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Do River Otters Conform to Habitat Suitability Assessments?

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Abstract: River otters (*Lontra canadensis*) were reintroduced from 1994-1996 into parts of Illinois where the species was extirpated due to over harvest and habitat loss. At the time of reintroduction, managing for the persistence of the population through habitat was very important and research was conducted to determine which watersheds had quality habitat and which needed increased management and protection. In a study conducted in the mid-1990s, biologists used pattern recognition (PATREC) modeling to identify high and low quality habitat for river otters at the subunit level (i.e., divided watershed), based on specific habitat attributes including wooded area, sinuosity, and wetland edge. We compared the habitat quality ratings of subunits with river otter use at 112 bridge sites from 2012-2014 to determine if river otters have distributed themselves according to previously determined habitat quality. We found that the PATREC model was a poor predictor of river otter use when sites were located close to the otter reintroduction points. The PATREC model was most likely a poor predictor of river otter use due to an over-emphasis on the importance of woody vegetation to habitat suitability for river otter in the model. We recommend that future work on the assessment of habitat suitability for river otter use, and accuracy of this assessment, be conducted at a local spatial scale and over a shorter temporal scale. We also recommend that watershed policies and habitat assessments consider changes to land-cover and follow an adaptive management approach to assess habitat suitability for reintroduced species.

Keywords: *Illinois, Lontra canadensis, pattern recognition (PATREC) model, reintroduced populations*

Management strategies often include policies to prioritize and protect certain habitat types to promote existence of species of conservation concern. Occasionally these policies are put into place without an adaptive management plan in mind, and hence no post-policy assessments are conducted (see Sutherland et al. 2004). However, when the successes are evaluated and reported, adaptive management plans can be used by other researchers to improve on their own designs (McLain and Lee 1996), especially where reintroduction efforts are concerned (Salz and Rubenstein 1995). When practiced correctly, adaptive management approaches prove valuable in species management by incorporating knowledge from multiple sources and modeling techniques (Sedon et al. 2007).

Many native species are at increased risk of extirpation due to rapid rises in habitat loss and fragmentation, introductions of non-native species, disease, and exploitation. Reintroductions, translocations, and augmentations have increased dramatically over the past decades as a result of species population declines (Dodd and Seigel 1991; Seigel and Dodd 2002). The stakes associated with reintroduction efforts are usually high from both a monetary and biodiversity point of view (Kleiman 1989). Because reintroduction biology frequently deals with endangered or threatened species, it is often impossible to perform replicated experiments on reintroductions. However, there are ways to deal with the lack of reproducibility, which include replicating the whole study (in a metapopulation fashion) or more recently, using adaptive management approaches (see Sedon et al. 2007). Many animal reintroductions take place in areas that were identified as suitable or ideal habitat for a specific species, and by following an adaptive management approach one can evaluate whether the species is actually using the previously identified "suitable habitat."

A recent example of a successful species reintroduction involves river otters (*Lontra canadensis*) in Illinois. River otters are mid-sized apex predators in riparian-stream systems (Gittleman and Gompper 2005). As apex predators, river otters may provide top-down control which can affect disease rates, CO_2 production, and biodiversity in the system (Estes et al. 2011). River otters primarily prey on fish and crayfish, but will also consume other aquatic invertebrates, amphibians, and mammals (Toweill 1974; Reid et al. 1994; Williamson 2009). Transfer of nutrients from these prey items to the local terrestrial system allows N to cycle within the local area and decreases the rate of nutrient spiraling (Ben-David et al. 1998; Roemer et al. 2009). River otters were listed as state endangered in Illinois in 1989. Decreased habitat availability and water quality, as well as over-exploitation by fur trappers, caused extirpation of river otters throughout most of midwestern North America (Melquist et al. 2003). Habitat and water quality improvements due to the Clean Water Act (1972), recovery of beaver populations, and reestablishment of wetlands by the early 1990's indicated that a reintroduction program in Illinois may be successful (Bluett 1995). To augment the river otter population, a recovery team was formed by the Illinois Department of Natural Resources (IDNR) to plan and implement a reintroduction program (Bluett et al. 1999). River otter sightings within Illinois identified relict populations in northwestern and extreme southern Illinois (Anderson 1995). The IDNR released 346 river otters from 1994 to 1996 in central Illinois in an effort to reestablish river otter populations throughout the state (Figure 1; Bluett et al. 1999).

