Évaluation de méthodes de suivi de la loutre de rivière (*Lontra canadensis*) et son potentiel en tant qu'indicateur de l'intégrité écologique des habitats riverains

Thèse soumise à la Faculté des sciences de
l'Université de Moncton pour l'obtention
d'une maîtrise ès sciences (biologie)

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Février 2006

Remerciements

Je désire premièrement remercier ma directrice de thèse, Liette Vasseur, ainsi que Céline Bérubé, qui fut co-directrice de thèse. Leurs expertises et conseils furent indispensables à la production de cette recherche. Merci aussi aux autres membres de mon comité aviseur, Stéphan Reebs et Marc-André Villard ainsi qu'à Jacques Nuckle, président du jury de thèse. Je remercie également Jean-François Robitaille, examinateur externe.

Je suis également très redevable à Mathieu Dumond et Éric Tremblay pour avoir initié le développement de ce projet de recherche au Parc national du Canada Kouchibouguac. Ce fut pour moi l'opportunité de travailler sur un projet très motivant.

Je désire remercier Mathieu Dumond et Sébastien Martinez pour la collecte des premières données pendant les hivers de 2000 et 2001 lors d'un projet pilote. Je remercie également Blain Peters, Pierrick Roguet, Greg Daigle, Sylvain Pouzet et Marcel Gallant pour leur aide lors des travaux sur le terrain en 2003 et 2004. Merci également à l'ensemble du personnel du Parc national du Canada Kouchibouguac pour le soutien logistique fourni. Enfin, merci à ma conjointe, Colombe Bouleke pour sa patience, son encouragement et soutien.

Cette étude fut réalisée grâce au soutien financier du Fonds de Fiducie de la Faune du Nouveau-Brunswick, du Parc national du Canada Kouchibouguac, de la Faculté des études supérieures et de la recherche de l'Université de Moncton par le biais de bourses Patrimoine Canada, ainsi qu'à la Chaire K. C. Irving en Développement Durable.

Résumé général

La majorité des travaux de recherche concernant le concept d'espèce indicatrice sont axés sur la sélection d'espèces potentiellement en mesure de refléter certains aspects de l'intégrité des habitats dans lesquels elles évoluent. Pour les espèces perçues comme ayant le potentiel d'être de bonnes espèces indicatrices, il y a un grand besoin de mener des recherches pour justifier leur utilisation dans un tel contexte. L'objectif principal de cette étude était d'évaluer le potentiel de la loutre de rivière (*Lontra canadensis*) en tant qu'espèce indicatrice de l'intégrité écologique des habitats riverains au sein des écosystèmes forestiers. Nous avons étudié l'influence de 12 caractéristiques des habitats riverains, ainsi que neuf catégories de perturbations humaines sur l'incidence et la distribution des signes de présence de cette espèce. J'ai effectué de longs transects riverains pour documenter l'incidence de signes de présence de la loutre en hiver dans le Parc national du Canada Kouchibouguac (46° 50' N, 65° 00' W) et sa région au Nouveau-Brunswick, territoire composé de zones protégées et de régions perturbées. Les caractéristiques des habitats riverains et les perturbations humaines furent documentées à chaque lieu où des signes de présence de loutres furent découverts, de même qu'à des sites indépendamment établis à intervalles de 500 mètres le long des rives de l'aire d'étude pour caractériser l'habitat disponible.

Des signes de présence furent découverts à 266 sites lors de suivis hivernaux effectués en 2003 et 2004. Seulement huit de ces sites étaient situés dans la partie non-protégée de l'aire d'étude. Selon les régressions logistiques effectuées sur les données de suivis, l'incidence de loutres sur le territoire était positivement corrélée avec plusieurs caractéristiques de l'habitat directement ou indirectement liées à la disponibilité de refuges terrestres pour cette espèce (ex. étangs de castor, forêts matures, conifères, sols riches en limon/vase ou matière organique, débris au sol, galeries le long des berges). Dans une moindre mesure, leur incidence était négativement corrélée avec certains types de perturbations humaines (ex. champs, routes pavées, habitations). L'incidence des signes de présence de loutres en hiver est donc associée à plusieurs caractéristiques d'intérêt au niveau de la gestion des habitats riverains au sein des écosystèmes forestiers.

L'incidence de la loutre de rivière sur le territoire en hiver peut donc être utilisée en tant qu'indicateur de certaines caractéristiques des habitats riverains non-perturbés. En élucidant quels facteurs régissent la distribution des signes d'activité de la loutre, les résultats obtenus contribuent à définir le rôle que peut jouer la loutre au sein d'un ensemble complémentaire d'indicateurs pour la gestion d'écosystèmes entiers.

À partir des données de suivis hivernaux de 2003 et 2004, en plus de données recueillies lors d'un projet pilote en 2000 et 2001 dans la même aire d'étude, j'ai également étudié la relation entre le nombre de loutres présentes sur une portion de rivière donnée (i.e., à partir des pistes en hiver) et l'abondance de sites où ces dernières déposent des fèces (i.e., latrines). Cette relation fut étudiée pour déterminer si les suivis populaires de fèces qui opèrent en classifiant des sites échantillonnés comme étant positifs (i.e., détection de l'espèce par la présence de fèces) ou négatifs (i.e., absence de fèces) sont adéquats pour faire le suivi de l'abondance de loutres sur un territoire donné. Cette relation est importante à élucider car c'est l'incidence de sites avec des fèces sur le territoire qui influence directement les probabilités de détecter ou non la présence de loutres aux sites scrutés lors de tels suivis.

Les résultats obtenus indiquent que l'abondance de latrines reflète mal le nombre de loutres présentes le long des cours d'eau échantillonnés. La relation entre le nombre de loutres détectées et l'abondance de latrines était non-linéaire et atteignait un plateau, au-delà duquel plus de loutres n'étaient pas associées à un plus grand nombre de latrines produites. Par ailleurs, le nombre de latrines par portion de rivière échantillonnée ne croissait pas de façon marquée en fonction du temps écoulé depuis la dernière chute de neige. Les loutres tendaient donc à déféquer répétitivement aux mêmes endroits. La distance sur laquelle les groupes de loutres suivis produisaient des signes de présence (i.e., fèces, pistes) ne croissait pas en fonction du temps écoulé depuis la dernière chute de neige. Les loutres tendaient donc à demeurer sur leurs territoires respectifs en hiver. Je discute des conséquences qu'entraîne la relation obtenue (i.e., abondance de loutres, nombre de latrines) quand il s'agit d'utiliser ces suivis de fèces pour effectuer

le suivi des populations de loutres. Bien que ces suivis puissent demeurer utiles pour déterminer la distribution d'une population de loutres, ils risquent de piètrement refléter l'abondance de loutres sur le territoire, de même que les changements au niveau de l'abondance des populations échantillonnées.

Une version particulière des suivis de fèces ou d'autres signes de présence consiste à utiliser les ponts routiers comme sites où effectuer des recherches pour déterminer la présence/absence de loutres à différents endroits d'une région. Grâce aux routes, ces sites sont faciles d'accès et cela permet l'échantillonnage d'un grand nombre de sites rapidement. Cependant, aucune recherche ne fut effectuée pour confirmer que les ponts, en tant que structures anthropiques, influencent la probabilité de détecter la présence des loutres sur les portions de rivières scrutées. À partir des données recueillies lors de suivis par transects riverains, nous avons calculé la proportion des présences connues de loutres qui auraient été détectées si des suivis de différentes longueurs à partir de ponts et de sites aléatoires avaient été effectués, au lieu d'échantillonnages complets des rivières. Mes analyses démontrent que la probabilité de détection est similaire, peu importe si des sites ayant des ponts ou des sites choisis aléatoirement sont utilisés pour effectuer les suivis. Le choix de sites ayant des ponts pour mener de tels suivis n'entraîne donc pas la diminution des chances de détecter la présence de loutres sur les portions de rives scrutées.

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Introduction générale

Le concept d'intégrité écologique est utile pour effectuer la gestion de la faune et la flore à grande échelle, tant spatiale qu'organisationnelle. Plutôt que de cibler certaines espèces ou populations particulières par intérêts politiques ou économiques, elle intègre toutes les composantes d'un écosystème au sein des préoccupations de gestion et de conservation. Tel que reconnu par Westra *et al.* (2000), l'intégrité écologique constitue un concept parapluie englobant une multitude d'autres concepts. Il est alors difficile de définir adroitement ce concept, puisque toutes les composantes liées à l'écosystème d'intérêt sont pertinentes lorsque vient le besoin de déterminer son niveau d'intégrité. Parmi les multiples définitions revues par Woodley (1993), la plus globale et complète d'un point de vue écologique est probablement celle de Karr et Dudley (1981), selon laquelle l'intégrité biologique ou écologique équivaut à la capacité d'un écosystème à maintenir une communauté intégrée, équilibrée et adaptative, de même qu'une composition en espèces et une organisation fonctionnelle comparable aux habitats locaux non-perturbées. Cette définition fut développée davantage (Karr, 1991; Angermeier & Karr, 1994; Karr, 2000), de sorte à considérer une localité comme écologiquement ou biologiquement intègre lorsqu'elle supporte une faune et une flore étant le produit de procédés évolutifs et biogéographiques ayant subis aucune ou peu d'influences d'origine anthropique. Ensemble, cette flore et faune doivent constituer un système équilibré et adaptatif, possédant toute la richesse en terme d'éléments (ex. gênes, espèces, assemblages) et de procédées (ex. mutations, démographies, interactions biologiques, dynamique énergétique, cycles de nutriments, et dynamique des métapopulations) étant attendue d'une région soumise à peu ou aucunes perturbations humaines. C'est cette définition générale à laquelle nous avons adhéré dans le cadre de cette recherche.

En tant qu'outil de gestion appliqué, le concept d'espèce indicatrice est un concept attrayant pour les gestionnaires de la faune et les écologistes. Il s'agit d'un moyen économique d'obtenir des informations indirectes sur l'état général d'un écosystème entier, sans toutefois effectuer le suivi de toutes les composantes potentiellement importantes pour le maintien ou l'amélioration de son intégrité écologique. L'utilisation d'espèces indicatrices devrait s'accroître au cours des prochaines années puisque l'on reconnaît de plus en plus la nécessité d'effectuer la surveillance à plus grande échelle pour mieux gérer les écosystèmes en entier (ex. Karr, 2000; Westra *et al.*, 2000).

Cependant, plusieurs critiques au sujet de ce concept démontrent combien son application de façon correcte et efficace peut être ardue. Puisque chaque espèce est unique et occupe une niche écologique distincte (Mannan *et al.*, 1984; Landres, 1992), il est improbable qu'une espèce quelconque puisse refléter toutes les caractéristiques propres à un écosystème en santé (Hilty & Merenlender, 2000). Il est également irréaliste de s'attendre à ce qu'une espèce puisse refléter l'abondance de toutes les autres espèces d'une communauté (Schroeder, 1987; Niemi *et al.*, 1997; Simberloff, 1998) ou la qualité de l'habitat pour ces autres espèces (Cairns, 1986; Landres *et al.*, 1988). Même si deux espèces ont des attributs similaires au niveau de leur écologie, il est improbable qu'elles réagiront pareillement aux perturbations humaines lorsqu'elles surviennent (Lindenmayer, 1999). Les données de suivi d'une espèce indicatrice particulière peuvent également être biaisées par des facteurs tels que les maladies, les parasites, la compétition intraspécifique, la prédation ou des variations stochastiques dans la population (Steele *et al.*, 1984). Conséquemment, pour gérer un écosystème entier avec succès par le biais d'indicateurs, il est recommandé d'effectuer le suivi d'un ensemble complémentaire d'indicateurs représentant entre autres une multitude de guildes, de niveaux trophiques, de types d'habitat et de perturbations naturelles (Hilty & Merenlender, 2000; Carignan & Villard, 2002).

Pour s'assurer de bien appliquer le concept d'espèce indicatrice, il ne suffit pas proposer des espèces potentielles ou d'identifier les caractéristiques que ces dernières devraient posséder pour être de bons indicateurs (ex. Noss, 1999; Dufrêne & Legendre, 1997; Canterbury *et al.*, 2000; Hilty & Merenlender, 2000; Carignan & Villard, 2002). L'étape suivante du processus de développement de ces outils de gestion que sont les indicateurs demeure largement inachevée. Il s'agit d'évaluer les espèces perçues comme étant de bons indicateurs potentiels afin de valider leur utilisation dans un tel contexte (Lindenmayer, 1999; Noss, 1999).

La loutre de rivière (*Lontra canadensis*) est une espèce d'intérêt à l'application du concept d'espèce indicatrice, étant donné que ses caractéristiques écologiques satisfont plusieurs critères proposés pour sélectionner des indicateurs potentiels. Carignan & Villard (2002) soutiennent que les espèces étroitement liées à certains facteurs de l'habitat peuvent s'avérer des indicateurs utiles puisque celles limitées à certains types d'habitats seraient plus susceptibles de disparaître d'une région suite à des perturbations d'origine anthropique. Les loutres possèdent un certain degré de spécialisation pour leur milieu. Elles sont semi-aquatiques, principalement mais pas strictement piscivores (Knudsen & Hale, 1968; Toweil, 1974; Melquist & Hornocker, 1983) et leurs domaines vitaux sont établis le long des rives des cours d'eau et des lacs (Melquist & Hornocker, 1983; Reid *et al.*, 1994; Sauer *et al.*, 1999). Elles sont donc étroitement liées aux habitats riverains, dont elles occupent le sommet de la chaîne trophique, mais ne sont pas spécialisées au point de ne pas pouvoir représenter la complexité de cet écosystème (Landres *et al.*, 1988). La taille des domaines vitaux chez cette espèce est considérable et peut atteindre plusieurs dizaines de kilomètres carrés (Melquist & Hornocker, 1983; Reid *et al.*, 1994; Bowyer *et al.*, 1995). L'adoption de pratiques de gestion afin d'assurer une disponibilité suffisante d'habitat pour sa persistance peut lui conférer le rôle additionnel d'espèce parapluie (Lambeck, 1997; Noss, 1999). L'espèce est résidente (Reid *et al.*, 1994). Un éventuel suivi ne serait donc pas biaisé par des facteurs externes à l'aire de gestion concernée (Bock & Webb, 1984; Landres *et al.*, 1988; Hilty & Merenlender, 2000).

Une autre caractéristique valorisée est la capacité de quantifier, chez une espèce indicatrice, une réponse rapide face à un changement dans l'environnement (Noss, 1990; Marshall *et al.*, 1993). Cela semble être le cas chez les loutres, car un an après un déversement de pétrole en Alaska, une diminution de diversité dans la diète (Bowyer *et al.*, 1994) et une augmentation de la taille des domaines vitaux fut observée pour les loutres de rivière habitant les rives affectées (Bowyer *et al.*, 1995). Les espèces clés sont reconnues comme pouvant être des indicateurs potentiels (Lambeck, 1997; Noss, 1999) en raison de leur influence disproportionnée sur les processus écologiques des écosystèmes dont elles font partie (Paine, 1995). Bien que la loutre de rivière ne puisse être considérée comme une espèce clé, cette dernière est cependant étroitement associée aux activités des castors (Dubuc *et al.*, 1990; Newman & Griffin, 1994; Reid *et al.*, 1994; Swimley *et al.*, 1998), une espèce clé des habitats riverains (Naiman *et al.*, 1986; Smith *et al.*, 1991; Schlosser & Kallemeyn, 2000; Bailey *et al.*, 2004).

Il est possible pour cette espèce non seulement de mesurer son abondance mais aussi d'autres variables telles que la fécondité ou le taux de survie, ce qui apporte plus d'information que la simple indication d'un changement dans l'habitat de l'espèce (Herricks & Schaeffer 1985). Il est également envisageable de faire le suivi des espèces proies de la loutre en échantillonnant les fèces sur le terrain, lesquelles sont regroupées en latrines facilement repérables (Bowyer *et al.*, 1995; Swimley *et al.*, 1998). Les résultats de plusieurs études suggèrent que les loutres tendent à sélectionner les espèces de poissons en fonction de leur disponibilité (Bowyer *et al.*, 1994; Watt, 1995; Carss *et al.*, 1998). Une caractéristique importante des vertébrés en tant qu'indicateurs est leur sensibilité aux polluants dans l'environnement (Landres *et al.*, 1988; Hilty & Merenlender, 2000). Les effets de certains polluants, comme la contamination par des produits organochlorés et des métaux lourds sont bien connus pour la loutre et furent le sujet de nombreuses études en laboratoire (résumé dans Wren, 1991). La contamination par bio-accumulation chez ce prédateur est également de mieux en mieux connue et plusieurs études évaluent son utilité pour effectuer le suivi de la pollution des cours d'eau (Evans *et al.*, 1998; Mierle *et al.*, 2000; Fortin *et al.*, 2001) et l'effet de polluants sur son écologie pour justifier son utilisation comme bio-indicateur de la qualité de l'eau et/ou de l'habitat (Bowyer *et al.*, 1994, 1995; Taylor *et al.*, 2000; Ben-David *et al.*, 2001). D'autres attributs favorisent la loutre comme espèce indicatrice potentielle. La loutre est une espèce charismatique, ce qui peut faciliter l'obtention et le maintient du support politique et financier pour la gestion/conservation (Lambeck, 1997; Noss, 1999). Tel que le recommande Hilty et Merenlender (2000), la taxonomie de la loutre est claire (van Zyll de Jong, 1987) et son écologie générale est bien connue (i.e., >30 articles publiés). Enfin, il est possible d'effectuer des suivis efficaces car les signes de présence sont faciles à identifier et repérer sur le territoire (i.e., pistes en hiver).

La loutre de rivière est alors une espèce ayant le potentiel d'être un indicateur utile pour effectuer le suivi de l'intégrité écologique des habitats riverains. La loutre de rivière est un mammifère semi-aquatique et ne possède pas les adaptations physiologiques nécessaires pour demeurer indéfiniment dans l'eau (Melquist & Dronkert, 1987). Puisqu'elle construit rarement ses propres refuges terrestres (Johnson & Berkley, 1999), cette espèce a une dépendance quotidienne envers la disponibilité des refuges terrestres le long des rives des cours d'eau. Cette espèce a donc le potentiel d'être étroitement liée à divers aspects terrestres des habitats riverains et pourrait ainsi servir d'espèce indicatrice à cet effet. Beaucoup d'études ont caractérisé les besoins de la loutre de rivière en terme d'habitat (ex. Melquist & Hornocker, 1983; Dubuc *et al.*, 1990; Reid *et al.*, 1994; Swimley *et al.*, 1998). Cependant, ces études furent réalisées sur des territoires très peu ou pas perturbés par les activités humaines. Pour évaluer son potentiel en tant qu'espèce indicatrice, il est nécessaire d'évaluer non seulement à quelles caractéristiques des habitats elle est associée, mais également comment elle réagit lorsque des perturbations humaines entraînent la perte de ces caractéristiques des habitats riverains dont elle pourrait être l'indicateur.

