sector 2 in 1991 is not available.

The survey was carried out over two years by nearly fifty participants in the field (see section Production Team, pp. iii and iv). The teams were composed of wildlife technicians, members of the Cree communities concerned, and biologists, distributed across six operational bases. The two phases of the survey were conducted by helicopter: two EC 120 helicopters and one Astar 350 in 2021, and three Astar 350 helicopters in 2023. The survey was conducted in accordance with the survey standards in effect at the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (Courtois 1991; Courtois et al. 1996).

The plots were surveyed along north–south flight lines spaced 500 m apart. In phase 1, the plots were first flown over to map track networks. In phase 2, the track networks of each plot were subsequently flown over to count and classify all moose detected.

The geographic coordinates of moose observations were recorded and then cross-referenced with the habitat quality value of the corresponding HQI hexagon (Figure 7). Where necessary, the location of the observation was corrected to represent the area used before the disturbance caused by the helicopter. The relationship between the number of moose observed and habitat quality was analyzed at the spatial scale of the 1-km² HQI hexagon mosaic. Thus, the stratification of the study area for population calculation used the spatial resolution of the HQI (Figure 6).

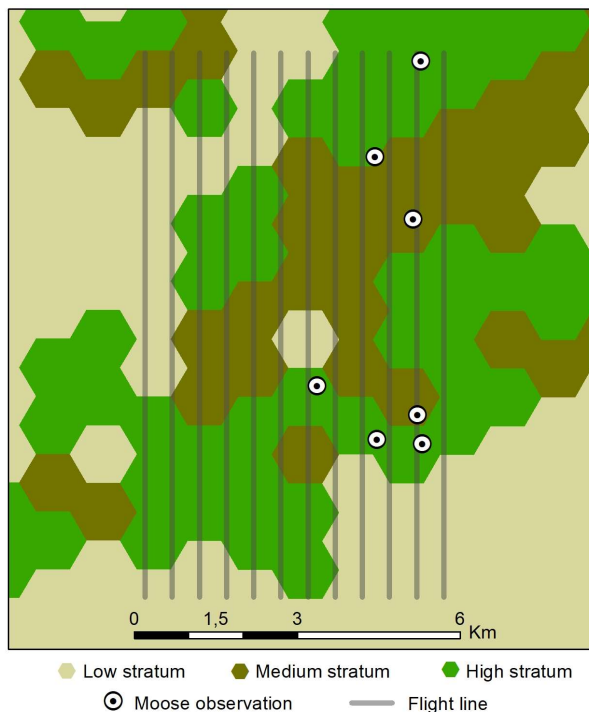


Figure 7. The flight lines within a 60-km² survey plot cover the mosaic of the Habitat Quality Index. The location of moose observations is linked to the habitat quality value of the 1-km² hexagon in which they are situated. One survey plot covers an area equivalent to 60 hexagons.

To assess population composition, individuals were counted and classified (sex and maturity) in all surveyed plots to obtain an adequate sample size within each stratum, despite the low moose density expected north of 50°N.

Wintering areas (moose yards) were not mapped, since sexing in all plots and the use of helicopters in both phases eliminated the need for selection criteria influenced by the size of wintering areas (Courtois 1996; Couturier et al. 2009).

The sex of adults was determined through observation of antlers, the vulval patch, and muzzle coloration, while moose size was used to distinguish calves from adults (Courtois 1991). Individuals aged 1.5 years and older were classified as adults.

During the survey, data related to track networks (phase 1) and to observed and sexed moose (phase 2) were entered, georeferenced, and recorded using the survey tools developed by the Ministère (Sebbane et al. 2013): IDO2 v9 and IDO v10 for ArcPad. Data were entered on Panasonic Toughbook tablets.

The moose population and its composition were assessed using the Invent.ori software developed by the Gouvernement du Québec (Leblanc et al. 1996) and updated with a version programmed in the R environment (Lavoie 2019). The number of available and surveyed plots corresponded respectively to the number of HQI hexagons in the study area and those flown over in the survey plots. Estimates were corrected using a visibility rate of 0.73, applied to surveys conducted in southwestern Québec (Courtois 1991), as was done during the previous survey in zone 22 (Maltais et al. 1993).

The population size and demographic structure presented in this report are derived from the combination of samples collected in winter 2021 and 2023. The winter population resulting from these two years is therefore used as a reference for calculating annual harvest rates from 2021 to 2023. The calculation of population size in the fall preceding the survey, before the sport hunting season, is usually presented in the survey reports of the Gouvernement du Québec. Such a calculation is not possible here because the estimate is based on two years of sampling and because of irregularities in the monitoring of the Indigenous harvest.

Study area

The survey plots were distributed within a study area of 75,666 km², of which 69,233 km² were considered potential moose habitat. This distribution made it possible to estimate density across three habitat quality strata. Estimates of average moose density can thus be adapted to the scale of various administrative boundaries relevant to moose management in sectors of the southwestern portion of zone 22.

The study area (Figure 2) is located in the western black spruce–feather moss bioclimatic domain. The landscape consists of a mix of hills and flatlands, dotted with many waterbodies and extensive peatlands. The forest stands are composed mainly of black spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh), jack pine (*Pinus banksiana* Lambert), tamarack (*Larix laricina* (Du Roi) K. Koch), and balsam fir (*Abies balsamea* (L.) Miller). The deciduous tree species found in mixed stands, and forming deciduous stands, are paper birch (*Betula papyrifera* Marshall) and trembling aspen (*Populus tremuloides* Michaux). Their distribution within the study area is primarily influenced by topography, soil type, and the time elapsed since the last disturbance of the forest cover. Commercial forestry is carried out on 29% of the study area (21,680 km²), bounded to the north by the limit of timber allocations, also called the northern limit of forestry.

The mapping of surficial deposits (morphosedimentological zones – Géologie Québec (gouv.qc.ca)) clearly illustrates the distinct landscapes and their relationship with topography (Figure 8). In general, moose habitat quality is low on organomineral sediments, composed of peat, sphagnum, or more or less decomposed sedges. This type of sediment characterizes a large portion of the study area, extending about 100 km inland from the James Bay coast, where the topography is low and poorly drained. Moose habitat quality improves with increasing distance from James Bay, as relief and drainage increase. Surficial deposits from the last glaciation, such as till and glaciolacustrine, glaciomarine, and ice-contact sediments (Figure 8), are associated with better habitat quality.

Although the study area represents only 22% of hunting zone 22, it accounted for approximately 60 to 70% of the harvest by non-beneficiary hunters. The distribution of sport harvest density (Figure 9) is influenced by habitat quality (Figure 6), regulations, and access. Hunting pressure is therefore higher south of the northern limit of forestry, in areas characterized by a dense network of forest roads. Further north, hunters use access to hydroelectric facilities and the few mining sites, as well as power transmission corridors. The network of lakes and rivers also provides access to areas remote from the road system. Sport hunting is prohibited in the Assinica Wildlife Reserve, which represents only 3% (2,046 km²) of the study area. However, Cree Category I and II lands make up 29% (21,800 km²) of the study area, where sport hunting is rare, as it is conditional on an additional hunting permit issued by the community concerned.

The majority of moose harvesting is carried out by Cree hunters. This is organized in accordance with the stewardship of Cree tallymen at the scale of their trapline. The study area overlaps wholly or partly with 99 traplines within the community territories covered by the survey, namely: Waswanipi (27), Oujé-Bougoumou (6), Nemaska (15), Waskaganish (37), and Eastmain (14).