Following the first otter-release, a set of indices were designed that ranked habitat suitability for otters (Woolf et al. 1997). Habitat suitability was determined by using pattern recognition (PATREC). This method used landscape-level habitat characteristics based on the locations of otters in southern Illinois and in other states. Their objective was to identify suitable habitat for river otters in southern Illinois, and to develop methods for continuous monitoring of river otter populations in Illinois.

Observations of river otters and the presence of kits increased in Illinois in the years immediately following the initial reintroduction (Bluett et al. 1999). Continued surveys indicated that the river otter population had become established throughout most of the state, and the species was delisted by IDNR in 2004 (Bluett et al. 2004). In 2012 a study was initiated in Illinois, whereby the presence and distribution of river otters in central and southern Illinois was recorded during repeated visits to bridge sites throughout the area. This study also incorporated land-cover data to investigate which habitat types most influenced river otter presence. Understanding how river otters use the landscape and verifying the accuracy of habitat assessments will increase the effectiveness of programs for river otter management. We compared the results from the most recent study of river otters in Illinois with the initial habitat assessment from Woolf et al. (1997) to determine the accuracy of the initial recommendation in promoting species persistence.

Methods

Study Area

The research conducted in the two comparison studies covered the majority of the southern third of Illinois, but there were minor differences in the study areas. Data used in the present study only included watersheds where the two previous study areas overlapped. Those watersheds included the Embarras, Little Wabash, Lower Wabash, Skillet, Saline, Cache, Big Muddy, Lower Kaskaskia, Middle Kaskaskia, Shoal, Lower Mississippi, and Ohio (42,282 km^2; Figure 1). Natural divisions within the study area were the grand prairie, middle Mississippi riverlands, southern till plain, Wabash border, Ozarks, lower Mississippi river bottomlands, Shawnee hills, and coastal plain (Schwegman 1973). Public areas within the study area included Shawnee National Forest, Crab Orchard National Wildlife Refuge, Middle Mississippi River National Wildlife Refuge, Cypress Creek National Wildlife Refuge, 13 state parks, and additional state-managed natural areas.