L'objectif du premier chapitre de la thèse fut d'évaluer le potentiel de la loutre de rivière en tant qu'espèce indicatrice de l'intégrité écologique des habitats riverains au sein des écosystèmes forestiers. Nous avons documenté la distribution des signes de présence de la loutre de rivière en hiver. Le gel des rivières en hiver améliore beaucoup l'accessibilité des habitats riverains (i.e., motoneige, raquette) et la neige facilite la détection de la présence des loutres (i.e., pistes facilement identifiables et repérables). Pour évaluer cet indicateur potentiel, nous avons étudié l'influence de diverses caractéristiques des habitats riverains, ainsi que de différents types de perturbations humaines sur l'incidence et la distribution des signes de présence de cette espèce. Le Grand Écosystème de Kouchibouguac, territoire où nous avons mené notre étude, se prêtait bien à l'objectif de recherche, puisqu'il est composé de régions non protégées et donc perturbées par divers types d'activités humaines (ex. habitations, routes, champs agricoles), de même que du Parc national du Canada Kouchibouguac, où les habitats riverains sont très peu perturbés (i.e., un minimum d'infrastructures de transport, de gestion et de tourisme).

Que l'on effectue des suivis de populations de loutres à des fins de conservation ou dans un contexte de surveillance de l'intégrité écologique par le biais d'indicateurs, un défi propre à cette espèce est qu'il est difficile de l'observer directement dans son milieu afin d'en estimer les effectifs. À la source du problème, nous pouvons compter les caractéristiques écologiques de l'espèce, tel le fait qu'elle soit plutôt nocturne ou crépusculaire (Melquist & Hornocker, 1983; Reid *et al.*, 1994) et présente à des densités relativement faibles sur le territoire (Melquist & Hornocker, 1983). Obtenir des données basées sur des observations directes d'individus nécessite beaucoup de ressources et de personnel, en plus d'être exigeant et complexe au niveau de la logistique (Ruiz-Olmo *et al.*, 2001).

Pour contourner ces problèmes, des suivis basés sur des indices de la présence de loutres (ex. principalement les fèces) sont utilisés pour en dériver des indices d'abondance de population. Puisqu'il fut démontré que la variabilité dans le nombre de fèces détectées rend incertain la relation entre l'abondance de fèces déposées sur les rives et le nombre de loutres occupant un territoire donné (Kruuk *et al.*, 1986; Conroy & French, 1987; Kruuk & Conroy, 1987), la majorité des chercheurs s'abstiennent d'utiliser le recensement de fèces comme indice d'abondance. Des sites préalablement choisis sont plutôt scrutés pour constater la présence/absence de signes de la présence de loutres. Des changements temporels dans la proportion de sites ayant des signes de présence sont interprétés comme étant une réflexion des changements dans l'abondance de loutres sur le territoire d'intérêt. Cette méthode a été couramment utilisée sur tous les continents ayant des populations indigènes d'une ou de plusieurs espèces de loutre, notamment en Amérique du Nord (ex. Shackleford & Whitaker, 1997; Bischof, 2003), en Amérique du Sud (ex. Chehébar, 1985; Chehébar *et al.*, 1986), en Europe (ex. Lodé, 1993; Brzeziński *et al.*, 1996), en Afrique (ex. Macdonald & Mason, 1982*a*; 1984) et en Asie (ex. Lee, 1996).

Malgré sa popularité, cette méthode particulière d'effectuer les suivis n'a jamais fait l'objet d'une validation rigoureuse et il y a donc lieu de s'interroger quant à son efficacité. Ce n'est pas directement l'abondance de fèces qui est en cause ici, mais l'abondance de sites ayant des fèces dans la région étudiée en relation avec l'abondance de loutres dans cette région. C'est cet aspect de la distribution des fèces qui influence directement la probabilité de détecter la présence de loutres sur une portion de rive scrutée. Il est envisageable que la relation entre le nombre de sites avec des fèces et le nombre de loutres les ayant produites soit particulièrement complexe, car la déposition de fèces et de sécrétions anales le long des rives joue un rôle dans la communication intraspécifique chez les loutres (Rostain *et al.*, 2004; Ben-David *et al.*, 2005) et ces fèces tendent à être concentrées dans des sites appelés latrines (Swimley *et al.*, 1998). L'objectif du deuxième volet d'étude fut donc de déterminer quel type de relation existe entre l'abondance de loutres sur une portion de rivière donnée et le nombre de sites où elles déposent des fèces, pour ensuite interpréter les conséquences que cela entraîne au niveau de la précision de cette méthode de suivi.

En raison des contraintes logistiques, une version particulière de cette méthode d'échantillonnage consiste à choisir les sites en fonction de leur facilité d'accès, c'est-à-dire en utilisant les ponts routiers comme sites d'échantillonnage (ex. Clark *et al.*, 1987; Shackelford & Whitaker, 1997; Bischof, 2003). Outre le fait que cela implique une sélection non-aléatoire d'emplacements géographiques, les ponts, en tant que perturbations anthropiques, pourraient avoir un effet néfaste sur l'utilisation de l'habitat par les loutres. La capacité de détecter la présence de loutres sur un cours d'eau pourrait donc être réduite lorsque de tels sites sont utilisés pour des suivis. L'objectif du troisième chapitre fut de déterminer si ces suivis à partir des ponts ont la même probabilité de détecter la présence de loutres que les suivis effectués à partir de sites sélectionnés de façon aléatoire.

CONTRIBUTION RELATIVE AU CHAPITRE 1

Le projet de recherche fut conçu par Mathieu Dumond et Éric Tremblay du Parc national du Canada Kouchibouguac. J'ai effectué la revue de littérature et participé à la collecte des données lors des suivis de la loutre de rivière en hiver. J'ai effectué la collecte de données pour caractériser l'habitat en été. J'ai effectué toutes les analyses statistiques et rédigé l'article au complet, sous la supervision de ma directrice de thèse, Liette Vasseur.

Evaluation of river otter distribution as an indicator of ecological integrity for riparian habitats in forest ecosystems

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Abstract

Most research on indicator species is still aimed at selecting potential species that could eventually be used as tools in conservation and management of ecosystems. A pressing need is to ensure the proper implementation of indicator tools in management and conservation programs by assessing the potential of proposed indicators to either disprove their perceived potential, or validate their use in specific contexts. Our goal was to evaluate the potential of using the distribution of river otter (*Lontra canadensis*) activity signs as an indicator tool of ecological integrity for riparian habitats in forest-type ecosystems at the regional scale. We studied how their activity signs were distributed along riverbanks in relation to twelve habitat factors and nine categories of anthropogenic disturbances within the protected areas of Kouchibouguac National Park, the Black River Provincially Protected Zone of New Brunswick, and surrounding unprotected areas in eastern New Brunswick, Canada. We collected data using long-range winter riparian transects. Habitat and anthropogenic factors were documented at each site found with activity signs, as well as at habitat sampling stations established at 500 m intervals along riverbanks. Activity signs were found in all sampled rivers. Of 266 locations found with activity signs during four winter surveys of the study area in 2003 and 2004, only eight were found in the unprotected zone, which had a higher incidence of anthropogenic disturbances (60.7 % of 295 habitat stations) than the protected areas (14.7 % of 271 habitat stations). Logistic regression analyses revealed that activity signs were positively correlated with many habitat factors (i.e., beaver ponds, mature forests, conifers, silt or organic matter dominated soil, river width, ground debris, overhanging vegetation, undercut riverbanks) and to a lower degree, negatively correlated with several types of anthropogenic disturbances (i.e., fields, paved roads, buildings). Overall, our results show that the distribution of their activity signs is linked to several riparian habitat characteristics that are of interest from a management standpoint, and that the local distribution of this species could be a useful tool as part of a complementary set of indicators.

1. Introduction

Conservation biologists and park managers have long been preoccupied with the definition of ecological integrity (Westra *et al.*, 2000) and how it can be measured and monitored (Loucks, 2000; Ulanowicz, 2000). The most complete and encompassing definition of this concept from an ecological standpoint is most likely the one developed by Karr (Karr, 1981; Karr, 1991; Angermeier & Karr, 1994; Karr, 2000). A location is considered to have biological or ecological integrity when it supports a flora and fauna that is the product of bio-geographical and evolutionary processes with little or no human influence. Such flora and fauna must constitute a balanced system with a full complement of components (e.g., genes, species, populations, assemblages) and processes (e.g., mutations, demographics, biological interactions, nutrient cycling, meta-population dynamics) expected from a region in an undisturbed state. This concept is useful to managers because it incorporates all components of a functional ecosystem into monitoring, management and conservation preoccupations.

Population monitoring has long been an integral part of management practices when particular species are targeted, but some managers and academics have been pushing for larger-scale ecosystem monitoring as a way to more effectively manage whole ecosystems (Karr, 2000; Westra *et al.*, 2000). Pursuing several monitoring programs, however, can be expensive and some environmental and ecosystem factors can be too difficult or costly to monitor directly. To avoid these issues, indicator species have been proposed as a way to obtain information on components of ecosystems and their level of ecological integrity (e.g., Noss, 1990; Noss, 1999; Dufrêne & Legendre, 1997; Canterbury *et al*., 2000; Hilty & Merenlender, 2000). They are an attractive and cost-effective approach to management of protected areas. The increasing number of critical reviews on the indicator species concept now allows managers to select potential indicators that can be used to monitor ecosystem components of interest based on objective criteria (reviewed in Carignan & Villard, 2002).

One limitation of the indicator species concept stems from the fact that each species occupies a distinct ecological niche (Mannan *et al*., 1984; Landres, 1992) and may not be representative of an entire ecosystem. Due to this uniqueness in habitat attributes required by each species, it is now recognized that assemblages of complementary indicator species need to be monitored to adequately assess the state of an ecosystem's integrity or overall health (Hilty & Merenlender, 2000; Carignan & Villard, 2002). The success of such assemblages of indicators depends not only on what characteristics of an ecosystem we choose to pay attention to, but also on reliable knowledge of the key factors that affect the selected indicators. Factors to which a potential indicator species responds are ultimately what that species can indicate and this will define its role within a complementary assemblage of indicators. Another major need is, thus, to evaluate potential indicator species to validate their use in specific habitats or ecosystems (Lindenmayer, 1999; Noss, 1999) and confirm the potential bestowed upon them through various selection schemes.

River otters (*Lontra canadensis*) are often viewed as a potential indicator species (e.g., Hilty and Merenlender 2000) because they satisfy many requirements outlined in literature related to indicator species theory (Table 1). They may be one of the indigenous top-level predators indicating several aspects of the health of riparian habitats in forest-type ecosystems. Their decline or change in distribution may be related to a loss in ecological integrity. As emphasized by Melquist and Dronkert (1987), for river otters, two important habitat characteristics need to be present along rivers and streams, access to prey and shelter. As top-level predators of freshwater ecosystems, river otters are resourceful and prey upon a wide diversity of mostly aquatic vertebrates

(Greer, 1955; Bowyer *et al.*, 1994). As a consequence, their distribution or abundance is less affected by fluctuations of a particular prey species in comparison to more specialized predators such as lynx, *Lynx canadensis* (O'Donoghue *et al.*, 1997). Their occurrence in a region would be ultimately restricted by dependence on availability of adequate terrestrial shelter.

River otters are semi-aquatic, do not possess the physiological adaptations to stay indefinitely in water (Melquist & Dronkert, 1987) and thus depend daily on terrestrial shelters. River otters rarely create their own burrows (Johnson & Berkley, 1999) and rely on pre-existing refuges such as natural formations (Melquist & Hornocker, 1983), burrows dug by other species (Melquist & Hornocker, 1983), mature forests and conifers that offer good cover along riverbanks (Newman & Griffin, 1994; Bowyer *et al.*, 1995; Swimley *et al.*, 1998), as well as beaver (*Castor canadensis*) ponds, lodges and burrows (Melquist & Hornocker, 1983; Dubuc *et al.*, 1990; Newman & Griffin, 1994; Reid *et al.*, 1994; Swimley *et al.*, 1998). River otter activity has also been associated with steep banks (Reid *et al.*, 1994; Swimley *et al.*, 1998) and soils of silt or organic matter (Reid *et al.*, 1994). Reid *et al.* (1994) hypothesized that steep banks facilitate the creation of short underwater burrows that possess air-filled chambers over the water level, whereas soils of silt or organic matter, which are easier to burrow into, would tend to contain more burrows than regions where banks are composed of rocks, boulders, gravel, or sand. Several of these characteristics are generally attributes of healthy, undisturbed forest stands having reached latter succession stages in terms of their development. Beavers not only create shelter opportunities for otters but also mediate forest development along watercourses. Their selective terrestrial foraging (Gallant *et al.*, 2004) increases the importance of tree species associated with late-seral forest, such as conifers (Donkor & Fryxell, 1999; 2000).

Because most studies on otter habitat selection have been conducted in regions with low (e.g., Melquist & Hornocker, 1983; Dubuc *et al.*, 1990; Reid *et al.*, 1994; Swimley *et al.*, 1998) or high (e.g., Bowyer *et al.*, 1994; 1995) levels of anthropogenic disturbances, it is not well known how river otter distribution and habitat use on a regional scale is affected by varied anthropogenic disturbances that can alter riparian habitats. We also need to understand the influence of protected areas adjacent to zones with anthropogenic disturbances on the ecology of species (e.g., Dumond *et al.*, 2001). This is especially important for protected areas of small size that suffer adverse external effects because of habitat fragmentation and the presence of human populations near their borders (Gurd & Nudds, 1999; Parks & Harcourt, 2002). For potential vertebrate indicators in particular, scrutiny of 100 such species (i.e., including river otter) by Hilty and Merenlender (2000) revealed that data correlating them with ecosystem changes are lacking for most of them.

The objective of our study was to evaluate the potential of using the winter distribution of river otter activity signs as an indicator of ecological integrity for riparian habitats in forest ecosystems. Using activity signs as a measure of winter distribution and habitat use, our specific objectives were to determine 1) what habitat characteristics influence the distribution of river otters along riparian habitats and 2) how anthropogenic disturbances influence river otter occurrence on the landscape. If the distribution of river otter activity signs (e.g., tracks, faeces) can indicate particular aspects of the ecological integrity of riparian habitats in forest ecosystems, we hypothesized that 1) they would be positively correlated with locations that possess habitat characteristics offering shelter opportunities along riverbanks, and 2) negatively correlated with anthropogenic disturbances, especially if they are associated with loss of habitat characteristics offering shelter. If river otter activity signs, as an indicator tool, are indeed correlated with ecosystem changes associated with anthropogenic activities (Hilty & Merenlender, 2000), we hypothesized that 3) activity signs in the unprotected zone of our study area would be less abundant than in the protected portion, which contains more intact riparian habitats.

2. Methods

2.1. Study area

The study area comprised Kouchibouguac National Park of Canada (KNPC) and its vicinity (Fig. 1). The Park covers an area of 238.8 km^2, is part of New Brunswick's lowlands and is representative of the Maritime Coastal Plains (Desloge, 1980). The topography is rather flat and contains eight major watercourses with numerous bogs and swamps: Portage River, Carrigan Brook, Fontaine River, Black River, Rankin Brook, Kouchibouguac River, Major Brook and Kouchibouguacis River (Desloges, 1980). Except for Portage River, all other watercourses empty into a lagoon and dune system (Fig. 1). The two main rivers, Kouchibouguac and Kouchibouguacis (Fig. 1), are both tidal. The climate is humid continental with important maritime influences near the shore (Graillon *et al.*, 2000). Average annual temperature is 4.8˚C, average freeze-free period is 177 days and annual precipitation averages 979 mm (Desloges, 1980). The majority of forested areas are mixed, dominated by balsam fir (*Abies balsamea* (L.) P. Mill.) and birch (*Betula* spp.), or coniferous with mostly black spruce (*Picea mariana* (P. Mill.) D.S.P., Graillon *et al.*, 2000). Speckled alder (*Alnus rugosa* (Du Roi) Spreng.) dominates the banks of smaller streams in the area. The study area also included the 39.46 km^2 Black River Provincially Protected Zone of New Brunswick (BRPPZNB, Fig. 1). The rest of the study area consisted of unprotected zones reaching further inland along the Portage, Kouchibouguac, Kouchibouguacis, and St-Charles rivers (Fig. 1). The unprotected portion of the study area is at various stages of succession, with low-density residential areas, agricultural lands, and regions of undisturbed forested riverbanks. Snowmobile traffic is prominent on the Kouchibouguacis River both in protected and unprotected zones, while all other rivers have little or no snowmobile traffic. In the unprotected portion of our study area, otter-trapping effort was very low and occasional. One person trapped otters in the region adjacent to our study area in 2002 only, and one of the otters caught was located at the limit of our study area on the St-Charles River. Otter trapping was not known to occur in or near our study area in 2003 and 2004.

2.2. Sampling protocol

We documented river otter activity signs from early January until the end of April 2003 and 2004 by conducting transects along the shores of the six main rivers of the study area (Fig. 1), as well as tributary streams associated with them. Detection of fresh activity signs is higher in winter because of the conspicuous, corridor-like tracks each animal leaves in the snow. All other activity signs are also more easily detectable because they can be found along these tracks. The homogeneous substrate left by recurrent snowfalls in winter also safeguards against possible biases linked to differential detection rates that can occur on the landscape in other seasons (Conroy & French, 1987; Romanowski *et al.*, 1996).

We conducted transects after a minimum of 12 h after each appreciable snowfall (i.e., >2 cm), thereby leaving time for otters to manifest their presence and produce activity signs on the fresh snow. We used light snowmobiles (Bombardier's Tundra models) when river width and ice thickness made it possible and snowshoes otherwise. We searched shores as two riders on separate machines, riding single file at slow speed (i.e., 5-10 km/h) along one shore after the other on the given river, and stopping at will to inspect and document all potential river otter activity signs found (i.e., snow tracks, faeces, burrows, water access holes, and direct sightings). We sampled rivers after each snowfall in random order and alternated the order for ensuing snowfalls. We maintained sampling effort up to five or six days after each snowfall and waited for another snowfall before continuing the survey. Otherwise, during extended periods between snowfalls, locations with resident otters would become saturated with activity signs and the locations designated to take geographical coordinates of otter activity would become arbitrary.

We conducted continuous transects, meaning that regardless of means of transport, one or two days were invested in scrutinizing the chosen river (i.e., full length of respective rivers within the study area). This maximized our ability to document river otter habitat use along the shores of the major watersheds in the study area. We sampled the study area (Fig. 1) with riparian transects three times over during the winter of 2003. This amounted to 769 km of riverbank inspections for otter activity signs. During the winter of 2004, we sampled the same area one time, with 239 km of riverbank inspections. We were able to conduct more transects in 2003 because snow precipitations were frequent and ice conditions were good for a longer period than in 2004. The sampled area represented approximately 131 km of riverbanks in the protected areas of KNPC and BRPPZNB, and 146 km in the unprotected areas, both shores of the six main rivers considered (Fig. 1).

We recorded coordinates (UTM, Grid #20, in meters, recorded with a Garmin12 XL Geographic Positioning System), date and time for the beginning and end of each transect, as well as for all sites with otter activity signs found. At each otter activity site, we documented the types of activity signs found and a variety of habitat factors known from the literature to be relevant to river otter ecology (Table 2, see references cited in introduction). We also recorded anthropogenic activities present at otter activity sites when they were within 100 m of given sites (Table 2). We documented studied habitat and anthropogenic factors as binary or categorical-ordinal variables by verifying and estimating them on location. In order to study what otters selected in the study area as a function of what was available to them and to assess habitat differences between protected and unprotected zones, we also quantified the same variables described in Table 2 at independently established sites that we called habitat stations. We determined their position in advance on topographical maps, at 500 m intervals along both shores of rivers and streams sampled during the winter surveys. The total number of habitat stations documented amounted to 251 in KNPC, 20 in BRPPZNB, and 295 in the unprotected portion of the study area. Habitat characteristics were documented within a 20-m radius at each habitat station.

