FACTORS AFFECTING THE DETECTABILITY AND DISTRIBUTION OF THE NORTH AMERICAN RIVER OTTER

by

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B.S., University of Idaho, 2005

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Division of Biology
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2009

Approved by:

Major Professor
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Abstract

The North American river otter (*Lontra canadensis*) was extirpated throughout much of its range but is now recovering in many areas. Consequently, there is a need to determine river otter occupancy and habitat associations. We conducted sign surveys from January to April 2008 and 2009 in eastern Kansas to assess how local- and landscape-scale habitat affects river otter occupancy and how survey methods and habitat affect the detectability of river otter sign. Multiple observers surveyed 3-9 400-m stretches of stream and reservoir shorelines for 110 randomly-selected sites and measured local-scale (within a 100 m buffer of site) habitat variables (e.g., stream order, sinuosity, proportion of land cover types) and landscape-scale (Hydrological Unit Code 14 watershed) habitat variables (e.g., road density, shoreline diversity, proportion of land cover types). We then modeled occupancy and detection probability as a function of these covariates using Program PRESENCE. The overall probability of occupancy accounting for detection probability was 0.329. The best-fitting model indicated river otter occupancy increased with the proportion of woodland cover and decreased with the proportion of cropland and grassland cover at the local scale. The best-fitting model also indicated occupancy increased with decreased shoreline diversity, waterbody density, and stream density at the landscape scale, possibly because of the influence of large reservoirs in the watershed. Occupancy was not affected by land cover or human disturbance at the landscape scale, perhaps due to our relatively homogeneous study area or because river otters are habitat generalists. Detection probability for 400-m surveys was highest in mud substrates ($p = 0.600$) and lowest in snow ($p = 0.180$) and litter substrates ($p = 0.267$). Detection probability for scat was more than double that for tracks, and detection probabilities were 17-64% lower for novice observers than experienced observers. Detection probability also increased with survey length. Sign surveys are a useful technique for

monitoring many species, including river otters, and accounting for detection probability will improve estimation of occupancy. Furthermore, understanding the ecological factors and the scale important to river otter occurrence will be useful in identifying areas for restoration and management efforts.

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Acknowledgements

This work would not have been possible without the mentoring, friendship, and support of my advisor, Dr. Craig Paukert. I appreciate him taking me on as a student (in spite of the fact that he is a fish squeezer), and his constant teasing about a project based on “poo” made for a laugh in every conversation. I would also like to thank Dr. Joanna Whittier for her encouragement and guidance. In particular, her assistance with GIS and other computer issues saved me from spinning my wheels too often. Much appreciation goes to Dr. Philip Gipson and Dr. Brett Sandercock for their involvement, comments, and suggestions throughout this project, as well as many thanks to the faculty, staff, and students whom I have worked with at Kansas State University and the Division of Biology. I have created lasting friendships with so many of you. And as a special note to Andrea Severson, Derek Moon, Joe Gerken, Wes Bouska, Rachel Pigg, Kristen Pitts, Josh Schloesser, and others in the Kansas Cooperative Fish and Wildlife Research Unit: thanks for always keeping Leasure Hall interesting and fun.

I would like to acknowledge the Kansas Department of Wildlife and Parks for providing funding for this project. In particular, the state furbearer biologist, Matt Peek, answered many questions and provided a steady reminder of the value and utility of this research. Numerous thanks to my technicians, Matthew Jeffress (plus Race the dog) and Kevin Blecha, and undergraduate researcher, Brandon Tristch, who spent many days in the cold and mud just to feel lucky to find an otter latrine or track. I am also grateful for the many cooperative landowners who gave us permission to access the streams and reservoirs on their property. And last but certainly not least, I appreciate my family and friends for their love and support throughout the last two years and beyond. This Idaho mountain girl would have been lost on the prairies of Kansas without you!

Dedication

I am extremely thankful to my father, Rick Shardlow, and fiancé, Matthew Jeffress, for fueling my passion about natural resources and for supporting and inspiring me. Therefore, I dedicate this work to them.

Preface

This thesis was formatted for submission to the *Journal of Wildlife Management*. Although I am the primary author, this thesis is written as a publication from multiple authors.

CHAPTER 1 - Introduction

There is overwhelming cause for concern regarding the reduction and extinction of many species. However, some formerly extirpated species are making a comeback. This is the case for the North American river otter (*Lontra canadensis*), where the species is recovering throughout much of its range due to reintroduction efforts and targeted conservation by wildlife management agencies (Ralls 1990, Raesly 2001). Yet, with this accomplishment comes a need to monitor and evaluate river otter populations to ensure proper management and continued restoration success (Gros et al. 1996). Noninvasive surveys are growing in utility and popularity to obtain information on the distribution and status of many wildlife species, particularly for rare or elusive carnivores (Long and Zielinski 2008). However, many wildlife surveys fail to account for imperfect detection, possibly biasing estimates and inferences from survey data. Improved methods are now available that use detection probabilities to improve estimates of site occupancy and knowledge of wildlife-habitat relationships (MacKenzie et al. 2006).

Understanding wildlife-habitat relationships is critical to wildlife conservation and management. Johnson (1980) hypothesized that animals select resources at several hierarchical spatial scales and that species can respond to attributes at these scales differently (Pearson 1993, Bissonette 1997). Large-scale landscape features have been shown to be most important to habitat use by some species while local-scale habitat may be more influential for others. Furthermore, it is common for wildlife to respond to attributes at multiple scales (Pearson 1993, Pedlar et al. 1997). Due to scale-dependent habitat associations, wildlife and habitat restoration, management, and planning are most effective when conducted at several scales (George and Zack 2001). Currently, little is known about the habitat use and importance of scale for the reintroduced and expanding populations of river otters, particularly in the Midwest U.S. (Boege-Tobin 2005).

The goal of this research was to assess the distribution and habitat associations of river otters in Kansas and to evaluate the sign survey methodologies commonly used to study river otters. Specifically, we aimed to 1) assess the influences of substrate type, sign type, observer differences, survey length, and proximity to access points (e.g., bridges and boat launches) on detection probabilities of river otters from sign surveys, and 2) evaluate the influence of local- and landscape-scale factors on occurrence of river otters. Results will be used to improve sign survey methodologies for wildlife and provide a better understanding of the factors and scale important to river otter occupancy for continued restoration and management.

This thesis is organized into 4 chapters with the first being this introduction to the study. In Chapter 2, we evaluate the detection probability of river otter sign during surveys and individually examine the effects of potential influencers. In Chapter 3, we look at the effects of habitat factors at 2 spatial scales and present the factors with the greatest influence on river otter occurrence. The last chapter, Chapter 4, is a summary of findings with conclusions and recommendations from our study results.

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CHAPTER 2 - Factors affecting the detectability of river otters during noninvasive sign surveys

Mackenzie Shardlow

Abstract

Scientifically sound monitoring programs and research projects are critical for successful wildlife restoration and management. Sign surveys are a popular, low-cost, noninvasive method used to study and monitor numerous wildlife species, including the North American river otter (*Lontra canadensis*). However, sign surveys have received criticism if they cover short distances during a single visit, which can lead to a lack of accountability for false absences (i.e., concluding a species was absent when it was present but undetected). Multiple observers surveyed for river otter sign over 3-9 400-m stretches of stream and reservoir shorelines for 110 randomly-selected sites in eastern Kansas from January to April 2008 and 2009 to determine if detection probability differed among substrates, sign type, and individual observers. We estimated detection probabilities (p) of river otters from sign surveys using occupancy models in Program PRESENCE. Our results indicated a relatively low mean detection probability (p = 0.34) for 400-m surveys among all habitats and substrates. However, mean detection probability was highest in mud substrates (p = 0.60) and lowest in snow (p = 0.18) and leaf litter substrates (p = 0.27). Scat had a higher detection probability (p = 0.53) than tracks (p = 0.18), and experienced observers had higher detection probabilities (p > 0.71) than novice observers (p < 0.55). Detection probabilities increased almost 3-fold as survey length increased from 200 m to 1,000 m, and otter sign was not concentrated near access points such as bridges. Accounting for imperfect detections and the factors affecting detection probability will improve occupancy estimations and analysis of wildlife-habitat relationships.

Introduction

Sign surveys measure spatial patterns of animals based on the detection or non-detection of animal tracks, feces, or other signs of animal presence and are a popular noninvasive, inexpensive, and relatively easy method to study animal distributions, habitat selection, behavior, abundance, and diet (Medina 1997, Ben-David et al. 1998, Heinemeyer et al. 2008). Sign surveys have been used for many species from elk (*Cervus elaphus*; Weckerly and Ricca 2000) and rhinoceroses (*Dicerorhinus sumatrensis*; Flynn and Abdullah 1984) to tortoises (*Gopherus agassizii*; Turner and Berry 1984) and rabbits (*Brachylagus idahoensis*; Rachlow and Svancara 2006), and are popular for carnivores (MacKay et al. 2008). Carnivores have unique social behaviors and often leave easily identifiable tracks and droppings that serve as evidence of their presence and possible territorial boundaries. Furthermore, sign surveys have been used extensively to study populations of otters (Lutrinae), including the North American river otter (*Lontra canadensis*) and the European otter (*Lutra lutra*; Lodé 1993, White et al. 2003, Olson 2006, Romanowski 2006).

Several types of sign surveys can be conducted for river otters including ground and aerial snow track surveys (Reid et al. 1987, Martin 2007), scent-station surveys (Humphrey and Zinn 1982, Foy 1984, Clark et al. 1987), and sign surveys for scat, latrines, and tracks, which are often focused at bridges or other shoreline access points (Shackelford and Whitaker 1997, Swimley et al. 1998). Sign surveys have been used to evaluate river otter distribution (Chromanski and Fritzell 1982), habitat preferences (Dubuc et al. 1990, Newman and Griffin 1994), and relative abundance (Reid et al. 1987, Shackelford and Whitaker 1997, Gallagher 1999).

Large-scale distribution and status information for North American river otter populations is difficult to obtain and has typically been limited to short-distance, single-visit "presence-absence" surveys (Long and Zielinski 2008). Consequently, the utility of presence-absence surveys has been debated due to a lack of accountability for false absences, which occur when a species is determined to be absent from a site but was actually present just not detected. Now these surveys are more properly being called "detection-nondetection" surveys (Ruiz-Olmo et al. 2001, MacKenzie et al. 2006, Evans et al. 2009). False absences can result in biased estimates of occupancy, underestimation of population size, and misrepresentation of important habitat variables (MacKenzie and Nichols 2004, Mazerolle et al. 2005, Pagano and Arnold 2009). Methods are now available to account for imperfect detection by measuring the detection probability, which is the probability of detecting a species during a survey given the site is occupied. Additionally, researchers can examine the factors influencing the detection probability, such as weather, time of day, and habitat structure (MacKenzie et al. 2006). Therefore, it is likely the detection probability of river otter sign in past sign surveys was <1, which, if left unaccounted for, may lead to errors in occupancy estimation for river otters (Ruiz-Olmo et al. 2001, Gallant 2007, Evans et al. 2009).

Substrate composition is an important factor in detection of animal sign (Murie and Elbroch 2005, Lowery 2006, Young and Morgan 2007) but studies that use sign surveys often do not account for potential substrate differences in their analysis (Clark et al. 1987, Shackelford and Whitaker 1997). Techniques for river otter sign surveys vary and surveys may focus on only a single sign type (i.e., scat or tracks; Reid et al. 1987, Lodé 1993, Evans et al. 2009). Therefore, detection probability of the sign of interest is important to consider. Additionally, wildlife surveys often rely upon trained observers to collect field data (Wilson and Delahay 2001, Evans et al. 2009), but recent studies have noted differences in observers' ability to detect animals or animal sign (Freilich and LaRue 1998, Conway and Simon 2003, Evans et al. 2009, Pagano and Arnold 2009, Russell et al. 2009). For example, Pagano and Arnold (2009) found that experienced observers had 12% higher detection probabilities than inexperienced observers for detecting 8 species of prairie-nesting ducks on ground-based waterfowl surveys. Consequently, the possibility of an observer overlooking sign and this leading to false-absences is high and every attempt should be made to account for this source of bias (Evans et al. 2009).

Since time, personnel, and funding are limited, wildlife surveyors are forced to choose between allocating more effort to search each site and surveying more sites (MacKenzie et al. 2006). Consequently, understanding how detection probabilities vary by search effort can help determine an optimal sampling design. Sign surveys tend to vary in length which may affect conclusions of occupancy and distribution based on these surveys. Surveys can be conducted on one or both sides of the stream shoreline, upstream and/or downstream of an access point, and at lengths from 200 m (Clark et al. 1987, Eccles 1989, Shackelford and Whitaker 1997) to 1,200 m (Roberts et al. 2008), with 600 m being most common (Mason and MacDonald 1987, Ostroff 2001, Bluett et al. 2004). Gallant et al. (2008) suggested that surveys be conducted over longer distances to increase detection rates. Although Mason and Macdonald (1987) attempted to predict the occurrence of European otter sign for up to 1,000 m with results from shorter surveys using logistic regression, no one has shown how detection probability improves with increased distances based on actual survey results.

Finally, many otter surveys are conducted near bridges due to their ease of access to shorelines (Clark et al. 1987, Shackelford and Whitaker 1997, Bischof 2003). However, bridges and other anthropogenic structures are not random sites and may influence the animal's behavior regarding marking and its use of the site. River otters may actually prefer to mark near or under bridges (Reuther and Roy 2001, Elmeros and Bussenius 2002), while Gallant et al. (2008) found that bridges had the same detection results as random shoreline searches. Therefore, surveys that focus on bridges may or may not affect detection probabilities for sign.

Occupancy modeling techniques incorporate detection probability through multiple visits in time and/or space to a survey site (MacKenzie et al. 2002). Although this technique has increased in popularity in recent years (Long and Zielinski 2008), the approach has not been applied to sign surveys for river otters. Determining current occupancy rates that correct for detection probability and the factors that affect these measurements will improve the current assessment of river otter distribution and our understanding of its habitat associations. Additionally, conducting systematic surveys over time is important to species monitoring, management and conservation (Gallant 2007) and efforts should be made to continually evaluate and improve methodologies (Yoccoz et al. 2001).

Our objective was to evaluate factors that affect detection probability of river otters from sign surveys. We predicted that substrates that tend to camouflage scat and tracks (i.e., leaf litter, grass) would have lower detection probabilities compared to open, muddy areas. We also predicted that the 2 common sign types, scat/latrines and tracks, would have different detection probabilities which could be confounded by different substrate types. By comparing the detection probabilities of individual observers, we can understand the frequency of false absences and determine if skill level of observers affects detection probability. We also sought to evaluate survey lengths and the effect of distance from access points to help identify optimal survey procedures.

Study Area

We conducted river otter sign surveys across the eastern third of Kansas (approx. 54,000 km^2) from the Missouri border running west to approximately Manhattan, KS (96.6°W), and between the borders with Nebraska and Oklahoma (Appendix A.1). The study area ranged in elevation from 204 m to 510 m and consisted of 5 Level III ecoregion classifications (Omernik 1987), including the Central Irregular Plains in the east, Flint Hills in the west, and Western Corn Belt Plains in the north. The area is predominately rural (> 95%) with 2 city populations >100,000 (Kansas City and Topeka; U.S. Census Bureau 2007). Grassland was the dominant land cover (56.3%), followed by cropland (25.4%) and woodland (11.1%). River otters are classified as a furbearer in Kansas but are not currently targeted for harvest.

Methods

Survey methods and design

We sampled 14-digit USGS Hydrological Unit Code (HUC 14) watersheds, which are a subwatershed classification generally ranging in size from 4,000 to 16,000 ha (Laitta et al. 2004). Watersheds containing a third order stream or higher and/or reservoirs with shorelines ≥3,600 meters (Dubuc et al. 1990, Kiesow and Dieter 2005, Barrett 2008) were selected as potential survey sites resulting in 529 watersheds available for sampling. First and second order streams were excluded from sampling due to their small size and low frequency of otter use (Prenda et al. 2001, Kiesow and Dieter 2005, Barrett 2008). Surveys began at bridges, low-water crossings, or locations where water was adjacent to a roadway, such as boat launches (Lodé 1993, Romanowski et al. 1996, Shackelford and Whitaker 1997, Bischof 2003, Barrett 2008). We conducted 3-9 continuous 400 m long x 5 m wide surveys for a total of 1,200-3,600 m of a shoreline, depending on access to private lands. Surveys were conducted on one side of the shoreline either upstream or downstream of the start point, which was determined by landowner permission or a coin toss.

We conducted sign surveys between 9 February and 13 April 2008 and 28 January and 8 April 2009. The late winter and early spring months are a common survey time because 1) it is the breeding season for river otters and when scent marking activity at latrines is highest, 2) differentiation of otter and raccoon (*Procyon lotor*) scat is easier due to different diets (i.e., otter scat is primarily composed of fish scales while raccoon scat is often a compilation of item including seeds and vegetation), and 3) vegetation density is lower than in other months making sign more visible (Swimley et al. 1998, Ostroff 2001). Sites sampled within the same year were kept ≥16 stream km apart while different year sites were kept ≥8 stream km apart to ensure spatial independence based on average home range sizes and past otter surveys in the Midwest (Shackelford and Whitaker 1997, Barrett 2008). Sites were not sampled within 2 days of measureable precipitation (>0.2 cm) to avoid sign degradation (Clark et al. 1987, Shackelford and Whitaker 1997, Barrett 2008).