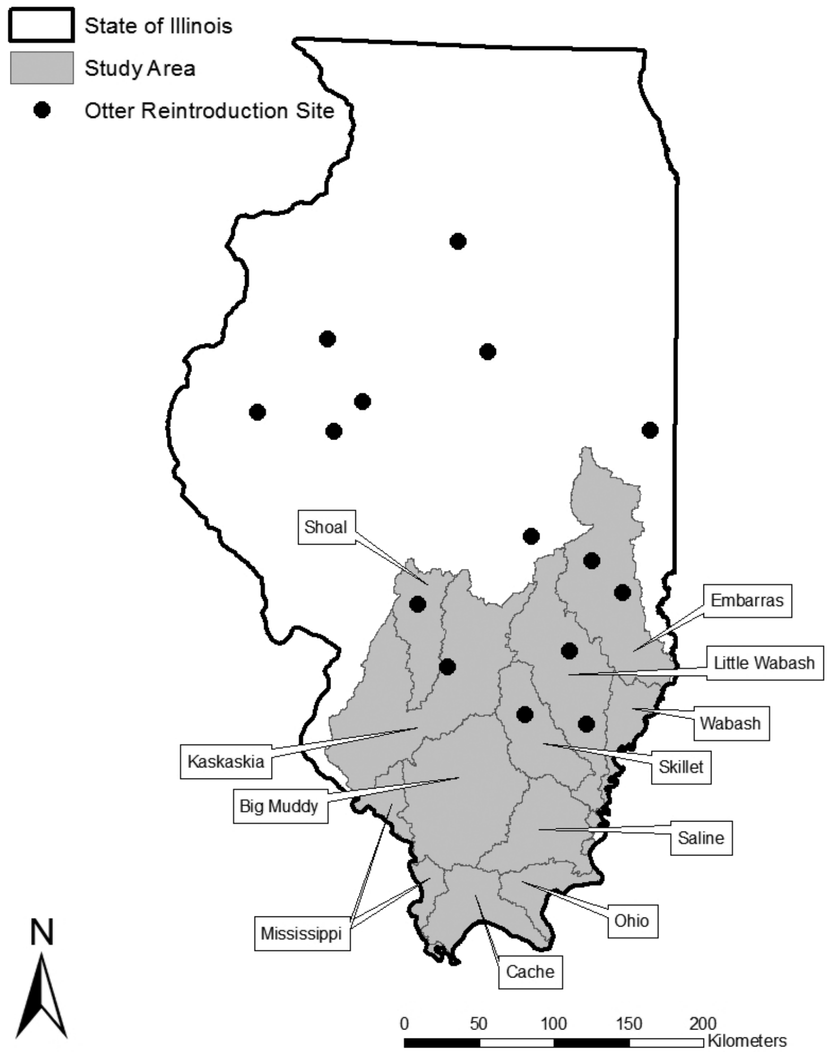

Figure 1. Map depicting reintroduction points and study area for the assessment of using PATREC model values to estimate proportion of visits with river otter use in Illinois, 2012-2014.

Elevation within the study area ranged from 88 to 324 m and the drainage density for the study area was 1.37 km of stream/km^2. Land-cover for the study area comprised primarily crops (48%), forest (23%), and pasture (16%); followed by areas with minor development (8%) and less than 2% each of open water, woody wetlands, grasslands, highly urbanized area, emergent wetlands, and bare land (Homer et al. 2015).

Data Acquisition and Analysis

PATREC is a habitat modeling method by which habitat is classified into different categories (e.g., suitable or unsuitable) based on certain habitat attributes (e.g., vegetation types, distance to urban settlements, etc.; Grubb 1988). The PATREC model output is a score between 0-1, which represents the probability that an area falls into a high suitability category. We used data from Woolf et al. (1997), a study that used the PATREC approach to classify subunits (natural watershed divided further to be of similar size at the landscape level) as suitable or unsuitable for river otters. The habitat attributes they considered for evaluation in their assessment included food availability, bank cover type, and human impacts. Specifically they suggested that food availability would be a function of the presence of water year round. The presence of woody vegetation on riverbanks would be indicative of suitable habitat for cover and dens for river otters, and urban development would be an indication of human impacts. Model refinements resulted in four habitat attributes: wooded stream length; stream shape index; increase in wooded riparian habitat due to wooded perennial wetlands; and length of intermittent wetland edge (Woolf et al. 1997). These attributes were then used to evaluate suitability of subunits for river otters. Based on these criteria and using National Wetlands Inventory data and other land-cover layers, subunits were classified as high, medium, or low suitability for river otters (Figure 2) and estimated river otter densities were assigned to each subunit based on these classifications.

We used data obtained from river otter sign surveys conducted at 112 bridge sites from 2012 – 2014, collected for a larger dynamic occupancy modeling study (Nielsen et al. 2015). Sites were visited four times from January – April each year by two observers. Each observer surveyed a 400 m stream segment per visit, walking along 800 m of stream bank looking for river otter sign (Lesmeister and Nielsen 2011). Observers surveyed a stream segment located either fully up or downstream of the bridge. A site was considered used by river otters if at least one observer identified river otter tracks or scat during the visit. We calculated proportion of visits with river otter detection for each site each year (site-year) based on the number of visits with river otter observations and the number of visits to the site that year (N = 306 site-years). Not all sites were visited every year due to logistical constraints and landowner permissions (1 year = 5 sites; 2 years = 21 sites). Flooding occasionally affected site visits resulting in only three visits in a year rather than four (23 site-years).