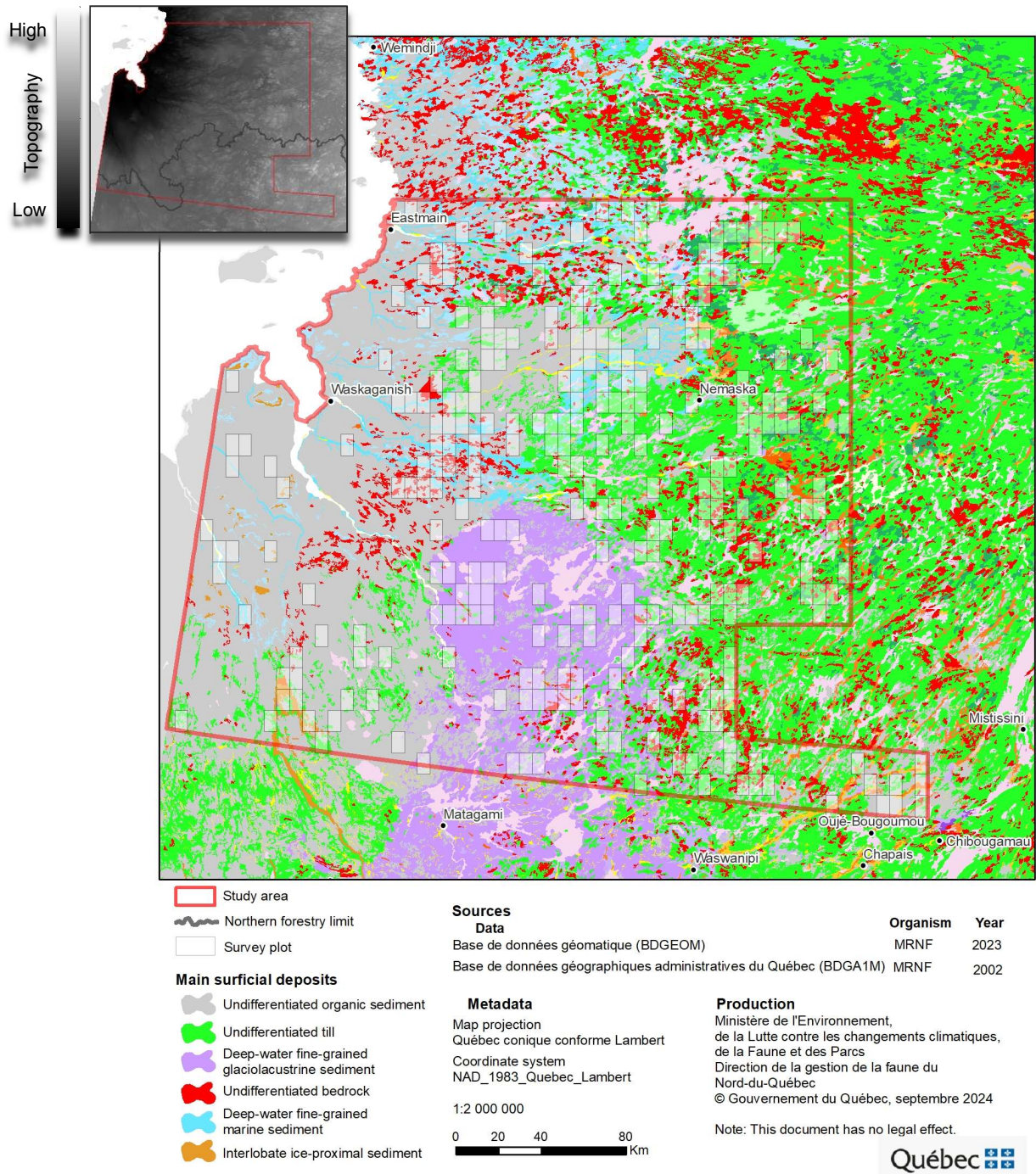
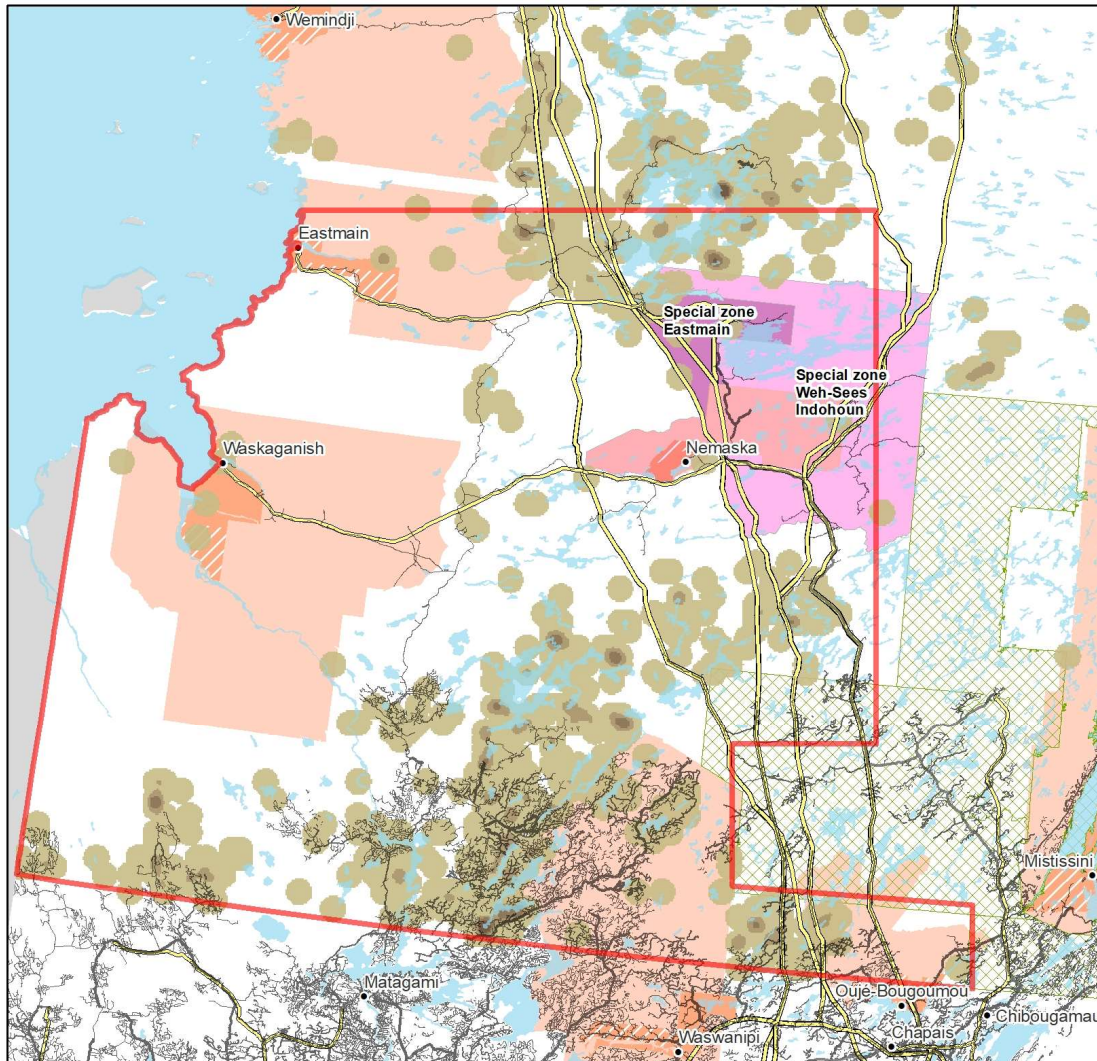


Figure 8. Distribution of the main surficial deposits in the study area in relation to the 60-km² survey plots. Organic sediments formed following the last glaciation generally support peatlands unsuitable for moose. Better-drained areas characterized by deposits from the last glaciation, such as till and glaciolacustrine, glaciomarine, and ice-contact sediments, support forest cover more suitable for moose.



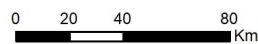
- Northern limit of forestry
- Study area
- Sport harvest density 2012-2023
- Power transmission line
- Main or forestry road
- Wildlife reserve
- Eastmain special zone
- Weh-Sees Indohoun special zone
- Category IA Cree
- Category IB Cree
- Category II Cree

Sources

Data	Organism	Year
Base de données géomatique (BDGEOM)	MRNF	2023
Base de données géographiques administratives du Québec (BDGA1M)	MRNF	2002

Metadata

Projection
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Production

Ministère de l'Environnement,
de la Lutte contre les changements climatiques,
de la Faune et des Parcs
Direction de la gestion de la faune du
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Figure 9. Sport harvest density in hunting zone 22 within the study area, in relation to terrestrial access routes and the delineation of areas subject to various restrictions on sport hunting. Harvest density represents the annual average number of moose harvested by sport hunters from 2012 to 2023 inclusive. Harvest density categories range from light to dark shading according to the following categories: $>0 - 0.25$, $0.25 - 0.5$, $0.5 - 0.75$, and $0.75 - 1.34$ moose/10 km².

Budget

The budget for this aerial survey of a portion of zone 22 was \$888,000. This amount excludes the regular salaries of employees of the Gouvernement du Québec, the Cree Nation Government (CNG), the Cree Trappers' Association (CTA) and the Cree First Nation of Waswanipi (CFNW). In 2021, the financial partnership represented an investment of \$94,000 by the Gouvernement du Québec (MFFP) and \$78,000 by the Canada Nature Fund administered by the CNG, for a total of \$172,000. In 2023, the Cree Nation Government invested \$420,000 and the Gouvernement du Québec (MELCCFP) \$296,000, independently of employee salaries. In total, this survey was made possible through an investment of \$498,000 by the CNG and \$390,000 by the Gouvernement du Québec, as well as an in-kind contribution, not quantified, from the CFNW. On average, the cost of implementation was \$3,241 per plot.

Survey implementation conditions

The survey was carried out from February 10 to March 5, 2021, and from January 24 to February 17, 2023. In total, 70 plots were flown in 2021 and 204 in 2023, for a total of 274 plots. This sampling required 165 flight hours for 3 helicopters in 2021 and 296 flight hours for 3 helicopters in 2023. This represents an average of 2.4 and 1.5 flight hours per plot in 2021 and 2023 respectively. The experience of the crews and the use of more efficient helicopters in 2023 explain the gain in efficiency in 2023. In total, 461 flight hours were required, distributed over 6 helicopters, for a ratio of 1.7 flight hours per plot, including travel between bases of operation and plots.

The weather conditions required for the surveys met the reference protocol (Courtois, 1991; Courtois et al., 1996). The surveys were carried out when visibility and snow conditions were adequate. Adverse climatic conditions required the suspension of operations, depending on the base of operation, for 3 to 6 of the 23 survey days in 2021, and for 2 to 3 of the 25 survey days in 2023. In 2023, two mechanical problems delayed two different helicopters by one and two days, respectively. In 2021, the survey required 43 helicopter-days out of the 52 helicopter-days available in the study area, excluding the positioning and withdrawal of the aircraft in the region. In 2023, 52 of the 65 helicopter-days were operational. In total, the 274 plots were flown in 95 helicopter-days, for an average of 2.9 plots per helicopter-day.

Snow characteristics, such as temperature, depth and hardness, greatly influence moose habitat selection behavior (Peek, 1998). Moose considerably reduce their movements when snow depth reaches 30 to 40 cm, regardless of sex or reproductive status (Melin et al., 2023). When snow cover exceeds 60 cm, the exponential increase in energy demand related to movement (Renecker and Schwartz, 1998) and considerations aimed at reducing predation risk (Dussault et al. 2005) influence moose habitat selection. The confinement of moose under a tall and dense forest canopy increases when snow depth exceeds 70 cm (Des Meules 1964; Oswald 1998). Ideally, surveys benefit from snow conditions that limit moose movements. However, it is preferable that snow cover remain below 1 m to avoid reducing the expected detection potential, due to a considerable reduction in movement and the confinement of moose under the tallest and densest canopies (Kelsall and Prescott, 1971).

During the 2021 survey period, snow cover estimated by the Environment and Climate Change Canada station at Matagami airport varied from 62 to 71 cm and from 51 to 57 cm at Chibougamau-Chapais airport. No significant snowfall was recorded during this survey. From February 21 to March 2, 2021, frequent wind gusts, varying from 31 to 78 km/h, helped distinguish recent tracks from old ones. The mean daily temperature of -16°C (standard deviation of 6°C) was the same for Matagami and Chibougamau.