Personnel conducting sign surveys were trained for 1 day in the field in sign identification before conducting surveys, and only sign that the observers recorded as definitive otter sign (recorded as 75-100% confident) was included. Locations of all tracks (≥1 foot track) and scat/latrine (≥1 piece of scat) and their descriptions (e.g., type, size) were recorded. Dominant substrate type (i.e., vegetation, mud, rock, litter, and snow) was visually estimated for every 400-m survey. Mean search time for sign was 18 minutes per 400-m survey. A subset of sites (n = 19) were surveyed with independent multiple (2-3) observers (4 different observers total) of 2 experience levels, novice (surveyed 7-20 sites) and experienced (surveyed 49-81 sites), for our assessment of observer effects on detection probability. All multi-observer surveys were conducted during the same day and observers either walked opposite ends of the survey or were spaced by time and distance to ensure independence.

Data analysis

We conducted 5 separate analyses to test our hypotheses. We developed several sets of *a priori* candidate models based on our experience and the literature to analyze the effects of substrate, sign type, observer, and proximity to access points on river otter sign detection probability (p). The probability of occupancy (ψ) was held constant across time and space in all models, and all models included the intercept on both ψ and p. Our simplest model represented one in which the probability of occupancy and the probability of detection were constant across all substrates, shoreline surveys, and habitat types ($\psi.\ p.$). We transformed all continuous covariates except for proportions using z-transformations and treated remaining covariates as dummy variables with values of 0 or 1 (Donovan and Hines 2007). All analyses were conducted using the PRESENCE Version 2.3 (Hines 2006).

We performed a single-season, single-species, custom occupancy estimation to evaluate the effect of substrate type on detection probability. We subdivided the 1,200 – 3,600 m sites into 400-m surveys for our detection replicates. The 2 models evaluated were substrate effect on detection probability ($\psi.\ p_{\text{substrate}}$) and detection probability held constant ($\psi.\ p.$). We ranked models using Akaike's Information Criterion corrected for small-sample size (AIC_c; Burnham and Anderson 2002), and used the AIC_c differences ($\Delta AIC_c = AIC_c$ – minimum AIC_c) and Akaike weights to evaluate model fit to the data. Models with $\Delta AIC_c \leq 2$ were considered competitive models (Burnham and Anderson 2002).

We then used a multi-method model to analyze the detection probabilities for the 2 sign types (scat and tracks). Multi-method models allow detection probabilities to vary for different methods of observation (i.e., sign type) and estimate an additional parameter, θ (the probability that an individual is available for detection at the site, given it is present; Nichols et al. 2008). The candidate models included effects of sign type ($\psi.\ \theta.\ p_{\text{type}}$) on detection probability, an additive effect of sign and substrate types ($\psi.\ \theta.\ p_{\text{type + substrate}}$) on detection probability, an interaction between sign and substrate types ($\psi.\ \theta.\ p_{\text{type x substrate}}$) on detection probability, and detection probability held constant ($\psi.\ \theta.\ p.$). We held ψ and θ constant for all of these candidate models.

To analyze the differences among observers, we used observers as replicates for each 400-m survey. Our candidate models for this analysis included effects of observer on detection probability ($\psi.\ p_{\text{observer}}$) and detection probability held constant ($\psi.\ p.$). We examined the differences in detection probabilities by survey length by running 5 additional analyses based on the encounter histories for 200, 400, 600, 800, and 1,000 m surveys. Given that we surveyed a total of 1,200-3,600 m of continuous shoreline for each site, a 200 m survey length had ≤18 survey replicates whereas a 1,000 m survey length had ≤2 survey replicates. We then used the simplest model ($\psi.\ p.$) to estimate the probability of detection for each survey length and compared these rates as survey length increased. Finally, we tested whether sign was concentrated near access points by comparing 2 models: 1) detection probability varying by 400-m survey ($\psi.\ p_{\text{survey}}$) and 2) detection probability held constant across all 400-m transects ($\psi.\ p.$).

We made 3 assumptions for our analysis. First, we assumed that river otter sign was never falsely detected. Second, we assumed that detection of sign at a point was independent of detecting sign at other points. Lastly, these single-season occupancy models assume the population is closed (MacKenzie et al. 2002). The closure assumption may not be met with large mammals with variable home ranges, however it can be relaxed if movement in and out of a sample area during the survey season is random (MacKenzie et al. 2004, Longoria and Weckerly 2007).

Results

One hundred and ten sites were surveyed over a 2-year period (46 in 2008; 64 in 2009). We detected otter sign at 35 sites resulting in a naïve estimate of occupancy of 0.318. Based on a model with all parameters held constant, our probability of river otter occupancy was 0.329 (SE 0.046) and our overall probability of detection was 0.337 (SE 0.029) per 400-m survey. All 110 sites were used to assess the effects of substrate type on detection probability and our best fit model included substrate. However, when the sign types were separated and analyzed by substrate, the best fit model included only the effect of sign type on detection probability. A total of 165 400-m surveys were conducted by at least 2 observers and our best fit model showed an observer effect on detection probability. Experienced observers had up to 5-fold higher detection probabilities than inexperienced observers. Candidate models and their rankings are presented in Table 2.1.

For the substrate analysis, the best fit model included a substrate effect on the detection probability. The mud substrate had the highest detection probability (p = 0.600; SE 0.075) and leaf litter (p = 0.267; SE 0.037) and snow substrates (p = 0.180; SE 0.116) had the lowest detection probabilities (Figure 2.1). For the sign type analysis, the best fit model included detection probability varying by sign type. Scat had an overall detection probability of 0.532 (SE 0.063) while tracks were only 0.180 (SE 0.035). Although not a competing model (ΔAIC_c = 3.17), the model including the interaction of sign and substrate type suggested that scat and tracks could be affected by the substrate type differently. Scat detection appeared highest in mud ($p = 0.755$; SE 0.100) and rock ($p = 0.577$; SE 0.172) and lowest in snow ($p = 0.370$; SE 0.229; Figure 2.2). Conversely, track detection was highest in vegetation ($p = 0.297$; SE 0.086), litter ($p = 0.160$; SE 0.047), and mud (0.137; SE 0.065) and lowest in rock ($p = 0.064$; SE 0.063). No tracks were found in snow substrates and snow was the dominant substrate for only 2.1% of surveys.

The 2 experienced observers were used to survey all sites for a given year while the 2 novice observers were used as secondary observers for a subset of sites. The best fit model for the observer analysis included an observer effect on detection probability. Experienced observers had the highest detection probabilities ($p = 0.782$; SE 0.132 and $p = 0.714$; SE 0.132; Figure 2.3). Of the novice observers, one was slightly lower than the experienced observers ($p = 0.545$; SE 0.101) while the other observer was lower than the others despite the same amount of training ($p = 0.145$; SE 0.078).

Detection probability was lowest for the 200 m surveys ($p = 0.227$; SE 0.018) and highest for the 1,000 m surveys ($p = 0.608$; SE 0.061; Figure 2.4). Detection probability increased nearly linearly as the survey length increased, with an average increase of 0.048 for every additional 100 m. The precision of the detection probability estimates decreased as the survey length increased because longer surveys resulted in fewer survey replicates. Finally, the detection probability did not appear to be affected by the proximity to the access point, with the best fit model including both occupancy and detection probability held constant ($\psi.\ p.$).

Discussion

Our study is the first to report use of spatial replication to assess detection probability for river otter sign surveys which allowed us to examine multiple factors that may affect detection probability. Our overall detection probability was 0.337 for a 400-m survey; meaning that when the species was present it was detected about a third of the time. Two primary sources of bias in detection of animals or their sign are perception bias and availability bias (Alpízar-Jara and Pollock 1996). Perception bias occurs when the observer(s) fail to detect the animal or sign during a survey, whereas availability bias happens when the observer cannot see the object, such as in cases where it hidden (Alpízar-Jara and Pollock 1996, Anderson 2001, Martin 2007). Our results indicated the presence of both perception bias caused by observer differences and availability bias due to substrate type, sign type, and survey length, which influenced the probability of detecting river otters during sign surveys.

Tracks had an overall detection probability that was almost 3 times lower than scat, which is cause for concern because track surveys are common for many species. Track surveys in dust and mud have been used for raccoon (Heske et al. 1999), mountain lion (*Puma concolor*; Smallwood and Fitzhugh 1995), and striped skunk (*Mephitis mephitis*; Engeman et al. 2003), and are commonly used in arid regions outside of North America (Heinemeyer et al. 2008). Track surveys in the snow are also common for northern ranging species like the wolverine (*Gulo gulo*; Ulizio 2005) and Canada lynx (*Lynx canadensis*; McKelvey et al. 2006), and both track surveying methods (snow and mud surveys) have been used in several otter studies (Ruiz-Olmo et al. 2001, Martin 2007, Evans et al. 2009). For example, Martin (2007) argued that otter snow tracks located from the air were easy to distinguish from tracks of other species and easier to find than latrine sites. However, the quality of snow and mud as tracking mediums could be affected by recent weather activity and many of these substrates are often not consistently available and have limited use for wide-spread systematic surveys (Heinemeyer et al. 2008).

In our study, more uniform substrates such as mud allowed for greater visibility and had higher detections for scat. As with tracks, scat has been the focus of several otter surveys (Mason and Macdonald 1987, Swimley et al. 1998, Maxfield et al. 2005) as well as for other species, such as American mink (*Mustela vison*; Bonesi and Macdonald 2004), swift fox (*Vulpes velox*; Harrison et al. 2004), and coyotes (*Canis latrans*; Prugh et al. 2005). Future survey efforts should focus on both sign types to maximize detections or use multi-method occupancy models while accounting for the potential substrate effects on detection probability of sign.

Detection probabilities varied by observer and were lower for novice observers than experienced observers. Our results conflict with those of Freilich and LaRue (1998) who found variability among observers' ability to find tortoises and their sign but could not be attributed to experience level. However, other studies have suggested observer experience can affect detection probability (Sauer et al. 1994, Laake et al. 1997, Pagano and Arnold 2009). Therefore, we suggest observers practice surveys to gain field survey experience and that at least a subset of sites be surveyed by multiple observers in order to correct for observer differences in all surveys.

The single-season occupancy models we used allow for false absences but not false presences (Royle and Link 2006). Observers can misidentify otter tracks and scat which may result in concluding the species is present when it is actually absent, and these errors could bias estimates of occupancy (Royle and Link 2006, McElwee 2008, Evans et al. 2009). Freilich and LaRue (1998) determined that observers overestimated numbers of tortoise burrows and McElwee (2008) found observers often confused raccoon and river otter scat. However, we only included sign that the observer ranked as certain otter sign to minimize bias from misidentification. Still, we suggest that observers be thoroughly trained and tested on scat and track identification. For example, Evans et al. (2009) used a standardized tracker evaluation program and documented improvement in observer skills after a training course. Genetic testing could be used to verify scat specimens (McElwee 2008), and scat detection dogs have been shown to be effective at locating scat from other carnivore species while ignoring non-target species (Long et al. 2007). Furthermore, if the frequency of false positives can be estimated, a recently developed misclassification occupancy model that allows for both false negatives and false positives could be used for analysis (Royle and Link 2006).

Detection probability increased almost 3-fold as survey length increased from 200 m to 1,000 m. Mason and Macdonald (1987) found that 69% to 79% of positive sites for otter sign were within the first 200 m of a survey, but our results showed a detection probability of only 0.23 for the same length. Mason and Macdonald (1987) also determined that extending surveys from 600 m to 1,000 m might increase the detection by 6-12%, which is relatively similar to our study where we found an increase of 19% with the same changes to length. Survey lengths of 200 m -1000 m had detection probabilities between 0.2 and 0.8, which are considered reasonable when determining the size of site to survey (MacKenzie et al. 2006). Consequently, this information can be used by future researchers when deciding how to allocate survey effort. Our results support the conclusions of Gallant et al. (2008) in that otter activity based on sign is neither higher nor lower at access points than other stretches of shoreline, and sampling at or near bridges does not likely bias survey results.

Past wildlife sign surveys have often failed to account for imperfect detection of species and refining survey and analysis methods may lead to less biased estimates of occupancy. However, additional factors may have affected river otter sign detection probability, such as waterbody type (Ruiz-Olmo et al. 2001) or population size (Kéry 2002). We encourage continued development of sign surveys to refine methods and suggest future studies conduct longer surveys with spatial and/or temporal replication, account for differences in substrate types and observers, and record both sign types. Our results may be used to help improve sign survey methodologies and to develop a standardized river otter survey protocol. A standardized protocol would allow for easier comparison of sign survey results and improve our understanding of the species occupancy rates and habitat associations at larger scales. Furthermore, our results could be applied to other species commonly sign surveyed and could be expanded to collect information on multiple species to provide more information about the biotic system with minimal additional effort.

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Table 2.1. The model sets and rankings for evaluating covariate effects on detection probability (*p*) based on 400-m river otter sign surveys conducted in eastern Kansas, USA, 2008-2009. The probability of occupancy (ψ) and the probability that individuals are available for detection conditional upon presence (θ) were both held constant across time and space. Information presented for each model includes the number of parameters (*K*), deviance, Akaike's Information Criterion corrected for small sample size (AIC_c), the difference between the model AIC_c and the best fit model AIC_c (ΔAIC_c), and the Akaike weight of the model (w_i).

Model structure	K	Deviance	AIC_c	ΔAIC_c	w_i
Substrate (n = 110)					
$\psi.\ p_{\text{substrate}}$	6	500.8	513.6	0.0	0.986
$\psi.\ p.$	2	518.0	522.1	8.5	0.014
Sign type and substrate (n = 110)					
$\psi.\ \theta.\ p_{\text{sign type}}$	3	688.5	694.7	0.0	0.790
$\psi.\ \theta.\ p_{\text{sign type x substrate}}$	11	673.2	697.9	3.17	0.162
$\psi.\ \theta.\ p_{\text{sign type + substrate}}$	7	685.2	700.3	5.58	0.049
$\psi.\ \theta.\ p.$	2	731.2	735.3	40.6	0.000
Observer (n = 165)					
$\psi.\ p_{\text{observer}}$	5	239.3	249.7	0.0	0.997
$\psi.\ p.$	2	257.3	261.4	11.7	0.003
Access point bias (n = 110)					
$\psi.\ p.$	2	518.0	522.1	0.0	0.984
$\psi.\ p_{\text{survey}}$	10	508.1	530.3	8.2	0.016

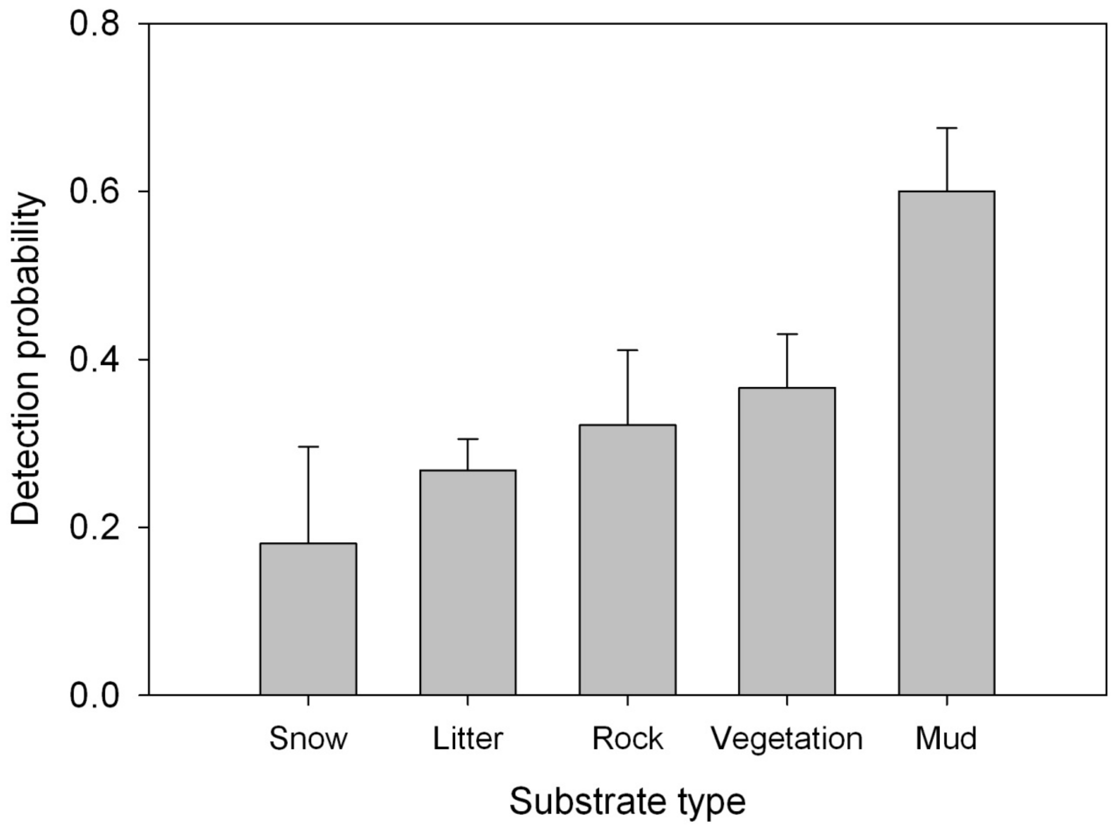

Figure 2.1. The probability of detecting river otter sign by substrate type for 400-m surveys conducted in eastern Kansas, USA, 2008-2009. Error bars represent one standard error.

