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Moose (*Alces americanus*) habitat suitability in temperate deciduous forests based on Algonquin traditional knowledge and on a habitat suitability index

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ABSTRACT

Traditional ecological knowledge (TEK) garners increasing attention in science-based wildlife management. We used the TEK of 16 First Nation hunters from the Eagle Village Algonquin community (Quebec, Canada) to evaluate moose (*Alces americanus*) habitat suitability in temperate deciduous forests, compared with a habitat suitability index (HSI) model. We found moderate to strong agreement between TEK and the HSI using Cohen's kappa (κ = 0.46–0.63). According to the Algonquin hunters, wetlands and lakes are frequented by moose to feed and to avoid temperature stress during warm summer days, something not taken into account by the HSI. Algonquin hunters also mentioned that unproductive areas are actively frequented by moose in the summer and during the rutting period, although they have a low weight in the HSI calculation. Also according to Algonquin hunters, mature coniferous stands and large-size regenerating areas are rarely used by moose. While the moose HSI model was developed in boreal mixed and coniferous forests, we have shown that it could also be used in temperate deciduous forests. It could be improved, however, to better correspond to TEK, notably by including wetlands and lakes, increasing the weight of unproductive stands and reducing weights of mature coniferous and regenerating stands.

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RÉSUMÉ

Les savoirs écologiques traditionnels (SET) sont de plus en plus utilisés en gestion de la faune. Nous avons utilisé les SET de 16 chasseurs autochtones de la communauté algonquine de Eagle Village (Québec, Canada) pour évaluer la qualité de l'habitat de l'orignal (*Alces americanus*) en forêt tempérée feuillue, comparativement à un indice de qualité d'habitat (IQH). Nous avons mesuré un accord modéré à fort entre les SET et l'IQH à l'aide du Kappa de Cohen (κ = 0,46–0,63). Selon les chasseurs algonquins, l'orignal fréquente les milieux humides et les lacs pour s'alimenter et éviter le stress thermique durant les chaudes journées d'été, ce qui n'est pas pris en compte par l'IQH. Les chasseurs algonquins ont aussi mentionné que les peuplements improductifs sont fréquentés activement par l'orignal durant l'été et en période de rut, mais ont un faible poids dans le calcul de l'IQH. Toujours selon les chasseurs algonquins, les peuplements résineux matures et les grandes superficies en régénération sont peu utilisés par l'orignal. Bien que le modèle d'IQH de l'orignal ait été développé en forêts boréales mixtes et résineuses, nous avons montré qu'il est aussi approprié pour la forêt tempérée feuillue. Il pourrait toutefois être bonifié pour être plus en phase avec les SET, notamment en tenant compte des milieux humides et aquatiques, en augmentant le poids attribué aux milieux improductifs, et en diminuant les poids attribués aux peuplements résineux matures et aux grandes aires en régénération.

Introduction

Indigenous knowledge contributes to the understanding of wildlife habitat use and is gaining international recognition in science-based natural resource management (e.g., Moller et al. 2004; Kendrick & Manseau 2008; Service et al. 2014; Voorhees et al. 2014). Aboriginal people possess traditional ecological knowledge (TEK) that can inform science-based wildlife management in various ways, including through population monitoring and by providing information on habitat use (e.g., Jacqmain et al. 2005; Wandel et al. 2011; Danielsen et al. 2014; Herrmann et al. 2014; Polfus et al. 2014). TEK represents "a cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and

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with their environment" (Berkes 2012, p. 7). TEK is cumulative and dynamic, because it is based on the experience of previous generations and is adapted to ongoing technical and socio-economic changes (Menzies & Butler 2006). Documenting TEK and engaging indigenous communities in the planning and implementation of forest management is a promising way to develop more socially acceptable forestry practices in indigenous contexts (Cheveau et al. 2008; Uprety et al. 2012; Asselin 2015).

Moose (*Alces americanus*, formerly *Alces alces*) is a large ungulate species that is valued in Canada for its socio-economic and cultural roles (Reeves & McCabe 2007). Moreover, moose is an important species in many aboriginal cultures (Jacqmain et al. 2005; Reeves & McCabe 2007). Traditional activities such as moose hunting are the backbone of the sustainability of Algonquin (Anishnaabeg) communities, and provide occasions to share traditional knowledge (Saint-Arnaud et al. 2009; LeBlanc et al. 2011).

