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Source: Wildlife Biology, 14(1) : 61-69

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/0909-6396(2008)14[61:EBSATD]2.0.CO;2

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Gallant, D., Vasseur, L. & Bérubé, C.H. 2008: Evaluating bridge ability to detect river otter *Lontra canadensis* presence: a comparative study. - Wildl. Biol. 14: 61-69.

Many researchers use bridges as search sites to monitor freshwater otter species along watercourses. Bridges enable rapid and easy access to their habitat, but for most otter species little is known on whether these anthropogenic structures affect their distribution, their marking preferences, and consequently, 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 capability 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 underrepresenting otter occurrence in 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.

Key words: bridge surveys, evaluation studies, Lontra canadensis, population monitoring

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Received 30 April 2006, accepted 6 November 2006

Associate Editor: Klaus Hackländer

Population monitoring is an integral part of resource management and has considerable importance for species at risk or those of commercial 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 include 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 and its marking behaviour). In Europe, available evidence indicates that Eurasian otters *Lutra lutra* do not avoid sites with bridges (Romanowski et al. 1996) and often defecate near or under them (e.g. Reuther & Roy 2001, Elmeros & Bussenius 2002). However, further inquiry is required to ensure that managers in other regions can rely upon bridge surveys for population monitoring and management decision-making.

It is therefore essential that this way of selecting sampling sites 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 effective at detecting North American river otter *Lontra canadensis* occurrence when bridges instead of random sites are designated for conducting transect searches along riverbanks. Almost nothing is known about North American river otter behaviour relative to roads and bridges. The model developed by Dubuc et al. (1990) for predicting river otter occurrence on Mount Desert Island, in Maine, did not retain the variables that were accounting for dirt and paved roads in their study area. Mowbray et al. (1976) reported a few findings of otter activity signs near roads. Based on this limited available information, we hypothesized that using bridges as search sites would not adversely affect otter detection rates, and that bridge sites would yield results similar to randomly chosen sites. 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.

Material and methods

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 covered an area of 238.8 km^2 and was representative of the Maritime Coastal Plains (Desloges 1980). The topography was flat and contained 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, were tidal. Average annual temperature was 4.8 °C, average freeze-free period was 177 days and annual precipitation averaged 979 mm (Desloges 1980). The park contained 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* dominated the shores of most of the smaller streams. The study area extended into

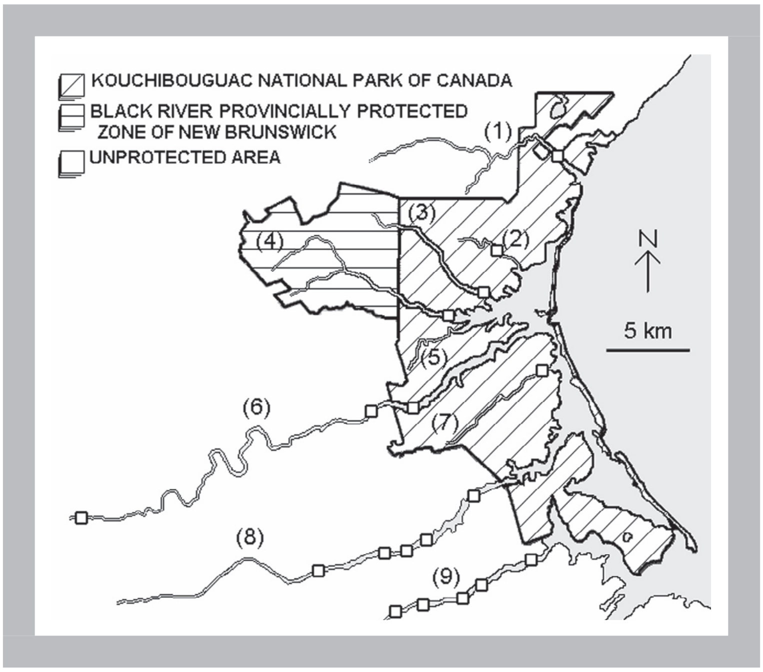

Figure 1. Location of the 18 bridges (□) in the study area comprising Kouchibouguac National Park of Canada, the Black River Provincially Protected Zone of New Brunswick, and unprotected areas in the vicinity. Major rivers and streams of the study area are: (1) Portage, (2) Carrigan, (3) Fontaine, (4)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

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 was adjacent to the park (see 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 (see Fig. 1). Salt and small gravel were spread on roads of the region in winter.