For logistical reasons, habitat and anthropogenic factors that could not be measured during winter surveys were completed during the summers of 2003 and 2004 for all habitat stations and locations with activity signs. Data on anthropogenic features were crosschecked with topographic maps and aerial photographs. We did not consider hiking trails as anthropogenic disturbances, since they were discrete and infrequently used. Abandoned fields were not considered as current disturbances when categorizing sites as having or lacking anthropogenic disturbances because they have been left untouched since the creation of the Park in 1969. They have patchily reverted to forests or bush-dominated parcels.

2.3. Data analysis

In order to interpret the relationships between the factors we measured on the landscape, we constructed a correlation matrix (e.g., Durbin, 1998) for the 21 factors considered in the current study using SPSS (version 8.0 for Windows). The matrix was hybrid because the test used to conduct a particular correlation varied according to the type of data (i.e., binary, ordinal) in a given pair of factors analyzed. Yule's coefficient of association (Q) was used in the matrix when the two factors in a correlation test were binary variables. When at least one of two factors considered in a correlation test consisted of an ordinal variable, Pearson correlations were used in the matrix. Yule's coefficient of association and Pearson correlations may range from –1.0 to 1.0, depending on the degree and direction of the association between two factors considered. However, when a pair of factors tested consists of a binary and an ordinal variable, Pearson's correlations can only range from –0.9 to 0.9. We considered correlation levels of 0.5 or larger to represent strong relationships between factors.

From the sites with river otter activity signs and the habitat stations, we created a single binary response variable, where the sites with activity sign were coded as "1" and the habitat stations as "0". Since our data consisted of a mix of binary and ordinal explanatory variables and a binary response variable, we used stepwise logistic regression procedures in SPSS to retain the habitat and anthropogenic factors that better explained the variability in occurrence of river otter activity signs. The four sweeps of the study area we accomplished in search of sites with activity signs constitute replication of samples, not replication of treatment (Hurlbert, 1984). We thus considered each survey as a distinct mensurative experiment and analyzed the four datasets separately. Within each dataset, two separate regressions were conducted. The first was for testing the effect of habitat features and the second, for that of anthropogenic features. We experimented with all available entry modes of variables in SPSS (i.e., forward conditional, LR, Wald and backward conditional, LR, Wald). Results were very similar for all entry modes and model-data fit only varied slightly (<1 %). We selected the backward Wald entry mode for presentation of results because it included fewer variables of marginal importance in final models having the best model-data fit.

3. Results

3.1. Habitat differences in protected versus unprotected areas

As expected, anthropogenic disturbances in the unprotected portion of the study area (present at 60.7 % of 295 habitat stations) were more abundant than in the protected zones of KNPC and BRPPZNB (present at 14.7 % of 271 habitat stations, Fig. 2). The majority of these disturbances in the unprotected zone consisted of fields (FIELD, 33.9 %), houses and other buildings (BLDNG, 29.5 %), and paved roads (PROAD, 20.3 %, Fig. 2). Within the protected areas, the few occurrences of anthropogenic disturbances mostly consisted of paved roads (8.5 %), dirt roads and ski/cycling trails (DROAD, 8.1 %), as well as abandoned fields (OFIELD, 7.7 %, Fig. 2). In the unprotected zone (9.2 %) and in protected areas (3.7 %), additional disturbances (OTHER factor) included a few small floating wharves, two small commercial fishing wharves, small fixed fishing nets and cabins used in winter, large electricity lines crossing rivers, parking lots, active cemeteries and gravel pits. We excluded from further analyses the two rarest anthropogenic variables recorded in our study area. For the 566 habitat stations sampled, logging (LOGNG) and highways (HIWAY) were only present at 11 and 3 of them respectively (Fig.2). Dirt roads were positively correlated with abandoned fields, camps, cottages or camping grounds (CAMPS), and the other anthropogenic disturbances grouped under the OTHER factor (Table 3). Paved roads were positively correlated with fields, houses and other buildings, as well as the OTHER disturbances (Table 3). Houses and other buildings were also positively correlated with the OTHER disturbances (Table 3).

Riverbanks in the protected areas had more forests (DOMVG, Fig. 3a), dense underwood (UDENS, Fig. 3d), organic matter or silt-dominated soils (SOIL, Fig. 3j), ground debris (DEBRIS, Fig. 3k) and beaver ponds (BPOND, Fig. 3l) than the unprotected area. River characteristics were also different since more tributary streams

(TRIBUT, Fig. 3g) and wider river stretches (RIWTH, Fig. 3f) were in the protected areas. On the other hand, the unprotected zone tended to have more sites with overhanging vegetation (OVEG, Fig. 3e) and banks with steeper slopes (SLOPE, Fig. 3h). Succession stage of vegetation (SUCST, Fig. 3b), canopy closure (CANOP, Fig. 3c), and undercut banks (UDCUT, Fig. 3i) were very similar for protected and unprotected zones. Dominant vegetation was positively correlated with canopy closure, vegetation succession stage, and underwood density (Table 3). Vegetation succession stage was positively correlated with underwood density (Table 3). Beaver ponds in our study area were situated away from houses and other buildings, as well as fields but to a lesser degree (Table 3).

3.2. Distribution of activity signs in relation to habitat and anthropogenic features

Overall, river otter occurrences responded first and foremost to habitat features. When both types of factors were commonly included in backward regressions, anthropogenic features tended to be completely left out of retained variables. The percentages of model-data fit for logistic regressions applied to anthropogenic factors were only slightly lower than those applied to habitat factors (Table 4). However, using both types of factors generally did not improve model-data fit over regressions applied to habitat factors alone (Table 4).

River otter activity signs were consistently associated with beaver ponds (see Wald’s statistic, regressions 1, 3, 5 and 7; Table 5). Other consistent relationships retained by backward logistic regressions included activity signs positively correlated with soils dominated by silt or organic matter and with ground debris along riverbanks (regressions 3, 5 and 7; Table 5). Activity signs were also positively correlated with river width (regressions 3 and 5), overhanging vegetation (regressions 3 and 7), undercut banks (regressions 5 and 7) and latter succession stages of vegetation such as mature forests (regressions 1 and 5, Table 5). On single instances, activity signs were also positively correlated with higher dominant vegetation categories such as forests (regression 7) and tributary streams (regression 1) and negatively correlated with the slope of riverbanks (regression 7, Table 5).

For anthropogenic factors, activity signs were mostly negatively correlated with active fields (regressions 2, 4 and 8; Table 5). Paved roads (regression 4), buildings (regressions 6 and 8) and the rarer disturbances grouped under the OTHER factor (regression 8) were retained in some regressions but their influence was marginal (see respective Wald's statistic and degree of statistical significance, Table 5). Otters did not avoid abandoned fields, which have a regular presence along riverbanks in the park, because activity signs tended to be positively correlated with them (regressions 2 and 4, Table 5).

3.3. Occurrence of activity signs in protected and unprotected areas

In total for the four surveys, 266 locations with river otter activity signs were recorded (Fig. 4a). When considering similar lengths of riverbanks searched inside and outside the protected areas of KNPC and BRPPZNB during these surveys (Fig. 4b), the abundance of sites with activity signs differed drastically between protected and unprotected zones, with the great majority of these (n = 258) detected within the protected areas (Fig. 4a). River otter activity signs were found all along the six major river systems sampled in KNPC, including along the north shore of St-Charles River, which constitutes the southern border of the park (Fig. 1). Activity signs were also found along Black River in the BRPPZNB (Fig. 1). Only eight activity signs were found in four locations of the unprotected zone (Fig. 4a). They were located along Portage River, which is undisturbed, and in a relatively undisturbed region of the Kouchibouguac River, 7.9 km from the nearest border of KNPC (Fig. 1). They were also found in proximity to the park on MacKay's Brook, which empties into Black River.

4. Discussion

Our results suggest that river otters meet the requirements for validation and proper use of potential indicator species. Consistent relationships (Niemi *et al.*, 1997; Noss, 1999) with habitat characteristics of interest from a management standpoint (Landres *et al.*, 1988) were observed. Winter river otter activity signs were positively correlated with several characteristics of riparian habitats and most of them were directly or indirectly associated with terrestrial shelter opportunities. Many of these characteristics have the potential to be representative of certain aspects of the ecological integrity of riparian habitats in forest-type ecosystems (e.g., cover offered by mature forests or conifers, structures created by beavers, ground debris, organic matter in soil). Of course, this is contingent upon the particular ecosystem or landscape that is the object of interest and the attributes we would expect to observe if it were in an undisturbed state. Some regions for instance, typically have soils with low organic matter content and this habitat feature will not be an issue in such cases.

In accordance with literature on river otter ecology, signs of winter activity were positively correlated with the presence of soils with a dominance of silt and organic matter (Reid *et al.*, 1994), ground debris such as fallen trees or logs (Swimley *et al.*, 1998), overhanging vegetation and latter forest succession stages as well as good conifer vegetation cover along river banks (Newman & Griffin, 1994; Bowyer *et al.*, 1995; Swimley *et al.*, 1998). Our study also showed that otters were associated with sites having vertical, undercut banks (Reid *et al.*, 1994; Swimley *et al.*, 1998). As in many other studies (e.g., Melquist & Hornocker, 1983; Dubuc *et al.*, 1990; Newman & Griffin, 1994; Reid *et al.*, 1994; Swimley *et al.*, 1998), our results showed that river otter activity signs are consistently (but not exclusively) associated with beavers, a key species having important and diverse influences on the structure and function of aquatic habitats in forested regions (e.g., Naiman *et al.*, 1986; Smith *et al.*, 1991; Bailey *et al.*, 2004) and a mediator of early forest succession along banks of watercourses (Donkor & Fryxell, 1999; 2000). Lodges and bank dens in beaver ponds increase shelter availability, while beaver ponds may contain large amounts of fish that otters can prey upon (Schlosser &

Kallemeyn, 2000), while other ponds may favor lentic species of fishes or large predatory fishes (Snodgrass & Meffe, 1998); both of which are potentially easier to capture. Activity signs were associated with wider portions of rivers, which are found in the park and constitute productive estuarine systems likely to contain more potential preys. Still, activity signs were readily found in upstream, narrow stretches of the Portage, Fontaine, and Black rivers that are also protected.

According to our results, habitat characteristics along riverbanks were more important than anthropogenic disturbances in describing the distribution of river otter activity signs. Similarly, Barbosa *et al*. (2001) studied Eurasian otters in Spain and determined that environmental (i.e., habitat) factors had a greater influence on otter presence than anthropogenic factors. This is not to say that anthropogenic disturbances did not have a great effect on river otters in our study, quite to the contrary. Most otter activity sites were found in the protected areas (Fig. 4a), which were much less disturbed than the unprotected part of our study area (Fig. 2), that contained buildings and maintained fields that otters apparently avoided. However, it appears that it is not the very presence of a given anthropogenic structure or activity that affects distribution of river otter activity signs the most, but the changes that certain anthropogenic activities and structures may bring to riparian ecosystems (Fig. 3), which translate into the loss of particular habitat features and thus, loss of those constituents of ecological integrity for riparian habitats.

The practical implication of this is that river otter occurrence acts primarily as an indicator of features attesting to certain aspects of the health and integrity of riparian habitats, rather than as a negative indicator of the presence of certain anthropogenic activities. It is not completely incompatible with the presence of human activities and will respond to the damage or changes they bring to riparian habitats rather than to their mere presence in an area. This is a valuable characteristic for indicators of ecological integrity. Similarly, Melquist and Hornocker (1983) observed that river otters preferred sites with low human activities, but would occupy more perturbed sites as long as food and shelter were available. From these observations, Prenda *et al*. (2001) proposed that the importance of the impact of anthropogenic disturbances on otters is conditioned by the availability of shelter. This concept might explain why others, such as Macdonald and Mason (1982*a*), found Eurasian otter activity signs abundant in locations with considerable levels of anthropogenic disturbance, while Mech (2003) found signs of river otter activity in an urbanized area.

River otters avoided anthropogenic disturbances that can cause substantial loss of vegetative cover along riverbanks such as fields, camps, cottages and camping grounds, as well as houses and other buildings, in favour of undisturbed sites having among other things, overhanging vegetation and late succession stages of vegetation such as mature forests. Lodé (1993) studied a highly fragmented population of Eurasian otters that was in decline in France in 1991 and found that otters persisted better in regions with good continuous vegetation cover along riverbanks. Similar to other studies (Dubuc *et al*., 1990; Durbin, 1998), the occurrence of river otter activity signs in our study was not adversely influenced by roads. On average, paved roads (42.08 ± 3.98 m) when present were farther from riverbanks compared to fields (29.03 ± 3.23 m) for instance, and did not constitute the most important agent of habitat alteration close to riverbanks in our study. River otters appeared to primarily react to habitat attributes and disturbances that are in proximity to watercourses. River otters did not avoid the abandoned fields in the park. Contrary to the maintained fields in the unprotected part of our study area, these fields are not maintained in any way and most have patchily reverted to a bushy or forested state and provide more cover than maintained fields. Logging sites near rivers in our study area were too rare to evaluate their effect on occurrence of river otter activity signs. It is expected that when present along riverbanks, logging areas will have effects similar to what we observed with buildings and fields because all these activities result in loss of shelter opportunities associated to forested riverbanks (e.g., tree cavities, ground debris, vegetative cover, burrows and other structures created by other animals). Bowyer *et al*. (1995) observed that commercially logged regions in their study area were devoid of otter latrines.

It is important to recognize that the winter distribution of activity signs for this species might not always indicate consistent patterns of changes in riparian habitat characteristics and anthropogenic disturbances on the landscape. Otters have variable and complex intra-specific social interactions, about which reliable knowledge is only emerging (e.g., Blundell *et al.*, 2002; Rostain *et al.*, 2004; Ben-David *et al.*, 2005). Their sociability is bound to influence their distribution within an area under study. Individual otters or groups establish overlapping home ranges that are at least partly maintained through mutual avoidance (Melquist & Hornocker, 1983; Ben-David *et al.*, 2005). The young are weaned at around 14 weeks (Shannon, 1991) but in areas where suitable habitat is already saturated with otters, it is possible that they will stay within the home ranges of their mother, who will continue to provide them solid food until they are 37 to 38 weeks old (Shannon, 1991). Some will dispense to less suitable habitat, and weaken habitat selection contrasts. Furthermore, analyses of habitat use data from radio-telemetry studies give variable results from one animal to another and one age group to another (Reid *et al.*, 1994; Durbin, 1998). Our results were quite consistent among the four surveys but some variability in distribution of activity signs was manifested, as can be seen from variations in the relative importance of particular factors from one survey period to the next (see Wald's statistics, Table 5). The complexity of their social behavior, although not thoroughly discussed here, can be expected to cause variability in their use of habitat and as a consequence, add variability in the distribution of their activity signs.

In this study, we focused on the effect of a variety of factors other than that of water quality, the latter being a popular topic for river otter research in a management or conservation context (e.g., Mierle *et al.*, 2000; Taylor *et al.*, 2000; Ben-David *et al.*, 2001). In regions where water pollution is an issue, river otters might be absent even if banks of rivers or streams appear undisturbed and suitable. Although this was not an issue in our study area, managers should consider water quality when monitoring the distribution of river otter activity signs. Moreover, our study was conducted in a productive estuarine region where accessibility to prey is unlikely to be an issue. It appears that river otters are so resourceful as predators, that they can still be able to find prey after ecological disasters that diminish prey diversity and abundance (Bowyer *et al.*, 1994). It is difficult to measure prey availability to a specific predator but like water quality, this factor should always be considered when interpreting the distribution of river otter activity signs in the context of an indicator.

Our study accounts for many factors affecting river otter occurrence in riparian habitats. It also demonstrates what the winter distribution of river otter activity signs, as an indicator tool, can potentially indicate along watercourses in a landscape with occurring anthropogenic disturbances in forest-type ecosystems. It is commonly accepted that no single indicator species can be expected to estimate all relevant characteristics of healthy ecosystems (Hilty & Merenlender, 2000), or the abundance of all other species in a community (Schroeder, 1987; Niemi *et al.*, 1997; Simberloff, 1998) and habitat quality for them (Cairns, 1986; Landres *et al.*, 1988). Also, sources of bias such as diseases, parasites, intraspecific competition, predation and stochastic variations in the population can beset the monitoring of single indicator species (Steele et al. 1984). In the management of ecosystems, it is generally recommended that complementary assemblages of indicators representing different guilds, trophic levels, habitat types, and natural perturbations be monitored (Hilty & Merenlender, 2000; Carignan & Villard, 2002). Our study helped define the place that river otters, as an indicator species, can have within a complementary assemblage of indicators.

Table 1: Summary of 12 characteristics associated with river otters that are also valued in indicator species theory and management activities.

Characteristic	Literature	
	River otter	Indicator species theory
Closely associated with particular habitat characteristics (e.g., riparian habitats) but not overly specialized	1	2, 3
Non-migratory species, year-round resident	4, 5	6, 2, 7
Rapid response to changes in the environment	8, 9	10, 11
Keystone species or close association with such species (e.g., beaver)	12, 13, 5, 14	15, 16
Possibility to measure variables other than abundance (e.g., fecundity, weight, survival rate, diet)	17, 18	19
Popular interest for charismatic species	n/a	15, 16
Unambiguous taxonomic status	20	7
Availability of cost-effective survey methods (e.g., tracks and sign surveys)	21, 22	n/a
Species ecology and distribution disrupted by water pollution	8, 9, 23	2, 7
Blood samples, biopsy, or autopsy can be used to monitor water pollution levels	24, 25, 26	2, 7
Use as an umbrella species	4, 5, 9	15, 16
Well documented ecology	1	7

[1] *Sensu* Larivière & Walton, 1998; [2] Landres *et al.*, 1988; [3] Carignan & Villard, 2002; [4] Melquist & Hornocker, 1983; [5] Reid *et al.*, 1994; [6] Bock & Webb, 1984; [7] Hilty & Merenlender, 2000; [8] Bowyer *et al.*, 1994; [9] Bowyer *et al.*, 1995; [10] Noss, 1990; [11] Marshall *et al.*, 1993; [12] Dubuc *et al.*, 1990; [13] Newman & Griffin, 1994; [14] Swimley *et al.*, 1998; [15] Lambeck, 1997; [16] Noss, 1999; [17] Tabor & Wight, 1977; [18] Pitt *et al.*, 2003; [19] Herricks & Schaeffer, 1985; [20] van Zyll de Jong, 1987; [21] Reid *et al.*, 1987; [22] Shackelford & Whitaker, 1997; [23] Ben-David *et al.*, 2001; [24] Evans *et al.*, 1998; [25] Mierle *et al.*, 2000; [26] Fortin *et al.*, 2001

Table 2: Variables quantified at all 566 habitat stations and 266 sites with otter activity signs detected during winter riparian transect surveys conducted in 2003 and 2004 in Kouchibouguac National Park and surrounding areas.