In 2023, snow depth was estimated at the center of each plot according to the precipitation model of the European Centre for Medium-Range Weather Forecasts (ECMWF; Windy.com). An estimate of snow depth and density (mean \pm standard deviation) was compiled on the day of the survey for each plot (Figure 10). According to this model, average snow depth was 67 ± 7 cm and snow density was 204 ± 9 kg/m³ [158–220]. In general, the density of fresh and slightly moist snow varies from 50 to 70 kg/m³, established snow

not affected by rain and warm temperatures ranges from 200 to 300 kg/m³, and wind-compacted snow varies from 350 to 400 kg/m³ (Paterson 2001 *in* Muskett 2012). According to this scale, the established snow cover in the study area was generally of low density. Snow depth measurements taken in 3 habitat types (conifer stands, mixed stands and shrublands) suggest an underestimation of about 15% of snow depth by the model. The average depth for 10 readings taken in 4 sites was 82 ±11 cm (n=40) and no ice crust was detected. Snow conditions were favorable to reduced moose movements and the use of yards for the vast majority of plots at the time they were surveyed.

The snow depth and density estimates from the ECMWF had not previously been used in addition to the ministerial protocol (Courtois 1996) to describe survey conditions based on snow depth and density. This model characterizes the variability of track detection conditions and of the constraints influencing moose behavior across all plots without increasing logistics or flight time. Forest cover type is one of the main components of the Habitat Quality Index (HQI) value (Dussault et al., 2006) used in the moose density analyses of this survey. The relationship between HQI and moose observation frequency presented in the following section would likely be influenced by the snow conditions specific to this survey.

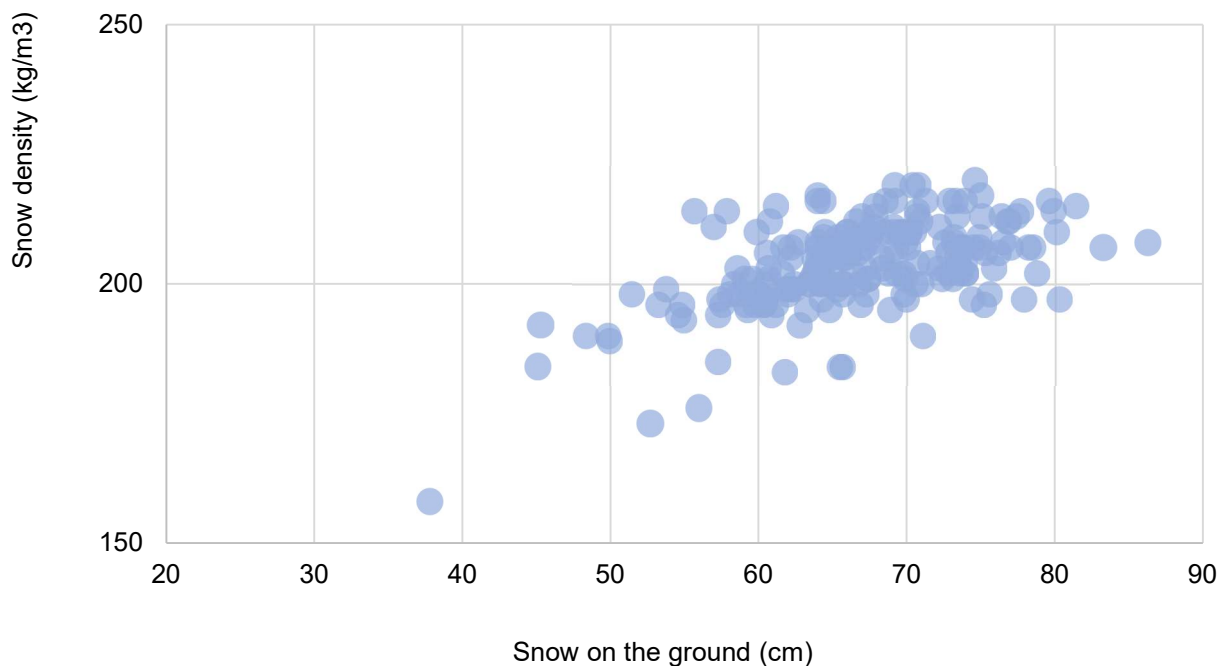


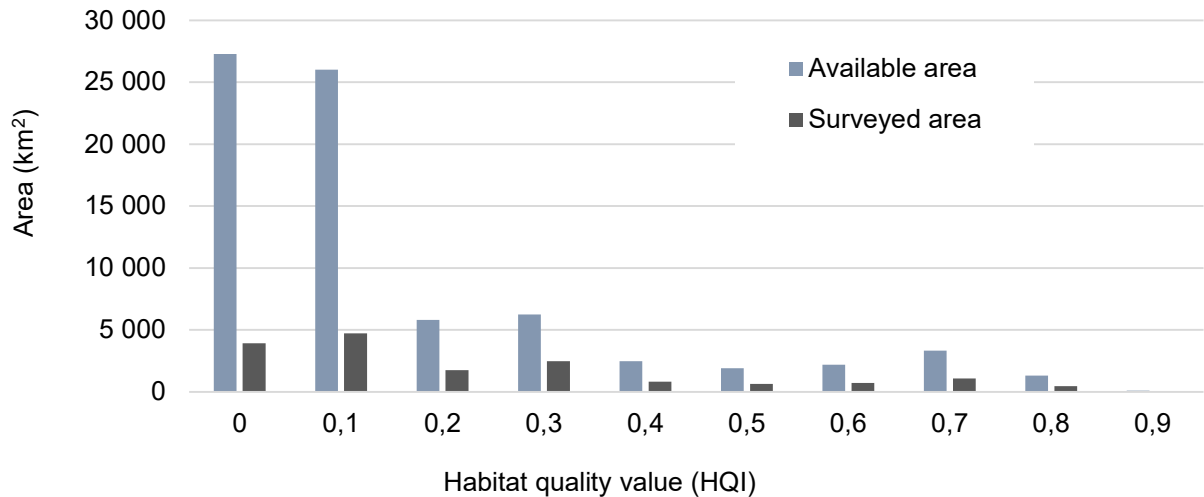
Figure 10. Relationship between snow accumulation on the ground and snow density for all plots surveyed in 2023. Snow cover was between 60 and 80 cm in the majority of plots and snow density was relatively uniform across all areas surveyed (ECMWF; Windy.com).

Results and discussion

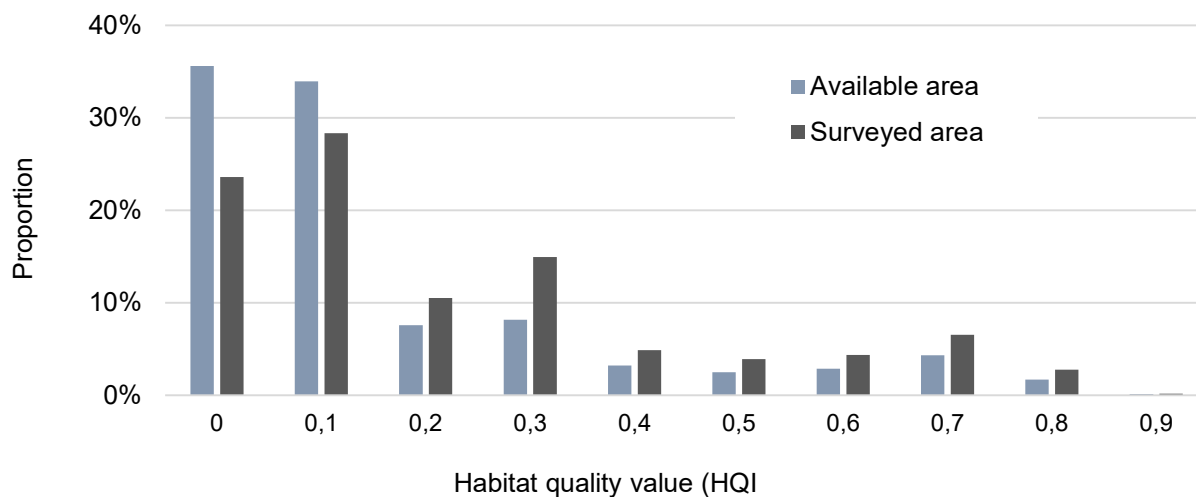
Stratification of habitat quality

The selected plots are representative of the full range of Habitat Quality Index (HQI) values available in the study area (Figure 11). Moose were observed in each HQI value, except for the highest value (0.9), which accounted for only 0.1% of the study area and 0.2% of the sampling rate.

a)



b)



Stratum: Low → High

Figure 11. a) Area of the study area for each HQI value [low to high; 0 – 0.9] compared to the areas flown during the survey, and b) the proportion of each HQI value in terms of availability in the study area and of the composition of the survey sampling rate.

The stratification of the survey zone was refined a posteriori by evaluating the relationship between the number of moose observed and the HQI value of the observation site (Figure 12). Thus, three strata were defined according to the distribution of the frequency of observations by HQI value, ranging between 0 and 0.8. The frequency of observations per unit of surveyed area for each HQI value was reported on a relative scale ranging from 0 to 1. This relationship showed that the number of moose observed increased with the HQI value. The slope of the linear regression was 10% and its coefficient of determination was satisfactory ($R^2 = 0.8$). The low [0 to 0.1], medium [0.2 to 0.3] and high [0.4 to 0.9] quality strata were defined arbitrarily based on this demonstration (Figure 12).