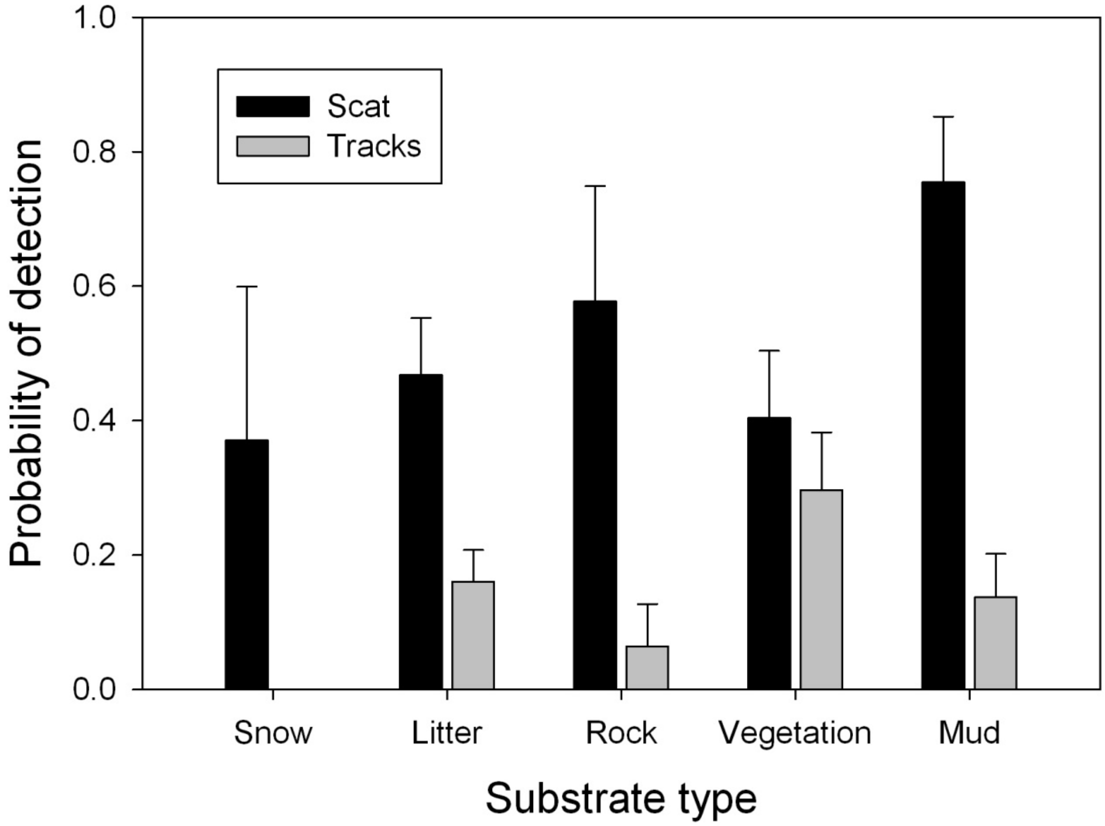

Figure 2.2. The probability of detecting river otter scat and tracks varying by substrate type per 400-m survey conducted in eastern Kansas, USA, 2008-2009. No tracks were found in snow. Error bars represent one standard error.

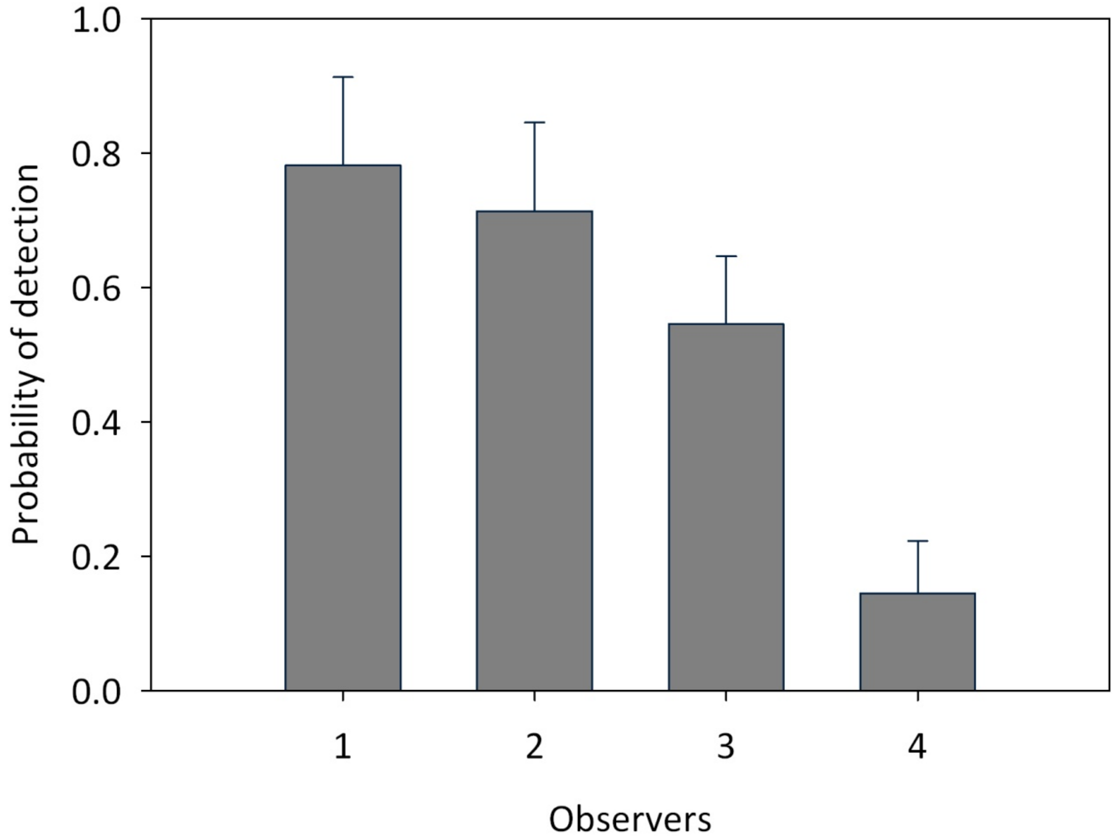

Figure 2.3. The probability of detection by observer for 400-m river otter sign surveys conducted in eastern Kansas, USA, 2008-2009. Observers 1 and 2 were experienced observers (surveyed 49-81 sites) while observers 3 and 4 were novice observers (surveyed 7-20 sites). Error bars represent one standard error.

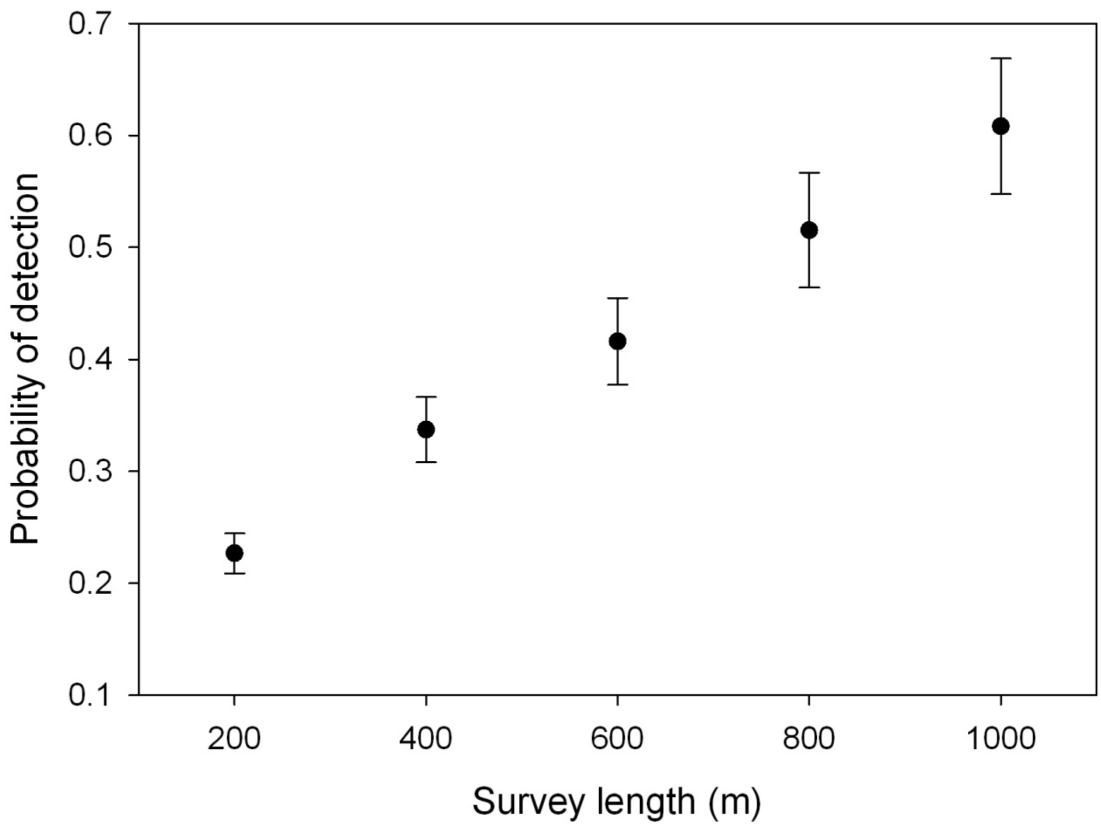

Figure 2.4. The probability of detection for 5 incremental survey lengths as estimated from river otter sign surveys conducted in eastern Kansas, USA, 2008-2009. Error bars represent one standard error.

CHAPTER 3 - Scale-dependent factors affecting river otter distribution in Kansas

Mackenzie Shardlow

Abstract

The North American river otter (*Lontra canadensis*) is recovering from near extirpation throughout much of its range. Although reintroductions, trapping regulations, and habitat improvements have led to the reestablishment of river otters in the Midwest, little is known about how their distribution is influenced by local- and landscape-scale habitat. Sign surveys are a common method for determining carnivore presence but past surveys have often failed to account for false absences, possibly biasing estimates of population parameters and inferences from wildlife-habitat models. We conducted river otter sign surveys from January to April in 2008 and 2009 in eastern Kansas to assess how local- and landscape-scale habitats affect river otter occupancy. We surveyed 3-9 400-m stretches of stream and reservoir shorelines for 110 sites and measured local-scale variables (e.g., stream order, land cover types) within a 100 m buffer of the survey site and landscape-scale variables (e.g., road density, land cover types) for Hydrological Unit Code 14 watersheds. We then used occupancy models that account for the probability of detection to estimate occupancy as a function of these covariates using Program PRESENCE. The best-fitting model indicated river otter occupancy increased with the proportion of woodland cover and decreased with the proportion of cropland and grassland cover at the local scale. Occupancy also increased with decreased shoreline diversity, waterbody density, and stream density at the landscape scale. Occupancy was not affected by land cover or human disturbance at the landscape scale. Understanding the factors and scale important to river otter occurrence will be useful in identifying areas for management and continued restoration.

Introduction

The North American river otter (*Lontra canadensis*) historically occupied most of North America (Toweill and Tabor 1982), but by the early 1900's, overharvest, habitat loss, and water pollution reduced river otter populations to less than 33% of their historic range in the contiguous 48 states (Nilsson and Vaughn 1978, Toweill and Tabor 1982, Larivière and Walton 1998). Concerns about population declines and extirpation of a species with ecological, economic, cultural, and aesthetic importance led many management agencies, including those in the Midwest, to initiate restoration programs in the 1980's (Raesly 2001). Over the past 30 years, >800 otters from several regions have been released into Missouri, 159 in Nebraska, 14 in Oklahoma, and 17 in Kansas (Fleharty 1995, Shackelford and Whitaker 1997, Gallagher 1999, Bischof 2003). Reintroductions, immigration from neighboring areas, habitat improvement, and stringent harvest regulations are credited with the reestablishment of the species to 90% of their historic range in the U.S., making for one of the most successful carnivore reintroductions in history (Raesly 2001, Melquist et al. 2003, Roberts et al. 2008).

River otters were believed to be common along all the major streams and rivers in Kansas during the early 1800's, but the last reported otter was trapped near Manhattan in northeastern Kansas in 1904 (Lantz 1905, Bee et al. 1981). Efforts to restore the river otter to Kansas began when Kansas Department of Wildlife and Parks released 17 river otters from Minnesota and Idaho into the South Fork of the Cottonwood River in Chase County, Kansas, from 1983-1985 (Fleharty 1995). River otters are classified as a furbearer in Kansas but there is currently no open harvest. Incidental trappings, roadkill carcasses, anecdotal sightings and results from limited sign surveys (Eccles 1989, Ostroff 2001) confirm that otters are present in Kansas, but little is known about their current distribution and how local- and landscape-level habitat affects their distribution.

The most common method to assess river otter presence and habitat associations is with sign surveys, which measure spatial patterns of animals based on the detection or non-detection of animal tracks, feces, or other sign (Raesly 2001, Heinemeyer et al. 2008). The most common sign types for otters are tracks and scat, which is often found at communal latrine sites. Several latrines are typically found throughout a river otter's home range and visitation to these sites is high (Ben-David et al. 1998). However, sign surveys often fail to account for false absences, which occur when a species is determined to be absent from a site although it was present but undetected (Ruiz-Olmo et al. 2001, MacKenzie et al. 2006, Evans et al. 2009). These false absences may lead to an underestimation of true occupancy and consequently imprecise conclusions from wildlife-habitat models (MacKenzie et al. 2002, 2006). Occupancy models have recently been developed to account for imperfect detection by incorporating estimates of detection probability and may improve inferences about species distributions and habitat relationships.

A better understanding of how habitat affects river otter occurrence can help predict areas of current and future occupancy, evaluate population trends, and identify areas for management focus and restoration. Although there have been several studies of otter habitat use, otters tend to exhibit regional differences in their habitat requirements (Melquist et al. 2003). Thus, a study that found conifers were important to river otter presence in Pennsylvania (Swimley et al. 1998) or that river otters preferred coastal marshes in Texas (Foy 1984) have limited applicability for determining river otter habitat in the Great Plains.

Additionally, the scale at which river otter occurrence is influenced by habitat is critical for proper recovery and management of the species. Johnson (1980) hypothesized that animals select resources at several hierarchical spatial scales. Studies of river otter habitat associations tend to evaluate only one habitat scale and often fail to adequately describe that scale. However, local-scale habitat may be important to river otter occurrence. For example, river otters are often associated with habitats that have denning structures produced by beavers (*Castor canadensis*; Melquist and Hornocker 1983, Dubuc et al. 1990, Waller 1992, Newman and Griffin 1994, Boege-Tobin 2005, Rosell et al. 2005). Stream channelization, water quality and land use practices can degrade aquatic food resources and reduce the availability of denning sites for river otters (Pitt et al. 2003). Griess (1987) observed that river otters tend to use waterways that are not heavily polluted, and in Europe, otter activity increased with stream order and a surrounding riparian cover of woodland and semi-natural grassland vegetation (White et al. 2003). In addition, a Kansas study found the percentage of woodland/riparian areas and the number of waterbodies within 300 m of the shoreline was positively associated with river otter presence (Ostroff 2001).

Local populations of animals are also likely affected by regional scale processes. However, the effects of variables at broader spatial scales (e.g., watersheds) have not been adequately addressed or contrasted with local-scale variables for river otters (Ricklefs 1987; Levin 1992; Barbosa et al. 2001, 2003). For example, European otters were more common in areas with a higher percentage of forest cover measured at a national scale (Robitaille and Laurence 2002). In Maine, river otter use was positively associated with watershed length and average shoreline diversity in a watershed, which can indicate an increased amount of shallow foraging habitat (Dubuc et al. 1990). Finally, human disturbance as measured by human and road densities has been shown to have a negative relationship with otter presence at regional and national spatial scales (Robitaille and Laurence 2002). Therefore, river otter distribution may be affected by land use and human disturbance at larger, landscape scales.

A primary objective of this study was to determine the factors affecting river otter distribution in eastern Kansas at 2 spatial scales, a local scale and a landscape scale. One method for identifying important scale(s) is to model sign data with occupancy models incorporating the potential relationships at multiple scales and determine which models fit the data best (Holland et al. 2004). Consequently, we developed several hypotheses regarding factors such as land cover and use, geographic location, hydrologic features, and human disturbance and their effects on the presence of river otters in eastern Kansas.