Factor abbreviation	Factor description and value ranges	Variable type
DOMVG	Dominant vegetation at site; bare soil (1), grass (2), shrubs (3), deciduous forest (4), mixed forest (5), coniferous forest (6)	ordinal
SUCST	Successional stage of dominant vegetation; non-existent (0), young (1), intermediate (2), or mature (3)	ordinal
CANOP*	Canopy closure at site; 0 to 25% (1), 25 to 50% (2), 50 to 75% (3), or 75 to 100% (4)	ordinal
UDENS	Understory density at site; absent (1), sparse (2), or dense (3)	ordinal
OVEG	Overhanging vegetation at site; none (1), scarce (2), abundant (3)	ordinal
RIWTH	River width at site; 0 to 1 m (1), 1 to 5 m (2), 5 to 10 m (3), 10 to 25 m (4), 25 to 50 m (5), 50 to 100 m (6), or >100m (7)	ordinal
TRIBUT	Tributary streams in the vicinity; presence (1), absence (0)	binary
SLOPE	Slope of the bank at site; 0° (0), weak 10° (1), considerable 45° (2), steep 75° (3), or abrupt 90° (4)	ordinal
UDCUT	Undercut bank at site; presence (1), absence (0)	binary
SOIL	Type of soil at site; rocks/gravel/sand (1), silt/organic matter (2), or mixed (1,5)	ordinal
DEBRIS	Ground debris at site; absent (1), rare (2), abundant (3), or very abundant (4)	ordinal
BPOND	Beaver pond in the vicinity; presence (1), absence (0)	binary
LOGNG	Logging within 100 m of site; presence (1), absence (0)	binary
FIELD	Fields within 100 m of site; presence (1), absence (0)	binary
OFIELD	Abandoned fields within 100 m of site; presence (1), absence (0)	binary
CAMPS	Camps, cottages or camping grounds within 100 m of site; presence (1), absence (0)	binary
BLDNG	Houses and other buildings within 100 m of site; presence (1), absence (0)	binary
DROAD	Dirt road within 100 m of site; presence (1), absence (0)	binary
PROAD	Paved road within 100 m of site; presence (1), absence (0)	binary
HIWAY	Highway within 100 m of site; presence (1), absence (0)	binary
OTHER	Other uncategorized anthropogenic disturbances within 100 m of site; presence (1), absence (0)	binary

* Because this is a winter study, the canopy closure estimations were based on conifers only.

Table 3: Hybrid* correlation matrix for habitat and anthropogenic factors documented at all 566 habitat survey stations sampled in Kouchibouguac National Park and surrounding areas.

	SUCST	CANOP	UDENS	OVEG	RIWTH	TRIBUT	SLOPE	UDCUT	SOIL
DOMVG	0.628	0.579	0.553	0.195	-0.186	-0.044	0.291	0.111	0.179
SUCST		0.384	0.533	0.317	-0.321	-0.061	0.256	0.141	0.119
CANOP			0.448	0.089	0.000	0.020	0.135	0.058	0.213
UDENS				0.189	-0.202	-0.039	0.154	0.117	0.155
OVEG					-0.454	-0.124	0.266	0.208	0.107
RIWTH						0.313	-0.170	-0.116	0.049
TRIBUT							-0.068	-0.082	0.106
SLOPE								0.463	0.071
UDCUT									0.257

Table 3: Continued.

	DEBRIS	BPOND	FIELD	OFIELD	CAMPS	BLDNG	DROAD	PROAD	OTHER
DOMVG	0.490	0.081	-0.229	0.017	0.043	-0.268	0.014	-0.192	-0.104
SUCST	0.406	0.080	-0.120	0.022	0.064	-0.167	0.000	-0.172	-0.068
CANOP	0.344	0.072	-0.098	-0.013	0.098	-0.132	0.010	-0.053	-0.086
UDENS	0.385	0.071	-0.191	-0.056	0.017	-0.318	-0.074	-0.209	-0.142
OVEG	0.243	0.089	0.000	-0.013	0.013	-0.116	-0.041	-0.118	-0.056
RIWTH	-0.101	-0.148	0.024	0.156	0.008	0.208	0.085	0.202	0.092
TRIBUT	0.022	0.262	-0.100	0.215	-0.143	0.186	0.260	0.135	0.201
SLOPE	0.230	-0.015	0.064	0.034	0.032	-0.065	0.072	-0.084	-0.006
UDCUT	0.059	-0.135	0.044	-0.016	-0.368	-0.427	-0.557	-0.393	-0.365
SOIL	0.244	0.101	-0.105	0.015	-0.061	-0.157	-0.084	-0.127	-0.122
DEBRIS		0.077	-0.146	-0.044	0.030	-0.243	-0.049	-0.095	-0.117
BPOND			-0.477	0.392	0.200	-0.768	0.017	-0.371	-1.000
FIELD				-0.636	0.268	0.867	0.013	0.650	0.407
OFIELD					0.321	-1.000	0.734	0.423	0.211
CAMPS						0.168	0.690	-0.051	0.243
BLDNG							0.391	0.855	0.804
DROAD								0.380	0.543
PROAD									0.685

*Yule's coefficient of association (Q) is presented for cases when the relationship assessment implicated two binary variables. In cases when one or both of the variables compared were ordinal (i.e., categories), Pearson correlations were calculated.

Table 4: Percentages of model-data fit for backward stepwise logistic regressions applied to the four surveys of the study area testing the influence of habitat and anthropogenic factors on the occurrence of river otter activity signs along riverbanks of Kouchibouguac National Park and surrounding areas.

	Survey 1	Survey 2	Survey 3	Survey 4
Factors in regression	*n* = 20 + 396*	*n* = 47 + 499	*n* = 94 + 553	*n* = 105 + 453
Habitat	95.19	93.77	85.94	84.23
Anthropogenic	95.19	91.39	85.47	81.18
All	94.71	93.59	85.47	85.84

* *n* = sites with activity signs + habitat stations.

Note: Exclusion of factors in respective regressions is based on the probability of Wald's statistic.

Table 5: Results of eight separate backward stepwise logistic regressions for habitat and anthropogenic features within the four surveys of the study area testing their influence on the occurrence of river otter activity signs along riverbanks of Kouchibouguac National Park and surrounding area.

Survey number and period	Logistic regression	Factor	*b*	SE	Wald's statistic	Statistical significance	*n*
1. 15/01/03 - 29/01/03	1. Habitat	BPOND	1.77	0.56	10.12	0.002	416
		SUCST	1.06	0.53	4.03	0.045	
		TRIBUT	0.89	0.50	3.16	0.075	
		Constant	-6.47	1.54	17.61	0.000	
	2. Anthropogenic	OFIELD	1.87	0.54	11.90	0.001	416
		FIELD	-7.23	17.33	0.17	0.677	
		Constant	-3.02	0.27	122.08	0.000	
2. 30/01/03 - 02/03/03	3. Habitat	BPOND	2.79	0.40	49.82	0.000	546
		SOIL	1.45	0.48	9.13	0.003	
		RIWTH	0.35	0.14	5.90	0.015	
		OVEG	0.55	0.26	4.35	0.037	
		DEBRIS	0.43	0.21	3.94	0.047	
		Constant	-9.22	1.33	47.91	0.000	
	4. Anthropogenic	OFIELD	1.37	0.48	8.15	0.004	546
		FIELD	-2.14	1.02	4.38	0.036	
		PROAD	-1.25	0.75	2.80	0.095	
		Constant	-2.19	0.17	165.33	0.000	
3. 27/02/03 - 11/04/03	5. Habitat	BPOND	1.88	0.32	33.79	0.000	647
		RIWTH	0.34	0.08	20.25	0.000	
		SOIL	0.77	0.29	6.85	0.009	
		SUCST	0.51	0.20	6.30	0.012	
		DEBRIS	0.33	0.16	4.12	0.042	
		UDCUT	0.50	0.26	3.70	0.054	
		Constant	-7.32	0.83	77.13	0.000	
	6. Anthropogenic	FIELD	-1.75	0.74	5.68	0.017	647
		BLDNG	-2.23	1.03	4.70	0.030	
		Constant	-1.52	0.12	174.35	0.000	
4. 10/02/04 - 23/03/04	7. Habitat	DEBRIS	0.75	0.16	20.76	0.000	558
		BPOND	1.51	0.36	17.64	0.000	
		OVEG	0.59	0.17	11.96	0.001	
		DOMVG	0.49	0.15	10.46	0.001	
		SOIL	0.80	0.32	6.11	0.013	
		UDCUT	0.78	0.33	5.57	0.018	
		SLOPE	-0.22	0.11	3.96	0.047	
		Constant	-7.88	0.94	70.78	0.000	
	8. Anthropogenic	FIELD	-2.72	1.02	7.16	0.008	558
		BLDNG	-7.69	15.85	0.24	0.628	
		OTHER	-7.75	23.86	0.11	0.745	
		Constant	-1.09	0.11	91.65	0.000	

Note: Chi-square analyses for all eight regression models were statistically significant ($p < 0.0001$, df = 1). Exclusion of factors in respective regressions is based on the probability of Wald’s statistic.

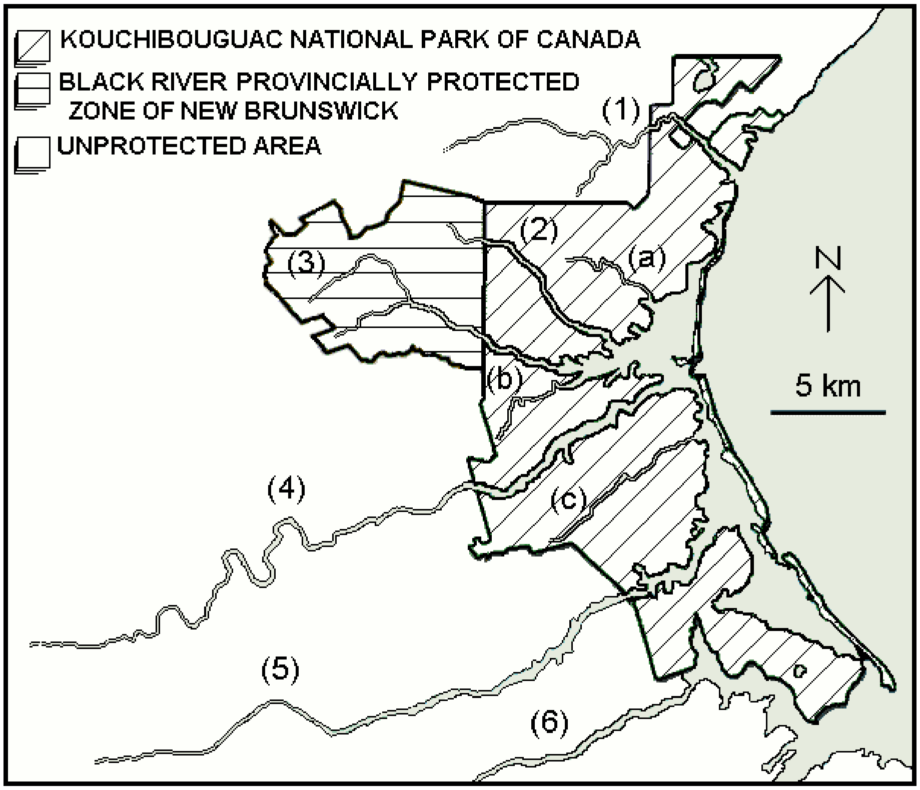

Fig. 1: Extent of the study area in New Brunswick Canada, which comprises Kouchibouguac National Park of Canada, the Black River Provincially Protected Zone of New Brunswick and unprotected areas in the vicinity. Rivers sampled were (1) Portage, (2) Fontaine, (3) Black, (4) Kouchibouguac, (5) Kouchibouguacis, and (6) St-Charles. Other watercourses not sampled in 2003 and 2004 were (a) Carrigan Brook, (b) Rankin Brook and (c) Major Brook.

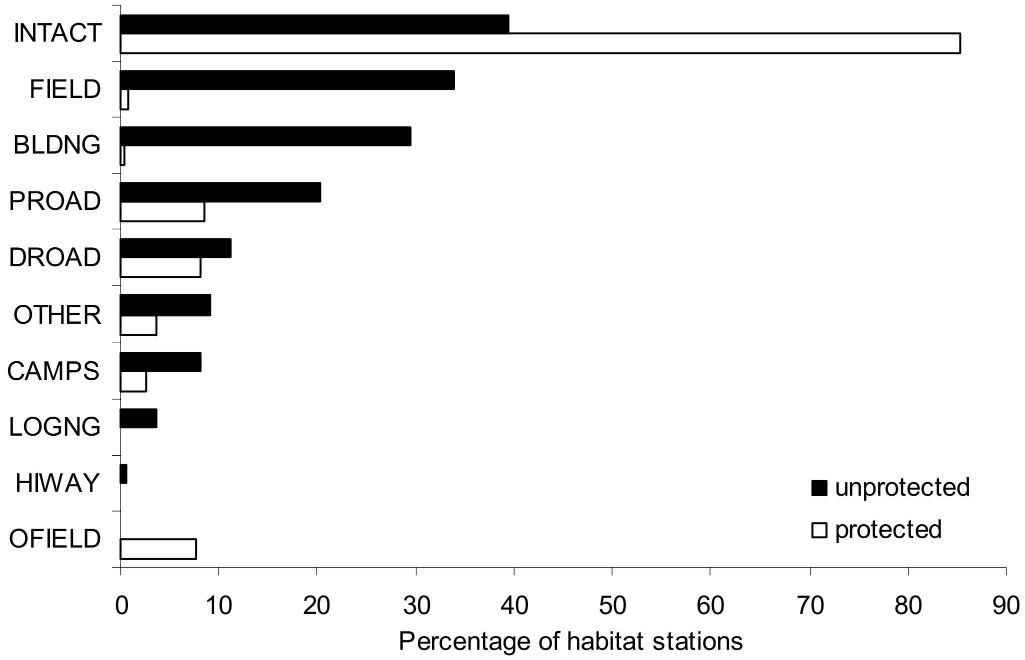

Fig. 2: Frequency of occurrence (%) of anthropogenic attributes at 271 habitat stations sampled in the protected areas of Kouchibouguac National Park of Canada and the Black River Provincially Protected Zone of New Brunswick and at 295 habitat stations sampled in the unprotected vicinity.

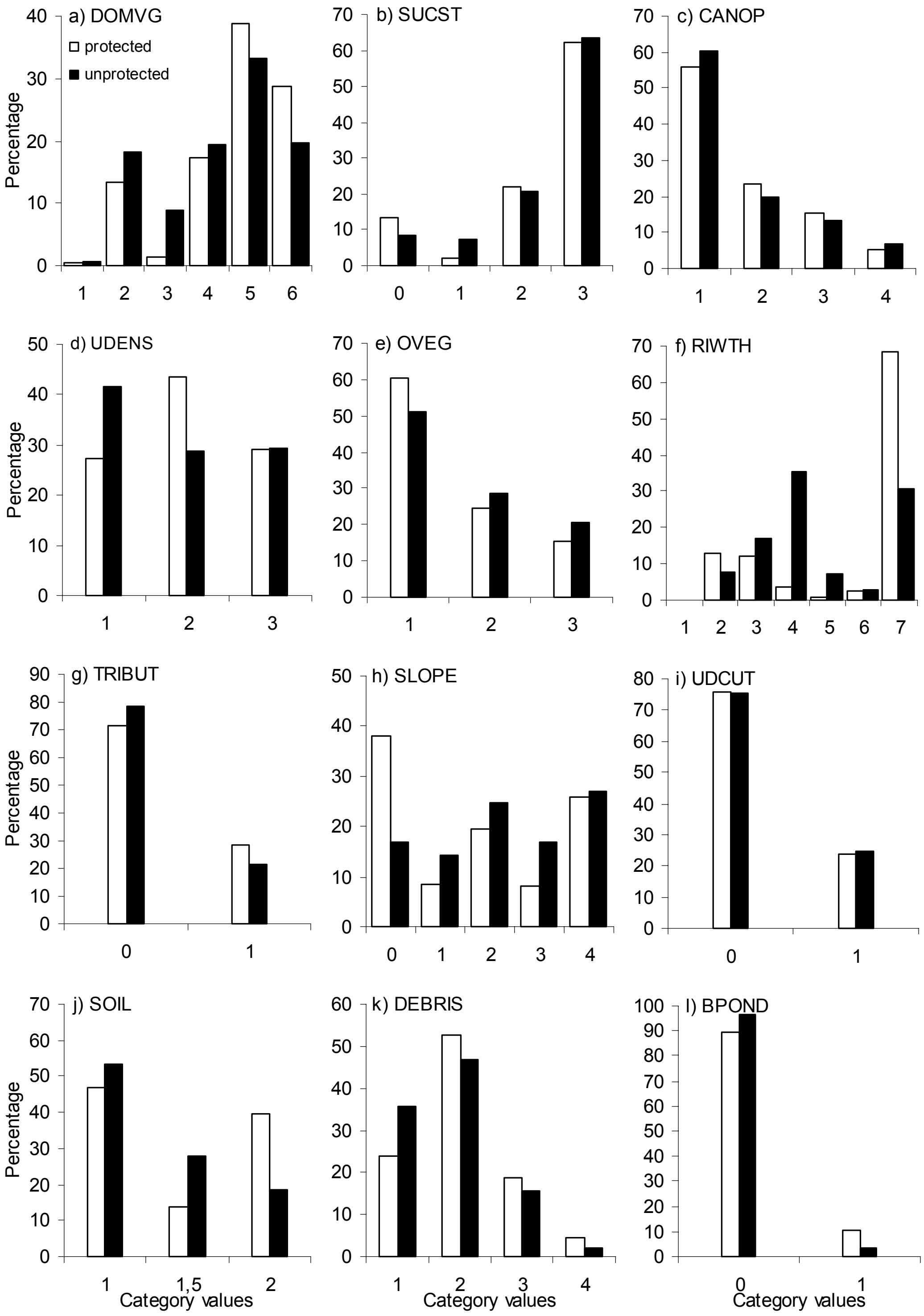

Fig. 3: Distribution of categorical habitat values expressed as percentages of 271 habitat stations sampled in the protected areas of Kouchibouguac National Park of Canada and the Black River Provincially Protected Zone of New Brunswick and 295 habitat stations sampled in the unprotected vicinity.

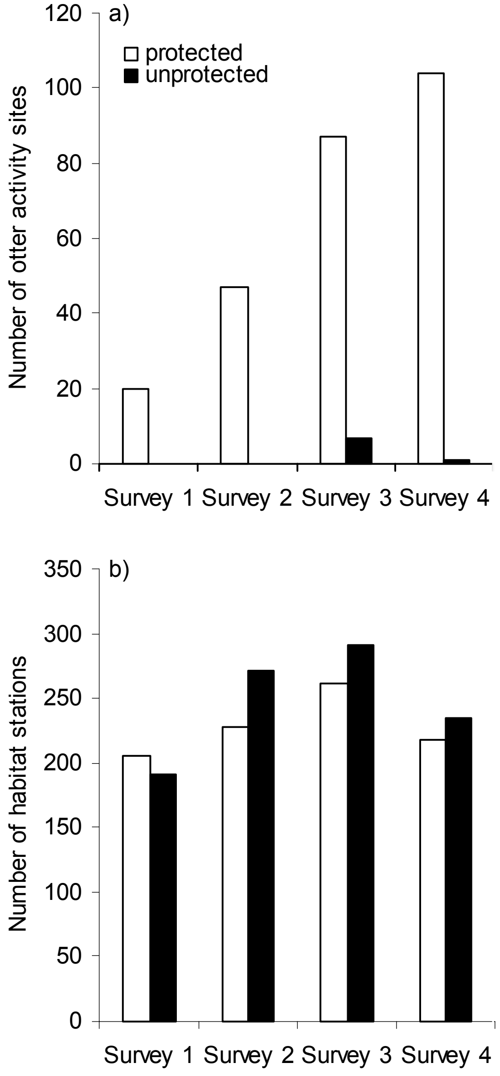

Fig. 4: Number of sites with (a) river otter activity signs and (b) number of habitat stations spanning the riverbanks searched for four surveys conducted in the study area that consists of Kouchibouguac National Park of Canada, the Black River Provincially Protected Zone of New Brunswick, and the unprotected surrounding area. Survey periods are 15/01/03 - 29/01/03 for survey 1, 30/01/03 - 02/03/03 for survey 2, 27/02/03 - 11/04/03 for survey 3, and 10/02/04 - 23/03/04 for survey 4.

