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Original article

Detecting river otter *Lontra canadensis* latrines near bridges: does habitat and season influence survey success?

Emily H. Just, Sadie S. Stevens, Romeo M. Spinola & Thomas L. Serfass

During 2006, we conducted riparian surveys to detect river otter *Lontra canadensis* latrines at 15 bridge-suites along riverine habitats in southwestern Pennsylvania and western Maryland, USA. We defined a bridge-suite as consisting of survey locations at the bridge, a random site and a site chosen by application of a Pattern Recognition Model developed for predicting the location of latrines, with each survey location consisting of both shorelines along a 200-m section of the river. We used occupancy modeling to assess the influence of the continuous covariate SiteScore (a probability derived from Pattern Recognition modeling, with higher scores predicting habitat conditions where river otters are most likely to establish latrines). We also included two categorical covariates with the modeling, each with three factor levels: SiteType (consisting of the three survey locations within a bridge-suite: Bridge, Random and Select, chosen based on having the highest SiteScore among non-Bridge sites within a bridge-suite) and Season (spring, summer and fall) on the probability of detecting a positive site (i.e. a site with $\geq$ 1 latrine). The selected model suggested that probabilities of detection were positively related to SiteScore (i.e. habitat quality), higher in spring and fall than in summer, and higher at Selected and Random sites than at Bridge sites. In our study areas, efficacy of surveys to detect river otter signs (i.e. scats at latrines) would be considerably enhanced by considering habitat quality when selecting survey locations and by conducting surveys during spring or fall.

Key words: bridge-sign surveys, habitat quality, latrine, Lontra canadensis, occupancy modeling, river otter

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The use of bridge-sign surveys to detect evidence of river otters (often scats at latrines, i.e. areas where otters scent mark; Ben-David et al. 2005, Kruuk 2006) has become a common method for monitoring extant and reintroduced populations in the United States (e.g. Clark et al. 1987, Berkley & Johnson 2000, Ostroff 2001, Breaux et al. 2002) and Canada (e.g. Gallant et al. 2008). Likewise, surveys to detect spraints and other signs has been a primary method for assessing the presence and distribution of Eurasian otters *Lutra lutra* (e.g. Mason & Macdonald 1987, Kruuk & Conroy 1987) and other species (Kruuk 2006), with bridges often being the focus, especially for the Eurasian otter (Reuther et al. 2000).

Conducting surveys to detect evidence of river otters at bridges has the inherent advantage of providing easy access to riverine habitats, and in being logistically less challenging than using techniques such as live-trapping (Serfass et al. 1996, Blundell et al. 1999) or remote cameras (Stevens & Serfass 2008). However, until recently, few studies have investigated the efficacy of bridge-sign surveys in determining the presence of river otters (e.g. in New Brunswick, Canada; Gallant et al. 2008 and in Missouri, USA; Roberts et al. 2008, Crimmins et al. 2009). However, these studies of river otters and studies of other otter species did not consider habitat conditions in their assessments.

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In the northeastern United States, river otters establish latrines along sections of shoreline associated with prominent in-stream and riparian features (Newman & Griffin 1994, Swimley et al. 1998), and more recently, Depue & Ben-David (2010) also identified an association with the location of otter latrines and nearby habitat features along riverine systems in Colorado, USA. Stevens et al. (2011) showed that selecting stream sections with certain of the in-stream and riparian features identified by Swimley et al. (1998) as being associated with latrines enhanced the likelihood that latrines would be present during surveys near bridges. However, Stevens et al. (2011) did not include a seasonal assessment of detection patterns for latrines including summer, a period potentially advantageous for conducting surveys (e.g. warmer water temperatures and typically lower water levels enables safer and easier opportunities to ford riverine systems), thus enhancing the efficiency of surveying opposite, adjacent shorelines. A limiting factor for surveys during the summer is the potential of lower marking during that period, as suggested by Olson et al. (2008) in a project that monitored river otter activity at latrines with remote cameras.