Field 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 in the winters of 2000, 2001, 2003, and 2004. We monitored river otter activity in riparian habitats by conducting wintertime transect surveys 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 hours 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 transect surveys as a team of two riders on separate machines, riding single file at slow speed along both shores of rivers and stopping to document river otter signs of activity. 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 transect surveys, with an entire day or two invested in scrutinizing each river. A typical continuous transect would take an entire day to survey, during which we would strive to survey as many kilometers of the chosen river as possible. Transects did not overlap each other within a given survey, but once all rivers and streams were searched, we resurveyed them as many times as possible within the given winter season. This maximized our ability to document river otter activity along the shores of the major watersheds in the study area (see 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. 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 used topographical maps to measure the straight-line distance (m) between bridges and the respective closest otter activity signs detected. We measured straight-line distance both upstream and downstream of bridges when activity signs were found on both sides of bridges.

Data analysis

For each field transect, 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:

$$A(x) = ax/(b + x) \quad (1),$$

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). We set the starting value at 1 for parameter estimations, with no restrictions and no limits imposed on the number of iterations. Computations were terminated and final parameter values accepted by SPSS when the relative reduction between successive residual sums of squares was < 0.00000001.

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 separate the effect of bridge from that of transect length, we created a companion set of random sites in order to investigate how results would change when random sites were used for transect searches. For each continuous transect, on each side of a bridge where otter activity signs were present as detected by the given transect, we selected a random site along the river for the companion dataset. For example, to select a random site downstream from the bridge on Portage River, we would use the random number tables in Zar (1999) 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 placed the given random site anywhere between the bridge and the river's mouth, rather than outright in the ocean. These sites were then taken to represent the center of randomly distributed transect searches for activity signs. We repeated, on an individual basis, the measurement of the distance between a random site and the closest sign of otter activity for the data of each continuous transect done in the field. The analyses were thus based on individual transect data. We compared results for scenarios using different transect lengths at these randomly chosen sites in tandem with bridge survey scenarios by applying the same non-linear regression analyses described above for bridge sites.

Because the data consisted 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. We designated distance (m) between respective bridges and their closest river otter activity sign as the dependent (i.e. response) variable and time elapsed (days) since last snowfall at the time of sampling as the independent (i.e. predictor) variable.

Results

During the winters of 2000, 2001, 2003 and 2004, we conducted 92 continuous riparian transect surveys, totalling 1,557 km of riverbank searches for river otter activity signs by repetitively surveying the study area. The network we surveyed amounted to approximately 150 km of rivers and streams (see Fig. 1). Transects averaged 6.18 km in length, with a standard error of 0.63 km. We recorded water access holes, burrows, direct sightings, faeces and snow tracks. Faeces and snow tracks were the most prevalent signs of otter activity in the landscape. 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 (see 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 closest otter activity signs were found upstream compared to downstream of bridges (Student's test: t_{59} = 1.580, P = 0.120). Therefore, we merged data from both upstream and downstream of bridges 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 statistically 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 = 1410.977-96.593x, $F_{1,59} = 1.106$, 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 Fig. 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. We converted values of these functions into percentage values before being plotted (see 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 (see Fig. 2), while the percentage of known otter presences that would have gone undetected diminished (see Fig. 3). For short to medium transect scenarios (i.e. 400-1,200 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 (see Fig. 2). Consequently, there would have been fewer undetected otter presences for searches at bridge sites (see Fig. 3) but the difference was marginal. For longer search scenarios, this