CONTRIBUTION RELATIVE AU CHAPITRE 2

J’ai eu l’idée d’entreprendre cette recherche. J’ai participé à la collecte des données lors des suivis hivernaux de la loutre de rivière. J’ai effectué toutes les analyses statistiques et rédigé l’article au complet, sous la supervision de ma directrice de thèse, Liette Vasseur et ma co-directrice, Céline Bérubé.

Unveiling the limitations of scat surveys to monitor social species:
A case study on river otters

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Sous presse dans *Journal of Wildlife Management*. Accepté le 6 février 2006

Abstract

The relationship between the production of sites with faeces (i.e., latrines) and river otter (*Lontra canadensis*) abundance was examined to determine whether scat surveys were adequate for monitoring relative population size for species leaving activity signs in a clumped distribution on the landscape. We conducted winter riparian transects to simultaneously monitor otter abundance via snow tracks and latrine sites along the rivers of Kouchibouguac National Park and surrounding area in New Brunswick, Canada. Our data showed that latrine abundance poorly reflected otter abundance for given stretches of rivers because the relationship was non-linear and reached a plateau. The number of latrine sites was not related to the time period since last snowfall, which indicated that otters repetitively defecated at the same sites. Individual otters and groups did not produce activity signs over larger distances as a function of time, which indicated that they tended to stay in their home ranges in winter. We discuss why scat survey protocols based on determining presence/absence of a species at predetermined search sites may poorly reflect population size, as well as population fluctuations in time. Caution is advised when interpreting data from such surveys for species for which faeces or other activity signs surveyed play a role in intraspecific communication and tend to be in a clumped distribution on the landscape.

1. Introduction

The use of scat surveys to study habitat selection by animal species or to determine the relative size of populations is common practice. These types of surveys are popular because they are inexpensive to conduct and constitute non-invasive methods for studying animal activity. Scat surveys often proved useful when studying species that are hard to detect because of their elusive behavior (e.g., Sharp *et al*., 2001), their rarity (e.g., Lozano *et al*., 2003) or the type of habitat where they occur (e.g., Lunney *et al*., 1998). Some scat surveys are known to produce results that are similar to other techniques used for monitoring population size. Eggert *et al*. (2003) found similar results between their multilocus genotyping of DNA extracted from faecal material and faecal enumerations for the forest elephant (*Loxodonta cyclotis*) population of Kakum National Park in Ghana. Sharp *et al*. (2001) also found correlated results with red fox (*Vulpes vulpes*) when counting faeces along a bait line perpendicular to transects of a nocturnal survey. However, the extent to which various types of scat surveys can be expected to reflect population trends is uncertain for a wide diversity of species.

It is difficult to observe freshwater otter species (e.g., *Lutra* spp., *Lontra* spp.) in nature, so scat surveys are often used to monitor their relative abundance and distribution. Many surveys were conducted on the Eurasian otter (*Lutra lutra*) in Europe and North Africa in the 1980s, while the species was in sharp decline (*sensu* Mason & Macdonald, 1987). Then followed a discord between studies favouring the use of scat surveys to monitor population size (Macdonald & Mason, 1987; Mason & Macdonald, 1987) and those expressing reserve or opposition to them (Kruuk *et al*., 1986; Conroy & French, 1987; Kruuk & Conroy, 1987). Some of these studies had difficulty finding correlations between otter abundance and faecal counts (Kruuk *et al*., 1986; Conroy & French, 1987). Several studies from that region and time period had shown that faecal counts could vary greatly within (Jenkins & Burrows, 1980) and among seasons (Macdonald & Mason, 1987; Conroy & French, 1987). They also varied according to coastline or bank characteristics (Bas *et al*., 1984; Conroy & French, 1987) and possibly several other factors (Kruuk & Conroy, 1987). In Scotland for instance, from November

1977 to March 1978, sustained snow tracking by Jenkins (1980) indicated no changes in otter numbers but monthly faecal counts during that winter period fluctuated wildly from 10 to 240 faeces detected (Jenkins & Burrows, 1980). Conroy and French (1987) found faecal counts at defecation sites to be extremely variable, reaching ± 200 % in some cases. For a seemingly unchanged population in terms of otter abundance, they also detected twice as many faeces in one winter compared with the following one (Conroy & French, 1987).

High variability in faecal counts rendered unreasonable the enumeration of individual faeces as a direct index of otter abundance. There are scat survey methods that avoid using faecal counts directly. Some researchers determine the presence or absence of otter activity at selected sites where standardized lengths of shores are searched for activity signs, chiefly faeces. The distribution and proportion of sites with otter detection are then used to show population distribution and relative population abundance over the geographical area of interest. This type of survey protocol based on presence/absence data became popular and has been used in almost every country of Europe and northern Africa to survey the Eurasian otter (e.g., Macdonald & Mason, 1983*a*, 1984; Prigioni *et al.*, 1986; Lodé, 1993). Subsequently, it was also used on other continents hosting freshwater otter species (e.g., Chehébar, 1985; Lee, 1996; Shackelford & Whitaker, 1997).

The results of such scat surveys, for which search sites are classified as having or lacking a particular species' presence, are directly influenced by the occurrence of locations where activity faeces are to be found. They are not influenced by the total number of faeces in a surveyed area, but by the number of locations with faeces in that area because this is what directly influences the odds of detecting otter activity at search sites. Otters tend to repeatedly defecate at particular sites called latrines (Macdonald & Mason, 1987; Swimley *et al.*, 1998). They are representative of species that leave activity signs in a clumped distribution on the landscape. Contrary to the number of faeces, virtually no research effort has been made to establish what is the relationship between the number of otters detected within a sampled region and the number of sites with faeces (i.e., latrines) they produce. For wildlife management, this relationship is important to study because these presence/absence scat surveys currently rely on the untested presumption that more otters in a surveyed area will translate into more search sites turning out positive (i.e., otter detection).

The objective of this study was to investigate and ascertain what kind of relationship exists between the numbers of North American river otters (*Lontra canadensis*, formerly *Lutra canadensis*) detected on given portions of rivers and the number of latrine sites (i.e., sites with faeces) they produced in a measured period of time. We then discuss the consequences this relationship has for presence/absence scat surveys. The logistic advantage of conducting winter riparian transects was used to simultaneously record otter abundance via snow tracks and the number of latrine sites associated with those tracks.

2. Study area

The study area comprised of Kouchibouguac National Park of Canada, and surrounding area (Fig. 1). The park covers an area of 238.8 km^2, is part of the province of New Brunswick's lowlands and is representative of the Maritime Coastal Plains (Desloge, 1980). The topography is rather flat and contains eight major watercourses with numerous bogs and swamps: Portage River, Carrigan Brook, Fontaine River, Black River, Rankin Brook, Kouchibouguac River, Major Brook and Kouchibouguacis River (Desloges, 1980). The two main rivers, Kouchibouguac and Kouchibouguacis, have tidal components that reach beyond the park's border. The climate is humid continental with important maritime influences near the shore (Graillon *et al.*, 2000). Average annual temperature is 4.8˚C, average freeze-free period is 177 days and annual precipitation averages 979 mm (Desloges, 1980). The majority of forested areas are mixed, dominated by balsam fir (*Abies balsamea*) and birch (*Betula* spp.), or coniferous and dominated by black spruce (*Picea mariana*, Graillon *et al.*, 2000). Speckled alder (*Alnus rugosa*) dominates the shores of smaller streams in the area. The study area also extended outside the park along the Portage, Kouchibouguac, Kouchibouguacis and St-Charles rivers

(Fig. 1). Also included was the portion of Black River outside the park, located in the adjacent Black River Provincially Protected Zone of New Brunswick (Fig. 1). Areas outside the park and the protected zone were at various stages of succession, with light residential areas, pasture and agricultural fields.

Watercourses in our study area usually completely freeze over during winter. However, spots of unfrozen or thin ice regularly occur at the junction of tributary streams and rivers, as well as at locations with springs along riverbanks. Further inland, shallower waters make it so that some spots also remain unfrozen or with thin ice because of occasional boulders having water cascading over them. River otters appeared to be able to access water anywhere in our study area because of the regular occurrence of such spots.

3. Methods

To monitor the movement of individual otters or groups, we conducted wintertime transects along the shores of the nine main rivers and streams of the study area (Fig. 1), as well as minor streams associated to them. In winter, detection rates are high because of the conspicuous tracks they leave in the snow, and all other activity signs will be linked to these tracks. The homogeneous substrate created by snowfalls also safeguards against biases in detection rates that can occur during other seasons because of the heterogeneous substrate of riverbanks (Conroy & French, 1987; Romanowski *et al.*, 1996). We documented all river otter activity signs detected within these transects: snow tracks, faeces, burrows, water access holes, and direct sightings. We collected data from early January until the end of April for the winters of 2000, 2001, 2003 and 2004. River otters are usually nocturnal or crepuscular, but can tend to be more diurnal in winter (Melquist & Hornocker, 1983). Before conducting the first transect after a snowfall, we respected a minimum waiting period of 12 h after each snowfall to ensure enough time for the otters to manifest their presence and produce activity signs on the fresh snow. We conducted transect searches with light snowmobiles (Bombardier’s Tundra models) when river width and ice thickness made it possible and by using snowshoes otherwise. Shores were searched by two riders on separate machines, riding single file at slow speed along one shore after the other on the given river, and stopping at will to inspect all potential otter signs detected. We sampled rivers after each snowfall in random order and modified the order for ensuing snowfalls. Transects were continuous, meaning that regardless of means of transport, a whole day or two was invested in scrutinizing the chosen river, hence maximizing our ability to document river otter movements along the shores of the major watersheds in the study area.

We recorded coordinates (UTM, Grid #20, in meters, recorded with a Garmin12 XL Geographic Positioning System), date and time for the beginning and end of each transect, as well as for all encountered signs of otter activity. We calculated time (hour) elapsed since last snowfall each time we began a new transect, as well as for every otter activity sign we detected. We counted latrines for each transect and also included lone scats in these counts because what we aimed to quantify is the production of sites with faeces by otters, regardless of the number of faeces at each site. From here onwards, latrine is defined as a site with at least one faece. We determined the number of otters active within each transect by inspecting the easily recognizable corridor-like tracks they leave in snow. Because river otter home ranges tend to be unidimensionally established along shores at the water-land interface (Bowyer *et al.*, 1995; Sauer *et al.*, 1999), it was possible for us to follow particular groups of otters from several hundred meters to over a kilometer along sampled rivers. This provided enough opportunities to establish the number of animals in groups and in transects with good confidence, by counting fresh tracks consistently oriented in the same direction and by comparing their width relative to each other.

3.1. Data analysis

To control for variability caused by how far otters travelled and how much time they had to produce activity signs, we divided the latrine counts within each transect by both the flight distance (straight line measurement of distance in kilometers) over which otters produced activity signs within each transect and the time (days) elapsed since the last snow fall at the beginning of each transect. Thus the dependent variable analysed was the number of latrines per km per day (latrines.km^{-1}.day^{-1}). For the number of sites with faeces (i.e., latrines) to adequately reflect otter abundance, the statistically ideal relationship between the two would be a linear one and most preferably for management purposes, a 1:1 relationship (Elzinga *et al*., 2001). To determine what is the relationship between production of latrine sites and otter abundance groups (i.e., one, two, three, four, five, and six otters), we favoured a descriptive approach and employed regression analysis to elucidate tendencies in our data. We used the regression curve estimation program in SPSS (version 8.0 for Windows) to determine the polynomial model that best described the data, based on the coefficient of determination (r^2) and the mean of squared residuals for regression curves obtained. To prevent loss of information with regard to the dependent variable, we used the individual value obtained in each transect for regression analyses and not a calculated mean for each otter abundance group (Freund, 1971). Because the absence of otter detections for a sampled stretch of river will inevitably be associated with absence of snow tracks and scats, regression models without constants (intercepts) were applied.

We also assessed the relationship between latrine abundance and the time since last snowfall. The dependent variable used was the number of latrines per km per otter (latrines.km^{-1}.otter^{-1}) and this controlled for variability in otter movement and abundance among the riparian transects. We again used the regression curve estimation program in SPSS to determine the polynomial model (without intercept) that best described this relationship. To determine if the flight distance travelled by river otters grew in relation to the time elapsed from the last snowfall to the time of documentation when conducting transects, we conducted linear regressions on the values of flight distances (km) of activity signs in relation to the time elapsed (days) since last snowfall for transects within each otter abundance group. Here, we did not force the regression model to pass through the origin because it would have biased the results by automatically producing statistically significant positive slopes.

4. Results

A total of 92 transects were conducted during the four winters of surveys, totalling 1,557 km of shoreline inspections. Seven of these transects were discarded from the database as outliers (conducted in May) and three others were not considered because it was impossible to estimate otter numbers from track counts, leaving 82 transects for analyses. Sampling effort varied according to year depending on the incidences of snowfalls, with 168, 381, 769 and 239 km of shoreline searches for the winters of 2000, 2001, 2003 and 2004 respectively. The highest sampling effort was in 2003, when regular snowfalls and thick ice allowed for frequent, long distance transects. Average transect length with standard error was 6.18 ± 0.63 km and varied as a function of means of transport, ease of progress along shoreline trajectories, and the number of times researchers stopped and documented otter activity signs. The mean flight distance over which individual otters or groups produced detectable signs was 1.69 ± 0.20 km, with 4.9 % of transects having otters that could be followed for more than 5 km along a given river. The number of otters detected per transect via snow tracks was quite evenly distributed among the abundance groups. No otters were detected in 17 transects, one otter in 16 transects, two otters in 14 transects, three otters in 14 transects, four otters in 18 transects and six otters in three transects. A total of 16 transects contained river otter tracks but no detectable faeces associated with them: nine of these transects had one otter, six had two otters and one had three otters detected (Fig. 2). No otters were detected in the developed areas along the Kouchibouguac, Kouchibouguacis and St.-Charles rivers, so otter activity was mostly confined to relatively undisturbed habitats, meaning the portions of rivers within Kouchibouguac National Park of Canada, the Black River Provincially Protected Zone of New Brunswick, and along the Portage River outside the park, which is free from anthropogenic disturbances. Because our data represent otters using mostly undisturbed riverbanks, it is unlikely that anthropogenic disturbances had any considerable influence on our results.

Our regression results (Table 1) showed that the relationship between latrine site production and the number of otters detected in transects (*x*) was best described by a third order polynomial (latrines.km^{-1}.day^{-1} = 8.2E-05x + 0.216x^2 – 0.033x^3, r^2 = 0.597). The relationship was non-linear and reached a plateau at the three otters group and beyond (Fig. 3). The fit of the third order polynomial was better than would be expected if the relationship was linear, with r^2 8.38 % larger, the mean of squared residuals 10.98 % smaller, and the uncertainty about this mean 8.79 % smaller than that of the linear function (Table 1). Conducting the regression analyses without the three values of the "six otters" abundance group did not change the fit of the regression (r^2 = 0.594), nor did it result in another type of polynomial being best fitted. Even with log-transformed data (log [x+1]), the relationship was still best described by a third order polynomial (r^2 = 0.740) rather than a linear function (r^2 = 0.693).

The relationship between the numbers of latrines.km^{-1}.otter^{-1} and time (days) since last snowfall (x) was also best described by a third order polynomial (latrines.km^{-1}.otter^{-1} = 0.476x – 0.090x^2 + 0.005x^3, r^2 = 0.521). Latrine abundance as a function of time since last snowfall reached a plateau, as otters did not produce more latrines.km^{-1}.otter^{-1} beyond three days after snowfall (Fig. 4). The flight distance over which otters produced activity signs within transects did not augment as time since the last snowfall increased. Linear regressions of the flight distance (km) of activity signs within respective transects on time (days) since last snowfall (x) had negative slopes (Fig. 5) that were not statistically significant for the one otter abundance group (flight distance = 1.637 – 0.116x, $F_{[1,14]}$ = 0.150, p = 0.700, r^2 = 0.011), the two otters abundance group (flight distance = 1.929 – 0.057x, $F_{[1,12]}$ = 0.090, p = 0.773, r^2 = 0.007), the three otters abundance group (flight distance = 3.986 – 0.508x, $F_{[1,12]}$ = 0.930, p = 0.355, r^2 = 0.072), and the four otters abundance group (flight distance = 2.684 – 0.079x, $F_{[1,16]}$ = 0.060, p = 0.816, r^2 = 0.003).

5. Discussion

The relationship between the number of otters detected within sampled stretches of rivers and the number of sites with faeces (i.e., latrines) they produced in this study show that latrine sites did not very sensibly reflect otter numbers at the scale of individual rivers. Larger numbers of river otters detected (i.e., three and over) in a given stretch of river was not necessarily associated with more sites having faeces (i.e., latrines); the relationship was non-linear and reached a plateau (Fig. 3). This has important consequences for presence/absence scat surveys in terms of the odds of detecting otter presence at search sites, which we address specifically in the management implications section. With Eurasian otters, Ruiz-Olmo *et al.* (2001) also found that there was no linear relationship between otter abundance and the number of positive search sites in their track and visual censuses. They also observed that there was rapid saturation of faeces and latrine sites without linearity as otter numbers rose. Elzinga *et al.* (2001) noted that this is a common problem with indices of population size based on presence/absence surveys. The index value becomes saturated when population density is high and hence, the given index reflects population size in low-density situations only. Our results and those of Ruiz-Olmo *et al.* (2001) show that for otter species, such saturation is quickly reached.

The logic of our results can be explained by the river otter's basic ecology. North American river otters are highly social mustelids and the basic social unit of the species is the family, composed of an adult female and her unweaned offspring (Melquist & Hornocker, 1983). Unrelated adults, yearling or juveniles, acting as helpers, are also known to be included in some family groups (Melquist & Hornocker, 1983; Reid *et al.*, 1994; Rock *et al.*, 1994). Reid *et al.* (1994) found adult males to be generally solitary but observed that they form temporary groupings, whereas Blundell *et al.* (2002) in a marine environment, found adult males to be very social and present in both all-male and mixed-gender groups. Groups of unrelated juveniles can also be observed (Melquist & Hornocker, 1983). Families and other groups hunt, travel, rest together and will use the same dens and latrines (Beckel, 1990; Reid *et al.*, 1994). The cohesiveness of these groups while in existence seems to partly explain why the presence of more otters in a given region need not result in more sites with faeces (i.e., latrines) being detected. If all otters in a group tend to defecate at the same latrine sites, as we observed, it is then understandable that a family of three for example, may not produce more sites with faeces than a family of four, five, six or more. Group size for river otters have been observed to vary from one to six (Beckel, 1990), one to eight (Bischof, 2003), one to nine (Blundell *et al*., 2002), and two to 13 animals (Rock *et al*., 1994). Considering this information and the relationship obtained in this study (Fig. 3), this exposes how larger numbers of otters risk not producing more sites with faeces for presence/absence scat surveys to potentially detect.