We assessed the accuracy of the habitat suitability models from Woolf et al. (1997) in Program R 3.1.2 (R Core Team 2014). We used a generalized linear model with a binomial distribution of y-values to determine the effect of subunit model scores and distance to nearest otter-reintroduction point, as well as an interaction between these two variables, on the proportion of visits with a river otter detection for each site-year. Distance to nearest otter-reintroduction point was calculated as the Euclidian distance from the bridge site to the nearest otter-reintroduction point. Year and site were included as random effects to account for possible range expansion of river otters or other temporal variation throughout the study, and to eliminate bias due to repeated sampling of the same sites over multiple years.

Results and Discussion

The 112 sites used in this analysis were in 83 of the subunits described by Woolf et al. (1997) with up to four sites being in one subunit. PATREC model scores ranged from 0.05 – 0.91, with an average score of 0.46 for all 112 sites (Table 1). Proportion of visits with otter detections ranged from 0 – 1, with an average of 0.33 and tended to increase over the study period averaging 0.28 in 2012, 0.30 in 2013, and 0.42 in 2014.

The global model indicated that all variables were significant. The PATREC model score (β = -1.982, SE = 0.884, $p = 0.025$), distance to nearest otter-reintroduction point (β = -0.032, SE = 0.010, $p = 0.002$), and their interaction (β = 0.043, SE = 0.015, $p = 0.005$) indicated that as the distance from surveyed sites to otter reintroduction points increased; the ability of PATREC model scores to predict proportion of visits with river otter detections also increased (Figure 3). PATREC model scores were a poor predictor of proportion of visits with river otter detections when sites were close to reintroduction points.

We elucidated the interaction between PATREC model score and distance to nearest otter-reintroduction point by examining the extremes of the relationship. Most of the subunits in the Embarras, Little Wabash, and Skillet watersheds, where five of the reintroduction points occurred, were classified as low quality habitat by the PATREC model (Figure 2). Woolf et al. (1997) stated that river otters were likely to first move into high quality areas near otter reintroduction sites; however after 20 years, river otters are still using subunits categorized as low quality near the original reintroduction sites. This length of time should be sufficient to allow river otter populations to move into higher quality habitat and away from low quality habitat, assuming low quality habitat significantly affects survival and

Table 1. Summary of data used in the analysis of 112 sites and 83 management subunits (natural watersheds divided to be of similar size) to determine the accuracy of PATREC model values in estimating proportion of visits with river otter use in Illinois from 2012-2014.

Watershed	# Sites	---Site Habitat Ranking---			Average	Distance to Otter	Proportion of
		High	Medium	Low	PATREC Score	Reintroduction Point (km)[a]	Visits with River Otters Use (km)[a]
Big Muddy	18	14	4	0	0.79	79.2	0.24
Cache	11	10	1	0	0.70	135.1	0.31
Embarras	14	0	3	11	0.17	36.7	0.28
Kaskaskia	21	3	3	15	0.31	46.0	0.31
Little Wabash	16	3	2	11	0.33	20.6	0.42
Mississippi	4	2	2	0	0.75	115.7	0.27
Ohio	4	2	2	0	0.60	114.1	0.48
Saline	8	4	1	3	0.54	81.1	0.26
Shoal	8	5	2	1	0.56	18.0	0.38
Skillet	6	1	1	4	0.30	25.6	0.56
Wabash	2	0	0	2	0.10	34.5	0.38

[a] Averaged across all sites within watershed.

reproduction (Van Horne 1983). The movement into higher quality habitat should reduce the proportion of visits with otter detections in low quality habitat near relocation sites. Additionally we assumed that low quality habitats were used less than high quality habitats (Morrison et al. 2006), but our measurement of river otter use does not reflect how the area is being used. Habitat quality may be more likely to affect denning and forage, but less likely to affect travel. However, the size of subunits classified by the PATREC model and used in this analysis (11,325 – 70,434 ha; Woolf et al. 1997) are larger than the average river otter home range (Female: 1,881.40 ± 665 ha, and Male: 4,495.40 ± 1,422 ha; A.U. Rutter unpublished data) and site use within the subunit is reflective of river otter status in the subunit. Because river otters have not moved away from subunits categorized as low quality by the PATREC model, it can be concluded that these areas are not as low quality as predicted or that habitat in these areas has improved over the last 20 years. These inaccuracies led to a negative relationship between PATREC model score and proportion of visits with river otter detection when sites were close to otter reintroduction points.