Our project was designed to assess the influence of habitat quality and seasonality (spring, summer and fall) on detecting river otter latrines near bridges by assessing aspects of previous, separate empirical studies (i.e. Swimley et al. 1998, habitat; Olson et. 2008, seasonality) not conducted with the presence of bridges as a consideration. To accomplish this assessment surveys were conducted at three types of sites associated with each bridge in our study: 1) the bridge, 2) a randomly chosen site and 3) a site chosen based on having habitat attributes identified by Swimley et al. (1998) as useful for predicting the presence of latrines. We predicted that latrines would be more frequently encountered at sites chosen from habitat criteria established by Swimley et al. (1998), and during spring or fall than during summer (Olson et al. 2008). Habitat quality was expected to vary not only among the three types of sites surveyed, but within each type of site. Thus, we predicted that detection of latrines should be similar among the various sites when habitat conditions were similar (i.e. if controlling for habitat quality). A different outcome, particularly at bridges, would thereby imply an influence of other factors, such as disturbance (e.g. vehicle traffic).

Material and methods

Study areas

Our study was conducted along the Youghiogheny

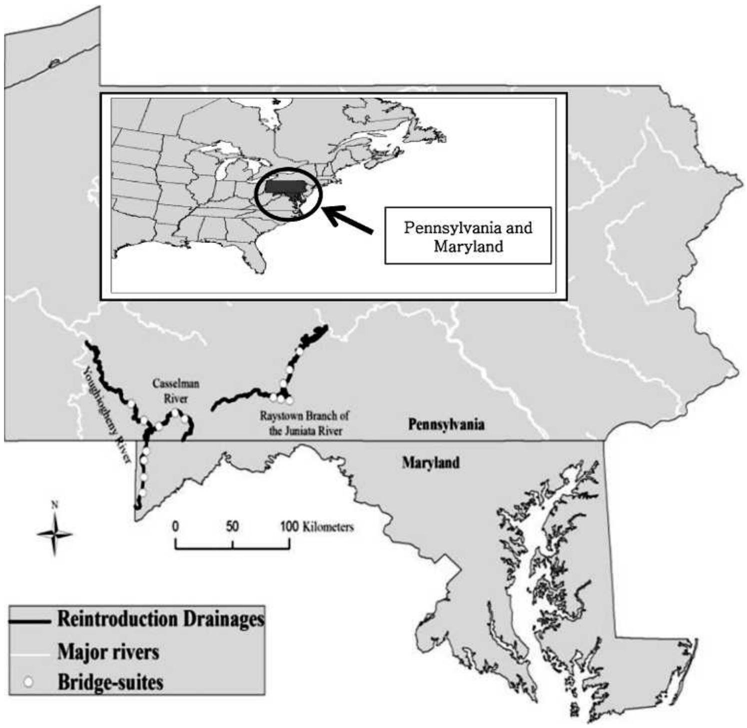

Figure 1. Locations of rivers and 15 bridge-suites at which riparian surveys were conducted to detect river otter latrines in Maryland and Pennsylvania, USA, in 2006.

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and Casselman Rivers in southwestern Pennsylvania and western Maryland, and the Raystown Branch of the Juniata River in south central Pennsylvania, USA (Fig. 1). These rivers are occupied by reintroduced populations of river otters (Serfass et al. 2003, Just 2007). The rivers support abundant fish and invertebrate populations, and riparian areas are forested (Serfass et al. 2003 discuss criteria used to select river otter reintroduction sites in Pennsylvania). Portions of the rivers included in the study were $\geq$ 4th order.

Methods

We surveyed 15 'bridge-suites' (combinations of a bridge site (Bridge), random site (Random) and chosen site (Select), levels of the factor SiteType; see Fig. 2 for a schematic example of a hypothetical bridge-suite) during portions of March-April (spring), July-August (summer) and October-November (fall) of 2006 to detect evidence of river otters (i.e. scats at latrines). We designed the survey for potential Random and Select sites in a bridge-suite to occur within 2.5 km upstream or downstream from the bridge (thus, a bridge-suite comprised a 5-km segment of riverine habitat; Just 2007, Stevens et al. 2011), and for bridges to be separated by $\geq$ 10 stream/river km (see Fig. 1). Each 5-km segment of a bridge-suite was partitioned into 50 100-m sections (100 m upstream and downstream from a bridge representing a bridge site). A survey site included both shorelines 100 m upstream and downstream from a bridge (the bridge site) and from the midpoint of Random and Select sections within a bridge-suite. We chose 5 km as the segment length for a bridge-suite to increase the chance that the same river otters would have access to all sites within a bridge-suite (i.e. sites within a bridge-suite were not intended to be independent), a choice based on previous studies of river otter movements (Serfass & Rymon 1985, Reid et al. 1994, Melquist et al. 2003). Conversely, to diminish chances for monitoring the same river otters among bridge-suites (i.e. achieve independence among bridge-suites) we selected bridges within a drainage that were separated by $\geq$ 10 stream/river km.