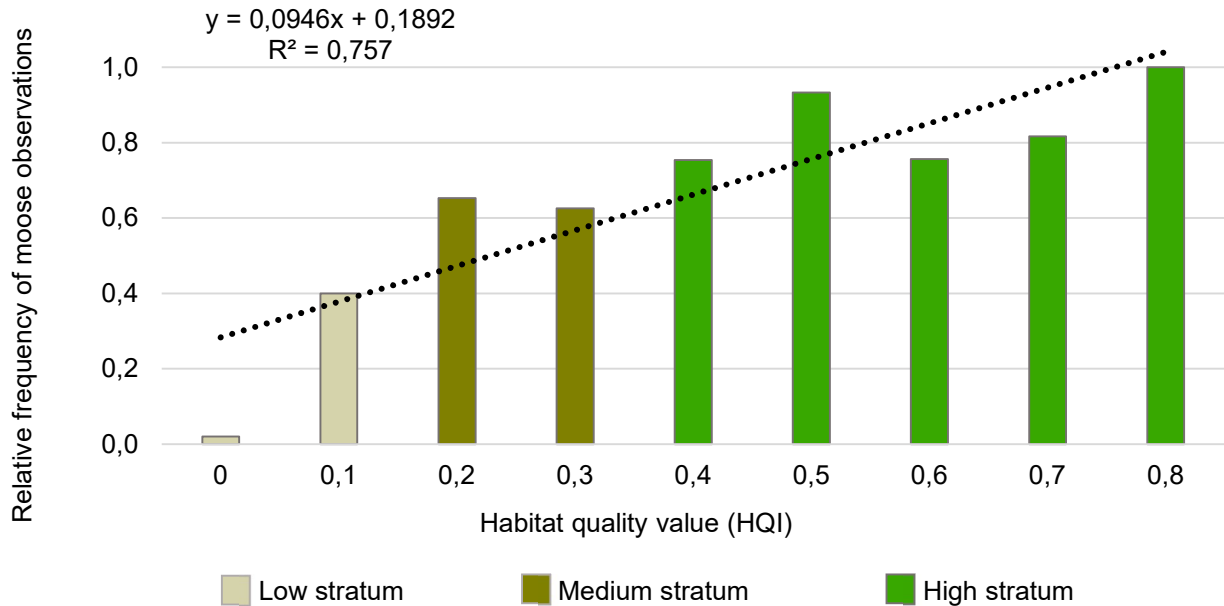


Figure 12. Comparison of the frequency of moose observations for each HQI class on a relative scale established according to the highest value observed (HQI class 0.8). The linear regression (dashed line) illustrates the positive relationship between habitat quality (HQI value) and the frequency of moose observations during the survey. The low [0 – 0.1], medium [0.2 – 0.3] and high [≥ 0.4] strata were established arbitrarily based on this relationship.

Estimation of population size

Across the 274 plots inventoried, 850 moose were observed in 520 sites. The sex and age class (adult or calf) could be determined for 832 moose, or 98% of those observed.

The winter moose population in the study area, located in the southwest of zone 22, was estimated at 3,944 moose (3,660 – 4,228; CI 90%), which corresponds to an average winter density of 0.57 moose/10 km² (0.53 – 0.61; CI 90%). The relative margin of error (CI) of this estimate is $\pm 7.2\%$ (± 0.04 moose/10 km²), a precision considered excellent for this type of survey. This survey indicates a 35.7% increase in moose density in the study area compared to the density estimate of 0.42 moose/10 km² $\pm 21.4\%$ (0.33 – 0.51; CI 90%) in Sector 2 (see Figure 6) in 1991 (Maltais et al., 1993). The moose density specific to Sector 2 in 2023 was identical to that of the entire study area, i.e., 0.57 moose/10 km². In 1991, the survey of the entire zone 22 had shown a very low density of 0.25 moose/10 km² (± 0.11) outside Sector 2, mainly in the bioclimatic domain of the lichen spruce forest. Subdividing the demographic monitoring of moose in zone 22 by bioclimatic domain seems relevant, given the differences in habitat quality between the lichen spruce

and the moss spruce forests. This approach also provides a subdivision of the area to be surveyed so that an appropriate sampling rate can be achieved under realistic logistics.

The survey of 274 plots results in an average sampling rate of 24% (Table 2), which provides a rigorous picture of the moose population because of its good confidence interval ($\pm 7.2\%$). This relatively high sampling rate was motivated by the partial result of the study area surveyed in 2021, which had yielded a wide confidence interval ($\pm 20.5\%$) despite a 23% sampling rate. The precision target ($\alpha=0.1$; CI 90%) of moose surveys in Québec is between 15 and 20% (Couturier et al., 2009). A power analysis had shown that achieving a relative error of $\pm 15\%$ (CI 90%) would have required a sampling rate of about 40% of the habitat area. The portion of the study area surveyed in 2021 is characterized by higher habitat quality and better access to hunters compared to the area surveyed in 2023. This context likely influences the variance in the relationship between habitat quality and the number of moose observed. The sampling rate planning for the 2023 survey was based on the prediction that this variance would be lower north of the northern forestry limit. Ultimately, a power analysis combining the 2021 and 2023 study areas indicates that a sampling rate of about 6% would have been sufficient to achieve a relative error of $\pm 15\%$ (CI 90%). Planning the sampling rate based on habitat quality benefits from integrating a qualitative analysis of hunting pressure when this information is available.

Moose density was significantly different (Welch's t-test; $p < 0.03$) for each of the three strata ($<>$ CI 90%), namely 0.34 moose/10 km² (0.29 – 0.39), 0.95 moose/10 km² (0.86 – 1.08), and 1.24 moose/10 km² (1.12 – 1.40) in the low, medium, and high strata respectively (Table 2). The moose population in a given sector can thus be calculated according to the proportion of its habitat area in each stratum. Transposing these results is appropriate for the western black spruce–feathermoss bioclimatic subdomain, assuming limiting factors similar to those of the study area of this survey.

Table 2. Characteristics of the sampling and estimation of the winter moose density (\pm CI 90%) in zone 22.

Stratum	Proportion of the study area (%)	Sampling rate ^a (%)	Number of moose observed	Corrected density ^b (moose/10 km ²)
Low	69.5	17.9	215	0.34 \pm 0.05
Medium	15.7	38.9	295	0.95 \pm 0.13
High	14.7	36.8	340	1.24 \pm 0.16
General value	100.0	24.0	850	0.57 \pm0.04

^a 274 plots of 60 km² were flown, corresponding to 16,440 hexagons of 1 km² having a Habitat Quality Index (HQI) value. The sampling rate is calculated according to the proportion of habitat quality hexagons flown/available in the study area.

^b Number of moose/10 km² corrected with a visibility rate of 73% to compensate for imperfect detection by observers during the two phases of the surveys.

The considerable extent of the areas burned in the Nord-du-Québec region in the summer of 2023, mostly located in zone 22, did not compromise the validity of the survey results. In total, 6,672 km² of moose habitat were affected by forest fire in the study area, or less than 10% of its surface area. These fires affected the three habitat strata in a proportion similar to their availability (Figure 13). The burns were distributed throughout the study area, and the largest ones mainly affected the low stratum (Figure 14). The largest burns covered 3,400 km², 2,000 km², and 1,200 km². However, a fire of about 700 km² affected a good moose sector in the southern part of the study area. According to the moose density estimated in winter by this survey (Table 2), about 350 moose would have been forced to relocate due to the fires of summer 2023. It is impossible to estimate how many moose would have perished; however, mortality would likely be marginal given their capacity to disperse over long distances.

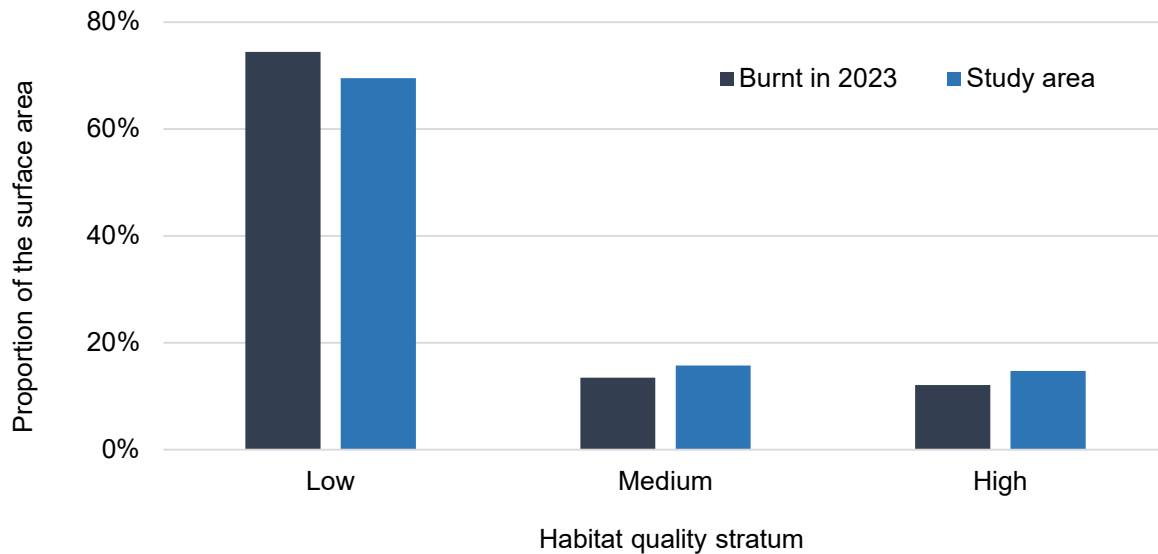
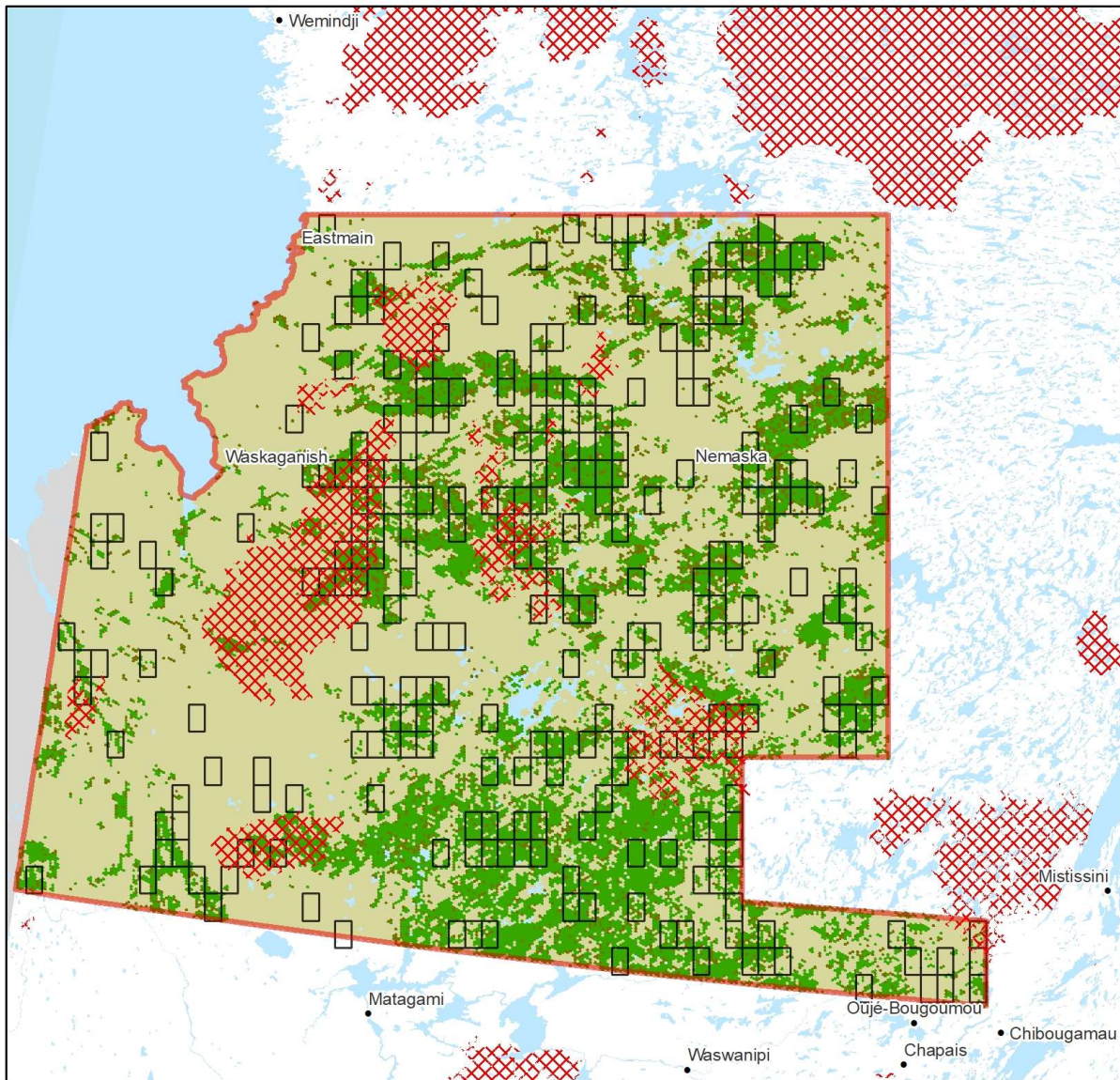