Habitat suitability index (HSI) models have been developed to evaluate the capacity of wildlife habitat to fulfill species' needs (Roloff & Kernohan 1999). The first HSI models were developed in the United States in the early 1980s to evaluate the consequences on wildlife of human-induced ecosystem modifications (Allen et al. 1987). Inspired by these early studies, the Government of Quebec developed and improved HSI models for a number of wildlife species, including moose (Courtois 1993; Dussault et al. 2002). The moose HSI model predicts habitat suitability as a function of the potential for food and cover. It has been developed in boreal mixed and coniferous forests based on habitat use data obtained from a telemetry study and validated using similar, but independent, data (Dussault et al. 2006). Although it is also used in temperate deciduous forests, the validity of the moose HSI model in this biome was only assessed in a single study (Joanisse et al. 2013). Further validation exercises are thus required to warrant using the moose HSI model in temperate deciduous forests.

This study was prompted by questions raised by the Land Management Office of the Eagle Village First Nation (western Quebec, Canada). The community was concerned that wildlife managers measure moose habitat suitability using an HSI model developed and validated in boreal mixed and coniferous forests, which markedly differ from the temperate deciduous forests typical of their traditional family hunting grounds. Our objective was thus to compare moose habitat suitability on the traditional territory of the Eagle Village First Nation as assessed from the TEK of Alonquin hunters and from the HSI model. Differences would indicate possible improvements to the HSI model for increased validity in temperate deciduous forests.

Methods

Study area

This study took place in the temperate deciduous forest of western Quebec, specifically in the sugar maple–yellow birch bioclimatic domain. The study area includes two forest management units covering a total area of 12,246 km^2 (Figure 1). Climate is of the continental subpolar type, with cold winters and warm summers. Mean annual temperature varies between 2.5 and 5.0°C. Mean annual precipitation is between 800 and 1000 mm, of which about 25% falls as snow (Environment Canada 2013). The mean elevation is 300 m above sea level and the area is dominated by rolling hills and numerous lakes and rivers.

The sugar maple–yellow birch bioclimatic domain lies in the northernmost part of the temperate deciduous forest. On mesic sites, yellow birch (*Betula alleghaniensis* Britt.) is one of the main companion species to the dominant sugar maple (*Acer saccharum* Marsh.) in deciduous stands. Black spruce (*Picea mariana* [Mill.] BSP), eastern white cedar (*Thuja occidentalis* L.), white pine (*Pinus strobus* L.) and eastern hemlock (*Tsuga canadensis* L.) dominate coniferous stands. Balsam fir (*Abies balsamea* [L.] Mill.) is mostly present in mixed stands.

The natural disturbance regime in the sugar maple–yellow birch bioclimatic domain is dominated by small-scale canopy gaps (Després et al., in press). Large-scale windthrows and wildfires are infrequent (Drever et al. 2009; Roy et al. 2010). Spruce budworm outbreaks (*Choristoneura fumiferana* [Clem.]) periodically affect coniferous species, mostly balsam fir (Bergeron et al. 1995). Outbreaks of the forest tent caterpillar (*Malacosoma disstria* [Hübner]) affect deciduous species, mostly trembling aspen (*Populus tremuloides* Michx.; Cooke & Lorenzetti 2006). Forest exploitation started in the area in 1866 (Moore 1982), and increased in intensity during the twentieth century. Partial cutting is currently the dominant management technique, favouring sugar maple dominance (Drever et al. 2006).

The study area includes part of the traditional territory of the Eagle Village Algonquin community (973 members; Aboriginal Affairs and Northern Development Canada 2015). The forest is at the heart of the Algonquin way of life and constitutes a cultural heritage (Saint-Arnaud et al. 2009). The traditional territory is subdivided into family hunting grounds,