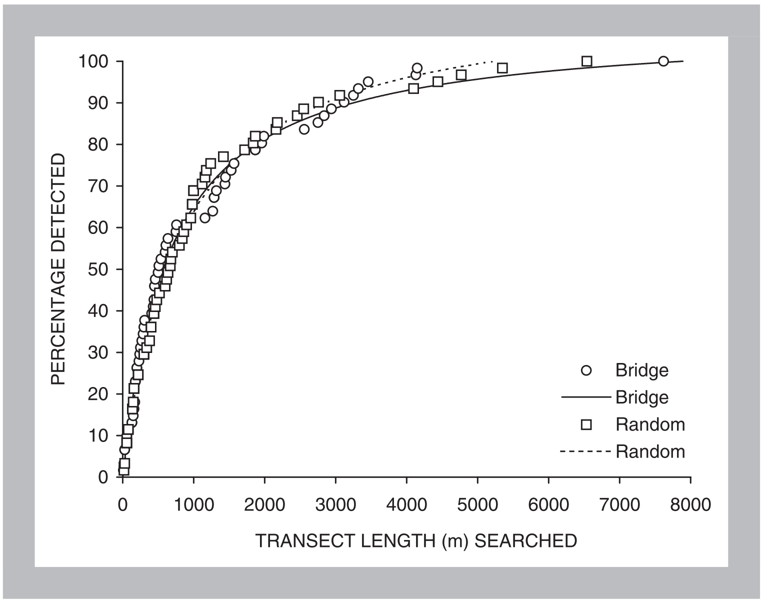

Figure 2. Cumulative percentage of known river otter presences that would have been detected as a function of various transect length scenarios for bridge locations used as search sites, A = 66.148x/(665.300 + x) and a companion set of randomly selected sites, A = 70.389x/(805.110 + x), based on data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

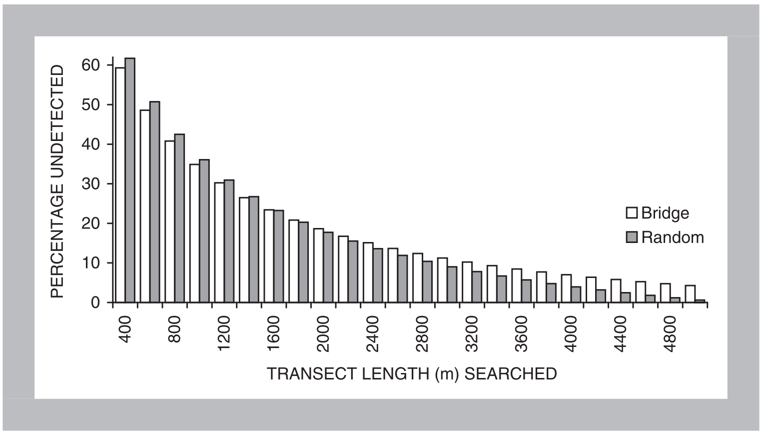

Figure 3. Percentage of known otter presences that would have gone undetected for various river otter survey scenarios, according to accumulation curves for bridge locations and a companion set of random search sites, based on data collected in Kouchibouguac National Park of Canada and surrounding area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

small difference was inversed (see Fig. 3). Overall, the survey scenarios based on bridge and random sites gave very similar results as shown by the overlapping accumulation curves (see Fig. 2). For scenarios with less than 2,000 m of search lengths, the point of largest divergence between the two curves was at 380 m, with only 2.4% of difference.

Discussion

Our study demonstrated that sign surveys using bridges as search sites can have the same capability to detect river otter presence than surveys using randomly distributed sites. Our results also suggested that river otters in our study area did not actively 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 otter occurrence. Working with Eurasian otters, Durbin (1998) found that only one of five animals studied with radio-telemetry avoided bridges. As a semi-aquatic top-level predator of riparian ecosystems, the river otter requires access to prey as well as adequate terrestrial shelter. North American river otter occurrence in the landscape has been associated with several characteristics offering shelter, such as overhanging vegetation along riverbanks and later 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 & Hornocker (1983) observed that river otters could be found at sites with anthropogenic disturbances, provided that these two essential habitat requirements (i.e. prey and shelter) 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. Detection success will depend on where bridges are located in relation to sites having habitat characteristics that meet the requirements of the otters; activity signs are most likely to occur in such places. This situation is equally relevant to surveys using randomly selected sites. The uniqueness of each potential study area precludes recommendations of definitive search distances that universally guarantee high detection rates. However, our research constitutes the first demonstration that bridges do not diminish the odds of detecting North American 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 in our data would have been detected. This relatively low detection rate for North American river otters could well have occurred for bridge surveys in other parts of North America, considering the fact that population density estimated from the 2000 data was 5.8 groups of otters per 100 km of river (M. Dumond & C.H. Bérubé, pers. comm.), and compares well with the 5.0 groups per 100 km obtained by Melquist & 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 depend on where the bridges are located in relation to habitat characteristics that otters use and this will vary from one region to another. Even with some locations with otters going undetected, bridge surveys may still be able to reflect temporal trends