Figure 13. Proportion of the area burned in the summer 2023 forest fires in each of the habitat quality strata compared to their availability in the study area of the aerial survey before the fires.



<p> Study area</p> <p> Survey plot</p> <p> 2023 fire – Perimeter</p> <p>Stratification de l'habitat avant feu</p> <ul style="list-style-type: none"> Low stratum Medium stratum High stratum 	<p>Sources</p> <p>Data</p> <p>Base de données géomatique (BDGEOM) MRNF 2023</p> <p>Base de données géographiques administratives du Québec (BDGA1M) MRNF 2002</p> <p>Metadata</p> <p>Projection Québec conique conforme Lambert</p> <p>Coordinate system NAD_1983_Quebec_Lambert</p> <p>1:2 000 000</p> <p>0 20 40 80 Km</p>	<p>Production</p> <p>Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs Direction de la gestion de la faune du Nord-du-Québec © Gouvernement du Québec, August 2023</p> <p>Note: This document has no legal effect.</p>
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Figure 14. Mapping of the summer 2023 forest fires in the study area of the aerial survey and its surroundings in relation to the inventoried plots flown and the stratification of habitat quality prior to the passage of the fire.

Population structure

The combined results of the 2021 and 2023 surveys indicate that the winter population is dominated by adult females (> 1.5 years), representing 53.8% of the moose, a value similar to the 54.7% measured in 1991 (Table 3). Adult males accounted for 23.3% of the population, a lower value than the 28.1% recorded in 1991. The proportion of calves was 22.8% of the winter population, higher than the 17.2% observed in 1991. The comparison of male and female proportions between two surveys is nuanced by the annual variability in the proportion of calves in the population. Their numbers is more variable than that of adults, notably because of their vulnerability to environmental conditions. The population productivity and calf survival are more strongly influenced by occasional threats. For this reason, the main findings on demographic structure are based on the sex ratio and the number of calves per 100 females. These ratios provide insight into potential issues related to selective hunting management or population productivity.

The sex ratio of the adult population is used to estimate the potential for selective harvesting of males in order to protect the female segment. The winter sex proportions among adults were 30.2% \pm 3.8 males and 69.8% \pm 3.8 females. These proportions result in a ratio of 43.3 \pm 7.8 males/100 females. This represents a decrease of 16% compared to the ratio calculated for Sector 2 of the 1991 survey. This value remains normal in a selective hunting context. Between 2006 and 2016, Cree hunters from the communities concerned by this survey reported to the Cree Trappers' Association that they harvested an average of 1.7 \pm 0.2 males for every 1 female harvested. Regarding sport harvest, the sex ratio has averaged 7.4 males: 1 female harvested since the implementation of alternate-year management in zone 22 in 1999. This system is intended to increase hunting pressure on males by prohibiting the harvest of females every other year. The proportion of males in the sport harvest for the 12 permissive years since 1999 has nevertheless remained high, at 4.0 \pm 0.7 males:1 female. This indicates that non-beneficiary hunters tend to select males even when they have the opportunity to harvest a female. Although the sport harvest is more selective, it represents only a small portion of the total harvest, which is dominated by the Indigenous harvest. In 1991, the balanced sex ratio (98 males/100 females; Figure 15) observed where selective hunting pressure was very low (Sector 1) provides a reference for measuring the impact of selective hunting on moose demographics.

In moose populations, a high proportion of females increases population growth potential. Conversely, the selective harvest rate of males must be controlled to avoid impacting the gestation rate of females. In this sector, the recently measured gestation rate of 87% was normal ($n = 31$ females > 2 years; MELCCFP, unpublished data). It is noteworthy that the number of calves per 100 females was lower in 1991 even though the number of males per 100 females was higher (Table 3). These findings suggest that the sex ratio measured in this survey is not a limiting factor for female productivity. Recruitment would be more constrained by calf survival during their first year of life.

The aerial survey provides information on the recruitment potential of the population by measuring the proportion of calves in winter, when they are about 9 to 10 months old. Recruitment was 42.4 \pm 6.3 calves/100 females in the study area. This value matches the ratio of 42 calves/100 females measured in zone 29 in winter 2024 (MELCCFP, unpublished data), as well as previously in zone 19, which included zone 29 up to the Basse-Côte-Nord (Gingras et al., 1989), both located at the same latitude and in the black spruce–feathermoss forest. In general, the growth potential of the moose population measured in the study area would be considered medium for moose in Québec (Crête and Dussault, 1986). This winter recruitment value would therefore be considered normal for a hunting zone whose forest landscape is dominated by black spruce and where predation is carried out by wolves and black bears. For comparison, the proportion of 29.8 calves/100 females measured in zone 17 in 2021 was considered low (Brodeur et al. 2022).

Table 3. Moose population structure observed during the survey conducted in 2021–2023 in the black spruce–feathermoss forest of zone 22, and in Sectors 2 (spruce-moss forest) and Sector 1 (spruce-moss and spruce-lichen forests) surveyed in 1991.

Parameter	Current survey 2021-2023	Sector 2 1991	Sector 1 1991
Corrected density (moose/10 km ²)	0.57 ±0.04	0.42 ±0.09	0.25 ±0.08
Population structure (%)			
Males	23.3 ±3.3	28.1 ±0.9	41.3 ±1.2
Females	53.8 ±3.0	54.7 ±0.9	42.1 ±0.7
Calves	22.8 ±2.7	17.2 ±0.3	16.5 ±0.3
Ratio (moose/100 females)			
Males	43.3 ±7.8	51.4 ±7.4	98.0 ±14.1
Calves	42.4 ±6.3	31.4 ±7.2	39.2 ±8.7

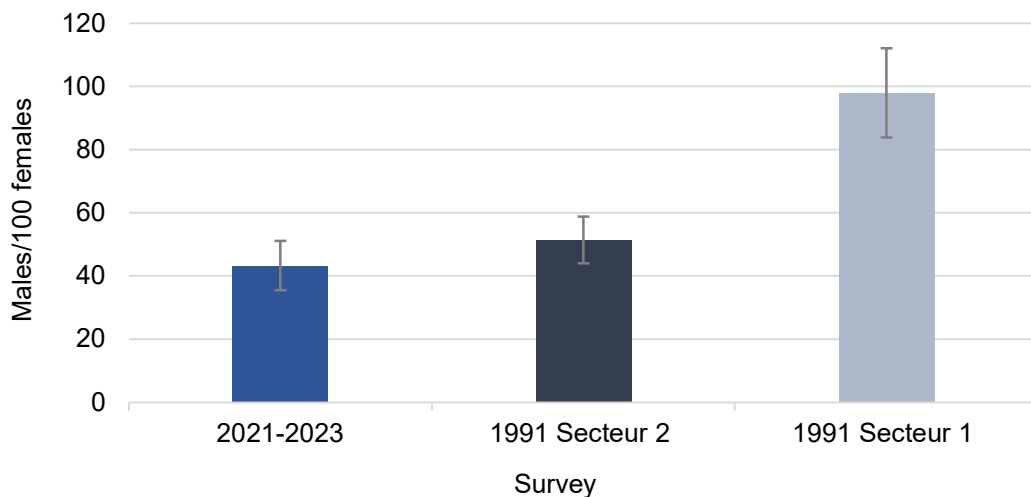


Figure 15. Number of males per 100 females (±90% CI) in the study area of the moose survey conducted in 2021 and 2023, as well as in Sector 2 of the 1991 survey, also located in the spruce-moss forest, and in Sector 1, located mainly in the spruce-lichen forest where selective hunting pressure was very low.