Usually, river otters do not actively defend territories and will instead mutually avoid each other (Melqusit & Hornocker, 1983). Individual animals and family groups however will establish home ranges for themselves (Reid *et al*., 1994; Bowyer et al., 1995). This was reflected in our data, as the flight distance travelled by individual river otters or groups did not increase with time (Fig. 5). Our data suggest that river otters quickly cover the distance of their home ranges and this is most likely because they are known to travel great distances in short periods of time (e.g., Melquist & Hornocker, 1983; Reid *et al*., 1994). Otters in our study did not produce ever-increasing numbers of sites with faeces (i.e., latrines) as the time after snowfall increased (Fig. 4). Otters defecate repetitively at the same sites and visitation rates to these latrines are high (Bowyer *et al*., 1995; Ben-David *et al*., 2005). Melquist and Hornocker (1983) observed that otters often repetitively defecate at conspicuous sites such as exposed logs, logjams, sand bars, large boulders, and elevated banks. Otters consistently mark some latrine sites for generations; some authors refer to these as traditional latrines (Melquist & Hornocker, 1983; Macdonald & Mason, 1987; Swimley *et al*., 1998). Considering this, occurrence of sites with faeces might be too stable temporally to fluctuate reliably with otter abundance in a region and accordingly change the odds of detecting otter presence at search sites.

Faeces, urine and anal secretions play a role in olfactory intraspecific communication for river otters (Melquist & Hornocker, 1983; Rostain *et al*., 2004). Kruuk (1992) suggested that scent marking by Eurasian otters is used to signal the use of resources, whereas recent results by Ben-David *et al.* (2005) suggest that social river otters use latrines for intra-group communication, solitary individuals for signalling mutual avoidance, and females for territorial defence. Much remains to be discovered about the various roles of this mode of communication for the different sex and age classes of river otters (e.g., Rostain *et al.*, 2004; Ben-David *et al.*, 2005). An important consequence of the social function of latrines is that not only will members of the same group defecate at the same sites, but otters venturing into the home ranges of other otters tend to defecate at pre-existing latrine sites on the landscape. Melquist and Hornocker (1983) observed that travelling otters generally marked at traditional landings when encountered. Several captive Eurasian otters were also observed sniffing an established latrine site and then urinated and/or defecated before ejecting contents of their anal sacs directly on top or alongside the excrements constituting the latrine (Gorman *et al.*, 1978). The communication function of their defecation behavior can further contribute to the phenomenon that more otters in a region will not necessarily translate into a meaningful increase in the number of sites with faeces for that region.

In our study area, at the scale of individual rivers, we did not detect very large numbers of otters within individual transect searches. For example, in four years of survey, we only detected as much as six otters within a given transect on three occasions. Still, it is clear from our data that a saturation plateau occurs at the three otters abundance group and beyond (Fig. 3). Had there been more data available for the abundance groups of over four otters, the difference of fit between curvilinear and linear functions could have been much greater. Lone river otters or groups are known to have home ranges that can partially overlap those of neighboring otters in a region (Melquist & Hornocker, 1983; Reid *et al.*, 1994). We could occasionally observe this in some transects when documenting snow tracks and could often distinguish between two neighboring otter groups because of locations where they interacted together or where both sets of tracks would overlap. Following otter movements along riverbanks can be difficult at times because they often alternate travel on snow and under ice. Errors could have been made occasionally by interpreting the snow tracks of two neighboring groups of otters as if it were those of one group. As an extreme scenario, consider a sampled stretch of river where two neighboring groups of four otters would be erroneously recorded as one group of four otters. The count of latrine sites obtained for that transect should have been put in the eight otters and not the four otters abundance group. Such errors, if they occurred, would have undermined our ability to obtain the relationship we described in this study (Fig. 3). We obtained a relationship that reaches a plateau despite the possibility of such errors and this attests the strength of the relationship we describe in this study.

Our results also showed that river otters could be present on a stretch of river without depositing faeces on riverbanks. This means that presence/absence scat surveys are prone to produce some false negatives (i.e., erroneously concluding that otters are absent at a searched location while actually present). The proportion of transects without faeces documented was quite high when only one and two otters were detected by snow tracks respectively (Fig. 2). This reflects Macdonald and Mason's (1983*b*) observations and Kruuk *et al.*'s (1986) warning that otters, when at low-density, may mark their range substantially less than when at higher density. Ben-David *et al.* (2005), studying river otters in a marine environment, found that solitary otters were located near more latrine sites than social otters, suggesting that solitary otters scent-mark at more latrine sites than social otters. However, they found that social otters visited the latrine sites they used more frequently than solitary otters. This was reflected in our winter study that implicates the covering of latrine sites by periodic snowfalls, because the one otter abundance group was associated with very low latrines.km^{-1}.day^{-1} values (Fig. 3). Furthermore, the proportion of scats deposited in the water as opposed to deposited on land is not well known and could be considerable (Kruuk & Conroy, 1987). Researchers using various scat survey methods to study some component of freshwater otter populations should acknowledge these inherent sources of bias and their implications.

6. Management implications

Presence/absence scat surveys have been deemed highly accurate for otters because their activity signs are concentrated along rivers (Chehébar, 1985) but given our results, we disagree with this assertion. Our results show that more otters do not translate into ever more sites with faeces (Fig.3) and so, the probability of detecting otter presence via faeces along portions of rivers searched will not increase appreciably with otter abundance in them because faeces are clumped at latrine sites. The major consequence of this finding is that more otters in a particular area will usually not translate into more positive searches when conducting scats surveys that operate by classifying searched sites as having or lacking the presence of otters. We conclude that scat surveys that work by determining presence/absence of animals at searched sites are inadequate as an index of relative population size for this species. We advise extreme caution when interpreting data from such surveys to monitor relative population size for species for which faeces or other surveyed signs play a role in social communication and tend to be in a clumped distribution on the landscape.

Table 1: Regression statistics for three feasible polynomial models describing the relationship between latrines.km^{-1}.day^{-1} values (dependant variable) and the number of otters detected for 82 riparian transects conducted in Kouchibouguac National Park of Canada and surrounding area during the winters of 2000, 2001, 2003 and 2004.

					Regression coefficients			Squared residuals	
Model curve	r^2	df	F	p	b^1	b^2	b^3	Mean ±	Std. error
Linear	0.547	81	97.70	<0.001	0.294			0.519	0.182
Quadratic	0.567	80	52.34	<0.001	0.470	-0.045		0.496	0.174
Cubic	0.597	79	38.96	<0.001	8.2E-05	0.216	-0.033	0.462	0.166

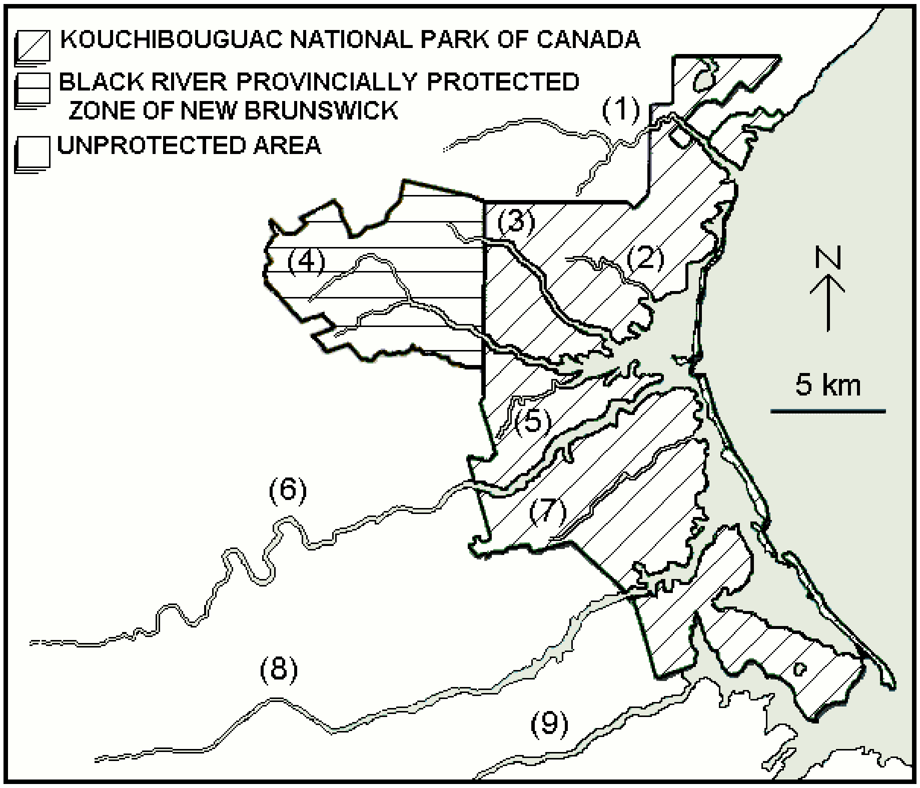

Fig. 1: Stretches of watercourses sampled in the study area in New Brunswick Canada, which comprises Kouchibouguac National Park of Canada, the Black River Provincially Protected Zone of New Brunswick and unprotected areas in the vicinity. Rivers and streams sampled are: (1) Portage, (2) Carrigan, (3) Fontaine, (4) Black, (5) Rankin, (6) Kouchibouguac, (7) Major, (8) Kouchibouguacis, and (9) St-Charles.

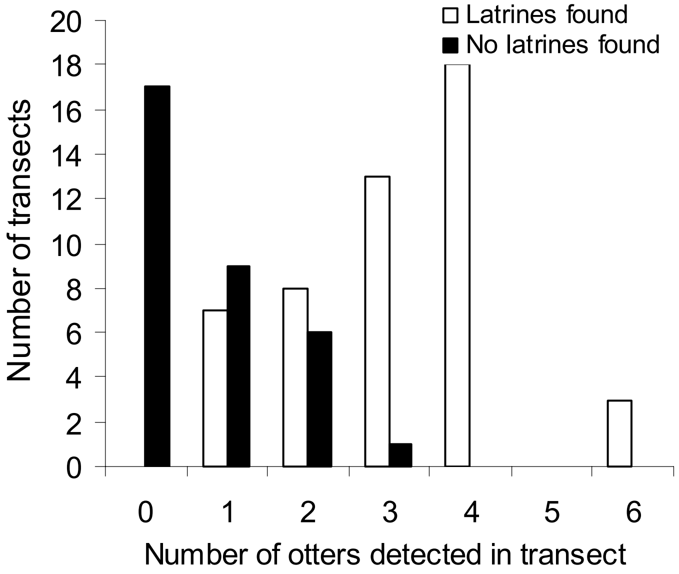

Fig. 2: Frequency distribution of transects with and without latrines detected as a function of the number of river otters detected by snow tracking for 82 riparian transects conducted in Kouchibouguac National Park of Canada and surrounding area during the winters of 2000, 2001, 2003 and 2004.

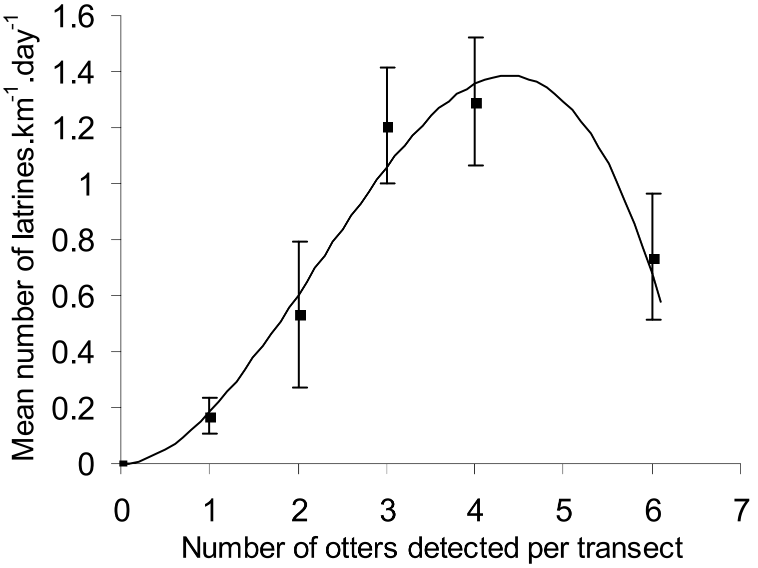

Fig. 3: Relationship between the number of latrines.km^{-1}.day^{-1} and the number of otters detected for 82 riparian transects conducted in Kouchibouguac National Park of Canada and surrounding area during the winters of 2000, 2001, 2003 and 2004. Here shown is the mean and standard error for each otter abundance group, equation for the curve is latrines.km^{-1}.day^{-1} = 8.2E-05x + 0.216x^2 – 0.033x^3.

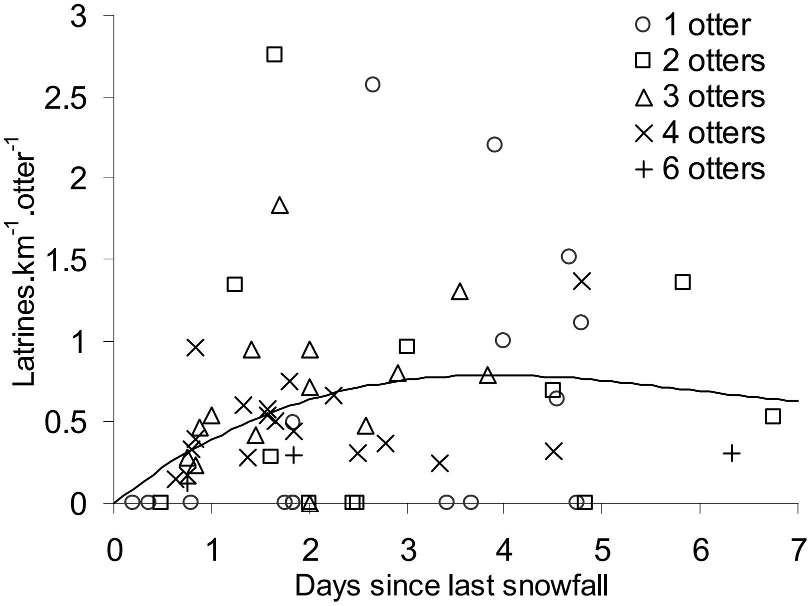

Fig. 4: Relationship between the number of latrines.km^{-1}.otter^{-1} and the number of days since last snowfall for 65 riparian transects conducted in Kouchibouguac National Park of Canada and surrounding area during the winters of 2000, 2001, 2003, 2004. Equation for the curve is latrines.km^{-1}.otter^{-1} = $0.476x - 0.090x^2 + 0.005x^3$.

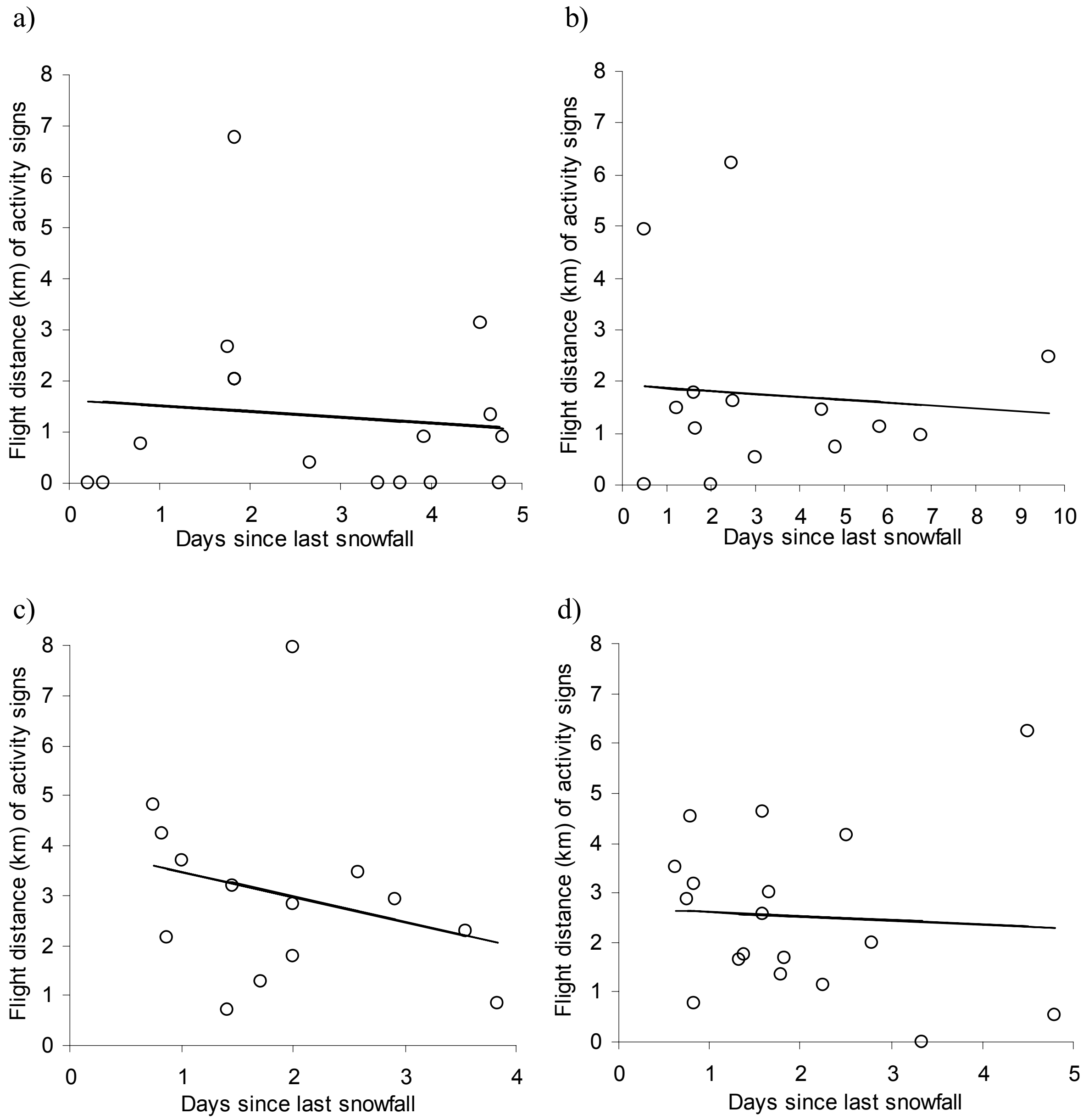

Fig. 5: Relationship between the flight distance (km) over which otters produced activity signs and the time (days) elapsed since last snowfall according to otter abundance within 65 riparian transects conducted in Kouchibouguac National Park of Canada and surrounding area during the winters of 2000, 2001, 2003 and 2004. Here shown are scatter plots and linear regression plots expressing non-significant slopes for the a) one otter (flight distance = 1.637 – 0.116*x*), b) two otters (flight distance = 1.929 – 0.057*x*), c) three otters (flight distance = 3.986 – 0.508*x*) and d) four otters (flight distance = 2.684 – 0.079*x*) abundance groups.

CONTRIBUTION RELATIVE AU CHAPITRE 3

J’ai eu l’idée d’entreprendre cette recherche. J’ai participé à la collecte des données lors des suivis hivernaux de la loutre de rivière. J’ai effectué toutes les analyses statistiques et rédigé l’article au complet, sous la supervision de ma directrice de thèse, Liette Vasseur et ma co-directrice, Céline Bérubé.