River otter occurrence has been linked to prey (i.e., fish) abundance and cover, which can be tied to the local landscape characteristics and water quality. Fishes are often more abundance in areas of woody debris (Angermeier and Karr 1984) which is linked to the amount of riparian woodland cover. In contrast, areas with increased agriculture land tend to have lower water quality and biotic integrity (Wang et al. 1997). Furthermore, the availability of cover and denning and resting sites, such as those created by beaver activity, provided by woodland riparian areas, and influenced by the land use practices have all been correlated with river otter occurrence (Newman and Griffin 1994, Swimley et al. 1998, Pitt et al. 2003). Therefore, we predicted the areas with predominant woodland and natural grassland cover type would have a higher probability of occupancy than sites that are mainly agricultural and urban land cover types. We also predicted that larger waterbodies and more sinuous and diverse shorelines would be indicative of reduced disturbance and higher prey availability and these factors would be positively associated with river otter presence. Conversely, we predicted areas with high levels of human disturbance, such as high road density and polluted waterbodies, and areas located far from possible source populations, such as Missouri and Oklahoma, which have harvestable river otter populations (Missouri Department of Conservation 2009, Oklahoma Department of Wildlife Conservation 2009), would have lower probabilities of occupancy.

Study Area

Our study area covered the eastern third of Kansas (approx. 54,000 km^2) from the Missouri border west to approximately Manhattan, KS (96.6°W), and from Nebraska south to Oklahoma (Appendix A.1). Major rivers in the study area included the Kansas River, Caney River, Little Caney Creek, Verdigris River, Neosho River, Marais Des Cygnes River, Little Osage River, and Marmaton River. The highest elevations are in the northwest portion of the study area (510 m) and the lowest elevations in the southeast (204 m). The area is predominately rural (>95%) with the Kansas City and Topeka metro areas being the largest urban areas (>100,000 people; U.S. Census Bureau 2007). The dominant land cover is grassland (56.3%) followed by cropland (25.4%) and woodland (11.1%).

Methods

Survey methods and design

Sampling effort was stratified into 7 watershed regions, which we refer to as otter units, to allow us to compare occupancy probabilities in different regions of the state. The otter units were further delineated into 14-digit U.S. Geological Survey Hydrological Unit Codes (HUC 14) watersheds that ranged in size from 4,000 to 16,000 ha (Laitta et al. 2004). Since river otter home ranges follow stream drainage patterns (Melquist and Hornocker 1983), watersheds are considered appropriate sample units and we assumed otter sign located at a site within a watershed indicated that river otters were using the watershed. Five hundred twenty-nine watersheds containing at least one third order or higher stream or reservoirs with shorelines ≥3,600 m were available for surveying. We did not survey first and second order streams due to their small size and low likelihood of river otter use (Prenda et al. 2001, Kiesow and Dieter 2005, Barrett 2008).

Surveys began at bridges, low-water crossings, or locations where water was adjacent to a roadway or access point (e.g., boat launch; Lodé 1993, Romanowski et al. 1996, Shackelford and Whitaker 1997, Barrett 2008). Sites with public land access were given preference to reduce the amount of time spent obtaining permission from landowners and when only multiple private sites were available, we randomly selected access points until permission was obtained. We conducted sign surveys between 9 February and 13 April 2008 (30 days), and between 28 January and 8 April 2009 (44 days), in eastern Kansas. The late winter/early spring months are a common survey time because 1) it is the breeding season of otters and scent-marking at latrines is expected to be at its highest, 2) there are differences in diets between river otter and raccoon (*Procyon lotor*) making their scat easier to differentiate, and 3) vegetation is less dense than in other months making sign easier to find (Swimley et al. 1998, Ostroff 2001). Sites sampled within the same year were ≥16 stream km apart while different year sites were ≥8 stream km apart to ensure spatial independence. This was based on average river otter home range sizes and past otter surveys (Shackelford and Whitaker 1997, Barrett 2008). Sites were not sampled within 2 days of precipitation (>0.2 cm) to avoid sign degradation (Clark et al. 1987, Shackelford and Whitaker 1997, Barrett 2008).

Most sites (82.7%) consisted of 9 continuous 400 m long by 5 m wide shoreline surveys. Each 400-m survey was considered an independent visit, thus allowing for spatial replication of surveys to determine the detection probability (MacKenzie et al. 2006). Personnel conducting sign surveys were trained in sign identification for 1 day in the field before conducting surveys and only surveys conducted by experienced observers (surveyed 49-81 sites) were used for this analysis (see Chapter 2). Furthermore, only sign that observers recorded as being 75-100% certain otter sign was included in this analysis. Locations of all tracks (≥1 foot track) and scat/latrines (≥1 piece of scat), visually-estimated dominant substrate type (i.e., mud, rock, litter, vegetative, and snow), and the presence of active beaver sign, as indicated by fresh cuttings and tracks, were recorded for each survey.

Data analysis

We created encounter histories for both sign types combined and used occupancy models that account for false absences to determine the local- and landscape-scale factors associated with river otter presence. The occupancy covariates were chosen based upon their potential influence on river otter use. We evaluated models at 2 spatial scales, a local scale and a landscape scale. The local-scale variables were measured within a 100-m buffer around the entire survey site (1,200-3,600 m) while HUC 14 watersheds (4,000-16,000 ha) were used to assess the landscape-scale variables. Most variables were measured or derived using ESRI's ArcMap 9.3 from maps and databases acquired from the Data Access and Support Center (http://www.kansasgis.org/) of the Kansas Geological Survey and other similar Geographic Information System (GIS) data access sites or were collected at the survey site. A complete list of data files and sources is provided in Table 3.1 and both local- and landscape-scale variables are listed in Table 3.2. These variables were primarily related to land use, human disturbance, stream size and type, and geographic position. We used *z*-transformations to standardize (i.e., the mean was subtracted from each value and then divided by the standard deviation) all continuous covariates, except the land cover variables which were left as proportions, and coded all categorical covariates (0 or 1) prior to analysis (Donovan and Hines 2007).

We assumed: (1) that river otter sign was never falsely detected at a point when absent and (2) detection of sign at a point was independent of detecting sign at other points. Occupancy modeling also requires the assumption that the population is closed during the sampling period (MacKenzie et al. 2002). We therefore assumed that otter movements over the survey season were random, which allowed us to relax this assumption (MacKenzie et al. 2004, Longoria and Weckerly 2007).

We developed a set of candidate models *a priori* based on our experience and the literature to model the factors associated with the probability of river otter occupancy (ψ) and river otter sign detection probability (p; Table 3.3). Our most basic model included the probability of occupancy and detection probability held constant across all substrates, surveys, and habitat types (ψ. p.). We then developed models with only local-scale variables, models with only landscape-scale variables, combination models with both local- and landscape-scale variables, and a global model with all local- and landscape-scale variables. All models were additive, and all models included the intercept on both ψ and p. Since the probability of detecting sign could be affected by substrate type, models were run with substrate effect on p and with p held constant. Our model set consisted of a total of 41 candidate models.

We performed a single-season, single-species, custom occupancy estimation analysis using Program PRESENCE Version 2.3 (Hines 2006). We evaluated goodness-of-fit and estimated overdispersion ($\hat{c}$) using the median $\hat{c}$ value from a parametric bootstrap test (n = 1,000) and adjusted for overdispersion prior to model selection (Burnham and Anderson 2002, MacKenzie and Bailey 2004). The estimated median $\hat{c}$ value for our global occupancy model was 1.52, suggesting slight overdispersion of the data (Burnham and Anderson 2002). Therefore, we ranked models using Akaike's Information Criterion corrected for small-sample size and overdispersion ($QAIC_c$; Burnham and Anderson 2002), and used the $QAIC_c$ differences and Akaike weights to evaluate model fit to the data. Models with $\Delta QAIC_c \leq 2.0$ were considered competitive models (Burnham and Anderson 2002).

Results

A total of 110 sites were surveyed in 2008 and 2009, 35 of which resulted in river otter detections (Figure 3.1). Eleven sites from 2008 were resurveyed in 2009 and 11 sites were surveyed twice in one year (early season [30 January - 25 February] and late season [1 - 8 April]) to record potential changes in occupancy over the study period. Of these resurveys, 18.2% of the sites differed in detections where sign was not found in one year but not the other and 36.4% of sites differed in detections from early season to late season. Due to the possible differences in sign detections during the season, we used only the late season survey for analysis when 2 surveys of the site had been conducted in the same season. Beaver sign was recorded for all but 6 sites (95%) and therefore was not included in the occupancy modeling.

When examining a model where the probability of occupancy varied by our 7 otter units, we observed regional differences throughout our study area. The probability of occupancy by otter landscape unit was highest in the Southeast unit ($\psi = 0.827$) and lowest in the Caney River ($\psi = 0.103$) and Kansas River units ($\psi = 0.114$; Figure 3.2). The Caney River unit had the highest proportion of grassland cover (0.844) and the lowest proportion of cropland cover (0.038). The Southeast Kansas unit had the highest proportion of woodland (0.173) while the Neosho River unit had the lowest (0.069). The proportion of urban area was highest in the Kansas River unit, but was still only 0.070.

Across all 14 digits HUCs in the study site, grassland covered the highest proportion of the HUC 14 watersheds (mean = 0.602) while woodland (mean = 0.125) followed by urban (mean = 0.020) were the least dominant land cover types. The cropland, grassland, and woodland cover types at the local scale were on average, relatively evenly distributed (Table 3.2). However, urban land cover was so sparse (only 3 sites were >0.01 urban) at the local scale it was excluded from analysis. Of the sites surveyed, 40% do not meet the water quality standards of the state and have been listed as impaired under the Clean Water Act (U.S. Environmental Protection Agency 2009). We sampled 18 reservoirs and 92 streams, with most streams (75%) being third and fourth order.

The overall probability of occupancy accounting for detection probability was 0.329 (SE 0.046). The overall probability of detection was 0.337 (SE 0.029) per 400-m survey. Models including the local-scale land cover variables and the landscape-scale water diversity variables ranked highest in explaining river otter occupancy (Table 3.4). The best model given our set of candidate models consisted of local-scale land cover and landscape-scale water diversity, including shoreline diversity, waterbody density, and stream density effects on occupancy with a substrate effect on detection probability. Although the top 3 models (QAICc < 2.01) included local-scale land cover, none of the competing models contained land cover measured at the landscape scale.

The probability of river otter occupancy increased with increased woodland and decreased grassland and cropland at the local scale (Figure 3.3). The probability of river otter occupancy decreased with increasing shoreline diversity, waterbody density, and stream density (Figure 3.4) though these relationships do not appear to be as strong as the relationship with land cover. Substrate type was also present in our top model for an effect on detection probability.

Mud substrates (p = 0.600; SE 0.075) had the highest detection probability while litter (p = 0.267; SE 0.037) and snow (p = 0.180; SE 0.116) substrates had the lowest detection probabilities (see Chapter 2).

Discussion

Local-scale land cover was the best predictor of river otter occupancy in eastern Kansas. Our best model for the probability of river otter occupancy included effects of the local land cover and the water diversity characteristics measured within the watershed. We observed an increase in river otter occupancy with increased woodland cover and decreased grassland and cropland cover at the local scale. In addition, river otter occupancy decreased with increased shoreline diversity, waterbody density, and stream density at the landscape scale and the significance of these variables may have been influenced by the presence of large reservoirs in the watershed. However, landscape-scale measures of land cover and human disturbance did not strongly affect river otter occupancy.

The positive relationship between woodland cover and occupancy supports our hypothesis that river otters prefer forested riparian areas even if sites averaged >75% grassland and cropland. Riparian land use that contains woodland may provide more woody debris in the streams, which may increase fish abundance (Angermeier and Karr 1984) and therefore prey availability for river otters. Additionally, obvious declines in habitat quality for fish have been observed when agriculture becomes the dominant land use at sites (≥50%; Wang et al. 1997). Although we expected grasslands to have higher occupancy than cropland, this finding might be explained by how grassland is defined. In our study, native, ungrazed grasslands were not differentiated from grazed grasslands. We documented cattle activity at 39% of our sites, and grazed areas may differ from the semi-natural grasslands that were found to be positively associated with latrine activity of the European otter (White et al. 2003). Furthermore, Bas et al. (1984) found that grazed land had fewer latrine sites for European otters which supports our conclusion that grasslands were associated with low river occupancy.

Lower stream density, fewer waterbodies, and reduced shoreline diversity at the landscape scale were positively related to river otter presence. The negative influence of water diversity model variables on river otter occupancy also countered our predictions. However, we found that watersheds containing large reservoirs (≥3600 m shoreline) tended to have high river otter occurrences while having the lowest shoreline diversities, stream densities, and waterbody densities. For example, 6 of the 10 watersheds that had the lowest steam densities contained large reservoirs, 5 of which were occupied by otters, and 13 of the 15 watersheds with the lowest shoreline diversities contained large reservoirs, 10 of which were occupied. Other researchers have proposed that the creation of small impoundments and major reservoirs has created more surface area of permanent water and shorelines which river otters prefer (Shackelford and Whitaker 1997, Melquist et al. 2003). It is possible that sites with large reservoirs provide more suitable habitat, particularly in the winter when smaller ponds and streams are often frozen and inaccessible. Therefore, the relationship between river otter presence and the water diversity variables may be masked by the presence of reservoirs in the watershed.

Additionally, our method of modeling stream order as a categorical variable may have reduced its ranking by penalizing the model for a high number of parameters. A model that included waterbody size as an effect on the probability of occupancy ($\psi_{\text{waterbody size}}\, p_{\text{substrate}}$) indicated that third order streams had a low probability of occupancy (ψ = 0.115; SE 0.054) compared to the higher order streams (ψ = 0.340-0.372; SE 0.085-0.160) and reservoirs (ψ = 0.683; SE 0.115; Figure 3.5). Furthermore, after combining stream orders *a posteriori* to reduce the model to 3 variables (third order, fourth-seventh order, and reservoirs), waterbody type became a competing model (AIC weight = 0.339). Our results suggest larger streams and reservoirs had higher river otter occupancy, similar to the results of White et al. (2003). Although river otters may use a wide variety of deepwater and wetland habitats (Newman and Griffin 1994), watersheds containing larger streams and reservoirs may be better suited for river otters in Kansas.

Contrary to Robitaille and Laurence (2002), higher human presence and road density did not influence river otter occupancy in Kansas. Lack of influence for some variables could be a result of their low variability among sites. For example, most watersheds were rural with a low proportion of urban land cover (0.016). Road density, which may affect wildlife distributions (Mech et al. 1988, Robitaille and Laurence 2002), was not related to river otter occupancy. However, road densities in Kansas were low (85 m/km^2) compared to densities in Oklahoma (118 m/km^2), Missouri (123 m/km^2), and Arkansas (189 m/km^2), all of which have established river otter populations (LaRue and Nielsen 2008). Additionally road density does not necessary represent human presence and disturbance. For instance, studies of wolves in North America have shown that wolves will select areas of higher road density if human presence is low (Boyd-Heger 1997, Whittington et al. 2005). Furthermore, European countries had similar road densities to our study area, although the human population densities in Europe (109 $people/km^2$; Robitaille and Laurence 2002) are much higher than Kansas (13 $people/km^2$; U.S. Census Bureau 2000) and likely equate to higher road use and other indicators of human presence compared to the many rural county roads in eastern Kansas. Finally, Robitaille and Laurence (2002) found that European otters were consistently absent when human densities reached >183 $people/km^2$ because otters appeared to have a threshold for human density. Clearly, Kansas is not near such a threshold and human disturbance appears to have little effect on river otter occupancy in the rural Great Plains.

Our study is the first to describe river otter habitat associations after accounting for imperfect detection. Pagano and Arnold (2009) documented that surveys based on the assumption of perfect detection underestimated waterfowl abundance by 10-29%, and Mazerolle et al. (2005) found that not accounting for detection probability led to underestimation and overestimation of the influence of certain habitat variables on pond occupancy by frogs. Measuring detection probability reduces bias and provides stronger inference about studies of habitat associations. Our study was the first to examine the detectability of river otter sign, and we found substrate type to be a factor affecting the detection probability. Therefore, we hope future studies will account for substrate in their habitat analysis.

We did not observe annual variation in detection results but did see some seasonal variation in probability of detection. Ten of the 11 sites that were sampled twice in one season had ice cover early season, 3 of which resulted in new sign detections after the ice had melted. Additionally, the only site that was sampled twice in one season and resulted in early season detections but not late season detections was flooded during the late season survey. Therefore, the seasonal differences we observed were likely due to early season ice cover or flooding throughout the season and future studies should attempt to account for temporal variation. Although beaver activity was not included in the modeling, we found evidence of fresh beaver activity at every site where river otters were detected, anecdotally supporting previous findings that river otter activity is highest where beavers are also present (Melquist and Hornocker 1983, Dubuc et al. 1990, Waller 1992, Newman and Griffin 1994, Boege-Tobin 2005, Rosell et al. 2005).

River otters appeared to be distributed throughout eastern Kansas. However, the highest occupancy was in southeastern Kansas, which coincides with a high number of furharvester sighting reports in that area (Peek 2005, Shardlow and Paukert 2009) and increased woodland cover. High occupancy may be attributed the high proportion of woodland cover in the unit. Furthermore, occupancy by otter unit was lowest in the Caney River, Kansas River, and Missouri River units, which had the highest proportions of grassland cover (Caney River), urban use (Kansas River), and cropland cover (Missouri River). Our results show that grassland at the local scale negatively influences river otter occupancy and this may also be the cause at this larger scale. Also, studies have found that the high urban and agricultural land use in watersheds reduces the biotic integrity of the aquatic system, which could consequently have negative impacts on otters (Wang et al. 1997, 2001). These correlations suggest there may be an effect of land cover at an even larger scale and future studies should consider examining these and other variables in the future.