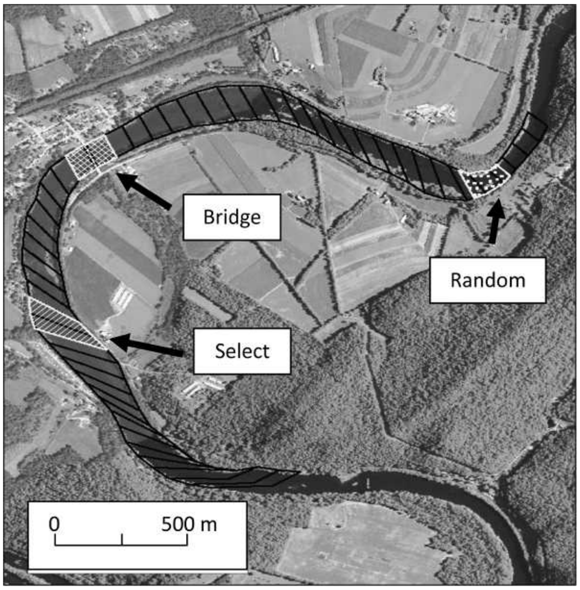

Figure 2. Schematic presentation of a bridge-suite, which is comprised of a bridge site (Bridge), random site (Random) and chosen site (Select). Surveys to detect river otter latrines were conducted among 15 bridge-suites along the Casselman and Raystown Branch of the Juniata Rivers in Pennsylvania and Youghiogheny River in Maryland and Pennsylvania, USA, in 2006, to determine the probability of detecting river otter latrines among the three types of sites.

We assessed the quality for each of the 50 100-m sections as prospective locations for river otter latrines by applying a Pattern Recognition Model developed by Swimley et al. (1998). Swimley et al. (1998) identified the presence of 10 riparian and riverine covariates (vertical banks, large rocks, points of lands, backwater sloughs, tributaries, beaver activity, conifers, bends in the stream/river channel, fallen logs, and deep pools) as positively influencing the occurrence of latrines, and each was included in their Pattern Recognition model. Application of the model required us to assess the presence of these covariates in each 100-m section within a bridge-suite, which we accomplished by viewing aerial photographs and topographic maps (Just 2007). Pattern Recognition modeling is based on Bayesian statistics and yields a probability for the occurrence of a feature in the landscape given the presence or absence of specific covariates, with higher probabilities indicating that the feature being assessed is more likely to occur. The probability of occupied habitat (O; i.e. for this application, the probability of a latrine being present along a 100 m section of shoreline) given inventory data (ID) for a location is calculated from Bayes rule: P (O/ID) = P(O) P(ID/O) / P(O) P(ID/O) + P(unoccupied (U) P(ID/U). P(O), or prior probability, is a best estimate of the occurrence of a feature in the landscape being assessed (in our case, a river otter latrine, for which we set P(O) = 0.10 from Swimley et al. 1998). In-

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ventory data refer to the proportion at which covariates occur at occupied and unoccupied sites, which was based on previous evaluations and then applied for our application of the model from Swimley et al. (1998; see Flather & Hoekstra (1985) and Grubb (1988) for further explanation and general examples of applications and calculations for Pattern Recognition modeling, and Swimley et al. (1998) for details related to the development of the Pattern Recognition model applied in this study). We used the midpoint of the section (one of the 48 non-bridge sections) with the highest Pattern Recognition value (hereafter Pattern Recognition values are referred to as SiteScores) to define the Select site for a bridge-suite. After identifying a Select site we used a random numbers generator to choose a Random site from among the remaining stream sections that did not encompass a Bridge or Select site.