Evaluating bridge survey ability to detect river otter presence

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Soumis à Acta Theriologica le 21 mars 2006

Abstract

Many researchers use bridges as search sites to monitor freshwater otter species along watercourses. Bridges enable rapid and easy access to their habitat, but little is known on whether these anthropogenic structures affect otter distribution and hence, the ability of such surveys to detect their presence. We investigated the bridge survey method using data gathered during four winters of survey along the rivers and streams of Kouchibouguac National Park and surrounding area in New Brunswick, Canada. Our results show that sign surveys using bridges as search sites can have the same probability to detect river otter (*Lontra canadensis*) occurrences as surveys using randomly distributed sites. Future surveys can be improved by increasing search distance at bridge sites. This will increase detection rates and safeguard against results under representing otter occurrence on the landscape, which could prompt unnecessary conservation actions. Researchers choosing to increase search distance are advised to augment survey efforts in order to maintain large sample sizes, ensuring sufficient statistical power for tests aiming to detect trends in river otter occurrence.

1. Introduction

Population monitoring is an integral part of resource management and has considerable importance for species at risk or those of economical interest. Long term monitoring programs required for proper management can be economically and logistically demanding. Therefore, considerable efforts are made by scientists to develop and test novel population monitoring methods (e.g., Kohn *et al.*, 1999; Eggert *et al.*, 2003), and to test the accuracy of existing cost-effective ones (e.g., Ruiz-Olmo *et al.*, 2001; Sharp *et al.*, 2001).

Freshwater otters are inconspicuous animals in nature. Because of this, populations of these species are most often monitored indirectly by searching for activity signs such as tracks and faeces (e.g., Lodé, 1993; Lee, 1996; Shackelford & Whitaker, 1997). Because these species typically establish home ranges along rivers and streams (Melquist & Hornocker, 1983; Reid *et al.*, 1994), searches for signs of activity are concentrated along their shores. These sign surveys consist of visiting predetermined sites where stretches of shoreline of standardized lengths are scrutinized for activity signs. Ideally, these sites would be selected at random. Because of accessibility constraints however, many sign surveys included bridges and roads passing close to rivers and streams as sites to search for activity signs (e.g., Liles & Jenkins, 1984; Prigioni *et al.*, 1986; Lodé, 1993; Brzeziński *et al.*, 1996). Some surveys in North America explicitly use bridges as search sites (e.g., Clark *et al.*, 1987; Shackelford & Whitaker, 1997; Bischof, 2003). Their ease of access by vehicle enables cost-effective survey of numerous search sites over a large geographical area.

The rationale for using bridges remains limited, considering the fact that they constitute anthropogenic disturbances that may influence the otters' habitat use and consequently, the potential for these searches to detect their presence in a given region. Moreover, using bridges is a non-random method of selecting search sites and the outcome of such surveys can be highly influenced by the ecology of the species (i.e., its reaction to bridges). In Europe, limited available evidence indicates that Eurasian otters (*Lutra lutra*) do not avoid sites with bridges (*sensu* Romanowski *et al.*, 1996) but further inquiry is required to ensure that managers can rely upon bridge surveys for population monitoring and management decision-making.

It is therefore essential that this monitoring technique be tested for other species and in other regions before determining that it is a universally effective survey method for otters. The objective of this study was to determine if sign surveys are less efficient at detecting North American river otter (*Lontra canadensis*) occurrence when bridges instead of random sites are designated for conducting transect searches along riverbanks. To compare bridges and randomly selected sites, we analyzed data collected during four years of monitoring a North American river otter population by conducting long-distance transects on rivers and streams crossed-over by several bridges.

2. Study area

The study area covered Kouchibouguac National Park of Canada (KNPC) and its vicinity (Fig. 1). Located in the province of New Brunswick, the park covers an area of 238.8 km^2 and is representative of the Maritime Coastal Plains (Desloge, 1980). The topography is flat and contains eight major watercourses with numerous bogs and swamps: Portage River, Carrigan Brook, Fontaine River, Black River, Rankin Brook, Kouchibouguac River, Major Brook, and Kouchibouguacis River (Desloges, 1980). The two main rivers, Kouchibouguac and Kouchibouguacis, are tidal. Average annual temperature is 4.8˚C, average freeze-free period is 177 days and annual precipitation averages 979 mm (Desloges, 1980). The park contains mixed forests dominated by balsam fir (*Abies balsamea*) and birch (*Betula* spp.), as well as coniferous forests of black spruce (*Picea mariana*) (Graillon *et al.*, 2000). Speckled alder (*Alnus rugosa*) dominates the shores of most of the smaller streams. The study area extended into regions outside the park along the Portage, Kouchibouguac, Kouchibouguacis, and St-Charles rivers, as well as along the Black River in the Black River Provincially Protected Zone of New Brunswick (BRPPZNB) that is adjacent to the park (Fig. 1). Areas outside the park and the protected zone were at various stages of succession, and included light residential areas and agricultural lands. The study area contained 18 bridges, with six of them in KNPC and none in the BRPPZNB (Fig. 1). Salt and small gravel are spread on roads of the region in winter.

3. Methods

Documenting otter movements during winter is advantageous in many regards. Detection probability is high because of the conspicuous tracks each animal leaves in the snow, and all other activity signs will be linked to them. The homogeneous substrate left by snowfalls also safeguards against possible biases linked to differential detection rates (Conroy & French, 1987; Romanowski *et al*., 1996). We conducted winter sign surveys of otter activity from early January until the end of April for the winters of 2000, 2001, 2003, and 2004. We monitored river otter activity in riparian habitats by conducting wintertime transects along the shores of the eight main rivers and streams of the study area, as well as tributaries associated to them. We respected a minimum delay of 12 h after snowfalls, thereby leaving enough time for otters to manifest their presence and produce activity signs on the fresh snow. We used light snowmobiles (Bombardier's Tundra models) when river width and ice thickness made it possible. We conducted transects as a team of two riders on separate machines, riding single file at slow speed along both shores of rivers and stopping at will to inspect all potential river otter signs. We accessed narrower sections of rivers and streams by snowshoe. We sampled rivers in random order and alternated the order for each survey period. We conducted continuous transects, with an entire day or two invested in scrutinizing each river. A typical continuous transect would take an entire day to conduct, during which we would strive to survey as many kilometers of the chosen river as possible. This maximized the ability to document river otter activity along the shores of the major watersheds in the study area (Fig. 1).

We recorded coordinates (UTM, Grid #20, in meters, with a Garmin12 XL Geographic Positioning System), date and time for the beginning and end of each transect, as well as for all encountered otter activity signs (i.e., snow tracks, faeces, burrows, water access holes, direct sightings). We calculated time (hour) elapsed since last snowfall each time a new transect began or an otter activity sign was detected. For each transect where bridges and otter activity were present, we then used topographical maps to measure the straight-line distance (m) between bridges and the respective closest otter activity signs detected. We measured strait-line distance both upstream and downstream of bridges when activity signs were found on both side of bridges.

3.1. Data analysis

By keeping track of the distance at which we found the closest otter activity signs from respective bridges, we were able to compute the detection rates that would have been obtained by conducting bridge surveys of different lengths (i.e., length of shoreline scrutinized at search sites with bridges as starting points). We then constructed a scatter plot of the cumulative percentage of known otter presences detected as a function of the maximum distance from bridges searched. The relationship obtained was described by plotting an accumulation curve defined as:

$$[1] \qquad A(x) = ax / (b + x)$$

where x is the maximum distance (m) of shoreline searched with bridges as the starting point, $A(x)$ is the cumulative number of instances with otter detection by bridge searches up to the given distance, a is the parameter that determines the asymptote of the function, and b is the parameter defining the rate at which the non-linear slope diminishes as x increases. This function is commonly used when estimating population size from genotyped faecal samples and is also known as a rarefaction curve (Kohn *et al.*, 1999; Eggert *et al.*, 2003). For our data, we obtained a and b values by using the Levenberg-Marquardt estimation method from the non-linear regression module in SPSS (version 8.0 for Windows). The starting value was set at 1 for parameter estimations, with no restrictions and no limit imposed on the number of iterations. Computations were terminated and final parameter values accepted when the relative reduction between successive residual sums of squares was < 1.000E-08.

In survey schemes where locations are searched for the presence/absence of a given species, researchers can make two types of errors in the field. The first is to conclude that a species is absent from a location when in fact it is present, and the second is to conclude that the species is present when in fact it is absent. When conducting sign surveys, the latter is practically impossible to make unless sympatric species produce similar activity signs that can confound species identity. River otter activity signs are quite unique and are unlikely to be confounded with those of other animals, except for regions of the world where sympatric species of otters are found (e.g., Rowe-Rowe, 1992). The type of error in the field that often plagues otter surveys is thus failing to detect otters at a site when they actually are present. Using the same accumulation curves, we computed the percentages of known otter presences that would have gone undetected in our study area if bridge surveys using different search distances had been used instead of long-distance riparian transects that sampled whole rivers.

It is foreseeable that longer transect searches will result in more of the known otter presences being detected. To investigate the bridge effect apart from that of transect length, a companion set of random sites was created in order to investigate how results change when random sites instead of bridges are used for transect searches. On each side of a bridge where otter activity signs were present as detected by a continuous riparian transect, a random site along the river was selected for the companion dataset. For example, to select a random site downstream from the bridge on Portage River, the random number tables in Zar (1999) would be used to generate a linear random distance (m) downstream from the bridge that would correspond to the location for the random site. For this particular example, we would repeat the procedure until we would obtain a random distance that places the given random site anywhere between the bridge and the river's mouth, rather than outright in the ocean. These sites are then taken to represent the center of randomly distributed transects. Results for scenarios using different transect lengths at these randomly chosen sites were compared in tandem with bridge survey scenarios by applying the same non-linear regression analyses described above for bridge sites.

Because the data consist of direct, on site scrutiny of riverbanks, our study concerns bridge surveys where riverbanks are inspected directly rather than observed at a distance with binoculars by standing on the bridge. In order to determine if time elapsed between snowfalls and continuous riparian transect searches influenced how far activity signs were found from bridges, we applied simple linear regressions on our survey data. Distance (m) between respective bridges and their closest river otter activity sign was designated as the dependent (i.e., response) variable and time elapsed (days) since last snowfall at the time of sampling was the independent (i.e., predictor) variable for the analysis.

4. Results

During the winters of 2000, 2001, 2003, and 2004, we conducted 92 continuous riparian transects, totalling 1,557 km of riverbank searches for river otter activity signs by repetitively surveying the study area. Most river otter occurrences were confined to the protected areas of KNPC and the BRPPZNB, with only 32 of the 643 documented signs of activity located in the unprotected portion of our study area. Consequently, our results are mostly associated to bridges within or in the vicinity of the mostly undisturbed, protected areas of KNPC (Fig. 1). Of the 92 transects, 50 included bridges and had otters present. From these 50 transects, we made 61 measurements of the distance between bridges and their closest otter activity sign. There were 26 measurements upstream and 35 measurements downstream from bridges. There was no statistically significant difference in the mean distance at which otter activity signs were found upstream compared to downstream of bridges ($t_{59} = 1.580$, $P = 0.120$). Therefore, data from both upstream and downstream of bridges were merged in order to conduct further analyses and thus, effective sample size was $n = 61$. Consequently, we used 61 random sites where measurements were made to compare results with bridge sites. Linear regression analysis indicated that time (days) since last snowfall had no significant influence on the distance at which we found closest activity signs from respective bridges for continuous riparian transects from our winter surveys (distance from bridges = $1{,}410.977 - 96.593x$, $F_{1,59} = 1.106$, $P = 0.297$, $R^2 = 0.018$).

Accumulation curves calculated for bridge sites ($A = 66.148x / (665.300 + x)$, df = 59, $R^2 = 0.990$) and random sites ($A = 70.389x / (805.110 + x)$, df = 59, $R^2 = 0.994$) are illustrated in Figure 2. They represent the cumulative percentage of known otter presences that would have been detected as a function of the different search distance scenarios applied to our data. Values of these functions were converted into percentage values before being plotted (Fig. 2) in order to facilitate comparisons. Figure 3 illustrates percentages of known otter presences that would have gone undetected for different bridge and random site survey scenarios in our study area, based on the accumulation curves for bridges and random sites respectively. As the search distance for bridge and random site surveys was increased, a higher percentage of known otter presences would have been detected (Fig. 2), while the percentage of known otter presences that would have gone undetected diminished (Fig. 3). For short transect scenarios (i.e., 400 to 1,200 m) in our study area, searches at bridge sites would have detected slightly more of the known otter presences in comparison to respective random sites (Fig. 2) and consequently, there would have been fewer undetected otter presences for searches at bridge sites (Fig. 3) but the difference was marginal. For longer transect scenarios, the very small difference was inversed (Fig. 3). Overall, the survey scenarios based on bridge and random sites gave very similar results as shown by the overlapping accumulation curves (Fig. 2). For scenarios with less than 2,000 m for transect lengths, the point of largest divergence between the two curves was at 380 m, with only 2.4 % of difference.

5. Discussion

Our results show that sign surveys using bridges as search sites can have the same probability to detect river otter presence than surveys using randomly distributed sites. Our results suggest that river otters in our study area did not avoid locations with bridges and this is in accordance with Dubuc *et al*., (1990), who did not find statistically significant effects of paved and dirt river crossings on river otter occurrence. Working with Eurasian otters, Durbin (1998) found that only one of five animals studied with radio-telemetry avoided bridges. The river otter, as a semi-aquatic top-level predator of riparian ecosystems, requires access to prey as well as adequate terrestrial shelter. Otter occurrence on the landscape has been associated with several characteristics offering shelter, such as overhanging vegetation along riverbanks and latter succession stages of vegetation like mature forests (Newman & Griffin, 1994; Bowyer *et al*., 1995; Swimley *et al*., 1998), silt and organic matter dominated soils (Reid *et al*., 1994), ground debris like fallen trees or logs (Swimley *et al*., 1998), vertical banks (Reid *et al*., 1994; Swimley *et al*., 1998), as well as beaver ponds, bank dens, and lodges (Dubuc *et al*., 1990; Newman & Griffin, 1994; Reid *et al*., 1994; Swimley *et al*., 1998). Melquist and Hornocker (1983) observed that they could be found at sites with anthropogenic disturbances, provided that these two essential habitat requirements were met. Considering this, it is to be expected that the capability of bridge surveys to detect otter presence will vary from one study area to another, and depend on where are bridges in relation to locations possessing characteristics that otters will use and hence produce activity signs to detect. This situation is equally relevant to surveys using randomly selected sites. The uniqueness of each study area prevents us from recommending particular search distances that universally guarantee high detection rates. However, our research contributes evidence that the bridges themselves do not diminish the odds of detecting river otter presence when they are used as starting points to conduct searches.

Our results also show that current bridge surveys (Table 1) could be improved by increasing the distance searched at each site. For example, by searching 600 m of riverbanks from bridges in our study area, only 51 % of known otter presences would have been detected. This relatively low detection rate could well have occurred for bridge surveys in other geographical areas, considering the fact that population density estimated from the 2000 data was 5.8 groups of otters per 100 km of river (M. Dumond and C. H. Bérubé, Kouchibouguac National Park of Canada, unpublished report), and compares well with the 5.0 groups per 100 km obtained by Melquist and Hornocker (1983) in Idaho. By increasing search distance, more sites with otter occurrence will be detected but as explained above, the level of increase in detection rates brought by extended searches will likely depend on where the bridges are located in relation to habitat characteristics that otters use and this will vary from one study area to another. Even with some locations with otters going undetected, if detection rates remain stable from one survey to the next, bridge surveys could still be able to reflect temporal trends in river otter occurrence on the landscape. However, we did no study this aspect of the performance of bridge surveys or other types of sign surveys because we do not possess appropriate long-term survey data.

Clark *et al*. (1987) found similar results when simultaneously conducting bridge and scent station surveys, with 100 m being searched on both sides of bridges. This suggests that very short searches might be sufficient to detect otter presence. Their study design appears to be inadequate for validating bridge sign surveys however, because scent stations were established at the end of the 100 m searches upstream and downstream of bridges. It is likely that otters would have left faeces and other activity signs closer to these bridges and on the 100 m search strips leading to the scent stations because otters were attracted to these sites by the scent stations. For our winter study, linear regression analysis indicated that activity signs were not closer or farther from bridges in continuous transects conducted several days after snowfall in comparison to those conducted shortly after snowfall. Therefore, the time at which we conducted transects after snowfalls was not a source of bias. The presence of other anthropogenic disturbances such as houses and fields in our study area could have limited our ability to determine if bridges had a negative impact on otter detection rates. Because we only analyzed data from continuous transects with otter detection and 95 % of detected activity signs were in the protected areas of KNPC and the BRPPZNB, anthropogenic structures and disturbances other than bridges probably had a negligible influence on our results because our data essentially came from these protected portions of our study area.

Our results and conclusions may not be directly transposable to bridge surveys conducted on landscapes inhabited by Eurasian otters. It appears that Eurasian otters frequently defecate under bridges and that most activity signs (>70 %) are found within 200 m of bridges (*sensu* Romanowski *et al*., 1996). This means that short transect searches at bridges could result in high detection rates for this species. However, the frequent findings of faeces under bridges might be an artifact of the absence of riparian vegetation under bridges, hence facilitating detection during seasons other than winter. Some surveys of Eurasian otters included sites with poor vegetation cover (e.g., Macdonald & Mason, 1983*a*; Lodé, 1993). It is possible that otters in such situations are attracted to the cover offered by bridges. Still, Romanowski *et al.* (1996) recommended extending searches from 600 m to 1 km in regions with low otter density. In their study, extended searches increased the number of positive sites by 27 %.

For North American river otters, it can be argued that they may demonstrate different defecation behavior in summer as opposed to winter. However, during past summer fieldwork on other research projects along the rivers and streams of KNPC (e.g., Gallant *et al.*, 2004), no otter latrines were ever found under bridges (Gallant, pers. obs.). This difference could be due to most bridge sites in our study being in forested areas, or that these two species of otters differ markedly in their behavioral response to bridges. Just as for other types of sign surveys, it is likely that our surveys did not detect all locations used by otters in our study area. Because our surveys used continuous transects and were conducted in winter, we judge that detection rates were high due to the conspicuous tracks left by otters on the snow, which link all other activity signs to them. However, it is unrealistic to consider that all locations without activity signs on ice or snow are locations devoid of otters. It is possible that they remained in the water under ice when passing through locations with bridges. Even if the North American river otter population we studied do not seem to use bridges as sites to deposit faeces and were not found as close to bridges as Eurasian otters, our similar results for bridge and random sites demonstrate that they do not actively avoid locations with bridges.

6. Management implications

Our results show that the performance of surveys using bridges as search sites can be similar to those using randomly selected sites. Until more research can confirm our results for other seasons, our results showed that at least in winter, bridges do not adversely affect the odds of detecting river otter presence. Management decisions based on surveys that underestimate a species' presence might prompt unnecessary conservation actions. If avoidance of survey results that under represent North American river otter presence on the landscape is important, our results (Fig. 2) suggest that past bridge surveys (Table 1) would have probably required longer searches at each site in order to maximize detection rates. This means that fewer bridge sites could have been sampled with the same investment of time and labour. Sample size is an important parameter defining the statistical power of tests applied to survey data (Strayer, 1999; Lewis & Gould, 2000). Wildlife managers, researchers and conservationists using longer search units in bridge surveys would benefit from increasing time and labour efforts in order to maintain large samples (i.e., visits at many bridges), if statistical tests applied to bridge survey data are to have sufficient power for detecting trends in river otter occurrence in a surveyed area.