Models based on presence-only data and used for the extrapolation of habitat quality are likely to generate results biased towards the original data. The PATREC model heavily relied on subunits in far southern Illinois to establish which attributes were necessary for suitable

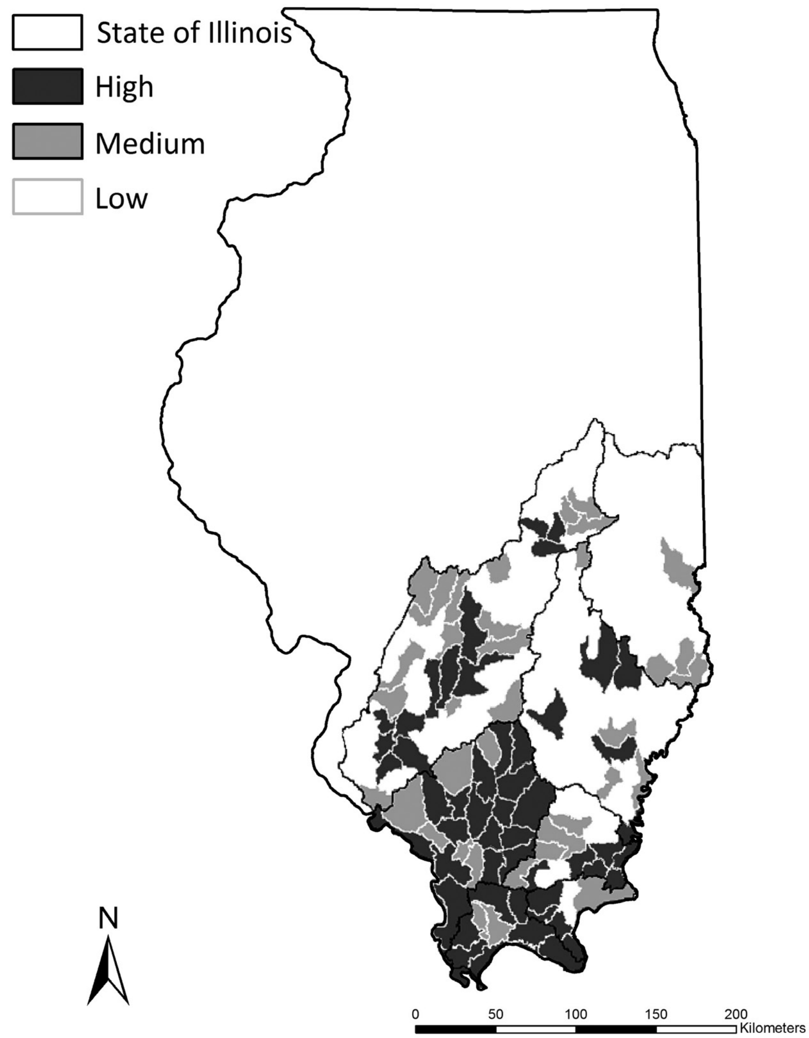

Figure 2. Map adapted from Woolf et al. (1997) depicting the distribution of subunits categorized as High, Medium, or Low quality habitat for river otters.

habitat for river otters. The PATREC modeling process required comparison between present and random subunits, and approximately half of the subunits with river otter present were clustered in the southern Illinois watersheds (Woolf et al. 1997). The land-cover and geology of southern Illinois is very different from central Illinois (i.e., the northern portion of the study area), and this uneven distribution of data resulted in a potential bias of high quality subunits in watersheds in the southern part of the study area. These watersheds were also the farthest away from the otter reintroduction points. The bias of the model towards assigning high and medium quality habitat to subunits in the far southern reaches of the study area resulted in a positive relationship between PATREC model score and proportion of visits with river otter detection when sites were far away from otter reintroduction points. This relationship may also in part be due to the river otter population that was established in the Cache watershed before river otter reintroduction.