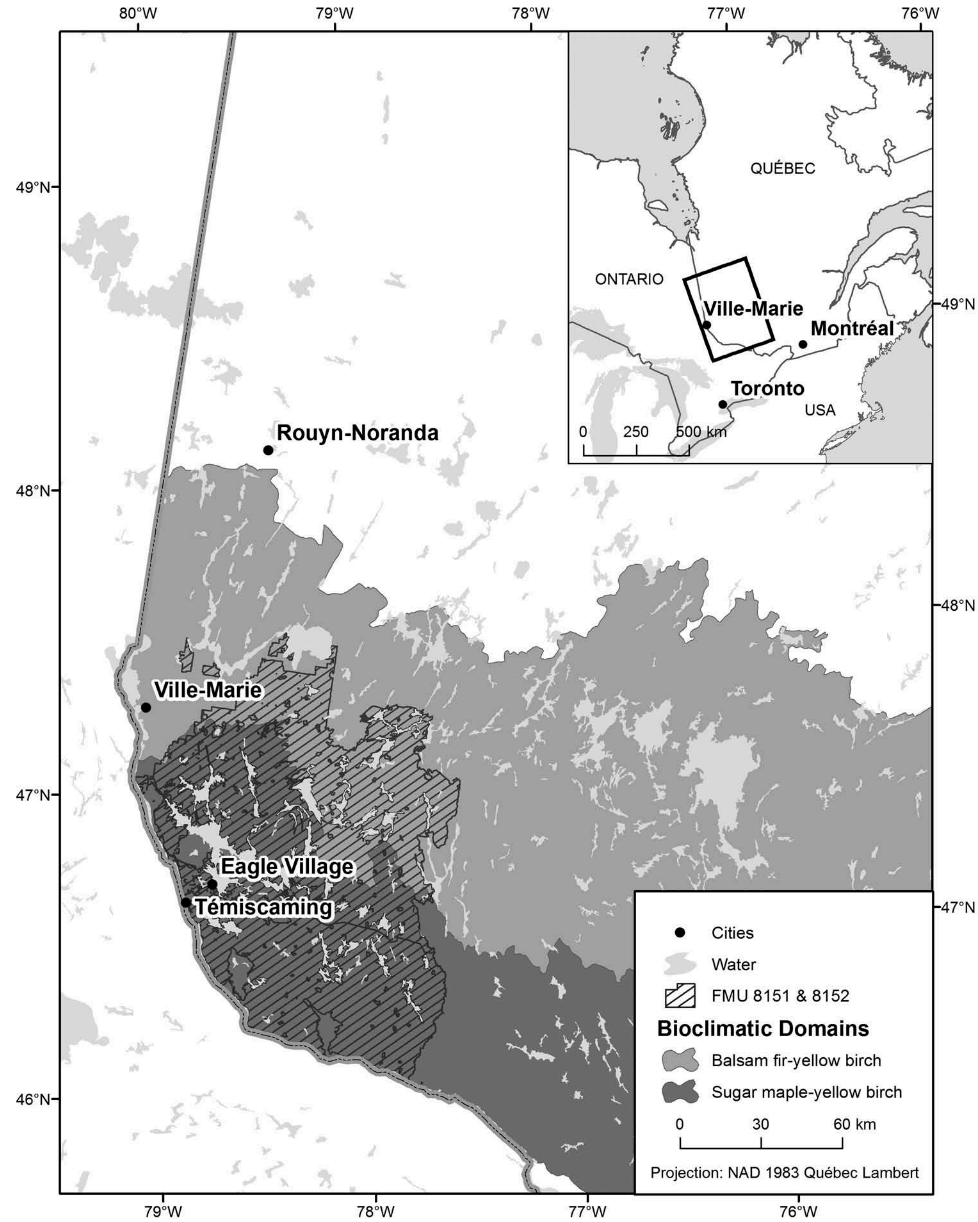

Figure 1. Study area (forest management units 8151 and 8152) within the balsam fir–yellow birch and sugar maple–yellow birch bioclimatic domains in Abitibi-Temiscamingue, Quebec, Canada.

which are considered integral ecosystems that must be sustainably managed (Leroux et al. 2004). Aboriginal people have an in-depth knowledge of wildlife habitat use. In addition to moose, other mammal species that are harvested in the study area include snowshoe hare (*Lepus americanus*), black bear (*Ursus americanus*) and various fur bearers (e.g., beaver *Castor canadensis*, marten *Martes americana* and fisher *Pekania pennanti*). Eagle Village's ancestral territory is on public land and the Quebec government is responsible for forest and wildlife management. The community must, however, be consulted during the development of management plans.

Traditional knowledge of moose habitat suitability

During winter and spring 2013, we collaborated with the Eagle Village First Nation Land Management Office to conduct semi-directed interviews with 16 hunters (15 men, one woman) from the community. The 16 family hunting grounds represent 22% of the total study area. Our goal was to assess hunters' perceptions of moose habitat suitability across their entire hunting grounds. We used semi-directed interviews because they resemble a conversation, which is well suited to the manner in which people like to share their knowledge and allows for unexpected subjects to emerge, thereby enriching the results (Huntington 2000). Nine hunters were older than 60 years of age (all of whom had more than 50 years of hunting experience) and seven were between 35 and 59 years old (with 20–45 years of hunting experience).