The recruitment potential observed in this study was higher than that measured in 1991 in Sector 2 and similar to that of Sector 1 (Table 3 and Figure 16). The increase in the proportion and the number of females in the adult population increases the potential for population growth, that is, the number of calves that can be produced for a given population size. In turn, the proportion of calves at the time of the survey would be a good indication of the recruitment rate of yearling moose in the adult population, since calf mortality is highest during the first months of life (Patterson et al., 2013; Severud et al., 2019). Sometimes, considerable late-winter and spring calf mortality may however occur in areas subject to severe winter tick (*Dermacentor*

albipictus) infections (Jones et al., 2019). The increase in the prevalence of this parasite has been reported by local residents over the past decade. When climatic conditions are frequently favorable, this parasite has the potential to affect high-density moose populations, particularly because of its pronounced effect on calf mortality (Ellingwood et al., 2020). However, natural survival of calves and adults in the study area appears normal. Climatic conditions in zone 22 remain relatively hostile to winter tick, notably because of low spring temperatures (Pouchet et al., 2024). Based on the demographics of the moose population in Zone 22, the increased occurrence of winter ticks would not appear to have a significant effect on population dynamics. The results of this survey suggest that moose population dynamics are primarily regulated by selective harvesting.

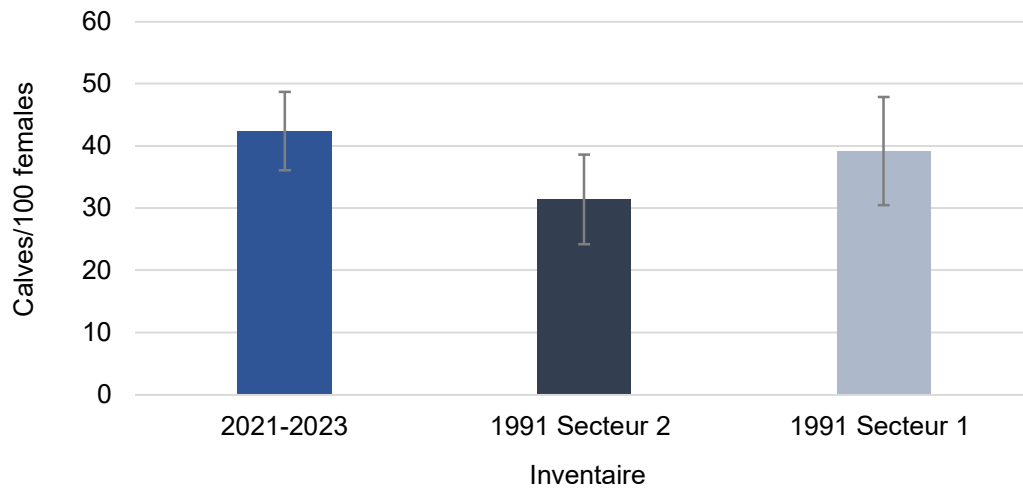


Figure 16. Number of calves per 100 females (\pm 90% CI) in the study area of the moose survey conducted in 2021 and 2023, as well as in Sector 2 of the 1991 survey, also located in the spruce-moss forest, and in Sector 1, located mainly in the spruce-lichen forest.

Harvest rate of the population

In Québec, the allocation of moose hunting licences is specific to the hunting zone. The number of non-beneficiary hunters of the JBNQA who hunt in zone 22 is therefore precisely estimated. Hunting effort is, however, not known at the scale of the study area of this survey, which only covers a portion of hunting zone 22. The location of the harvest site within the hunting zone is nonetheless recorded. Non-beneficiary hunters are legally required to register their moose harvest at a registration station or online at Québec.ca. The Québec Big Game Registration System compiles, among other things, harvest data for all big game species. In the territory under the JBNQA, the harvest database compiled by the Cree Trappers' Association (CTA) contributes to documenting the number of moose taken through hunting. This database provides information on the sex and maturity of harvested moose, as well as the approximate location of harvests by Cree hunters.

Zone 22 is essentially frequented by hunters from the nine Cree communities of Québec. The community territories of these communities are largely or entirely included within zone 22. Some Cree hunters from Moosonee and MoCreebec, Ontario, also hunt in zone 22 due to its proximity to Waskaganish (Figure 1). Hunters from Washaw Sibi, a community recognized by the Cree Nation Government, also use this zone. Since 1988, Cree harvests have been compiled by the CTA on a voluntary basis at the scale of the Cree trapline (see Figure 2 for spatial resolution). The participation rate in this harvest registry is unknown. However, the bias associated with variability in reporting rates is thought to have been relatively constant until 2016. After that, reporting rates declined noticeably at the regional scale for all species recorded by the CTA. A modernization of the CTA harvest monitoring system is underway. The implementation of the *CTA Wildlife* mobile application by the CTA (Geoportal for Eeyou Istchee, 2024) improves its capacity to track harvesting activities and environmental conditions. Since 2020, the Cree Nation Government has implemented a program of Indigenous Guardians of the Eeyou Istchee territory (*Eeyou Istchee Land Keeper/Wildlife Protection Assistant*). The Cree First Nation of Waswanipi also has its own Indigenous Guardian program for its territory. These initiatives encourage good hunting practices and enable harvest data collection. Recent Cree harvest data have not been transmitted to the Québec government. For the purposes of this report, statistics on moose harvests by Cree hunters at the scale of community territories are analyzed up to 2016, together with non-beneficiary harvest data.

In the study area, between 1991 and 2023, the average harvest by non-beneficiary hunters under the JBNQA was 87 moose \pm 53 annually. In hunting zone 22, these hunters prioritize the harvest of adult males even during permissive years (Figure 17). Since the first permissive year (2001) following the implementation of alternating-year management (1999), females have accounted for only 20.7% \pm 3.3 of the non-beneficiaries' harvest during permissive years. Since 1999, calves have represented on average 5% \pm 2.3 of the harvest. Although hunting zone 22 is the largest moose hunting zone in Québec, the number of sport hunters and moose harvested by sport hunters is considerably lower than in zones 29 and 19, which are also located north of 50°N.

The harvest density of adult males is the best indicator of variations in moose abundance when hunting effort is known and constant (Lavoie and Dussault, 2024). Such data exist for non-beneficiary hunters. In the study area, excluding Category I and II lands, as well as the special management zones Whe-Sees Indohoun and Eastmain, the harvest density of adult males averaged 0.018 moose/10 km² (\pm 0.007) of habitat between 1991 and 2023. During this period, the variability in the average annual harvest density of males ranged between 0.007 and 0.035 moose/10 km² of habitat. This was largely dependent on variation in hunting effort in hunting zone 22; between 418 and 889 hunters frequented the zone annually during this period. Under these circumstances, the hunting success of adult males remains the best indicator of population trends derived from hunting statistics (Figure 18). However, its scope is limited by the low number of hunters and its variability. In general, the low harvest density by non-beneficiaries is mainly explained by the relatively small number of non-beneficiary hunters in hunting zone 22, since their hunting success is relatively good.

The regulations in force in hunting zone 22 set a harvest limit of one moose for a group of two non-beneficiary hunters holding a license. The hunting success of non-beneficiaries in hunting zone 22 is calculated based on the number of hunters and the number of moose harvested. The hunting success of non-beneficiaries increased considerably between 1999 and 2010 in hunting zone 22 (Figure 18). Total success (all segments) reached 25.3% per license, meaning that one out of two groups of hunters managed to harvest a moose (limit of one moose for 2 hunters). This is very high despite the low moose density. The challenge of hunting in a low-density zone is possibly offset by hunting grounds with little competition due to the low number of hunters. The hunting success of adult males was also high, reaching 23.1% in 2010. The quality of hunting likely led to an increase in the number of hunters in hunting zone 22, with more than 800 hunters recorded between 2011 and 2017 (Figure 18). However, hunting success decreased with the increase in the number of hunters. Since then, the number of hunters has declined annually, reaching 515 hunters in 2023, despite the suspension of sport hunting for an indefinite period in hunting zone 17 in 2022. Despite the nearly 50% reduction in the number of hunters in just a few years in zone 22, hunting success also declined and, from 2015 to 2023, averaged 17.7% \pm 2.8 per license in permissive years (all segments) and 12.6% \pm 1.5 per license for the adult male segment in restrictive years. This value is similar to the hunting success observed in hunting zones 29 and 19, also located in the black spruce–feather moss forest. These demographic indicators suggest that the moose population in hunting zone 22 was higher in the early 2000s, and that it declined over the past decade. However, the analysis of sport hunting statistics does not indicate any issue with the management of harvest by non-beneficiaries in hunting zone 22, particularly since hunting success has remained good.

Mistissini

The community territory of Mistissini is located outside the study area, in the eastern part of hunting zone 22. It is the largest of the 9 Cree community territories, covering an area of about 122,500 km², or approximately one third of hunting zone 22. It extends over both black spruce–feather moss forest and black spruce–lichen woodlands, and hunting by non-beneficiaries of the JBNQA is either prohibited (*réserve faunique des Lacs-Albanel-Mistassini-et-Waconichi*, *parc national Nibiischii*) or little practiced, as the territory is difficult to access. Mistissini accounts for 37.0% of the harvest recorded by the Cree Trappers' Association (CTA) in zone 22 between 1991 and 2016. The possibility of extending the results of this survey to the portion of the Mistissini community territory located in black spruce–feather moss forest is not assessed in this report.

Cree harvest reporting is compiled by the Cree Trappers' Association (CTA) at the level of the traplines specific to each community (Figure 2). Although the voluntary nature of Indigenous harvest reporting only provides a minimum estimate, its analysis remains useful. Between 1991 and 2016, harvest declared in hunting zone 22 was carried out in a proportion of 75.2% \pm 9.0 by Cree hunters. At the scale of hunting zone 22, declared Cree harvest averaged 368 moose \pm 111 annually. Of this declared harvest, 48.8% occurred in community territories covered by the study area. This survey therefore provides information on a substantial portion of the moose hunting areas of Eeyou Istchee. At the scale of the study area, 68.5% \pm 13.7 of the declared harvest between 1991 and 2016 was carried out by Cree hunters (Figure 19). The annual average of declared harvest by the communities concerned between 1991 and 2016 was 185 moose \pm 48. This represents 4.5% \pm 1.2 of the population of 4,130 moose estimated in the relevant community territories (see Table 5 for the breakdown of estimates by community). However, it is not possible to rigorously calculate a harvest rate by Cree hunters for the year of the survey because harvest reporting has been discontinued since 2016.