Table 1: Examples of maximum distance (m) scrutinized in search of otter activity signs for studies that use bridges as search sites.

Study	Species	Distance (m) searched	Country
Macdonald and Mason 1982*a*	*Lutra lutra*	600	Portugal
Macdonald and Mason 1982*b*	*Lutra lutra*	600	Greece
Macdonald 1983	*Lutra lutra*	600	Britain and Ireland
Macdonald and Mason 1983*a*	*Lutra lutra*	600	Tunisia
Macdonald and Mason 1983*c*	*Lutra lutra*	600	Italy
Liles and Jenkins 1984	*Lutra lutra*	600	Yugoslavia
Prigioni et al. 1986	*Lutra lutra*	600 – 1,000	Albania
Clark et al. 1987	*Lontra canadensis*	100	United-States (Georgia)
Lodé 1993	*Lutra lutra*	400	France
Brzeziński et al. 1996	*Lutra lutra*	600 – 1,000	Poland
Shackelford and Whitaker 1997	*Lontra canadensis*	500	United-States (Oklahoma)
Bischof 2003	*Lontra canadensis*	not specified	United-States (Nebraska)

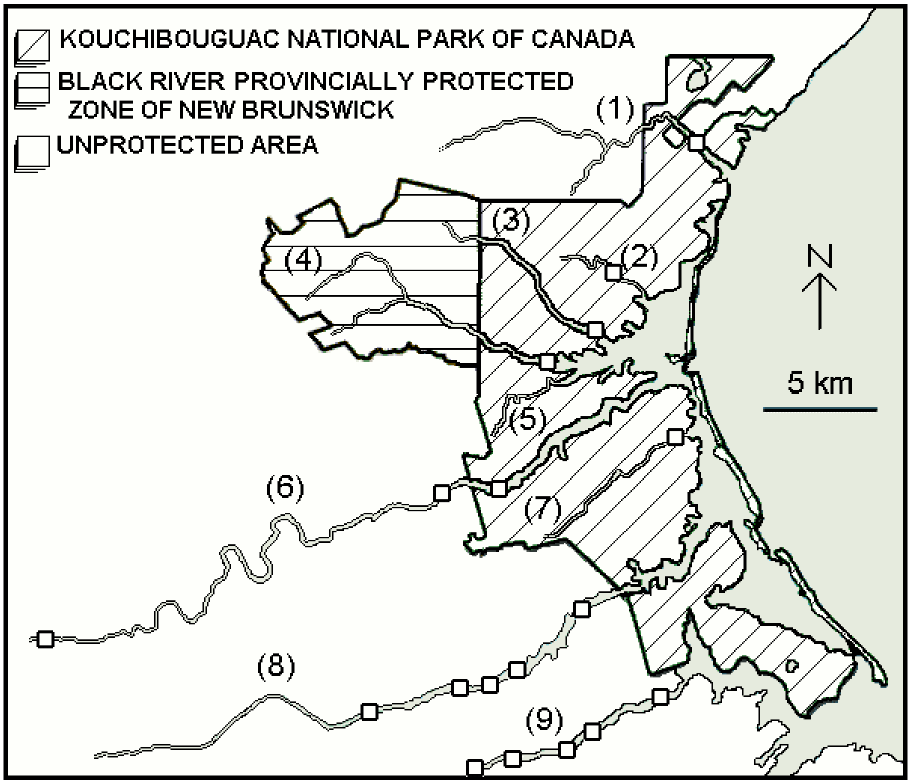

Fig. 1: Location of the 18 bridges (open squares) in the study area comprising of Kouchibouguac National Park of Canada, the Black River Provincially Protected Zone of New Brunswick and unprotected areas in the vicinity. Rivers and streams of the study area are: (1) Portage, (2) Carrigan, (3) Fontaine, (4) Black, (5) Rankin, (6) Kouchibouguac, (7) Major, (8) Kouchibouguacis, and (9) St-Charles.

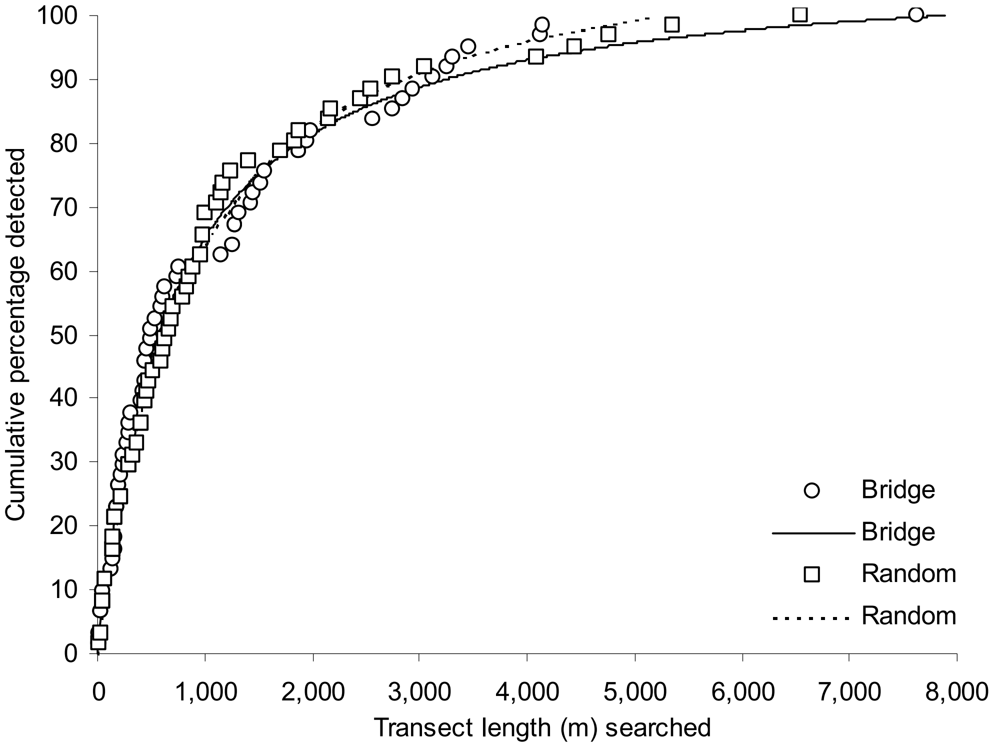

Fig. 2: Cumulative percentage of known river otter presences that would have been detected as a function of various transect length scenarios for bridge locations used as search sites, $A = 66.148x / (665.300 + x)$ and a companion set of randomly selected sites, $A = 70.389x / (805.110 + x)$, based on data collected in Kouchibouguac National Park of Canada and surrounding area during winter surveys in 2000, 2001, 2003, and 2004.

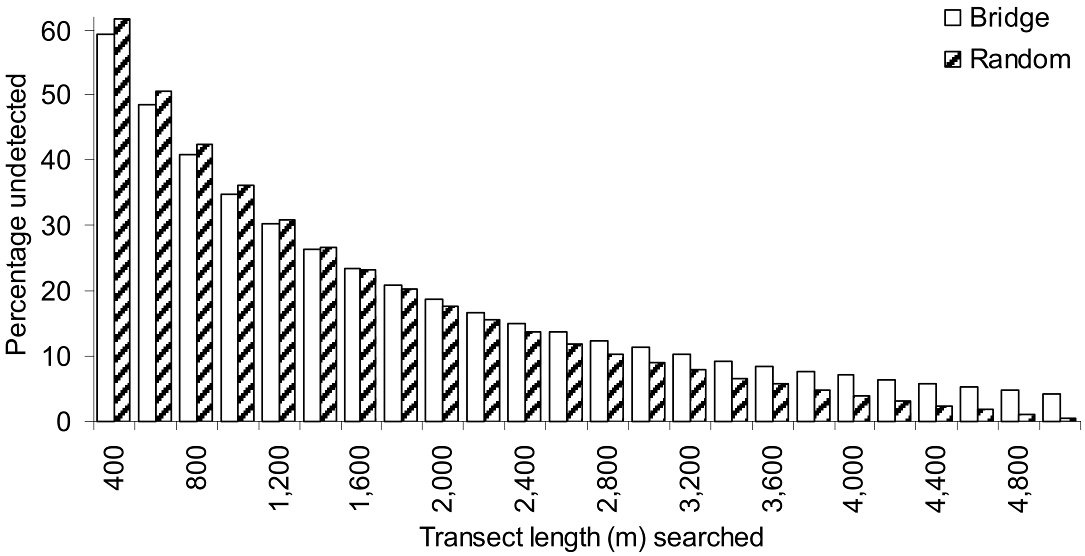

Fig. 3: Percentage of known otter presences that would have gone undetected for various river otter survey scenarios, according to accumulation curves for bridge locations and a companion set of random search sites, based on data collected in Kouchibouguac National Park of Canada and surrounding area during winter surveys in 2000, 2001, 2003, and 2004.

Discussion générale

D'après les résultats obtenus au chapitre 1, la distribution des signes de présence de la loutre s'avère un outil indicateur utile car elle répond à des critères reconnus pour valider les espèces potentiellement indicatrices. C'est-à-dire que l'incidence de loutres de rivière sur le territoire était associée de façon constante (Niemi *et al.*, 1997; Noss, 1999) à des caractéristiques d'intérêt au niveau de la gestion (Landres *et al.*, 1988) des habitats riverains au sein des écosystèmes de type forestier. La majorité des caractéristiques de l'habitat auxquelles la présence de loutres était corrélée sont directement ou indirectement liées à la disponibilité de refuges terrestres que cette espèce peut potentiellement utiliser. Plusieurs de ces caractéristiques ont le potentiel d'être représentatives de certains aspects de l'intégrité écologique des habitats riverains. Évidemment, cela dépendra de l'écosystème en particulier où le suivi de la loutre est souhaité. Il devient alors important de connaître l'histoire naturelle de la région concernée et de déterminer quels attributs devraient caractériser l'écosystème en question, s'il était dans un état naturel et non-perturbé.

Conformément à la littérature scientifique, l'incidence de la loutre de rivière sur le territoire était positivement corrélée à des sols dominés par du limon/vase ou de la matière organique (Reid *et al.*, 1994), à l'abondance de débris au niveau du sol (Swimley *et al.*, 1998), à la végétation offrant de l'ombrage au-dessus des cours d'eau, de même qu'au forêts matures et à la présence de conifères le long des rives (Newman & Griffin, 1994; Bowyer *et al.*, 1995; Swimley *et al.*, 1998). De façon similaire aux études démontrant l'importance des rives verticales (Reid *et al.*, 1994; Swimley *et al.*, 1998), nous avons déterminé que les loutres étaient associées à la présence de rives possédant des galeries pouvant potentiellement servir de refuge. Nos résultats confirment l'importance des étangs de castors (ex. Melquist & Hornocker, 1983; Dubuc *et al.*, 1990; Newman & Griffin, 1994; Reid *et al.*, 1994; Swimley *et al.*, 1998), auxquels les loutres étaient systématiquement associées. Les castors sont une espèce clé des habitats d'eau douce dans les zones boisées et exercent des influences multiples sur ces types d'écosystèmes (ex. Naiman *et al.*, 1986; Smith *et al.*, 1991; Bailey *et al.*, 2004). Certains étangs peuvent contenir une abondance marquée de proies potentiellement faciles à capturer (Snodgrass & Meffe, 1998; Schlosser & Kallemeyn, 2000). Les castors agissent également en tant que médiateurs de la succession forestière car leurs choix sélectifs en terme de végétation ligneuse (Gallant *et al.* 2004) tendent à favoriser la dominance des conifères (Donkor & Fryxell, 1999; 2000).

Nos analyses suggèrent que les facteurs de l'habitat étaient plus importants que ceux liés aux activités humaines pour décrire la variabilité dans l'incidence de la présence des loutres dans l'aire d'étude. Barbosa *et al.* (2001) ont tiré la même conclusion pour la loutre eurasienne en Espagne. Les perturbations humaines ont tout de même une très grande influence sur l'incidence de loutres. Ces perturbations modifient l'habitat riverain et cela peut entraîner la perte de plusieurs caractéristiques de l'habitat offrant des refuges potentiels pour les loutres de rivière. Cela implique que la loutre semble réagir principalement à la présence/absence de certaines caractéristiques des habitats riverains non-perturbés, plutôt qu'à la simple présence de certaines activités ou infrastructures de nature anthropique dans leur milieu. La loutre n'est pas complètement incompatible avec les activités humaines et va surtout réagir aux changements ou à la dégradation que ces activités humaines causent aux habitats riverains. Ceci est une caractéristique plutôt désirable pour une espèce indicatrice potentielle. Melquist & Hornocker (1983) avaient eux aussi observé que la loutre de rivière semblait préférer les endroits moins perturbés mais qu'elle pouvait occuper des régions avec plus d'activités humaines si les proies potentielles et les refuges étaient disponibles. Sur la base des observations de Melquist & Hornocker (1983), Prenda *et al.* (2001) proposèrent l'hypothèse selon laquelle le degré d'impact que les activités humaines ont sur les loutres dépend principalement de la disponibilité de refuges terrestres dans le milieu.

Il est reconnu qu'une espèce indicatrice unique ne peut pas indiquer toutes les caractéristiques représentatives d'un écosystème en santé (Hilty & Merenlender, 2000). Il est également irréaliste de supposer qu'elle puisse également indiquer l'abondance (Schroeder 1987, Niemi *et al.*, 1997; Simberloff, 1998) ou la qualité de l'habitat (Cairns, 1986; Landres *et al.*, 1988) pour toutes les espèces d'un écosystème donné. De plus, des facteurs additionnels comme les maladies, les parasites, la compétition intraspécifique, la prédation et la variabilité stochastique dans la population peuvent biaiser le suivi d'une espèce indicatrice unique (Steele *et al*., 1984). La majorité des chercheurs s'entendent maintenant sur le fait que des ensembles complémentaires d'espèces indicatrices doivent êtres suivies pour gérer des écosystèmes entiers de façon efficace (Hilty & Merenlender, 2000; Carignan & Villard, 2002). Notre étude démontre comment le suivi des signes d'activité de la loutre de rivière en hiver peut être utilisé comme outil indicateur, de même que le rôle que la loutre de rivière peut potentiellement jouer au sein d'un ensemble complémentaire d'indicateurs.

Concernant la pratique d'utiliser des suivis basés sur la présence/absence de fèces à des sites scrutés pour effectuer le suivi des tendances de population, nos résultats (chapitre 2) montrent que de plus grands nombres de loutres ne se traduiront pas nécessairement en la production de plus de sites avec des fèces (i.e., latrines). La relation entre ces deux facteurs atteint un plateau, au-delà duquel davantage de loutres sur une portion de rivière donnée ne correspond pas à plus de latrines produites. Conséquemment, les chances de détecter la présence de loutres aux sites échantillonnés risquent de ne pas augmenter de façon appréciable en fonction de l'abondance de loutres. Si la probabilité de détecter la présence de loutres ne varie pas de façon marquée en fonction de leur nombre, cela implique donc que la proportion des sites classés positifs (i.e., détection de la présence de loutres) lors des suivis ne fluctuera pas de façon appréciable en fonction de l'abondance de loutres sur le territoire dont il est question. Nous concluons donc que les suivis de fèces qui classifient des sites comme étant positifs ou négatifs (i.e., détection ou non de la présence de loutres) ne sont pas adéquats pour faire le suivi de l'effectif d'une population de loutres. La prudence est de mise lorsque l'on utilise ce type de suivi pour évaluer les fluctuations d'effectifs de population pour des espèces où les fèces ou tout autre type de signe d'activité suivi jouent un rôle de communication sociale, et par conséquent, pourraient avoir une distribution contagieuse sur le territoire.

De telles méthodes de suivi peuvent demeurer adéquates pour déterminer la distribution géographique des loutres. Cependant, pour que des déclins de population soient reflétés dans les résultats de ce type de suivi, il est probablement nécessaire que l'espèce disparaisse complètement de certaines parties du territoire sous étude (Elzinga *et al.*, 2001). Une telle contrainte au niveau de la performance de ces suivis peut s'avérer particulièrement problématique si l'espèce concernée est déjà rare, existe à de faibles densités ou si la population concernée possède déjà une distribution géographique restreinte. Étant donné que la majorité des espèces de loutres utilisent des latrines, nos résultats s'appliquent potentiellement à la majorité des 14 espèces de loutres. Parmi les espèces susceptibles de déposer leurs fèces de façon contagieuse au niveau de leur distribution sur le territoire, nous pouvons compter par exemple: la loutre eurasienne (*Lutra lutra*), la loutre lisse (*Lutra perspicillata*) et la loutre cendrée (*Aonyx cinerea*) en Eurasie (ex. Kruuk *et al.*, 1994), la loutre à cou tacheté (*Hydrictis maculicollis*) et la loutre à joues blanches (*Aonyx capensis*) en Afrique (ex. Rowe-Rowe, 1992), de même que la loutre du Chili (*Lutra provocax*), la loutre géante (*Pteronura brasiliensis*) et la loutre à longue queue (*Lontra longicaudis*) en Amérique du Sud (ex. Chehébar, 1985; Carter & Rosas, 1997; Pardini & Trajano, 1999).

Au Chapitre 3, nos analyses ont démontré qu'au niveau de la détection de la présence de loutres de rivière, les suivis à partir de ponts peuvent être aussi performants que ceux effectués dans des sites choisis de façon purement aléatoire. Des recherches additionnelles seraient nécessaires pour confirmer nos résultats pour les autres saisons. En ce qui concerne les suivis effectués en hiver, notre étude démontre que les ponts n'influencent pas négativement la capacité de détecter la présence de loutres lorsqu'ils sont utilisés comme sites d'échantillonnage. Les loutres de rivière ne semblent pas éviter les ponts de façon active. Similairement, Dubuc *et al.* (1990) n'ont pas pu déceler d'effets statistiquement significatifs des ponts de routes pavées et non-pavées durant leur étude sur l'île Mount Desert, dans le Maine. Durbin (1998), étudiant la loutre eurasienne, détermina que seulement une des cinq loutres qu'il suivit par télémétrie évitait les sites avec des ponts.

Nos résultats suggèrent également qu'il est possible d'augmenter le taux de détection de loutres en augmentant la longueur des transects effectués à chaque pont à la recherche de signes de la présence de loutres. De plus grandes distances de recherche à chaque site impliquent que pour un même effort de main d'œuvre, il ne sera pas possible de fouiller autant de sites. La taille d'échantillonnage exerce une importante influence sur la puissance statistique des tests potentiellement appliqués sur les données de suivi (Strayer, 1999; Lewis & Gould, 2000) pour détecter des tendances temporelles dans l'incidence de loutres sur le territoire. Les chercheurs et gestionnaires de la faune s'engageant à maximiser les chances de détection en augmentant la quantité de rive scrutée à chaque site, auraient intérêt à augmenter l'effort de main d'œuvre afin de maintenir des tailles d'échantillons suffisamment grandes pour garantir un niveau de puissance statistique acceptable pour les tests qui seront éventuellement appliqués sur les données recueillies.

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