We obtained consent from the participating hunters. We prepared an interview guide in collaboration with the Eagle Village Land Management Office so that it would reflect the community's knowledge and needs (Asselin & Basile 2012). We obtained a certificate from the Human Ethics Review Board of Université du Québec en Abitibi-Témiscamingue. The interviews were structured along three main themes: areas used (or not) by moose in different seasons; characteristics of sites used for food, cover, rest and reproduction; and moose habitat management techniques. All interviews were conducted in the presence of a community facilitator appointed by the Eagle Village Land Management Office, who helped identify participants and translated from Anishnaabemowin (the Algonquin language) to French/English and *vice versa*, when needed. We asked each participant to draw contour lines on a map that depicted sites where moose habitat suitability was high, good, low or null. We used the NVivo software (QSR International, Melbourne, Australia) to perform content analysis on the interview transcripts to separate the data into themes and to establish links between themes (May 2002). We shared and discussed all results several times with the Eagle Village Land Management Office to make sure the themes revealed by content analysis accurately reflected the views of the community (Asselin & Basile 2012).

Moose habitat suitability index

We used data from the decennial forest inventories of the Quebec Ministry of Forests, Wildlife and Parks that are available on ecoforestry maps to evaluate moose habitat suitability using the HSI model developed by Dussault et al. (2006). Data from the fourth decennial forest inventory (ca. 2012) were updated using annual reports of forest interventions.

The moose HSI model is a combination of two suitability indices that are based on food (forage) and the interspersion of food and cover in different stand types (Dussault et al. 2006). Specifically, the study area is subdivided into 5 km^2 cells, a scale that reveals the greatest correspondence between habitat preference and suitability indices (Dussault et al. 2006). The food suitability index (SI_{food}) is based on the percentage of different habitat types within each cell (Equation (1)); each habitat is weighted to represent the potential for feeding based on field inventories (Dussault et al. 2006):

$$\begin{aligned} SI_{food} = & [(\%Mi10 + \%Dt50 + Mt50) \times 1.00] \\ & + [(\%Di50 + \%Mi30) \times 0.50] \\ & + [\%Mi50 \times 0.40] \\ & + [\%C10 \times 0.3] + [\%CS30 \times 0.15] \\ & + [\%IMP \times 0.10] + [\%CF30 \times 0.05] \end{aligned} \tag{1}$$

For example, mixed forests with intolerant hardwood species (Mi50) are given a higher weight (0.40) than conifer forests with fir or spruce (CF30; 0.05). Abbreviations of habitat types are explained in Table 1.

The edge index (SI_{edge}) represents the amount of edge between food habitat and cover habitat in a cell (Equation (2)); it integrates edges within and between stands (Dussault et al. 2006):

$$\begin{aligned} SI_{edge} = & \%\,Mi50 + [(1 - \%Mi50) \\ & \times (\text{edge density between food and cover} \\ & \text{stands/70th percentile of food}-\text{cover} \\ & \text{density across all cells})] \end{aligned} \tag{2}$$

The edges within stands are calculated as the proportion of mixed stands with intolerant deciduous species

Table 1. Current proportions of each habitat type within the 16 family hunting grounds of the Eagle Village Algonquin community (Abitibi-Temiscamingue, Quebec).

Habitat type	Age class (years)	Habitat code	Food suitability	Cover type	Proportion (%)
Intolerant hardwoods	≥50	Di50	Moderate	Summer	4
Mixed with intolerant hardwoods	30	Mi30	Moderate	Summer	6
Mixed with intolerant hardwoods	≥50	Mi50	Moderate	Summer/winter	12
Tolerant hardwoods	≥50	Dt50	High	Summer	13
Mixed with tolerant hardwoods	≥50	Mt50	High	Summer	25
Mixed (regeneration)	10	Mi10	High	–	6
Conifers (regeneration)	10	C10	High	–	3
Conifers with fir or spruce	≥30	CF30	Low	Summer/winter	3
Conifers without fir or spruce	≥30	CS30	Low	Summer/winter	7
Unproductive areas[a]	–	IMP	Low	–	3
Other habitat types	–	OTH	N/A	N/A	18

Note: N/A, not available.
[a]Unproductive areas can be covered by herbs and shrubs. When trees are present, the density is too low to permit industrial logging.

older than 50 years (Mi50), because these stands offer the best interspersion of food and cover (Dussault et al. 2006). The edges between stands represent the contact of stands offering high food suitability (Dt50, Mt50, Mi10) and stands providing good cover (CF30, CS30, Mi50, C30). This proportion is calculated in all stands except Mi50 stands, which are already used in the within-stand edge portion of the equation. Stands in the 70th percentile of cover-food edge density (calculated in m/ha) are considered to offer optimal edge between stands (Dussault et al. 2006), so the edge suitability index for a given cell is computed as the ratio of edge density in the cell to edge density in the 70th percentile across the study area (maximum = 1.00).