Comparing the harvest rate of the moose population with its growth potential is a fundamental exercise in assessing the sustainability of hunting. This calculation takes into account total mortality from hunting, regardless of the type of user. Typically, the main bias in estimating the total harvest rate stems from the voluntary nature of Indigenous harvest reporting. This bias varies annually and is difficult to quantify. Although incomplete, Cree harvest monitoring data provide an estimate of a minimum harvest rate. Exceptionally, the CTA's time series of harvest records, which dates back to 1988, has been interrupted

since 2016. The relevance of analyzing harvest data prior to 2017 in relation to the population estimate from the 2023 survey is limited, since the moose population is unlikely to have been stable during this period. Indeed, monitoring of non-beneficiaries' hunting success suggests that the moose population has declined over the last decade. The harvest rate in the study area is therefore presented only for sport hunting, carried out by non-beneficiaries.

During the reference period from 2021 to 2023, the harvest rate of non-beneficiary hunters averaged 1.5% [1.3% – 1.9%] of the moose population (Table 4). This hunting pressure is considered very low, even for a population whose recruitment potential is assessed as medium, with 42 calves/100 females in winter. Moreover, hunting effort appears to be distributed throughout the study area, particularly in most sectors where moose habitat is suitable (see Figures 6 and 9). Due to selective hunting, the harvest rate for the male segment is higher than the harvest rate for all segments. In this context, the imbalance in the sex ratio of the population, at around 43 males/100 females, further increases hunting pressure on this segment. Thus, the annual harvest rate of the male segment by sport hunters ranged between 4.1% and 6.2% (Table 4). Hunters prioritize the protection of females when their harvest is permitted by choosing the adult male. As a result, the hunting success of adult males does not vary significantly despite the application of alternating rules, remaining high even when female harvest is permitted (Figure 17). The harvest rate for the adult male segment therefore appears to remain sustained despite alternation. Survey results suggest that the male harvest rate has led to a decrease in the number of males/100 females since 1991 (Figure 15). Historical CTA data also show that Cree harvest prioritizes the conservation of females. The revision of the harvest rate for the male segment should therefore integrate objectives for both beneficiaries and non-beneficiaries.

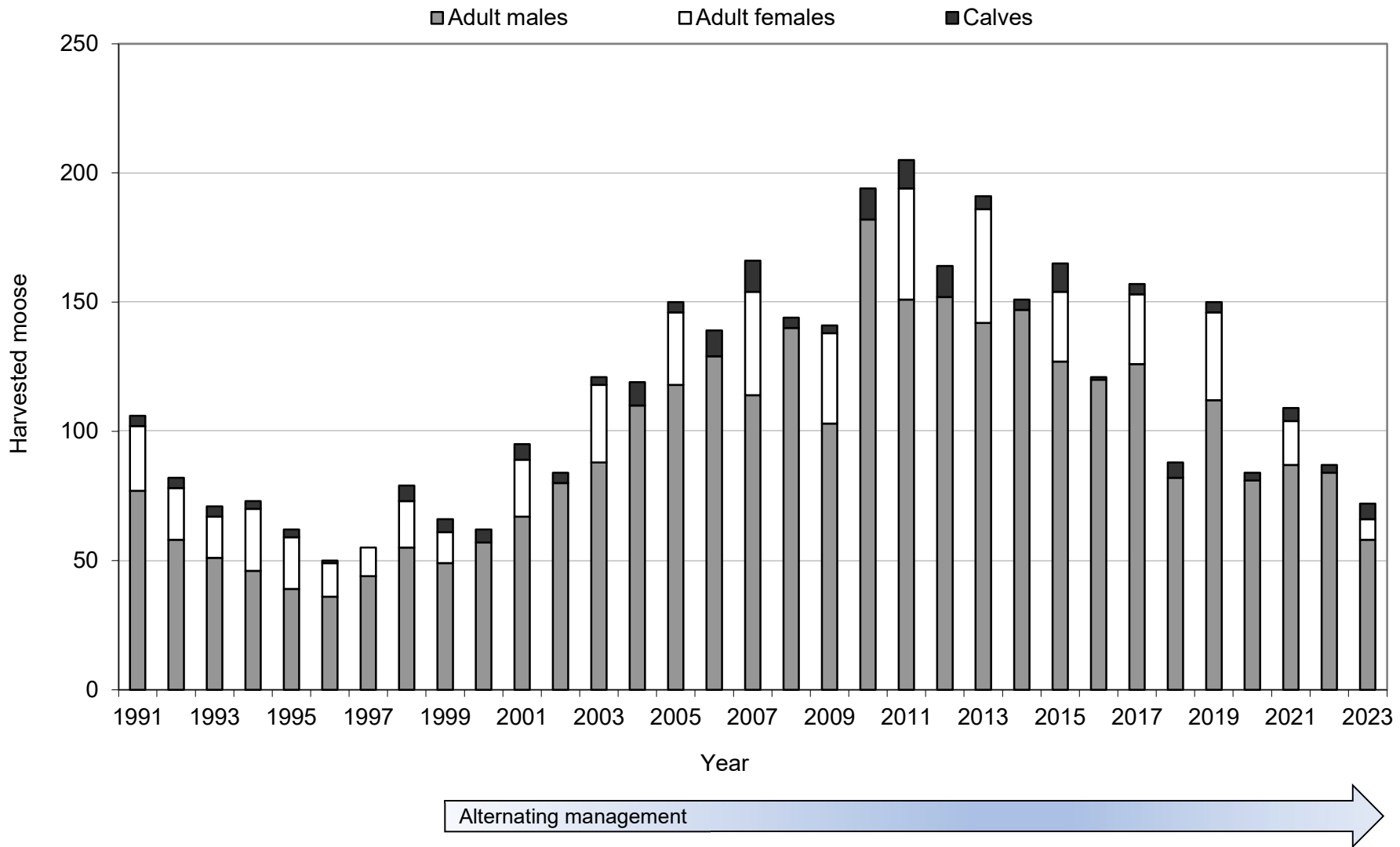


Figure 17. Number of moose harvested by non-beneficiary hunters under the JBNQA in zone 22, broken down into adult males and females (> 1 year), and calves. Since 1999, the application of alternate-year management has authorized the harvest of all segments in odd years, and the harvest of males and calves in even years.

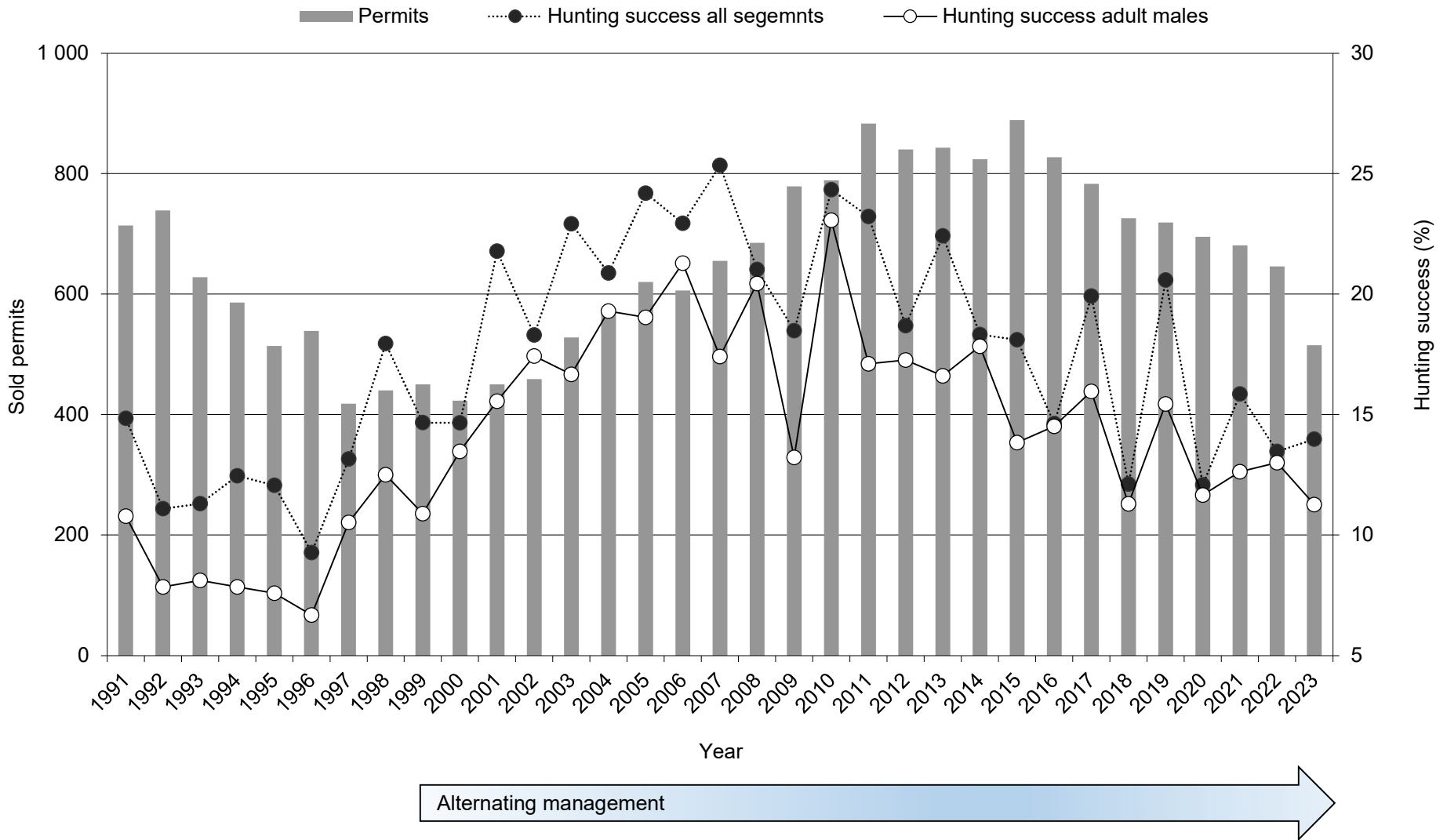


Figure 18. Number of hunting licenses specific to zone 22 obtained by non-beneficiary hunters under the JBNQA (left axis), and their hunting success (right axis) overall, including adults (males and females) and calves, as well as their hunting success for the harvest of adult males (> 1 year) only. Since 1999, the application of alternate-year management has authorized the harvest of all segments in odd years, and the harvest of males and calves in even years.