During surveys we counted the number of latrines at each survey site. A site was considered positive if a latrine (defined as a location having $\geq$ 1 scat) was detected.

Data analysis

We included three covariates in our assessments: SiteScore, SiteType and Season (spring, summer and fall). We used descriptive statistics (0, SE and range) to summarize SiteScore values overall and for factor levels within SiteType, and we conducted a one-way Analysis of Variance to assess if SiteScores differed ($P < 0.05$) among SiteTypes. We used percentages to describe the frequencies that latrines occurred among bridge-suites by drainage, Season and SiteType. We used an occupancy modeling (MacKenzie et al. 2006) approach to assess the contributions of the covariates Season, SiteType and SiteScore on detection probability. We assumed river otters were present and travelled among all sections within bridge-suites and had access to all sections of the shoreline, hence we set occupancy to equal 1 (note: setting occupancy to equal 1 is equivalent to a logistic regression approach, while adequately addressing temporal replication among seasons for each bridge-suite). We based our decision to set occupancy equal to 1 from studies in portions of our study areas (e.g. Olson et al. 2008, Stevens & Serfass 2008), ongoing evaluations at these reintroduction sites (T. Serfass, pers. obs.) and movement patterns reported for river otters in riverine systems (Melquist & Hornocker 1983, Serfass & Rymon 1985, Reid et al. 1994).

For the categorical covariates (SiteType and Season), we used Bridge as the reference for SiteType, and spring as the reference for Season. We used Akaike's Information Criterion adjusted for small sample size (AIC_c) for selecting models that best explained the data and Akaike weights to assess evidence in support of each model (Burnham & Anderson 2002). We ranked all models by AIC_c values and considered the best models as those with smallest AIC_c values and largest Akaike weights (w_i; Burnham & Anderson 2002). From the AIC criterion, models with ΔAIC_c values < 2 would also be

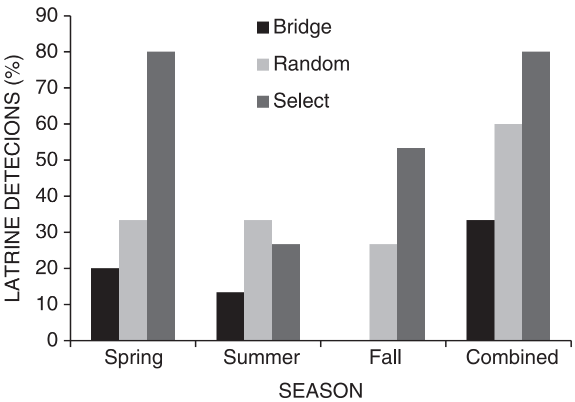

Figure 3. Percent of sites within bridge-suites by Season (spring, summer and fall) and SiteType (Bridge, Random and Select) where river otter latrines were detected (i.e. positive sites) during riparian surveys along the CasselmanRiver and Raystown Branch of the Juniata River in Pennsylvania, and Youghiogheny River in Maryland and Pennsylvania, USA, in 2006.

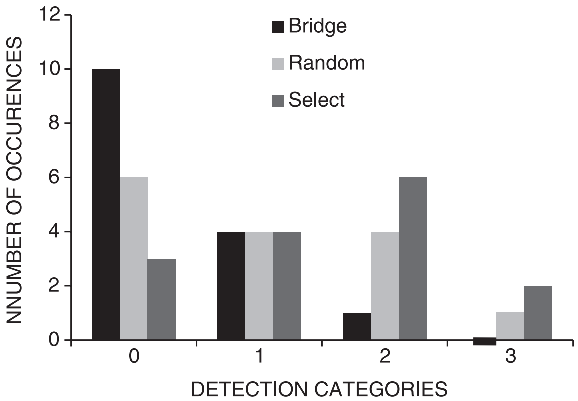

Figure 4. Number of occurrences of positive sites (site where a river otter latrine was detected) among detection categories, which ranged from 0 (no detections during surveys) to 3, SiteType (Bridge, Random and Select) during three riparian surveys (one each during spring, summer and fall) along the Casselman and Raystown Branch of the Juniata Rivers in Pennsylvania, and Youghiogheny River in Maryland and Pennsylvania, USA, in 2006.