Finally, the global HSI for each 5 km^2 cell is determined as follows:

$$HSI_{global} = SI_{food} \times 0.45 + SI_{edge} \times 0.55 \quad (3)$$

A slightly higher weight is given to SI_{edge}, because it explains a higher proportion of the variation in moose density (Dussault et al. 2006). The HSI model includes values between zero and one, and is represented on maps using four categories: null (<0.20), low (0.20–0.40), good (0.41–0.60) and high (0.60). We used ArcGIS 10.0 (ESRI, Redlands, CA, USA) and version 1.2.5 of the HSI model to map moose habitat suitability (Massé et al. 2013).

We calculated the moose HSI for 16 Algonquin family hunting grounds, which covered a total area of 2650 km^2 (mean ± standard deviation = 120 ± 56 km^2), to facilitate comparisons with interview data (see later). We computed four iterations of the HSI, each time slightly moving the centre of the 5 km^2 cells, following the recommandation of Labbé et al. (2012) to reduce edge effects.

Agreement between TEK and HIS

We numerized the contour lines drawn by Algonquin hunters using ArcGIS 10.0 to produce a map of moose habitat suitability according to TEK. We superposed a 5 km^2 grid onto the TEK maps to attribute a TEK habitat suitability value (high, good, low, null) to each 5 km^2 cell for direct comparison with HSI data. If a cell included more than two TEK suitability index values (because a contour line ran through it), it was given the value covering the highest proportion.

We used Cohen's kappa (κ) to evaluate agreement between TEK and HSI models (Cohen 1960). Calculation of the kappa value is based on the difference between observed and expected agreements for each of the 16 family hunting grounds separately, and for all family hunting grounds taken together. Kappa values range between 1 (perfect agreement) and −1 (perfect disagreement) (Cohen 1960). Some disagreements are more problematic than others because they oppose more dissimilar categories. For example, a disagreement between high and null is more problematic than a disagreement between high and good. Therefore, Cohen (1968) suggested a weighted version of the kappa coefficient where a different weight is attributed to each cell of the contingency table to reflect the importance given to disagreements. Also, the weighted version is recommended when the categories can be ordered, as was the case in our study. We used linear weighting (Vanbelle & Albert 2009) and determined the weight of each cell in the contingency table as follows:

$$W_{ij} = 1 - \frac{|i - j|}{r - 1} \quad (4)$$

where W_{ij} is the weight attributed to cell ij, i is the ith column, j is the jth line and r is the number of categories. Maximum weight (W_{ij} = 1) was given to the diagonal cells (perfect agreement). We used the Z statistic to verify the statistical significance of the kappa values; that is, if they significantly differed from zero (Ben-David 2008).

Results

Algonquin hunters' knowledge

Most of the hunters mentioned that mixed and deciduous stands were preferentially selected by moose. Some hunters specified that moose habitat use varied from season to season. During the winter, moose benefit from the protection of low-lying branches in coniferous stands (e.g. eastern white cedar). However, food availability is low during that period. Moose also use riparian strips as travel corridors during the winter. In spring and summer, moose use sites that are rich in forage, such as sites regenerating from recent disturbances, wetlands, lakes, islands and hilltops, where they are less vulnerable to predation. Hunters also noted that moose used "dense and healthy" stands to hide from predators and to benefit from the shade during warm periods. In the autumn, moose are more mobile in open areas that have been recently disturbed by wildfire, windthrow or logging, which offer abundant food resources.

According to Algonquin hunters, good moose habitat must include regenerating deciduous stands as well as mature mixed and deciduous stands, lakes and wetlands. Regenerating stands are important food sources, but the hunters insisted that residual forest should be left in logged areas to provide cover and escape corridors. Furthermore, hunters mentioned that moose abandon large cut blocks or large burns for several years, until regeneration occurs in sufficient amount. Some hunters also said that large regenerating areas offer poor habitat for other species of high cultural value, such as marten.