Wildlife ecology and management is recognizing the need to account for scale in wildlife-habitat associations, but scale has not been analyzed in previous river otter studies. River otters tend to be generalist species (Habib et al. 2003), and it is possible they are able to make use of locally-distributed resources in a variety of landscapes (Pearson 1993). Future work should further examine the impacts of land use practices on river otter habitat, and our results suggest that habitat restoration and management may be most beneficial at the local scale. Studies should also look for trends at a regional scale. Furthermore, research of wildlife-habitat relationships should use occupancy modeling techniques that account for imperfect detection for less biased estimates and inferences.

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Table 3.1. Data layers and sources used to measure variables associated with occupancy modeling of river otters based on sign survey data collected in eastern Kansas, USA, 2008-2009.

Source	Description	Year of data	Resolution
Kansas Dept. of Transportation	State and county roads	2006	
Kansas Aquatic Gap Analysis Program (GAP)	National Hydrography Dataset (NHD) streams with order classification	2003	1:24,000
U.S. Geological Survey	NHD waterbodies	2006	1:24,000
Kansas Applied Remote Sensing Program	Kansas Land Cover Patterns	2005	30-meter
Farm Services Agency	National Agriculture Imagery Program (NAIP) color aerial imagery by county	2006	1-meter
U.S. Environmental Protection Agency	NHD locations for impaired (Section 303(d) listed) waters		
U.S. Geological Survey	Hydrologic Unit Code (HUC) 14 watersheds	1993	

Table 3.2. Environmental variables evaluated for their effects on river otter occupancy, eastern Kansas, USA, 2008-2009. Values in the mean column for presence / absence (P/A) variables are the percentage of sites with the variable present (e.g., 44 sites [40.0%] were listed for impaired water quality [303(d) listed; US Environmental Protection Agency 2009]). SE = standard error.

Variable	Description	Mean (SE)	Range
Local scale variables (n = 110)			
CropS	Proportion of survey w/100 m buffer comprised of cropland	0.24 (0.02)	0.00-0.71
GrassS	Proportion of survey w/100 m buffer comprised of grassland	0.30 (0.02)	0.00-0.95
WoodS	Proportion of survey w/100 m buffer comprised of woodland	0.46 (0.02)	0.05-0.97
Sinuous*	Site shoreline sinuosity (length of site shoreline/distance between end points; m/m)	1.72 (0.05)	1.01-5.17
Dist*	Stream distance of site to nearest of border line for either Missouri or Oklahoma (km)	93.80 (6.63)	1.07-257.01
Impaired	The waterbody had impaired water quality impaired (P/A)	40.0%	
Third order**	The site was a 3rd order stream (P/A)	32.7%	
Fourth order**	The site was a 4th order stream (P/A)	30.0%	
Fifth order**	The site was a 5th order stream (P/A)	12.7%	
Sixth-seventh order**	The site was a 6th-7th order stream (P/A)	8.2%	
Res	The site was a reservoir (P/A)	16.4%	
Landscape scale variables (n = 110)			
UrbanW	Proportion of watershed comprised of urban	0.02 (0.01)	0.00-0.46
CropW	Proportion of watershed comprised of cropland	0.26 (0.02)	0.01-0.88
GrassW	Proportion of watershed comprised of grassland	0.60 (0.02)	0.08-0.94
WoodW	Proportion of watershed comprised of woodland	0.13 (0.01)	0.03-0.51
Shore*	Sum of the waterbody perimeters / sum of waterbody areas for entire watershed (km/km^2)	0.06 (0.00)	0.00-0.09
Stream*	Sum of stream (≥3rd order) km within the watershed / watershed area (km/km^2)	0.26 (0.01)	0.08-0.70
Bodies*	Number of waterbodies within the watershed / watershed area (count/ km^2)	1.62 (0.68)	0.24-3.71
Road*	Sum of road km within the watershed / watershed area (km/km^2)	1.59 (0.05)	0.45-5.76

*variables were standardized
** based on Strahler order (Strahler 1957)

Table 3.3. Set of candidate models considered to explain the probability of river otter occupancy (ψ) and detection probability (*p*) at sites surveyed in eastern Kansas, USA, 2008 to 2009.

Model name	Model structure* ψ	Model structure* *p*	No. Parameters*
Local scale models			
Waterbody	Sinuous Orders Res	Substrate	11
Pollution	Impaired	Substrate	7
Distance to borders	Dist	Substrate	7
Land cover	WoodS GrassS CropS	Substrate	9
Landscape scale models			
Water diversity	Shore Stream Bodies	Substrate	9
Disturbance	Road UrbanW	Substrate	8
Land cover	WoodW GrassW CropW	Substrate	9
*Hybrid models***			
Local scale + landscape scale	See models above	See models above	≤20

* Intercept parameters for ψ and *p* were included in all models. Nineteen models were run for 2 scenarios of *p* (i.e., substrate, *p* constant).
** Models consisted of every combination of a local-scale model (e.g., waterbody, land cover) with a landscape-scale model (e.g., water diversity, disturbance)

Table 3.4. The highest-ranked models for the probability of river otter occupancy (ψ) and detection probability (p) based on 400-m sign surveys conducted in eastern Kansas, USA, 2008-2009. See Table 3.3 for model variables. Models with Akaike weights <0.05 are not shown. Information presented for each model includes the number of parameters (K), deviance, Akaike's Information Criterion corrected for small sample size and overdispersion ($QAIC_c$; $\hat{c}$ = 1.52), the difference between the model $QAIC_c$ and the best fit model $QAIC_c$ ($\Delta QAIC_c$), and the Akaike weight of the model (w_i).

Model structure						
ψ	p	K	Deviance	$QAIC_c$	$\Delta QAIC_c$	w_i
Local land cover + Water diversity	Substrate	12	469.8	336.3	0.0	0.316
Local land cover + Water diversity	Constant	8	487.0	337.8	1.5	0.150
Local land cover	Substrate	9	484.2	338.3	2.0	0.116
Distance + water diversity	Substrate	10	482.1	339.4	3.1	0.069

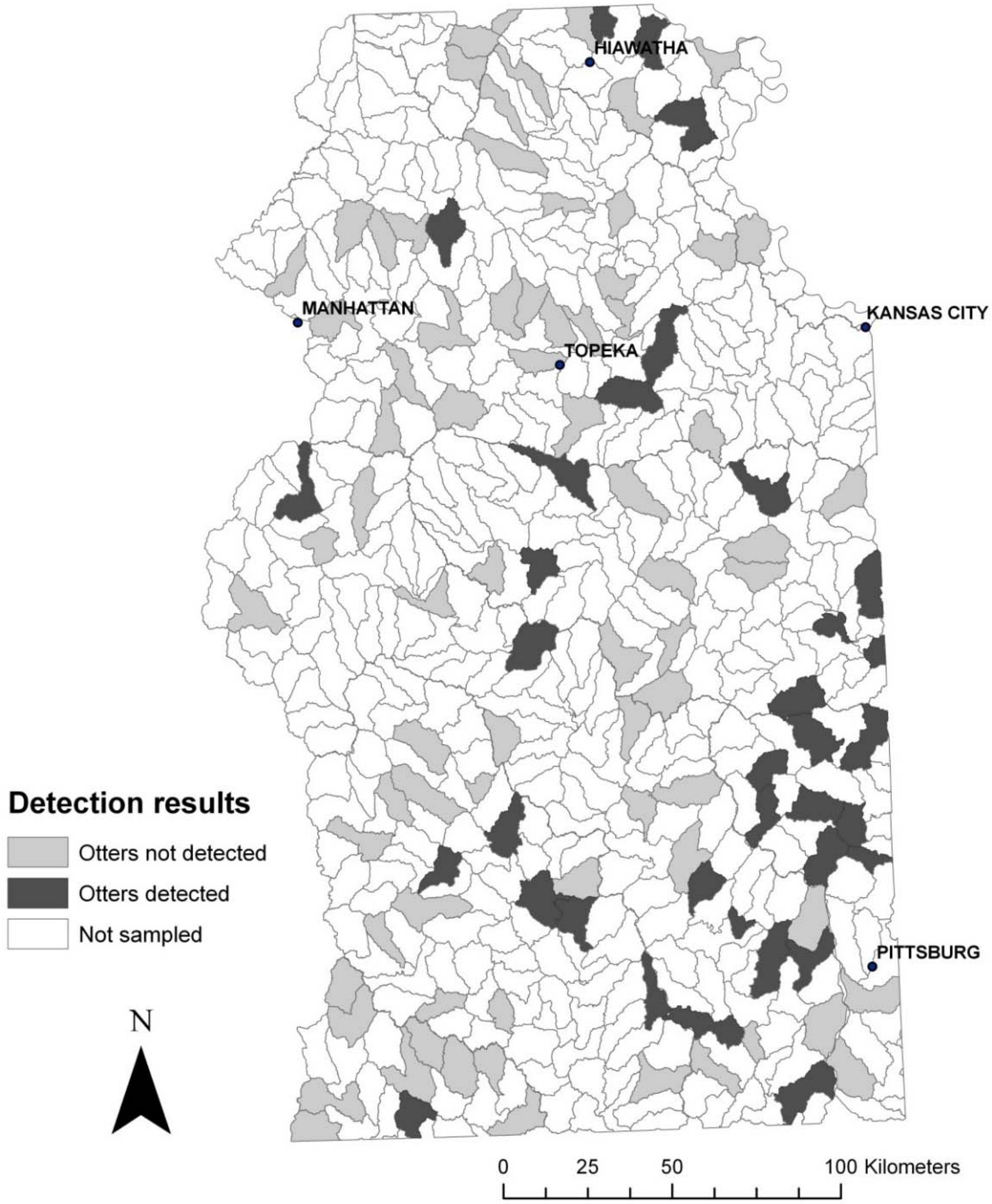

Figure 3.1. Hydrological Unit Code 14 watersheds surveyed and detection results for river otter sign in eastern Kansas, USA, 2008-2009.

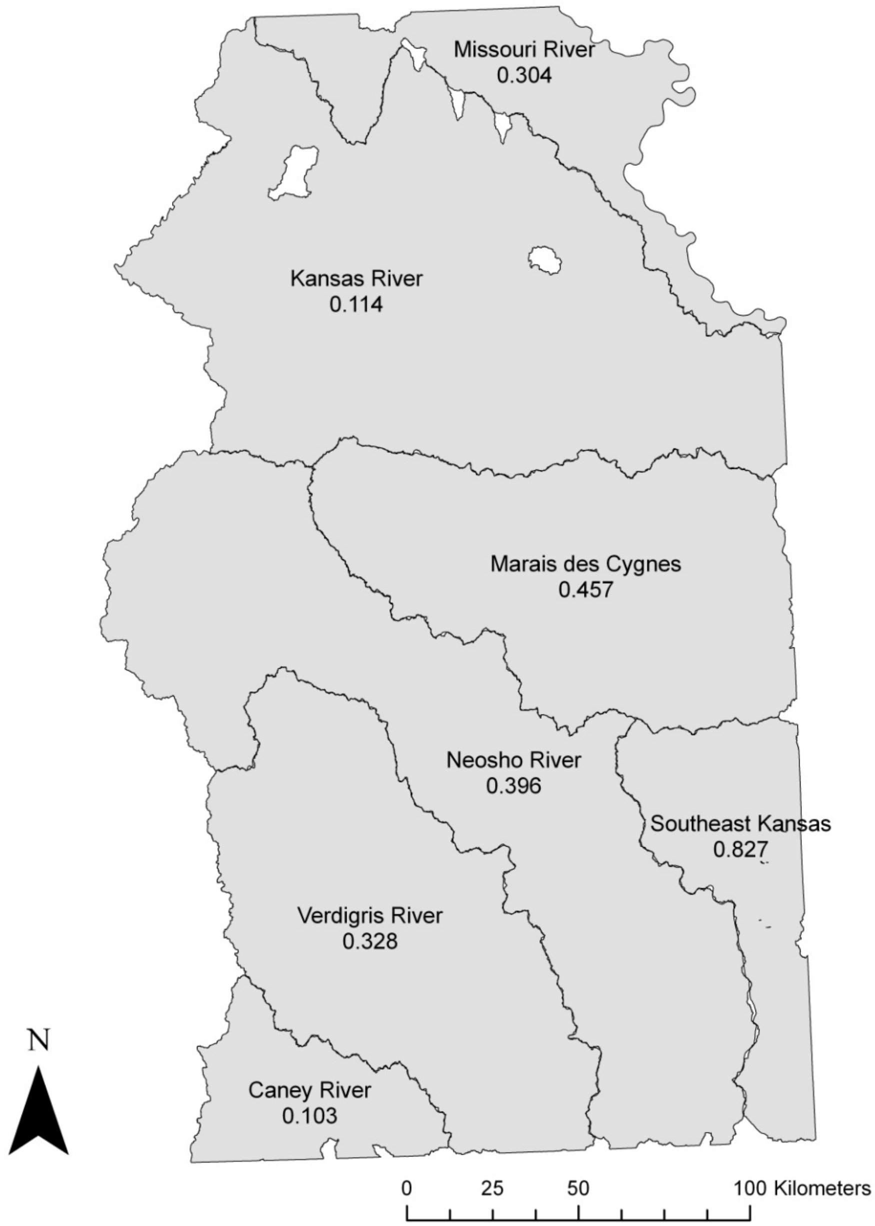

Figure 3.2. The probability of site occupancy stratified by the 7 otter units as estimated from river otter sign surveys conducted in eastern Kansas, USA, 2008-2009.

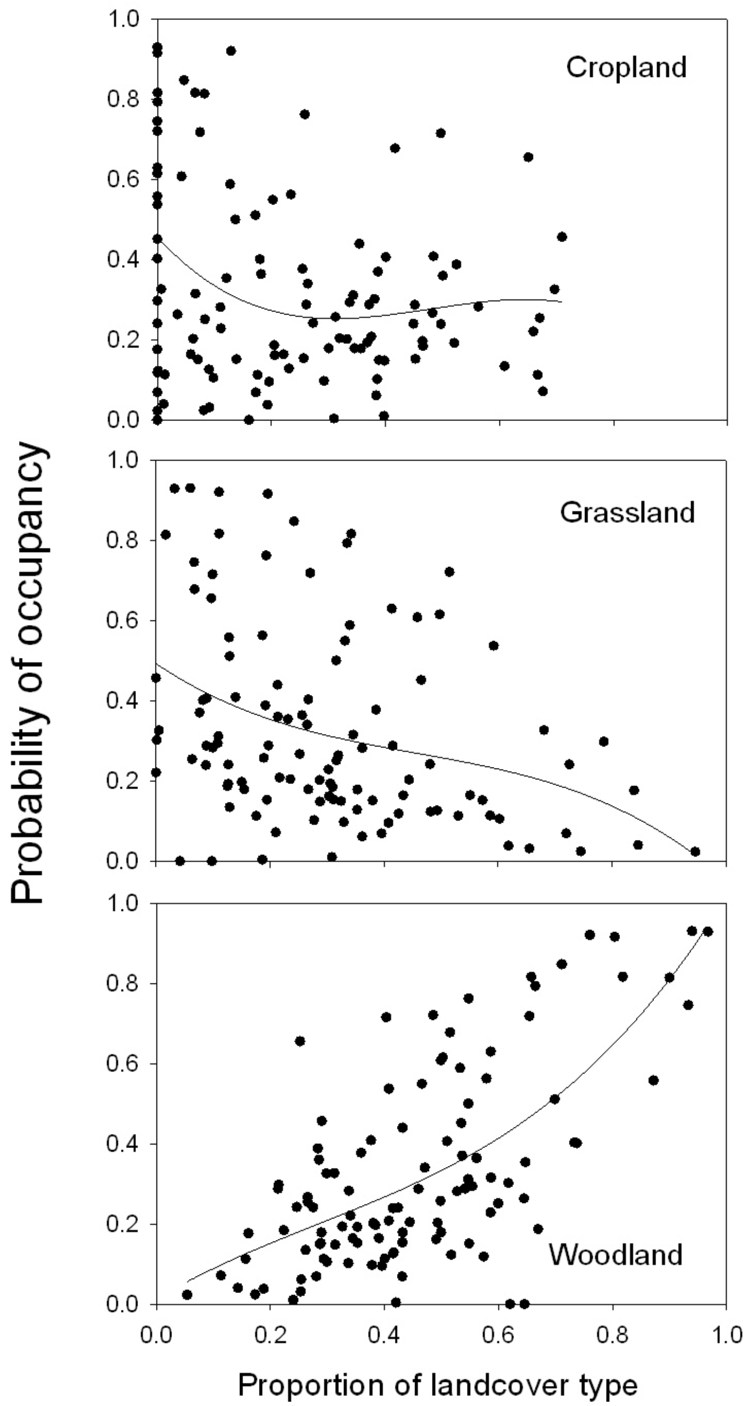

Figure 3.3. Relationships between the probability of river otter occupancy and the proportion of local-scale cropland, grassland, and woodland cover types as derived from the best fit model, eastern Kansas, USA, 2008-2009.