Two of the four habitat attributes used to quantify suitable habitat in subunits for the PATREC model included aspects of wooded riparian area. Even though the presence of forested riparian buffers increases overall stream quality (Sweeney and Newbold 2014), the probability of

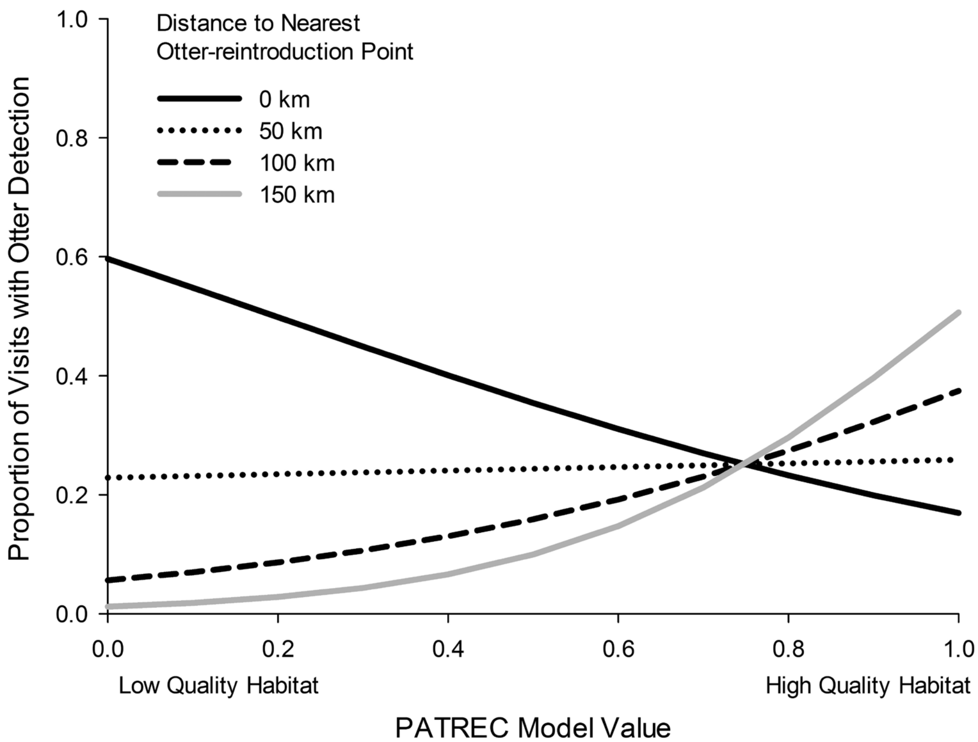

Figure 3. Relationship of PATREC model score and the distance to nearest otter reintroduction point (km) to the estimated proportion of visits used by river otter in Illinois, 2012-2014.

river otter occupancy was not predicted by woody vegetation cover in a recent study, but rather aspects of stream size, urban land-cover, and the presence of mink (*Neovison vison*; Bennett 2014; Nielsen et al. 2015). Additionally, persistence of river otters at sites was correlated with prey availability (Nielsen et al. 2015). Woolf et al. (1997) considered land-cover metrics relating to urban areas and prey availability (assumed to be related to permanent water sources) among the variables evaluated for use in the PATREC model; however these metrics were not used to assess habitat suitability of the subunits. The inclusion of these metrics may have improved the ability of the PATREC model scores to predict the proportion of visits with river otter detection.

Evaluation of the effects of habitat quality on animal movements, behavior, and demographics should be assessed at the scale at which animals perceive differences in quality (Morrison et al. 2006). The PATREC model categorized habitat at the landscape scale for river otters and could not detect variation within subunits at the local scale (Woolf et al. 1997). We assumed that the sites surveyed for river otters were representative of the subunit. In addition to the PATREC model, Woolf et al. (1997) also developed a local scale habitat suitability index (HSI). Since we used local scale data for river otter detection based on relatively short stream segments, an assessment of the accuracy of the HSI would have been more appropriate. Unfortunately, the specific HSI data were not available for use in this analysis. If these data had been available, and river otters perceive habitat quality at the local scale, the HSI may have been more accurately reflected by proportion of visits with river otter detection than the PATREC model.