Moose habitat suitability was judged "good" by nine of the 16 hunters, while the seven other hunters judged it to be "low" because of disturbance due to forestry, mining, road building or windthrows. Areas with low habitat suitability accounted for 19% of the area covered by the 16 family hunting grounds, whereas good and high suitability habitats accounted for 48% and 33% respectively (Figure 2a). None of the hunters interviewed used the null suitability class. One hunter stated: "If moose does not use an area, it does not mean the suitability is null."

Habitat suitability index

The mean HSI value calculated for the 16 family hunting grounds was 0.64, which corresponds to high habitat suitability. Cells with good and high habitat suitability accounted for 43% and 35% of all cells

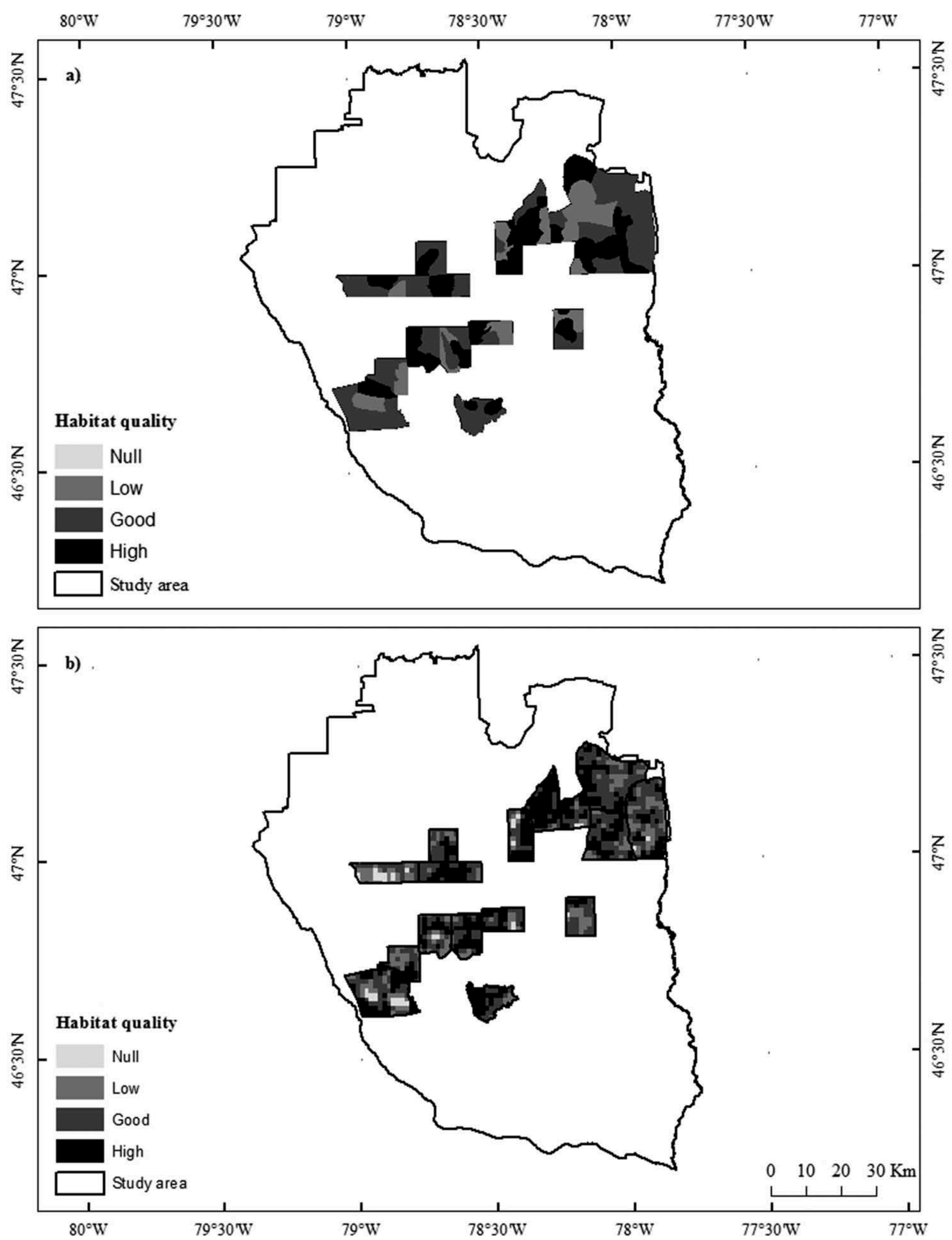

Figure 2. (a) Moose habitat suitability as determined by Algonquin hunters within the 16 family hunting grounds. (b) Moose HSI model calculated for the 16 family hunting grounds.

respectively, whereas cells with null or low habitat suitability accounted for 4% and 19% respectively. Family hunting grounds located in the northern part of the study area had more cells with high habitat suitability (Figure 2b).