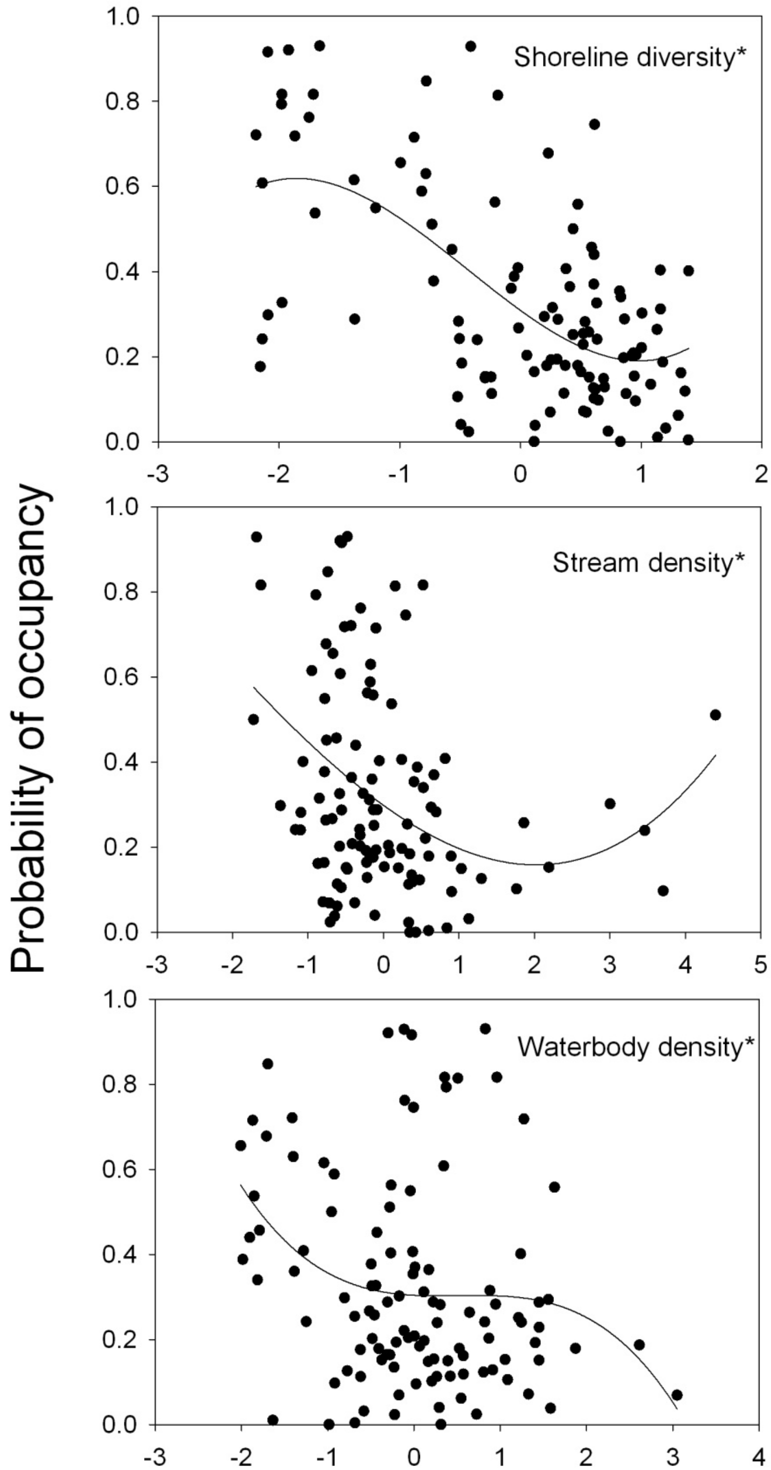

Figure 3.4. Relationship between probability of river otter occupancy and the *z*-transformed shoreline diversity (km/km^2), stream density (km/km^2), and waterbody density (count/km^2) as derived from the best fit model, eastern Kansas, USA, 2008-2009.

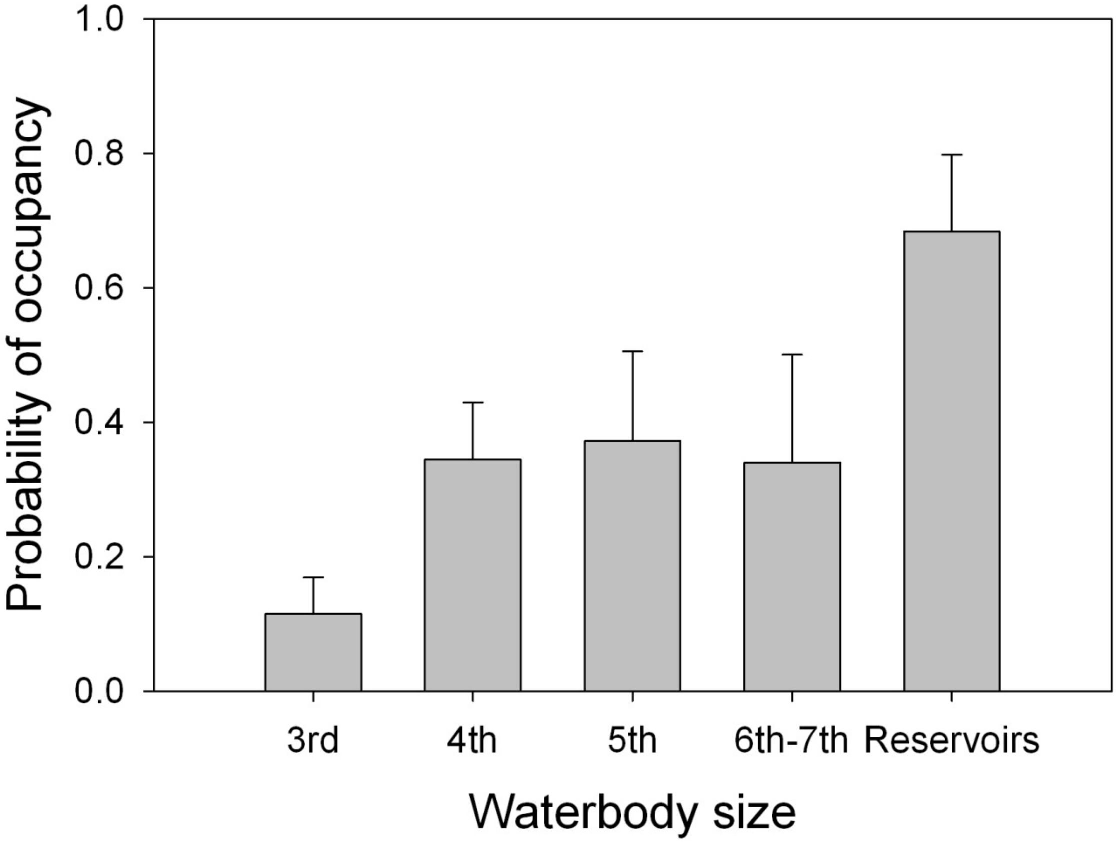

Figure 3.5. The probability of river otter occupancy per 400-m survey by waterbody size as derived from model $\psi_{\text{waterbody size}}\ p_{\text{substrate}}$ in eastern Kansas, USA, 2008-2009.

CHAPTER 4 - Conclusions

Understanding the environmental factors that affect the distribution of a species is crucial to wildlife management. Distribution, population status, and habitat association information is often gathered through wildlife surveys and efforts should be made to improve these methodologies whenever possible. We were able to assess the current distribution of river otters in eastern Kansas and the factors affecting their occupancy using noninvasive sign surveys. We found the local-scale habitat variables of land cover were most important, although waterbody diversity at the landscape scale may also be important. However, the land cover and human disturbance at the landscape scale did not appear to strongly influence river otter occupancy in eastern Kansas.

We recommend the continued use of sign surveys but hope that our results will be used to improve and standardize sign survey methodologies and analysis. We propose that studies account for detection probability, attempt to adequately train and test observers, and collect information on both scat and tracks. MacKenzie et al. (2006) suggest that sites should be large enough to have a detection probability of 0.2-0.8 and that at least 3 surveys be conducted per site. Program GENPRES could be used to simulate data sets and this software, along with our detection probability estimates for various survey lengths, could help researchers assess their proposed sampling designs (Bailey et al. 2007). Furthermore, we suggest that future studies examine additional spatial and temporal factors for effects on detection probability and occupancy. For example, Ruiz-Olmo et al. (2001) found significant differences in detection of river otter sign for waterbodies of different sizes while another study found that population size and sampling season were factors affecting detection probability (Kéry 2002).

We propose that agencies and researchers standardize survey protocols so monitoring and study results can be evaluated regionally and a broader scale analysis of factors affecting river otters can be achieved. Additionally, we suggest surveys be conducted at the same sites over time (i.e., every 3-5 years), allowing for examination of changes in occupancy, including the extinction and colonization rates (MacKenzie et al. 2006). The utility of river otter sign surveys could be increased by coordinating with diet and genetics studies using fecal matter, thus providing information on prey items, population status and relative abundance, behavior, and inbreeding (Greer 1955, Hansen et al. 2008). These surveys could also be expanded to include other species, such as American mink, beaver, raccoons, and muskrat, to obtain a better understanding of the animal communities inhabiting aquatic riparian areas. Finally, we hope the information gathered will provide data necessary to develop and guide monitoring and management decisions about river otters in Kansas and the Midwest.

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Appendix A - Study area and survey sites

Table A.1. Sites surveyed for river otter sign in eastern Kansas, USA, 2008-2009. UTM coordinates (NAD83 Zone 14N) are of starting location. Stream order is based on the Strahler order classification and an "R" in the Stream order column indicates that a site was on a reservoir. A "1" for otter sign indicates that sign was detected while a "0" means that no sign was detected during the survey. Under Waterbody name, an "R" stands for River, "Ck" for Creek, "L" for Lake, and "Res" for Reservoir.

Site ID	Easting	Northing	Waterbody name	Stream order	Public	Survey length (m)	Date(s) surveyed	Otter sign
Caney River Unit								
C-10A	723587	4109591	Caney R.	5	No	3600	3/6/2009	0
C-11A	718254	4101112	Rock Ck.	3	No	3200	2/22/2009	0
C-12A	767963	4117600	Bee Ck.	4	No	3600	2/22/2009	0
C-14B	724311	4137837	Caney R.	4	No	3600	3/26/2009	0
C-17A	760868	4111854	North Caney Ck.	4	No	3200	4/3/2009	0
C-19A	747706	4125340	Murray Gill L.	R	No	3600	3/31/2009	0
C-1B	743503	4100304	Cedar Ck.	4	No	3600	2/26/2008	1
C-4A	742138	4115011	Middle Caney Ck.	4	No	3600	3/26/2008	0
C-5B	723003	4129757	Spring Ck.	3	No	3600	2/26/2008	0
C-9A	770645	4100098	Little Caney R.	6	Yes	3600	3/8/2008	0
Marais Des Cygnes River Unit								
D-12A	816384	4247630	Pottawatomie Ck.	5	No	2000	2/27/2009	0
D-13B	842829	4274178	Marais des Cygnes R.	6	No	3600	2/20/2009	0
D-19A	765865	4269665	Marais des Cygnes R.	5	Yes	3600	2/7/2009	0
						3600	4/7/2009	0
D-1A	874191	4245419	Marais des Cygnes R.	6	Yes	3600	2/14/2008	1
						3600	3/20/2009	1
D-26A	859956	4227946	Mound City L.	R	Yes	3600	2/20/2009	1
D-2A	884126	4239171	Marais des Cygnes R.	6	Yes	3600	2/14/2008	1
						3600	4/6/2009	1
D-38A	784454	4267740	Melvern Res.	R	Yes	3600	2/7/2009	0
						3600	4/8/2009	1
D-3A	839958	4266871	Mosquito Ck.	3	No	3600	2/28/2008	0
D-4A	818752	4268341	Payne Ck.	3	No	3600	2/20/2008	0
D-54A	794426	4288389	Pomona Res.	R	Yes	3600	3/15/2008	1
						3600	3/2/2009	1

Site ID	Easting	Northing	Waterbody name	Stream order	Public	Survey length (m)	Date(s) surveyed	Otter sign
D-55A	852700	4287157	Hillsdale L.	R	Yes	3600	3/15/2008	1
						2400	3/9/2009	0
D-5B	819140	4229282	E. Branch Cedar C.	3	No	3600	3/27/2008	0
D-6A	805865	4288828	Appanoose Ck.	3	No	3600	1/30/2009	0
						3600	4/7/2009	0
D-72B	879621	4259383	North Sugar Ck.	R	Yes	3600	3/27/2008	1
						3600	4/6/2009	1
D-7A	806062	4240364	Pottawatomie Ck.	4	No	3600	2/20/2008	0
D-8B	867610	4283224	North Wea Ck.	4	No	3600	3/9/2009	0
Kansas River Unit								
K-11A	781393	4408836	Delaware R.	3	No	3600	3/12/2008	0
K-12A	803600	4367777	Coal Ck.	3	Yes	3600	2/15/2008	0
						3600	4/1/2008	0
						3600	3/18/2009	0
K-14A	749644	4338656	N. Branch Turkey Ck.	3	No	3600	2/18/2008	0
K-17A	724987	4368391	Rock Ck.	4	No	3600	3/11/2008	0
K-18A	811351	4316400	Clinton L.	R	Yes	3600	2/19/2008	1
						3600	3/4/2009	1
K-19A	754087	4359454	Cross Ck.	4	No	3600	4/13/2008	1
K-20A	765857	4393559	Spring Ck.	3	No	3600	4/2/2008	0
K-25B	735597	4319496	South Branch Mill Ck.	4	No	3600	2/26/2009	0
K-26A	771016	4405286	Muddy Ck.	3	No	2800	1/29/2009	0
K-27A	804475	4351654	Perry Res.	R	Yes	3200	2/8/2009	0
						3200	4/8/2009	0
K-2B	779463	4344198	Little Soldier Ck.	4	No	3600	3/12/2008	0
K-30A	722671	4340708	Kansas R.	8	Yes	3600	1/28/2009	0
K-31C	770518	4340932	Soldier Ck.	4	No	2400	3/4/2009	0
K-34A	740994	4326100	Mill Ck.	5	No	3600	4/11/2008	0
K-36A	812577	4328303	Kansas R.	8	Yes	3200	2/18/2009	1
K-38A	835694	4357904	Stranger Ck.	5	No	3600	2/18/2009	0
K-39A	795369	4310286	Wakarusa R.	4	No	3600	2/19/2009	0
K-3C	788622	4374131	Elk Ck.	4	No	3600	2/8/2009	0
K-40A	782736	4329645	Kansas R.	8	Yes	2800	2/16/2009	0
K-49A	762979	4315608	Mission Ck.	4	No	3600	2/27/2009	0
K-4C	785703	4334111	Halfday Ck.	3	No	2400	3/17/2009	0
K-53B	734439	4362141	Indian Ck.	3	No	2400	4/1/2009	0
K-54A	794777	4339879	Muddy Ck.	3	No	3600	3/17/2009	0
K-67A	833171	4301984	Douglas State L.	R	Yes	3600	3/30/2009	0
K-6H	740348	4367102	Jim Ck.	3	No	3200	1/29/2009	0
K-72A	707836	4349740	Tuttle Creek Res.	R	Yes	3600	4/4/2008	0
						3600	3/30/2009	0

Site ID	Easting	Northing	Waterbody name	Stream order	Public	Survey length (m)	Date(s) surveyed	Otter sign
K-86A	806662	4336687	Perry Res.	R	Yes	3600	4/1/2008	0
						3600	3/18/2009	0
Missouri River Unit								
M-10A	801920	4433746	Noharts Ck.	4	No	3600	3/19/2009	1
M-14A	761616	4422290	Deer Ck.	3	No	2800	2/17/2009	0
M-15A	772671	4429964	Rock Ck.	3	No	3200	4/1/2009	0
M-16A	818282	4427882	Cedar Ck.	4	No	3200	3/19/2009	1
M-1A	848787	4366260	Salt Ck.	3	No	3600	2/15/2008	0
M-2A	809415	4411996	South Fork Wolf R.	3	No	3600	2/29/2008	0
M-3D	757036	4414792	Harris Ck.	3	No	3600	3/11/2008	0
M-4A	825302	4398512	North Branch Independence Ck.	3	No	3600	1/30/2009	1
M-6A	833738	4417328	Mosquito Ck.	3	No	3600	4/2/2008	0
M-8B	793709	4426445	Walnut Ck.	4	No	3600	2/17/2009	0
Neosho River Unit								
N-11A	775725	4240108	John Redmond Res.	R	Yes	3600	2/9/2008	1
						2800	4/6/2008	1
N-12B	837683	4114257	Deer Ck.	3	No	3200	3/1/2009	0
N-13B	832266	4174045	Canville Ck.	3	No	3600	3/7/2009	1
N-14A	861862	4158181	Lightning Ck.	3	No	3600	3/2/2009	0
N-18B	846069	4126710	Neosho R.	6	No	3600	4/4/2009	0
N-1A	858081	4141883	Lightning Ck.	4	No	3600	2/13/2008	1
N-22A	773682	4214843	South Big Ck.	3	No	3200	3/21/2009	0
N-23D	846992	4149526	Hickory Ck.	4	No	3200	3/8/2009	1
N-25A	854101	4105859	Fly Ck.	4	No	3600	3/8/2009	1
N-26A	716779	4275173	East Ck.	4	No	2800	3/5/2009	0
N-28B	699284	4251933	Middle Ck.	4	No	3600	2/23/2009	0
N-2A	861751	4128341	Cherry Ck.	3	No	3600	3/9/2008	0
N-37A	748082	4257197	Neosho R.	5	No	3600	4/3/2009	0
N-3C	834188	4132325	Labette Ck.	5	Partial	3600	2/21/2009	1
N-40A	714035	4284406	Council Grove Res.	R	Yes	3600	2/25/2008	1
						3600	4/6/2008	1
						3600	3/25/2009	1
N-4D	730212	4285596	Rock Ck.	4	No	3600	3/25/2008	0
N-50A	839693	4158903	Flat Rock Ck.	5	No	3600	1/30/2009	1
						3600	4/4/2009	1
N-6A	812724	4190804	Neosho R.	6	No	3600	2/27/2008	0
N-7C	807585	4211016	Indian Ck.	3	No	3600	2/27/2008	0
N-8A	822773	4172757	Big Ck.	4	No	3600	3/9/2008	0
N-9C	827100	4199657	Elm Ck.	3	No	3600	3/20/2009	0
Southeast Kansas Unit								
S-10B	852344	4211159	Limestone Ck.	3	No	3600	2/6/2009	1
S-13C	883699	4180816	West Fork Dry Wood Ck.	4	No	3600	3/26/2009	1