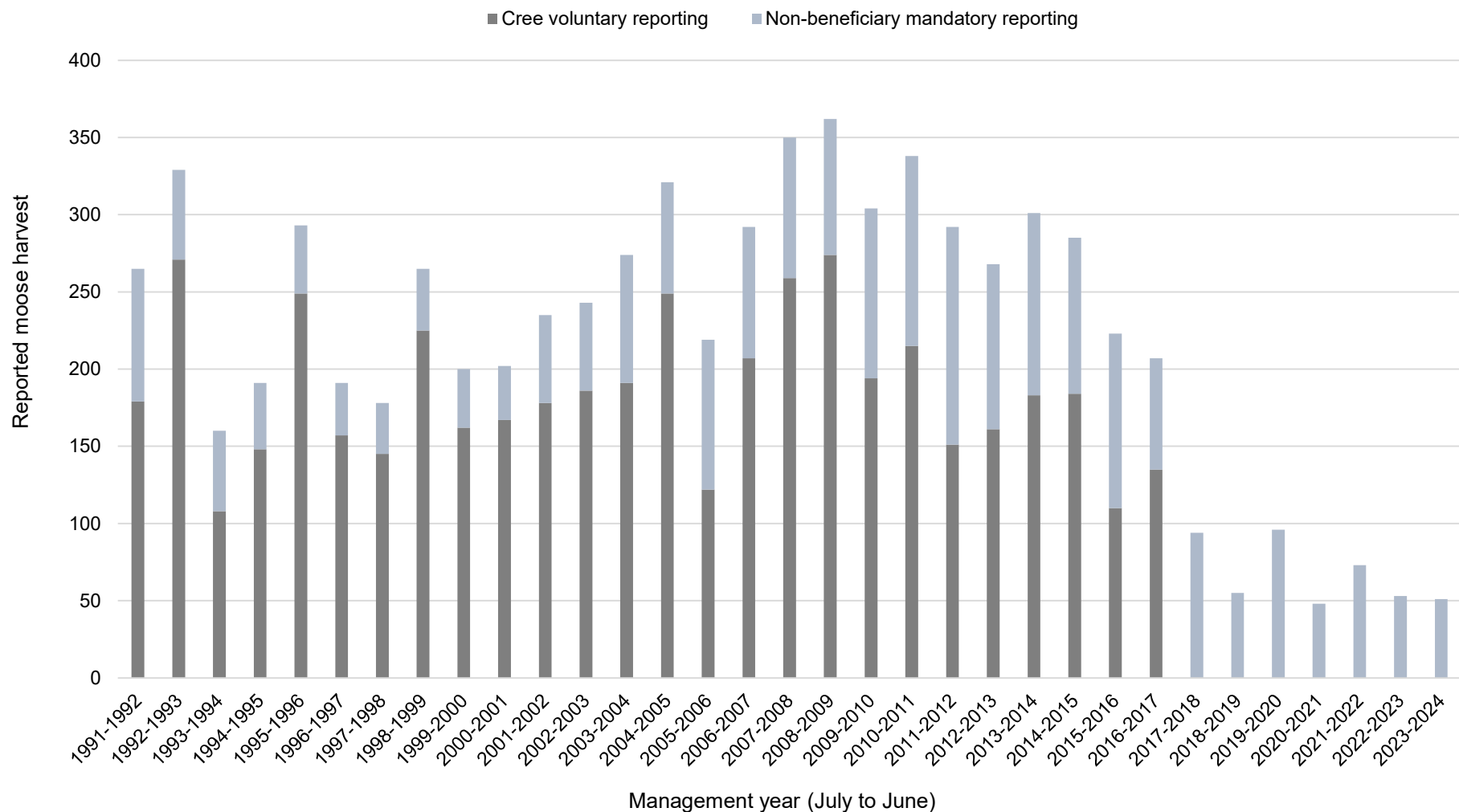


Figure 19. Annual estimate of the minimum moose harvest in the study area based on the voluntary harvest reporting registry of the Cree Trappers' Association (CTA) and the mandatory harvest reporting for non-beneficiaries under the JBNQA. CTA harvest data are presented up to 2016.

Table 4. Estimated harvest rate of the moose population by sport hunting in the study area covered by the survey for the years 2021, 2022, and 2023. The harvest of adult females was prohibited in 2022 due to alternate-year management.

Year	Sport harvest in the study area					Harvest rate**	
	Male	Female	Calf	Total	Proportion of the hunting zone 22 harvest*	Population (study area)	Male segment (study area)
2021	57	13	3	73	67.6 %	1.9 %	6.2 %
2022	50	0	3	53	60.9 %	1.3 %	5.4 %
2023	38	7	6	51	70.8 %	1.3 %	4.1 %
Mean	48	7	4	59	66.4 %	1.5 %	5.2 %

* Proportion of the total sport harvest recorded in the whole of zone 22 where the location of the kill was situated within the study area of the survey.

** Theoretical exercise based on the premise that the moose population estimated by the survey remained stable between 2021 and 2023.

A number of moose reserved for the Cree was defined for each of the communities established at the time of the signing of the JBNQA (8 of the 11 communities currently recognized by the Cree Nation Government). Act D-13.1 commits the provincial government to assess whether moose populations are sufficient to at least ensure the Guaranteed Levels of Harvesting (GLH) for beneficiaries of the Agreement. To this end, the mapping of the three habitat quality strata at the scale of the community territories provides an estimate of their respective moose populations. Calculating a sustainable harvest rate of the moose population identifies the number of moose that could be harvested. This number is then compared to the GLH to assess whether the size of the moose population allows the fulfillment of this harvesting right granted to beneficiaries. For this theoretical exercise, a modest harvest rate of 10% was used. Although the proportion of habitat quality varies among communities, this harvest rate exceeds the GLH of each of the communities (Table 5). As a reference, the average sport harvest (54 moose) for the permissive year (2021) and the non-permissive year (2022), combined with the Cree community GLHs in the study area (262 moose), represents a harvest rate of 7.7% of the moose population in the study area. The low number of moose harvested by non-beneficiary hunters in the study area of this survey would therefore not compromise the achievement of these wildlife management thresholds in the context of sustainable harvest management.

Table 5. Interpretation of the result of the aerial survey specific to the 5 Cree community territories according to their habitat quality, and comparing their Guaranteed Level of Harvesting (GLH) to a theoretical harvest rate of 10% of their respective moose populations.

Community	Average density (moose/10 km ²)	Habitat area (km ²)	Habitat quality stratum (%)			Number of moose		
			Low	Medium	High	Population	Theoretical 10% harvest rate	GLH
Waswanipi (portion of zone 22)	0.78	13,866	47	15	38	1,075	108	79
Nemaska	0.58	13,163	66	22	12	769	77	60
Waskaganish	0.49	28,636	80	11	9	1,391	139	98
Eastmain	0.50	13,288	77	17	6	658	66	25
Oujé-Bougoumou (portion of zone 22)	0.69	3,449	57	15	28	236	24	N/A*
All communities	0,57	72,402	69	15	15	4,129	414	262

* The Guaranteed Level of Harvesting specific to the community of Oujé-Bougoumou was not defined following the recognition of the community in 1989 by the Gouvernement du Québec.

Conclusion

The results of the aerial survey show that the moose population in the southwestern portion of hunting zone 22 increased by 36% between 1991 and 2023. The winter density was estimated at 0.57 moose/10 km². This density is similar to the objective of 0.60 moose/10 km² established in the Plan de gestion de l'original for hunting zone 22 (Morin 2015, Plan de gestion de l'original 2012–2019, in Lefort and Massé [eds.], 2015). The interpretation of sport harvest data, over the 30 years separating the two surveys, suggests that the population reached a peak between 2005 and 2010. The total harvest rate was likely higher than the productivity of the population during the following years. The harvest of moose by Cree beneficiaries of the JBNQA represented more than 69% of the total harvest in the study area. Since 2016, irregularities in the monitoring of the Cree harvest have prevented the calculation of the current harvest rate for all users. Initiatives are underway to re-establish stewardship and monitoring of the Cree harvest. The harvest rate of non-beneficiaries (sport hunters) in the study area between 2021 and 2023 was very low, averaging 1.5% of the population. Selective harvesting of males by all users has reduced the sex ratio from 51 to 43 males/100 females since 1991. This survey provides a demographic update motivated by management needs related to the harvest of JBNQA beneficiaries and for the revision of the objectives of the provincial Plan de gestion de l'original.

Findings

- The moose population has increased by about 36% since 1991 and was probably highest in the early 2000s.
- The estimated winter density in 2023 is similar to the objective established in the Plan de gestion de l'original 2012–2025.
- Selective harvest pressure on adult males has reduced the number of males/100 females since 1991 without compromising population productivity and growth.
- Monitoring of management indicators suggests that the harvest rate in the last decade was higher than the productivity of the population.
- Partial monitoring of the Cree harvest limits the interpretation of the survey results and the calculation of factors limiting moose population growth.

Management perspectives

1. These aerial survey results will be used to revise moose hunting regulations with the general objective of maintaining sound management of the moose population that allows for sharing of the resource between JBNQA beneficiaries and non-beneficiaries.
2. The update of the demographic profile will inform the interpretation and mitigation of the impacts of industrial development, forestry, and natural disturbances on moose habitat quality.

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