The different habitat types varied in abundance within the 16 family hunting grounds (Table 1). The most abundant habitat types offering cover during the summer – Mt50 and Dt50 – covered 38% of the area, also offering high feeding potential. The most abundant habitat types offering cover during the winter – Mi50 and CS30 – were half as abundant (19%) and offered a low feeding potential. A total of 21% of the area that was covered by the 16 family hunting grounds was classified as unproductive or non-forest.

Agreement between TEK and HSI

We found moderate agreement between TEK and HSI (κ = 0.46) using four habitat suitability classes (data not shown). However, Algonquin hunters did not use the null suitability class (Figure 3). Agreement was strong (κ = 0.63) when recalculated using only three suitability classes (high, good, low) by combining values of the null and low classes (Table 2).

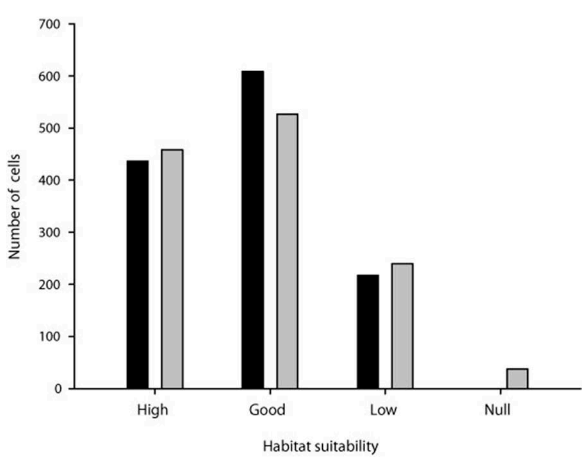

Figure 3. Distribution (number of 5 km^2 cells) of habitat suitability classes according to TEK (black bars) and HSI (grey bars).

Table 2. Contingency table between HSI and TEK for the total area covered by the 16 family hunting grounds, using three suitability categories (high, good, low).

	HSI			
TEK	High	Good	Low	Total
High	335	233	82	650
Good	126	309	82	517
Low	12	37	22	71
Total	473	579	186	1238

Note: observed agreement $Po_{(w)} = 0.74$; expected agreement $Pe_{(w)} = 0.45$; weighted kappa $κ_{(w)} = 0.63$; $Z_2 = 25.98$, $P < 0.001$.

Sources of disagreement between TEK and HSI

Cells for which moose habitat suitability was judged good or high by TEK but low by HSI often coincided with lakes, islands, rivers, unproductive sites or wetlands. The TEK model attributed good or high suitability to deciduous and mixed stands with low density (<40%) and height (<17 m), whereas HSI values for such stands were low. Cells for which suitability was considered lower by TEK than by HSI coincided with areas that were severely disturbed over the last 30 years (clearcut, large-scale windthrow, severe insect outbreak) and mature coniferous stands (height > 22 m and 60–80% density).

Discussion

Agreement between TEK and HSI

Our results are in line with a limited but growing number of studies that have shown agreement between TEK models and animal behaviour or between TEK and HSI models. For example, in the Swiss Alps, Doswald et al. (2007) found that HSI models based on local and expert knowledge were strongly correlated with lynx (*Lynx lynx*) habitat selection. Another study comparing TEK and HSI models based on resource selection functions for caribou habitat in the territory of the Taku River Tlingit First Nation (northern British Columbia, Canada) found strong agreement (κ = 0.65) for summer habitat, but lower agreement (κ = 0.34) for winter habitat (Polfus et al. 2014). In our study of 16 family hunting grounds we found strong agreement (κ = 0.63) between the TEK and HSI models when we used three habitat suitability classes (high, good, low).

According to Algonquin hunters, moose prefer mixed and deciduous stands with abundant regeneration. A similar result was obtained by Germain (2012) from TEK gathered from the Pikogan Algonquin community in boreal mixed and coniferous forests of Quebec. The abundance of mixed (49%) and deciduous stands (17%) in our study area could explain why most Algonquin hunters judged moose habitat suitability to be good or high. Similarly, tolerant hardwood or mixed stands with tolerant hardwoods were also given maximum weight in the HSI model we used (Dussault et al. 2006). Biologists indeed consider mixed stands as the best habitat for moose because they offer abundant food and shelter (Courtois 1993). The similar importance given to mixed and deciduous stands in both the TEK and HSI models probably explains a large part of the high level of agreement. Hunters also mentioned that moose use hilltops to minimize predation risk. Interestingly, in a telemetry study, Leblond et al.