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Table 1. Occupancy models used to assess the influence of the covariates SiteScore, Season and SiteType on the presence of river otter latrines at survey sites within bridge-suites surveyed along the Casselman River and Raystown Branch of the Juniata River in Pennsylvania, Youghiogheny River in Maryland and Pennsylvania, USA, in 2006, based on Akiake's Information Criterion adjusted for small sample size (AIC_c).

Terms	K[a]	AIC_c	ΔAIC_c[b]	Akaike weight[c]	R^2
Detect-1 {SiteScore, SiteType, Season}	7	153.71	0	0.802	0.87
Detect-2 {SiteType, Season}	6	156.95	3.24	0.159	0.81
Detect-3 {SiteScore, SiteType}	5	160.46	6.75	0.027	0.72
Detect-4 {SiteType}	4	163.29	9.58	0.007	0.61
Detect-5 {SiteScore, Season}	5	164.95	11.24	0.003	0.62
Detect-6 {Season}	4	167.60	13.89	<0.001	0.47
Detect-7 {SiteScore}		170.68	16.97	<0.001	0.26
Detect-8 {null}	2	173.04	19.33	<0.001	0.00

[a] Number of parameters in the corresponding model.
[b] Difference between the lowest AIC value and that of the proceeding AIC value.
[c] Probability that a model best approximates the data in comparison to the other models being considered.

considered useful in explaining the data (Burnham & Anderson 2002). We calculated R^2 values to assess the fit of each model. Occupancy models were fitted and R^2 values were calculated using the package 'unmarked' (Fiske et al. 2010) within R 2.14.0 (R Development Core Team 2011).

Results

SiteScores ranged from 1.7 to 89.6%. Among SiteTypes, Select had the highest mean SiteScore ($\bar{x} = 49.9$, SE = 7.1%, range: 4.0-89.6), followed by Random ($\bar{x} = 32.13$, SE = 7.6%, range: 1.7-89.6) and Bridge ($\bar{x}$ = 27.2, SE = 6.6%, range: 1.7-86.7). SiteScores were marginally significant among SiteTypes ($F_{2,42} = 2.83$, $P = 0.07$).

We detected latrines at 12 of 15 (80.0%) of the bridge-suites; three of three (100%) at the Casselman River, four of six (66.7%) at the Raystown Branch of the Juniata River and five of six (83.3%) at the Youghiogheny River. Bridge-suites with the most detections occurred during spring and fall (12 of 15 ~ 80.0% and 10 of 15 ~ 66.7%, respectively), and bridge-suites with least detections occured during summer (six of 15-16 ~ 40.0%; Fig. 3). Among sites within bridge-suites, latrines were detected most frequently at Select sites (12 of 15 ~ 80%), followed by Random sites (nine of 15 ~ 60.0%) and Bridge sites (five of 15 ~ 33.3%; see Fig. 3). Select sites also had the highest number of repeated uses among the three seasonal surveys (Fig. 4).

Based on the AIC_c criterion, we judged the full model (Detect-1; g(x) = -4.212 + 0.015 (SiteScore) 1.312 (Random) + 2.064 (Select) - 1.710 (summer) - 0.446 (fall)) as the only model appropriate for assessing the probability of detecting a latrine (The second best model (Presence-2) had a ΔAIC_c value of 3.47 and $w_{Detect-1}$ about 5.5 times > $w_{Detect-2}$.; Table 1). Detection probability was positively associated with SiteScore (Table 2), and this positive relationship was consistent when controlling for factor levels within SiteType and Season (Figs. 5 and 6, respectively). For SiteType, the predicted probability of detecting a latrine was positive (i.e. higher predicted detections) for Random and Select compared to Bridge, with the highest probability of detection occurring at Select (see Table 2 and Fig. 5). A negative relationship within Season occurred in predicted detection probabilities (i.e. fewer predicted detections) for summer and fall in reference to spring (see Table 2). However, examination of 95% CIs and graphical evidence estimated this relationship to be much stronger for summer than for fall (see Table 2 and Fig. 6).