Our dependent variable, proportion of visits with river otter detection, did not account for the probability of detection. Incorporating probability of detection is important when estimating site occupancy, as sites may be occupied but animals may not be detected (MacKenzie et al. 2002). Therefore our dependent variable may have underestimated river otter use at sites. Probability of river otter detection is affected by observer, substrate, and water level (Jeffress et al. 2011;

Williamson and Clark 2011; Bennett 2014), thus variations in surveys may have affected proportion of visits with river otter detections. We assumed that proportion of visits with detection is related to habitat use, despite known issues of not accounting for probability of detection.

The increased proportion of visits with detections in 2014 (this study) and increased probability of occupancy in 2014 (Nielsen et al. 2015) indicate that river otters may still be expanding their range throughout Illinois, 20 years after reintroduction efforts. Rates of expansion for recolonizing populations are likely to differ in suitable and unsuitable habitats with slower expansion rates through suitable habitats and higher rates through unsuitable habitats (Lubina and Levin 1988). Additionally, expanding populations, such as those used to create the PATREC model, may use habitats differently than established populations. As the river otter population expands in size and number, habitat preferences may also change (Hobbs and Hanley 1990). If river otter populations are still expanding, the use of low quality habitat is less likely; however, a three year study is not long enough to establish the status of the river otter population or conclude that range expansion is occurring.

Watershed Policy Implications

Woolf et al. (1997) recognized the importance of prey availability and urbanization in determining habitat quality for river otters, but emphasized woody riparian buffers in evaluating habitat suitability. Our results indicate that woody riparian buffers may not be as important for river otter use as originally thought. However, the positive impacts of woody buffers (including woody debris) on streams and rivers are innumerable. The presence of forested buffers (and other woody material) aids in temperature regulation and nutrient absorption, decreases erosion, promotes macro-invertebrate communities, and ultimately leads to greater fish abundances (Erol and Rhandir 2013; Sweeney and Newbold 2014), which may affect river otter use. To the same account, increased urban development impacts streams and watersheds by altering the hydrology of streams during high rain events (increasing flood peak and intensity) and increasing pollutants (Rhandir and Raposa 2014); therefore, managing urban development close to riparian habitats should have impacts on watersheds at more than just a species level (Erol and Rhandir 2013).

Woody riparian vegetation is characteristic of forested upland watersheds, but not all watersheds are naturally forested. Since 1830, Illinois has lost 99.9% of native tallgrass prairie land-cover (Samson and Knopf 1994). The upper reaches of prairie watersheds are naturally open and not forested, resulting in unique systems that differ from forested watersheds (Wiley et al. 1990; Dodds et al. 2004). Although most of the tallgrass prairie has been lost in Illinois, communities in watersheds that were once prairie are most likely still adapted to characteristics of prairie systems, such as open canopy. The historic range of river otters covers most of North America, including the Great Plains region, indicating that river otters are able to utilize a variety of watershed types. The emphasis of Woolf et al. (1997) on riparian woody vegetation gives the impression that watersheds throughout Illinois should be forested.

When management protocols and policies are put in place for overall improvement of the watershed, land-cover changes within the watershed should be considered and will ultimately lead to improvement of habitat for species adapted to recently changed environments. Overall improvement (e.g., decreased urban development near streams and increased prey availability) of stream systems within any watershed type will allow for the persistence of river otters, a species that has generalist habitat preferences within freshwater systems. The habitat variables used here do not seem to predict river otter use; however, other aspects of habitat (i.e., prey availability) are likely important to river otter presence. The identification of variables which relate directly to river otter use is necessary for management of river otter populations. To summarize: there is great value in predictive ecological modeling to assess habitat needs of species as long as previous land-cover types are considered, appropriate habitat quality variables are identified, and adaptive management is used to update assessments. Success of reintroduction programs not only depends on an adaptable species, but also on the accuracy of habitat assessments and maintenance of necessary habitats.

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