(2010) found that females moved to hilltops during spring in search of suitable calving sites.

Objective comparison of the disagreements between the TEK and HSI models can yield useful insights into both methodological approaches. Sources of disagreement were generally about wetlands, lakes, unproductive areas, mature coniferous stands and regenerating stands. According to Algonquin hunters, moose habitat suitability is good to high around lakes and wetlands, something that was not taken into account in the HSI calculation. Morris (2014) provides a review on preferential use of aquatic and wetland habitats by moose. Cree hunters from Waswanipi (northern Quebec) also mentioned that wetlands were sought after by moose in the boreal coniferous forest, for the ground softness and cool environment they provide (Jacqmain et al. 2008). Algonquin hunters from Pikogan mentioned that moose actively frequent wetlands and lakes in the summer to eat aquatic plants and to avoid heat stress (Germain 2012). Aquatic plants are preferred by moose in summer, as observed in other areas (Morris 2014). Wetlands also allow moose a better view of the surrounding environment (Bowyer et al. 1999), thereby reducing predation risk. The HSI model does not take wetlands and lakes into account, because they are not considered a limiting factor in mixed and coniferous boreal forests (Massé et al. 2013). The situation, however, is different in temperate deciduous forests, especially in southeastern Quebec, where wetlands and lakes are not as abundant (Ménard et al. 2013).

Algonquin hunters mentioned that unproductive areas were frequently used by moose. Although unproductive from an industrial forestry perspective, such areas are often dominated by deciduous shrubs, which are a preferred moose food (Renecker & Schwartz 2007). However, unproductive areas have a low weight in the HSI model.

According to Algonquin hunters, mature coniferous stands are rare in the study area and seldom juxtaposed with deciduous or mixed stands for feeding. Consequently, the habitat suitability of mature coniferous stands was judged low in the study area, where moose prefer mixed and deciduous stands during all seasons. Mature coniferous stands (height > 17 m; density > 40%) had a relatively low weight in the HSI model; although they offer good shelter from sun, snow and predators (Peek et al. 1976), they have low food potential (Dussault et al. 2005). The weight of mature coniferous stands is low in the HSI model, but it is higher than that of unproductive areas, which were shown to be frequented by moose. Hence, reducing the weight of mature coniferous stands could better reflect habitat use in temperate deciduous forests.

Algonquin hunters attributed low suitability to recently disturbed areas. According to them, moose avoid large disturbed areas where they are more vulnerable to predation. Hunters nevertheless acknowledged that small regenerating stands are highly suitable moose habitat as food sources. Algonquin hunters from Pikogan mentioned that clearcuts are generally too large and are thus avoided by wildlife (Germain 2012); a finding also reported by wildlife biologists (Courtois et al. 2002). However, regenerating stands that have experienced a severe disturbance have a high weight in the HSI model regardless of their size, because they offer abundant food.

The high road density within the family hunting grounds has also been criticized by Algonquin hunters, who mentioned that roads increase access to hunting grounds for non-aboriginal hunters, thereby engendering conflict with aboriginal hunters. Roads were also said to facilitate movements of natural moose predators such as wolf and black bear. Similar findings were reported in the wildlife management literature (James & Stuart-Smith 2000; Houle et al. 2010; Laurian et al. 2012) and in a review of the ecological and social impacts of forest roads on First Nations (Kneeshaw et al. 2010). Limiting factors that act on moose density, such as hunting and predation, were thus taken into account by hunters, but are not included in the HSI model (Dussault et al. 2006), which probably explains part of the observed disagreement.

Conclusion

This study adds to a growing body of work demonstrating that traditional and scientific knowledge can be used jointly in wildlife management. While the moose HSI model was developed and validated in boreal mixed and coniferous forests, we have shown that it could be used in temperate deciduous forests because a comparison with the TEK held by Algonquin aboriginal hunters yielded moderate to strong agreement. Modifications could be made to the moose HSI for it to better reflect TEK in temperate deciduous forests, notably by integrating wetland and aquatic habitats, by increasing the weight of unproductive stands and by reducing the weights of mature coniferous stands and regenerating stands. Telemetry studies on actual moose habitat use in temperate deciduous forests would allow specifying the magnitude of the necessary changes to the HSI model.

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Disclosure statement

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