Table 2. Parameter estimates for the model (Detect-1) identified by occupancy modeling using Akiake's Information Criterion adjusted for small sample size (AIC_c) as most useful for predicting the occurrence of river otter latrines at bridge-suites[a] along the Casselman and Raystown Branch of the Juniata Rivers in Pennsylvania, and Youghiogheny River in Maryland and Pennsylvania, USA, in 2006.

Parameter	β	SE	95% CI
Intercept	-1.929	0.578	-3.062 to -0.796
SiteScore	1.925	0.837	0.284 to 3.566
SiteType			
Random	1.312	0.572	0.191 to 2.433
Select	2.046	0.475	1.115 to 2.977
Season			
Summer	-1.710	0.556	-2.800 to -0.620
Fall	-0.446	0.475	-1.377 to 0.485

[a] See methods for the definition of bridge-suite and explanation of covariates measured at bridge-suites.

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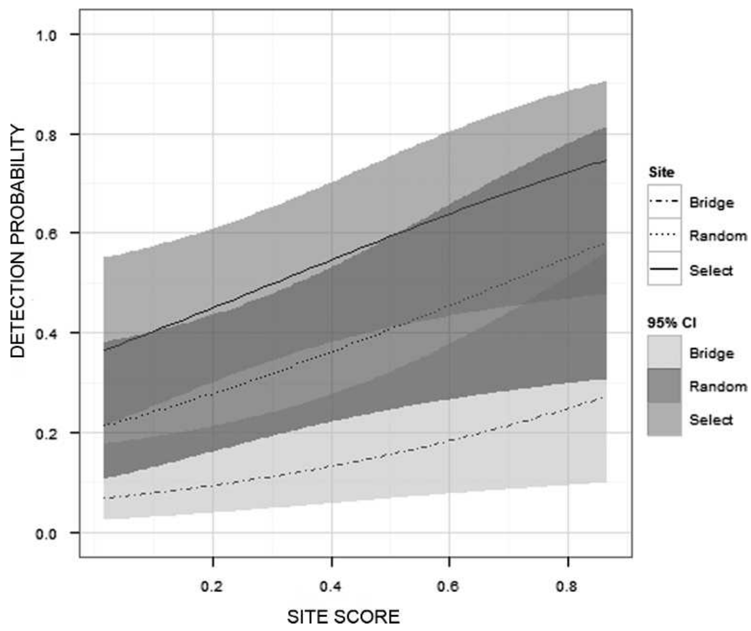

Figure 5. Relationship between SiteType (Bridge, Random and Select) and SiteScore (a percentage with higher values suggesting a greater likelihood for the occurrence of latrines) based on the best model derived from occupancy modeling to evaluate the probability of detecting river otter latrines during riparian surveys along the Casselman and Raystown Branch of the Juniata Rivers in Pennsylvania, and Youghiogheny River in Maryland and Pennsylvania, USA, in 2006.

Discussion

&_deflt_Latrines are relatively easy to detect and surveys for them have become the standard method for determining the presence of river otters, especially near bridges where there is easy access to riparian areas (e.g. Clark et al. 1987, Berkley & Johnson 2000, Ostroff 2001, Breaux et al. 2002). Habitat conditions and seasonality have been shown to respectively influence the location of latrines in riparian areas and the intensity of scat marking at latrines (habitat, Newman & Griffin 1994, Swimley et al. 1998 and seasonality, Olson et al. 2008). However, these studies were conducted in relatively undisturbed areas and their combined influence was not assessed concurrently. Thus, their utility in predicting the occurrence of otter latrines had not been validated by these studies in disturbed areas, such as at or near