Site ID	Easting	Northing	Waterbody name	Stream order	Public	Survey length (m)	Date(s) surveyed	Otter sign
S-15C	876527	4113273	Brush Ck.	4	No	3600	3/2/2009	0
S-16A	846013	4189559	Bourbon L.	R	Yes	3600	1/31/2009	0
						3600	4/5/2009	1
S-18A	873317	4190608	Fort Scott L.	R	Yes	1600	3/26/2009	1
S-1A	861974	4194994	Marmaton R.	4	No	1600	2/19/2009	1
S-2A	867586	4189170	Pawnee Ck.	4	Partial	3600	2/13/2008	1
S-3F	883299	4141227	Cow Ck.	4	No	3600	3/10/2008	0
S-5A	877074	4215447	Little Osage R.	4	No	3600	2/28/2008	1
						1200	3/16/2008	1
S-6C	863853	4218065	Lost Ck.	3	No	1600	2/6/2009	0
						1600	4/5/2009	1
Verdigris Unit								
V-10A	751420	4196794	Homer Ck.	3	No	3600	2/5/2009	0
V-14A	779369	4173821	Verdigris R.	5	No	3600	3/6/2009	1
V-16B	730724	4185041	Spring Ck.	4	No	2800	3/5/2009	0
V-18B	749423	4213386	West Ck.	3	No	3600	3/21/2009	0
V-19A	791756	4161518	Verdigris R.	5	No	3600	3/7/2009	1
V-1B	810410	4109128	Pumpkin Ck.	4	No	3600	2/1/2009	0
V-23B	754753	4138524	Elk R.	5	No	3600	3/22/2009	0
V-24A	752115	4177220	Fall R.	5	Yes	3600	3/7/2008	1
						3600	3/22/2009	0
V-29A	793548	4178217	Wilson State L.	R	Yes	3600	2/21/2009	0
V-2B	748958	4166966	Salt Ck.	3	No	3600	3/8/2008	0
V-3C	741104	4194110	Bachelor Ck.	3	No	2400	3/25/2008	0
V-44A	769988	4182124	Toronto L.	R	Yes	3600	3/26/2008	1
V-4A	762612	4198421	Verdigris R.	5	No	3600	3/7/2008	0
V-59A	814010	4135129	Big Hill Res.	R	Yes	3600	3/16/2008	1
V-6A	773203	4131692	Elk R.	5	Yes	3600	2/12/2008	0
V-9A	740624	4150579	Rock Ck.	3	No	3600	2/5/2009	0

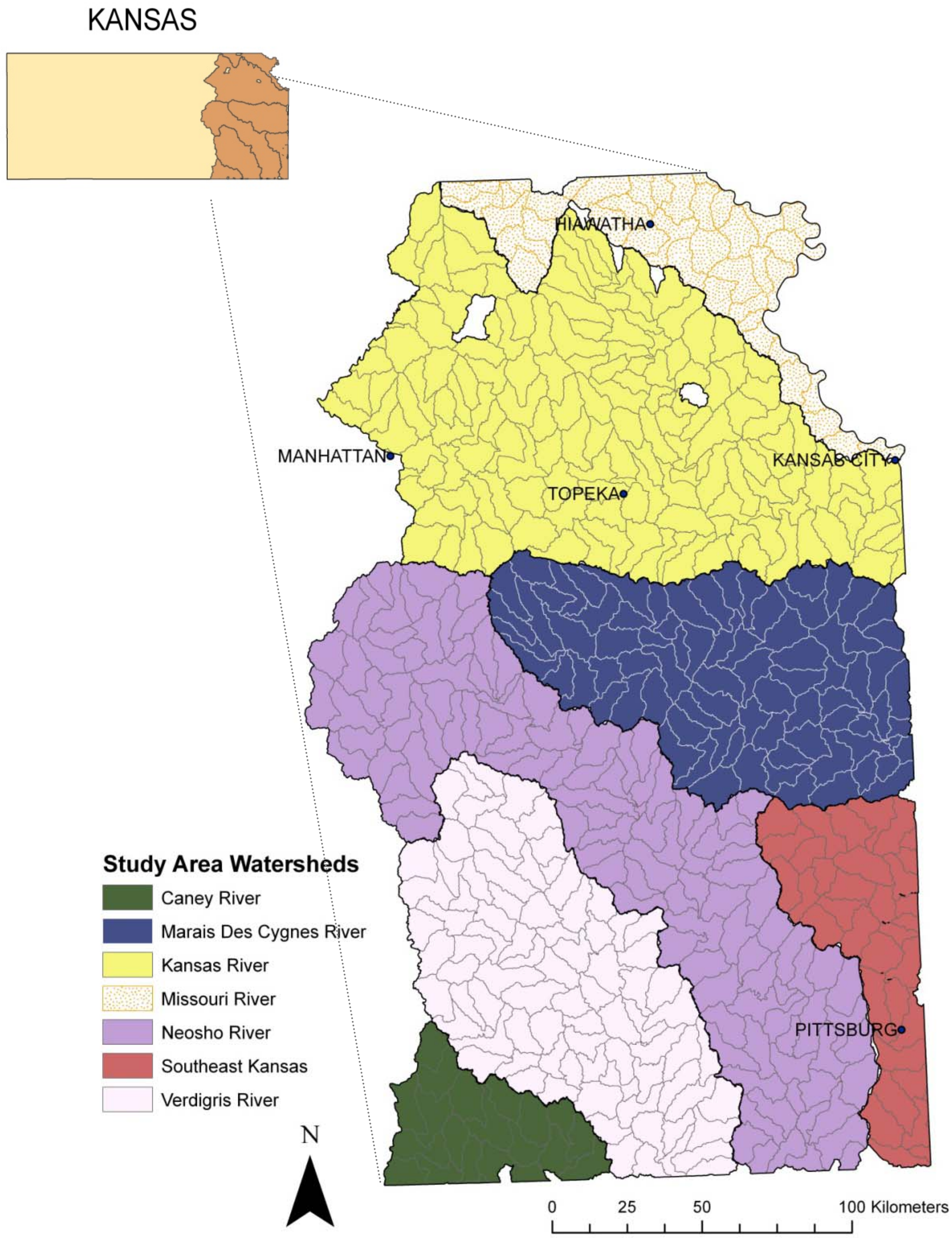

Figure A.1. Study area for river otter sign survey project with USGS Hydrologic Unit Code (HUC) 14 watersheds grouped into 7 otter units, eastern Kansas, USA, 2008-2009. All colored watersheds contain third order streams or higher.

Appendix B - Encounter histories

Table B.1. All encounter histories for both sign types broken into 3-9 400-m surveys conducted per site (1,200-3,600 m) as collected during river otter sign surveys in eastern Kansas, USA, 2008-2009. Sites in gray were used to compare observers but not used in the habitat analysis. A “0” indicates no detection, “1” indicates a detection, and “.” indicates the survey was missing. Observers were Brandon Tristch (BT), Kevin Blecha (KB), Mackenzie Shardlow (MS), and Matthew Jeffress (MJ).

	Survey Number										
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
C-10A	0	0	0	0	0	0	0	0	0	3/6/2009	KB
C-11A	.	0	0	0	0	0	0	0	0	2/22/2009	KB
C-12A	0	0	0	0	0	0	0	0	0	2/22/2009	KB
C-14B	0	0	0	0	0	0	0	0	0	3/26/2009	KB
C-17A	0	0	0	0	0	0	0	0	.	4/3/2009	KB
C-19A	0	0	0	0	0	0	0	0	0	3/31/2009	MS
C-19A	0	0	0	0	0	0	0	0	0	3/31/2009	KB
C-1B	0	0	0	0	0	0	0	0	1	2/26/2008	MJ
C-4A	0	0	0	0	0	0	0	0	0	3/26/2008	MJ
C-5B	0	0	0	0	0	0	0	0	0	2/26/2008	MJ
C-9A	0	0	0	0	0	0	0	0	0	3/8/2008	MJ
D-12A	0	0	0	0	0	.	.	.	.	2/27/2009	KB
D-13B	0	0	0	0	0	0	0	0	0	2/20/2009	BT
D-13B	0	0	0	0	0	0	0	0	0	2/20/2009	KB
D-13B	0	0	0	0	0	0	0	0	0	2/20/2009	MS
D-19A	0	0	0	0	0	0	0	0	0	2/7/2009	BT
D-19A	0	0	0	0	0	0	0	0	0	2/7/2009	KB
D-19A	0	0	0	0	0	0	0	0	0	4/7/2009	KB
D-1A	0	0	1	0	0	0	1	0	0	2/14/2008	MJ
D-1A	1	0	1	1	1	1	0	0	1	3/20/2009	KB
D-26A	1	0	0	0	0	0	0	0	0	2/20/2009	BT
D-26A	1	1	1	1	1	1	1	0	.	2/20/2009	KB
D-26A	.	.	.	1	1	1	1	1	0	2/20/2009	MS
D-2A	0	0	0	0	0	0	1	0	0	2/14/2008	MJ
D-2A	0	1	1	0	0	0	0	0	0	4/6/2009	MS
D-2A	1	0	0	1	0	0	1	1	0	4/6/2009	KB
D-2A	0	0	1	0	0	0	0	0	0	4/6/2009	BT
D-38A	0	0	0	0	0	0	0	0	0	2/7/2009	MS
D-38A	0	0	0	0	0	0	0	0	0	2/7/2009	KB
D-38A	0	0	0	0	1	1	0	0	0	4/8/2009	KB
D-3A	0	0	0	0	0	0	0	0	0	2/28/2008	MJ
D-4A	0	0	0	0	0	0	0	0	0	2/20/2008	MJ

	Survey Number										
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
D-54A	0	1	1	1	0	1	1	1	1	3/15/2008	MJ
D-54A	0	0	0	1	0	0	1	0	0	3/2/2009	MS
D-55A	0	1	0	1	0	1	1	0	1	3/15/2008	MJ
D-55A	1	1	1	1	0	1	0	0	1	3/15/2008	MS
D-55A	0	0	0	0	0	0	.	.	.	3/9/2009	KB
D-5B	0	0	0	0	0	0	0	0	0	3/27/2008	MJ
D-6A	0	0	0	0	0	0	0	0	0	1/30/2009	KB
D-6A	0	0	0	0	0	0	0	0	0	4/7/2009	KB
D-72B	1	0	0	0	0	0	0	0	0	3/27/2008	MJ
D-72B	0	0	0	1	0	0	1	1	1	4/6/2009	KB
D-72B	0	0	0	0	0	0	0	1	0	4/6/2009	BT
D-72B	0	0	0	0	0	0	0	1	0	4/6/2009	MS
D-7A	0	0	0	0	0	0	0	0	0	2/20/2008	MJ
D-8B	0	0	0	0	0	0	0	0	0	3/9/2009	KB
K-11A	0	0	0	0	0	0	0	0	0	3/12/2008	MJ
K-12A	0	0	0	0	0	0	0	0	0	2/15/2008	MJ
K-12A	0	0	0	0	0	0	0	0	0	4/1/2008	MJ
K-12A	0	0	0	0	0	0	0	0	0	3/18/2009	KB
K-14A	0	0	0	0	0	0	0	0	0	2/18/2008	MJ
K-17A	0	0	0	0	0	0	0	0	0	3/11/2008	MJ
K-18A	0	1	1	1	1	1	0	0	0	2/19/2008	MJ
K-18A	0	0	0	0	1	0	0	0	0	3/4/2009	KB
K-19A	0	0	0	0	0	0	0	0	0	4/13/2008	MS
K-19A	0	0	0	0	0	0	1	0	0	4/13/2008	MJ
K-20A	0	0	0	0	0	0	0	0	0	4/2/2008	MJ
K-25B	0	0	0	0	0	0	0	0	0	2/26/2009	KB
K-26A	0	0	0	0	0	0	0	.	.	1/29/2009	KB
K-27A	.	0	0	0	0	0	0	0	0	2/8/2009	KB
K-27A	.	0	0	0	0	0	0	0	0	4/8/2009	KB
K-2B	0	0	0	0	0	0	0	0	0	3/12/2008	MJ
K-30A	0	0	0	0	0	0	0	0	0	1/28/2009	KB
K-31C	0	0	0	0	0	0	.	.	.	3/4/2009	KB
K-34A	0	0	0	0	0	0	0	0	0	4/11/2008	MJ
K-34A	0	0	0	0	0	0	0	0	0	4/11/2008	MS
K-36A	0	0	0	1	0	0	0	0	.	2/18/2009	KB
K-38A	0	0	0	0	0	0	0	0	0	2/18/2009	KB
K-39A	0	0	0	0	0	0	0	0	0	2/19/2009	KB
K-3C	0	0	0	0	0	0	0	0	0	2/8/2009	KB
K-40A	0	0	0	0	0	0	0	.	.	2/16/2009	KB
K-49A	0	0	0	0	0	0	0	0	0	2/27/2009	KB
K-4C	0	0	0	0	0	0	.	.	.	3/17/2009	KB
K-53B	0	0	0	0	0	0	.	.	.	4/1/2009	KB
K-53B	0	0	0	0	0	0	.	.	.	4/1/2009	MS
K-54A	0	0	0	0	0	0	0	0	0	3/17/2009	KB
K-67A	0	0	0	0	0	0	0	0	0	3/30/2009	MS
K-67A	0	0	0	0	0	0	0	0	0	3/30/2009	KB
K-6H	0	0	0	0	0	0	0	0	.	1/29/2009	KB
K-72A	0	0	0	0	0	0	0	0	0	4/4/2008	MJ

				Survey Number							
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
K-72A	0	0	0	0	0	0	0	0	0	4/4/2008	MS
K-72A	0	0	0	0	0	0	0	0	0	3/30/2009	MS
K-72A	0	0	0	0	0	0	0	0	0	3/30/2009	KB
K-86A	0	0	0	0	0	0	0	0	0	4/1/2008	MJ
K-86A	0	0	0	0	0	0	0	0	0	3/18/2009	KB
M-10A	1	0	0	0	0	0	0	0	0	3/19/2009	KB
M-14A	0	0	0	0	0	0	0	.	.	2/17/2009	KB
M-15A	0	0	0	0	0	0	0	0	.	4/1/2009	KB
M-15A	0	0	0	0	0	0	0	0	.	4/1/2009	MS
M-16A	1	0	1	0	1	1	0	0	.	3/19/2009	KB
M-1A	0	0	0	0	0	0	0	0	0	2/15/2008	MJ
M-2A	0	0	0	0	0	0	0	0	0	2/29/2008	MJ
M-3D	0	0	0	0	0	0	0	0	0	3/11/2008	MJ
M-4A	0	0	0	0	1	0	0	0	0	1/30/2009	KB
M-6A	0	0	0	0	0	0	0	0	0	4/2/2008	MJ
M-8B	0	0	0	0	0	0	0	0	0	2/17/2009	KB
N-11A	0	1	0	0	1	0	0	0	1	2/9/2008	MJ
N-11A	.	.	0	0	0	0	0	0	0	4/6/2008	MS
N-11A	.	.	0	0	0	0	0	0	0	4/6/2008	MJ
N-12B	0	0	0	0	0	0	0	0	.	3/1/2009	KB
N-13B	0	0	0	0	0	0	0	0	1	3/7/2009	KB
N-14A	0	0	0	0	0	0	0	0	0	3/2/2009	KB
N-18B	0	0	0	0	0	0	0	0	0	4/4/2009	KB
N-1A	1	0	1	0	0	0	0	0	0	2/13/2008	MJ
N-22A	.	0	0	0	0	0	0	0	0	3/21/2009	KB
N-23D	0	0	0	0	0	1	0	0	.	3/8/2009	KB
N-25A	1	0	0	0	0	0	0	0	0	3/8/2009	KB
N-26A	0	0	0	0	0	0	0	.	.	3/5/2009	KB
N-28B	0	0	0	0	0	0	0	0	0	2/23/2009	KB
N-2A	0	0	0	0	0	0	0	0	0	3/9/2008	MJ
N-37A	0	0	0	0	0	0	0	0	0	4/3/2009	KB
N-3C	0	0	0	0	0	0	0	0	0	2/21/2009	BT
N-3C	0	0	0	0	0	0	0	0	1	2/21/2009	KB
N-3C	0	0	0	0	0	0	0	0	0	2/21/2009	MS
N-40A	0	1	0	0	0	0	0	0	0	2/25/2008	MJ
N-40A	1	1	1	1	0	0	0	0	0	4/6/2008	MS
N-40A	1	1	1	1	0	0	0	0	1	4/6/2008	MJ
N-40A	1	1	0	1	0	0	1	0	0	3/25/2009	KB
N-4D	0	0	0	0	0	0	0	0	0	3/25/2008	MJ
N-50A	0	1	1	0	0	1	0	0	1	1/31/2009	KB
N-50A	0	1	1	0	1	1	0	0	1	4/4/2009	KB
N-6A	0	0	0	0	0	0	0	0	0	2/27/2008	MJ
N-7C	0	0	0	0	0	0	0	0	0	2/27/2008	MJ
N-8A	0	0	0	0	0	0	0	0	0	3/9/2008	MJ
N-9C	0	0	0	0	0	0	0	0	0	3/20/2009	KB
S-10B	0	0	0	1	0	0	0	0	0	2/6/2009	KB
S-13C	0	0	0	1	1	0	0	0	0	3/26/2009	KB
S-15C	0	0	0	0	0	0	0	0	0	3/2/2009	KB