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 searched (m)	Country
Macdonald & Mason 1982a	*Lutra lutra*	600	Greece
Macdonald & Mason 1982b	*Lutra lutra*	600	Portugal
Macdonald 1983	*Lutra lutra*	600	Britain and Ireland
Macdonald & Mason 1983b	*Lutra lutra*	600	Tunisia
Macdonald & Mason 1983a	*Lutra lutra*	600	Italy
Liles & Jenkins 1984	*Lutra lutra*	600	Yugoslavia
Prigioni et al. 1986	*Lutra lutra*	600-1000	Albania
Clark et al. 1987	*Lontra canadensis*	100	United-States (Georgia)
Lodé 1993	*Lutra lutra*	400	France
Brzeziński et al. 1996	*Lutra lutra*	600-1000	Poland
Shackelford & Whitaker 1997	*Lontra canadensis*	500	United-States (Oklahoma)
Reuther & Roy 2001	*Lutra lutra*	600	Germany
Elmeros & Bussenius 2002	*Lutra lutra*	300	Denmark
Bischof 2003	*Lontra canadensis*	not specified	United-States (Nebraska)
Georgiev 2005	*Lutra lutra*	< 600	Bulgaria

in river otter occurrence in the landscape, if detection rates remain stable from one survey to the next. We did not study this aspect of the performance of bridge surveys or other types of sign surveys, as it would require a long-term study to evaluate the temporal stability of detection rates. However, caution is advised if survey results are interpreted in the form of presence-absence data, as is often the case (e.g. Prigioni et al. 1986, Lodé 1993, Lee 1996, Shackelford & Whitaker 1997). Temporal fluctuations in the number of positive searches over time may not accurately reflect trends in true population size when activity signs of the surveyed species play a role in intra-specific communication and exist in a clumped distribution in the landscape (Gallant et al. 2007). Such presence-absence survey data are best used for monitoring species distribution rather than for estimating population size.

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 are not directly transposable to bridge surveys conducted in landscapes inhabited by Eurasian otters. Contrary to what we observed for North American river otters, this species frequently defecates under bridges (e.g. Romanowski et al. 1996, Reuther & Roy 2001) and most activity signs tend to be found within 100-200 m from bridges (Romanowski et al. 1996, Reuther & Roy 2001, Elmeros & Bussenius 2002). 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 1983b, 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%. Elmeros & Bussenius (2002) also remarked that not all bridges have adequate substrate under them for attracting defecation and marking by Eurasian otters.

For North American river otters, it can be argued that they may demonstrate different defecation behaviour 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 (D. Gallant, pers. obs.). This difference could be due to most bridge sites in our study being in forested areas, but our results suggest the possibility that these two otter species differ markedly in their behavioural 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 linked 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 did 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 clearly demonstrate that they do not actively avoid locations with bridges.

Management implications

Our results showed that the performance of surveys using bridges as search sites can be similar to those using randomly selected sites and that bridges do not adversely affect the odds of detecting North American river otter presence. Management decisions based on surveys that underestimate a species' presence might prompt unnecessary conservation actions. If avoidance of survey results that underrepresent North American river otter presence in the landscape is important, our results (see Fig. 2) suggest that past bridge surveys (see 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.

Acknowledgements - we are thankful to É. Tremblay and park staff at KNPC for significant and sustained logistical support for the duration of the study. We are grateful to M. Dumond, S. Martinez, B. Peters, P. Roguet, G. Daigle, S. Pouzet and M. Gallant for their assistance in collecting data. This research was funded in part by the New Brunswick Wildlife Trust Fund (C.H. Bérubé), the Faculté des Études Supérieures et de la Recherche, Université de Moncton, with Canadian Heritage Scholarships (D. Gallant), the K.C. Irving Chair in Sustainable Development (L. Vasseur), and Kouchibouguac National Park of Canada. We are grateful to J-F. Robitaille, M-A. Villard, and S. Reebs for valuable suggestions made to an earlier draft of this manuscript. We also thank K. Hackländer and two anonymous reviewers for comments that helped improve the manuscript.

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