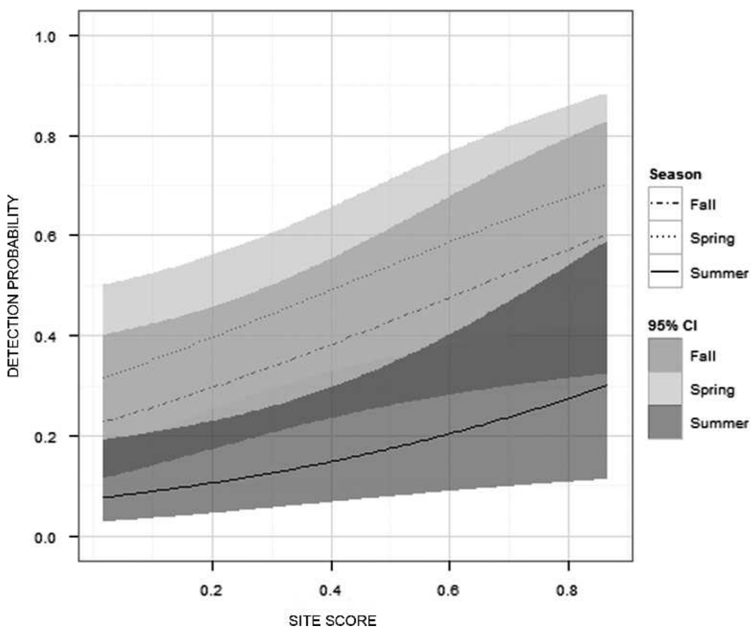

Figure 6. Relationship between Season (spring, summer and fall) and SiteScore (a percentage with higher values suggesting a greater likelihood for the occurrence of latrines) based on the best model derived from occupancy modeling to evaluate the probability of detecting river otter latrines during riparian surveys along the Casselman and Raystown Branch of the Juniata Rivers in Pennsylvania, and Youghiogheny River in Maryland and Pennsylvania, USA, in 2006.

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bridges, nor had the value of integrating these factors in the design of surveys been demonstrated.

Collinearity between SiteScore and SiteType was a potential concern in our analyses because Selected sites were chosen based on having the highest SiteScore among non-Bridge segments within bridge-suites. However, our study demonstrated that the probability of detecting latrines increased with increasing SiteScore (i.e. increasing habitat quality based on Swimley et al. 1998), independent of SiteType (see Fig. 4). Also, SiteType was a useful predictor of latrine occurrence, with much lower detection rates at Bridge in comparison to Select sites. Crimmins et al. (2009) suggested that disturbances at bridges may influence the detection of river otter sign near bridges and our outcome would seem to support the assertion that surveys in the vicinity of bridges may be the least likely locations to detect latrines. However, neither projects were designed with the specific intent of assessing the influence of various disturbance levels at bridges. Future studies designed to control for levels of disturbance and habitat quality would be extremely useful for further understanding factors influencing detection probabilities of latrines at bridges. Likewise, assessing the influence of distance on detection of otter signs (e.g. Gallant et al. (2008), bridge surveys in New Brunswick to detect otter signs in the snow; and Jeffress et al. (2011), surveys starting at non-bridge sites and conducted during late winter and early spring in eastern Kansas) from bridges, also controlling for disturbance and habitat quality, would likewise contribute substantially to enhancing survey protocols. Regardless, our study raises doubt about the appropriateness of bridges as primary places to detect evidence of river otters by sign surveys, clearly warranting the aforementioned controlled studies to better understand factors influencing detection rates at or near bridges, and similar evaluations would likewise seem appropriate for other species of otters.

Seasonality was an important factor in our study, with the probability of detecting latrines being much lower in summer than spring or fall. Detection rates were nonetheless positively associated with increasing SiteScore during all seasons (see Fig. 5). Higher detection rates during spring and fall correspond to two distinct periods in the natural history of river otters: the breeding season and increased activity of family groups (young with the mother), respectively (Melquist et al. 2003, Olson et al. 2008, Stevens & Serfass 2008). The spring increase in activity at latrines has been suggested from increased marking by males searching for reproductively active females (Stevens & Serfass 2008), with the fall increase corresponding to young in family groups contributing to marking (Olson et al. 2005).

Conducting surveys at bridges without consideration of habitat conditions and seasonality will likely decrease opportunities to accurately determine if river otters inhabit a riverine system. From our outcomes the probability of detecting latrines will be substantially enhanced by identifying riparian areas associated with habitat conditions, identified by Swimley et. al (1998) and supported by Stevens et al. (2011) as being associated with latrines, and by conducting surveys during spring and fall as opposed to summer when river otters were less active at latrines.

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