	Survey Number										
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
S-16A	0	0	0	0	0	0	0	0	0	1/31/2009	KB
S-16A	0	0	1	1	0	0	1	1	1	4/5/2009	KB
S-18A	1	0	0	0	.	.	.	.	.	3/26/2009	KB
S-1A	0	1	1	1	.	.	.	.	.	2/19/2009	KB
S-2A	0	0	0	0	1	0	1	0	0	2/13/2008	MJ
S-3F	0	0	0	0	0	0	0	0	0	3/10/2008	MJ
S-5A	1	1	1	0	1	1	0	0	0	2/28/2008	MJ
S-5A	1	1	1	.	.	.	.	.	.	3/16/2008	MS
S-6C	0	0	0	0	.	.	.	.	.	2/6/2009	KB
S-6C	1	1	1	0	.	.	.	.	.	4/5/2009	KB
V-10A	0	0	0	0	0	0	.	0	0	2/5/2009	KB
V-14A	1	1	1	1	1	1	1	1	1	3/6/2009	KB
V-16B	0	0	0	0	0	0	0	.	.	3/5/2009	KB
V-18B	0	0	0	0	0	0	0	0	0	3/21/2009	KB
V-19A	1	1	1	1	1	1	1	0	1	3/7/2009	KB
V-1B	0	0	0	0	0	0	0	0	0	2/1/2009	KB
V-23B	0	0	0	0	0	0	0	0	0	3/22/2009	KB
V-24A	0	1	0	1	0	0	0	0	0	3/7/2008	MJ
V-24A	0	0	0	0	0	0	0	0	0	3/22/2009	KB
V-29A	0	0	0	0	0	0	0	0	0	2/21/2009	KB
V-29A	0	0	0	0	0	0	0	0	0	2/21/2009	BT
V-29A	0	0	0	0	0	0	0	0	0	2/21/2009	MS
V-2B	0	0	0	0	0	0	0	0	0	3/8/2008	MJ
V-3C	0	0	0	0	0	0	.	.	.	3/25/2008	MJ
V-44A	0	1	0	0	0	1	0	0	0	3/26/2008	MJ
V-4A	0	0	0	0	0	0	0	0	0	3/7/2008	MJ
V-59A	0	0	0	1	0	0	0	1	0	3/16/2008	MJ
V-6A	0	0	0	0	0	0	0	0	0	2/12/2008	MJ
V-9A	0	0	0	0	0	0	0	0	0	2/5/2009	KB

Table B.2. Encounter histories for scat and tracks broken into 3-9 400-m surveys for otter sign surveys in eastern Kansas, USA, 2008-2009. A “0” indicates no detection, “S” indicates a scat detection, “T” a track detection, “ST” both detected, and “.” indicates the survey is missing. Observers were Brandon Tristch (BT), Kevin Blecha (KB), Mackenzie Shardlow (MS), and Matthew Jeffress (MJ).

	Survey Number										
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
C-10A	0	0	0	0	0	0	0	0	0	3/6/2009	KB
C-11A	.	0	0	0	0	0	0	0	0	2/22/2009	KB
C-12A	0	0	0	0	0	0	0	0	0	2/22/2009	KB
C-14B	0	0	0	0	0	0	0	0	0	3/26/2009	KB
C-17A	0	0	0	0	0	0	0	0	.	4/3/2009	KB
C-19A	0	0	0	0	0	0	0	0	0	3/31/2009	MS
C-19A	0	0	0	0	0	0	0	0	0	3/31/2009	KB
C-1B	0	0	0	0	0	0	0	0	S	2/26/2008	MJ
C-4A	0	0	0	0	0	0	0	0	0	3/26/2008	MJ
C-5B	0	0	0	0	0	0	0	0	0	2/26/2008	MJ
C-9A	0	0	0	0	0	0	0	0	0	3/8/2008	MJ
D-12A	0	0	0	0	0	.	.	.	.	2/27/2009	KB
D-13B	0	0	0	0	0	0	0	0	0	2/20/2009	BT
D-13B	0	0	0	0	0	0	0	0	0	2/20/2009	KB
D-13B	0	0	0	0	0	0	0	0	0	2/20/2009	MS
D-19A	0	0	0	0	0	0	0	0	0	2/7/2009	BT
D-19A	0	0	0	0	0	0	0	0	0	2/7/2009	KB
D-19A	0	0	0	0	0	0	0	0	0	4/7/2009	KB
D-1A	0	0	T	0	0	0	T	0	0	2/14/2008	MJ
D-1A	T	0	T	T	T	T	0	0	T	3/20/2009	KB
D-26A	S	0	0	0	0	0	0	0	0	2/20/2009	BT
D-26A	S	S	S	S	S	S	S	0	.	2/20/2009	KB
D-26A	.	.	.	S	S	S	S	S	0	2/20/2009	MS
D-2A	0	0	0	0	0	0	T	0	0	2/14/2008	MJ
D-2A	0	S	ST	0	0	0	0	0	0	4/6/2009	MS
D-2A	S	0	0	T	0	0	T	T	0	4/6/2009	KB
D-2A	0	0	T	0	0	0	0	0	0	4/6/2009	BT
D-38A	0	0	0	0	0	0	0	0	0	2/7/2009	MS
D-38A	0	0	0	0	0	0	0	0	0	2/7/2009	KB
D-38A	0	0	0	0	S	S	0	0	0	4/8/2009	KB
D-3A	0	0	0	0	0	0	0	0	0	2/28/2008	MJ
D-4A	0	0	0	0	0	0	0	0	0	2/20/2008	MJ
D-54A	0	S	S	S	0	S	S	S	S	3/15/2008	MJ
D-54A	0	0	0	S	0	0	S	0	0	3/2/2009	MS
D-55A	0	S	0	S	0	S	S	0	S	3/15/2008	MJ
D-55A	S	ST	S	S	0	S	0	0	S	3/15/2008	MS
D-55A	0	0	0	0	0	0	.	.	.	3/9/2009	KB

Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
				Survey Number							
D-5B	0	0	0	0	0	0	0	0	0	3/27/2008	MJ
D-6A	0	0	0	0	0	0	0	0	0	1/30/2009	KB
D-6A	0	0	0	0	0	0	0	0	0	4/7/2009	KB
D-72B	S	0	0	0	0	0	0	0	0	3/27/2008	MJ
D-72B	0	0	0	S	0	0	S	S	S	4/6/2009	KB
D-72B	0	0	0	0	0	0	0	S	0	4/6/2009	BT
D-72B	0	0	0	0	0	0	0	S	0	4/6/2009	MS
D-7A	0	0	0	0	0	0	0	0	0	2/20/2008	MJ
D-8B	0	0	0	0	0	0	0	0	0	3/9/2009	KB
K-11A	0	0	0	0	0	0	0	0	0	3/12/2008	MJ
K-12A	0	0	0	0	0	0	0	0	0	2/15/2008	MJ
K-12A	0	0	0	0	0	0	0	0	0	4/1/2008	MJ
K-12A	0	0	0	0	0	0	0	0	0	3/18/2009	KB
K-14A	0	0	0	0	0	0	0	0	0	2/18/2008	MJ
K-17A	0	0	0	0	0	0	0	0	0	3/11/2008	MJ
K-18A	0	S	S	S	S	T	0	0	0	2/19/2008	MJ
K-18A	0	0	0	0	S	0	0	0	0	3/4/2009	KB
K-19A	0	0	0	0	0	0	0	0	0	4/13/2008	MS
K-19A	0	0	0	0	0	0	S	0	0	4/13/2008	MJ
K-20A	0	0	0	0	0	0	0	0	0	4/2/2008	MJ
K-25B	0	0	0	0	0	0	0	0	0	2/26/2009	KB
K-26A	0	0	0	0	0	0	0	.	.	1/29/2009	KB
K-27A	.	0	0	0	0	0	0	0	0	2/8/2009	KB
K-27A	.	0	0	0	0	0	0	0	0	4/8/2009	KB
K-2B	0	0	0	0	0	0	0	0	0	3/12/2008	MJ
K-30A	0	0	0	0	0	0	0	0	0	1/28/2009	KB
K-31C	0	0	0	0	0	0	.	.	.	3/4/2009	KB
K-34A	0	0	0	0	0	0	0	0	0	4/11/2008	MJ
K-34A	0	0	0	0	0	0	0	0	0	4/11/2008	MS
K-36A	0	0	0	S	0	0	0	0	.	2/18/2009	KB
K-38A	0	0	0	0	0	0	0	0	0	2/18/2009	KB
K-39A	0	0	0	0	0	0	0	0	0	2/19/2009	KB
K-3C	0	0	0	0	0	0	0	0	0	2/8/2009	KB
K-40A	0	0	0	0	0	0	0	.	.	2/16/2009	KB
K-49A	0	0	0	0	0	0	0	0	0	2/27/2009	KB
K-4C	0	0	0	0	0	0	.	.	.	3/17/2009	KB
K-53B	0	0	0	0	0	0	.	.	.	4/1/2009	KB
K-53B	0	0	0	0	0	0	.	.	.	4/1/2009	MS
K-54A	0	0	0	0	0	0	0	0	0	3/17/2009	KB
K-67A	0	0	0	0	0	0	0	0	0	3/30/2009	MS
K-67A	0	0	0	0	0	0	0	0	0	3/30/2009	KB
K-6H	0	0	0	0	0	0	0	0	.	1/29/2009	KB
K-72A	0	0	0	0	0	0	0	0	0	4/4/2008	MJ
K-72A	0	0	0	0	0	0	0	0	0	4/4/2008	MS
K-72A	0	0	0	0	0	0	0	0	0	3/30/2009	MS
K-72A	0	0	0	0	0	0	0	0	0	3/30/2009	KB
K-86A	0	0	0	0	0	0	0	0	0	4/1/2008	MJ
K-86A	0	0	0	0	0	0	0	0	0	3/18/2009	KB

	Survey Number										
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
M-10A	T	0	0	0	0	0	0	0	0	3/19/2009	KB
M-14A	0	0	0	0	0	0	0	.	.	2/17/2009	KB
M-15A	0	0	0	0	0	0	0	0	.	4/1/2009	KB
M-15A	0	0	0	0	0	0	0	0	.	4/1/2009	MS
M-16A	T	0	T	0	T	T	0	0	.	3/19/2009	KB
M-1A	0	0	0	0	0	0	0	0	0	2/15/2008	MJ
M-2A	0	0	0	0	0	0	0	0	0	2/29/2008	MJ
M-3D	0	0	0	0	0	0	0	0	0	3/11/2008	MJ
M-4A	0	0	0	0	T	0	0	0	0	1/30/2009	KB
M-6A	0	0	0	0	0	0	0	0	0	4/2/2008	MJ
M-8B	0	0	0	0	0	0	0	0	0	2/17/2009	KB
N-11A	0	S	0	0	T	0	0	0	S	2/9/2008	MJ
N-11A	.	.	0	0	0	0	0	0	0	4/6/2008	MS
N-11A	.	.	0	0	0	0	0	0	0	4/6/2008	MJ
N-12B	0	0	0	0	0	0	0	0	.	3/1/2009	KB
N-13B	0	0	0	0	0	0	0	0	S	3/7/2009	KB
N-14A	0	0	0	0	0	0	0	0	0	3/2/2009	KB
N-18B	0	0	0	0	0	0	0	0	0	4/4/2009	KB
N-1A	S	0	S	0	0	0	0	0	0	2/13/2008	MJ
N-22A	.	0	0	0	0	0	0	0	0	3/21/2009	KB
N-23D	0	0	0	0	0	S	0	0	.	3/8/2009	KB
N-25A	S	0	0	0	0	0	0	0	0	3/8/2009	KB
N-26A	0	0	0	0	0	0	0	.	.	3/5/2009	KB
N-28B	0	0	0	0	0	0	0	0	0	2/23/2009	KB
N-2A	0	0	0	0	0	0	0	0	0	3/9/2008	MJ
N-37A	0	0	0	0	0	0	0	0	0	4/3/2009	KB
N-3C	0	0	0	0	0	0	0	0	0	2/21/2009	BT
N-3C	0	0	0	0	0	0	0	0	ST	2/21/2009	KB
N-3C	0	0	0	0	0	0	0	0	0	2/21/2009	MS
N-40A	0	S	0	0	0	0	0	0	0	2/25/2008	MJ
N-40A	S	S	S	S	0	0	0	0	0	4/6/2008	MS
N-40A	S	S	S	S	0	0	0	0	S	4/6/2008	MJ
N-40A	S	S	0	S	0	0	S	0	0	3/25/2009	KB
N-4D	0	0	0	0	0	0	0	0	0	3/25/2008	MJ
N-50A	0	T	S	0	0	S	0	0	ST	1/31/2009	KB
N-50A	0	T	T	0	T	ST	0	0	T	4/4/2009	KB
N-6A	0	0	0	0	0	0	0	0	0	2/27/2008	MJ
N-7C	0	0	0	0	0	0	0	0	0	2/27/2008	MJ
N-8A	0	0	0	0	0	0	0	0	0	3/9/2008	MJ
N-9C	0	0	0	0	0	0	0	0	0	3/20/2009	KB
S-10B	0	0	0	S	0	0	0	0	0	2/6/2009	KB
S-13C	0	0	0	T	T	0	0	0	0	3/26/2009	KB
S-15C	0	0	0	0	0	0	0	0	0	3/2/2009	KB
S-16A	0	0	0	0	0	0	0	0	0	1/31/2009	KB
S-16A	0	0	S	S	0	0	S	S	S	4/5/2009	KB
S-18A	S	0	0	0	.	.	.	.	.	3/26/2009	KB
S-1A	0	ST	T	ST	.	.	.	.	.	2/19/2009	KB
S-2A	0	0	0	0	S	0	S	0	0	2/13/2008	MJ

	Survey Number										
Site ID	1	2	3	4	5	6	7	8	9	Date	Observer
S-3F	0	0	0	0	0	0	0	0	0	3/10/2008	MJ
S-5A	S	ST	ST	0	ST	S	0	0	0	2/28/2008	MJ
S-5A	T	ST	ST	.	.	.	.	.	.	3/16/2008	MS
S-6C	0	0	0	0	.	.	.	.	.	2/6/2009	KB
S-6C	T	T	ST	0	.	.	.	.	.	4/5/2009	KB
V-10A	0	0	0	0	0	0	.	0	0	2/5/2009	KB
V-14A	S	S	S	S	S	S	S	S	S	3/6/2009	KB
V-16B	0	0	0	0	0	0	0	.	.	3/5/2009	KB
V-18B	0	0	0	0	0	0	0	0	0	3/21/2009	KB
V-19A	S	S	S	S	S	S	S	0	S	3/7/2009	KB
V-1B	0	0	0	0	0	0	0	0	0	2/1/2009	KB
V-23B	0	0	0	0	0	0	0	0	0	3/22/2009	KB
V-24A	0	S	0	S	0	0	0	0	0	3/7/2008	MJ
V-24A	0	0	0	0	0	0	0	0	0	3/22/2009	KB
V-29A	0	0	0	0	0	0	0	0	0	2/21/2009	KB
V-29A	0	0	0	0	0	0	0	0	0	2/21/2009	BT
V-29A	0	0	0	0	0	0	0	0	0	2/21/2009	MS
V-2B	0	0	0	0	0	0	0	0	0	3/8/2008	MJ
V-3C	0	0	0	0	0	0	.	.	.	3/25/2008	MJ
V-44A	0	S	0	0	0	S	0	0	0	3/26/2008	MJ
V-4A	0	0	0	0	0	0	0	0	0	3/7/2008	MJ
V-59A	0	0	0	S	0	0	0	S	0	3/16/2008	MJ
V-6A	0	0	0	0	0	0	0	0	0	2/12/2008	MJ
V-9A	0	0	0	0	0	0	0	0	0	2/5/2009	KB