AN ABSTRACT OF THE THESIS OF

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Title: Distribution and mesohabitat characteristics of river otter in eastern Kansas

Abstract approved: Elmer J. Finck

Abstract: The river otter (*Lontra canadensis*) was extirpated from Kansas in the early 1900s. From May of 1983 to 1984, Kansas Department of Wildlife and Parks reintroduced 17 river otters in eastern Kansas. Missouri also began a reintroduction program that released over 800 individuals between 1982 and 1992. In addition to the location of the release and the potential movement into the state from Missouri, river otter distribution in Kansas may also depend on the amount of suitable habitat and food availability. Bridge surveys in the field during 1999 and 2000 were used to determine distribution of river otter. ArcInfo and ArcView were used to determine the potential habitat use by river otter in eastern Kansas. Stepwise discriminant function analysis was applied to the data of surveyed bridge sites. Thirty-one variables, measured from the field and digitally include: the presence or absence of river otter and beaver (*Castor canadensis*), stream order, number of tributary streams, a measure of curvilinearity of the stream segment, proximity to wetlands and/or farm ponds, size characteristics of wetlands and/or farm ponds, shoreline diversity of water bodies, and percentage of land cover types. The number of water bodies within the first 300 m of the core area of the channel was determined to be the only significant variable relative to river otter occurrence for 120 bridge sites ($P < 0.085$) and 59 bridge sites of concentrated river otter

occurrence ($P < 0.019$). Information from my study of mesohabitat characteristics has the potential to assist other Great Plains states in designating habitat for river otter reintroduction as well as help determine river otter distribution patterns in states with reintroductions already implemented.

DISTRIBUTION AND MESOHABITAT CHARACTERISTICS OF RIVER OTTER IN EASTERN KANSAS

A Thesis

Presented to

The Department of Biological Sciences

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Master of Science

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by

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PREFACE

Ideas for my thesis research originated because of the need of distribution information by the Kansas Department of Wildlife and Parks. Initially, my thesis research plan consisted of comparing methods of monitoring river otter in Kansas. After learning more about the truly low population numbers of river otter, the focus of my research was redirected to include habitat analysis from a larger scale, the mesoscale.

My study examined the possibilities of using GIS to analyze the habitat of a reintroduced species in its early stages of expansion. My thesis is written in the format acceptable for publication in the Journal of Wildlife Management.

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INTRODUCTION

Historically, the river otter (*Lontra canadensis*) was distributed over most of North America. Habitat destruction, human intervention, and overharvesting have reduced its abundance and distribution. During the 19th century, overharvesting caused severe declines of many furbearers, including the river otter (Melquist and Dronkert 1987). River otter was considered extirpated from Kansas in the early 1900s (Bee et al. 1981, Toweill and Tabor 1982).

During 1983 and 1984, Kansas Department of Wildlife and Parks (KDWP) reintroduced 17 river otters to the south fork of the Cottonwood River in eastern Kansas (Eccles 1989). Kansas is among many states including Arizona, Colorado, Illinois, Indiana, Iowa, Kentucky, Maryland, Minnesota, Missouri, Nebraska, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, and West Virginia as well as Alberta, Canada, that have been involved in reintroduction programs to aid in the restoration of river otter populations (http://www.furbearmgmt.org; Melquist and Dronkert 1987). Since 1983, the number of sightings in Kansas slowly has increased and the distribution has been recorded based upon reports of road kill, live sightings, and incidental trapping (C. Roy, KDWP, personal communication). In addition to the location where the river otters were reintroduced, its distribution in Kansas also may depend on the amount of suitable habitat, food availability, and the movement from neighboring states, such as Missouri, where over 800 river otters were reintroduced during 1982-1992 (Hamilton 1998).

River otter presence can be determined by observing their sign, which include tracks, scat deposits, rolling places, sign mounds, and slides along the banks of water bodies or stream channels (Melquist and Hornocker 1979, Swimley et al. 1998). Where river otters are present, tracks along channel banks are the most likely sign encountered. Scat also is used to identify the presence of river otter, particularly at a latrine site. Usually this type of sign is accompanied by tracks, however latrine sites can also be detected when the substrate is too dry for tracks to be found. A river otter latrine site is typically a high point of land, often at the junction of a tributary stream and the main waterway where an individual animal repeatedly visits to deposit feces. The latrine is located at the apex of a "pulling out" place, or "haul out", a worn path where river otters emerge from the water (Melquist and Hornocker 1979). River otters also tend to defecate on logs, rocks, or any object that protrudes from the water or that crosses its path of travel on land (Swimley et al. 1998). An individual river otter may have several latrine sites within its home range. In addition to latrine sites, rolling places can be found in grassy or sandy areas near the stream channel. Characteristically the grass in these areas is matted down for 1-3 m^2 where a river otter rolls around to dry off, groom, or engage in social interactions (Melquist and Hornocker 1979). Sign mounds are bundles of twisted grass or grass scraped into small piles with anal secretions deposited onto them, which are often found at rolling places along with a fecal deposit. Even though sign mounds and slides are types of beaver (*Castor canadensis*) sign as well, tracks in the immediate vicinity help distinguish between the two furbearer signs. In addition, beaver scat, which looks like a clump of sawdust, is very different from river otter scat, and is typically deposited into the water, not directly onto the sign mound.

Sign surveys typically are used to determine river otter distribution. Sign surveys should be conducted between the fall and spring for several reasons. First, river otter scent-marking peaks during the breeding season, which occurs between November and March (Humphrey and Zinn 1982). River otter inhabit large rivers during the fall and winter and move into wetlands, farm ponds, and backwater sloughs during the dry season where water is available and food sources are concentrated more (Humphrey and Zinn 1982). Without prior knowledge of wetland and pond use by river otters in an area, detection of river otter occurrence at these locations would be happenstance. One might maximize the probability of encountering river otter sign by surveying the main river stretch. Second, between the fall and spring, there is much less vegetation growth to fight when surveying the river banks and searching for identifiable tracks in the substrate. Third, in the summer, crayfish readily are available. During these times, river otter scat easily can be confused with raccoon (*Procyon lotor*) scat (Swimley et al. 1998, personal observation). Between the fall and spring, river otter scat will consist mostly of fish scales, which is a unique characteristic used to distinguish river otter scat from other carnivores.

Population status and trends of river otter often are assessed by using capture data, age demographics, and reproductive information collected during annual harvest seasons (Chilelli et al. 1996). The use of trapper surveys and harvest records to monitor the river otter population are not feasible options in Kansas because they cannot be legally trapped and incidental takes are infrequent. Exclusively conducting sign surveys to determine their distribution can be very time consuming and labor intensive. Therefore determining the habitat use by river otters in Kansas potentially may narrow down search areas and where river otters might occur.

A habitat suitability model was developed by researchers in Maine (Dubuc et al. 1990) to provide information of river otter use, given different habitat configurations on Mount Desert Island. In their study, various habitat parameters, such as watershed length, mean shoreline diversity, vegetation type, the area of water bodies, and number of active beaver lodges, were found to have a positive relationship with the river otter use of certain watersheds (Dubuc et al. 1990). Similarly, Swimley et al. (1998) found that rock formations, points of land, tributary streams, and beaver activity most closely were associated with latrines along the upper Pine Creek in Pennsylvania.

A study conducted in Idaho identified food availability as having a strong influence on river otter habitat use (Melquist and Hornocker 1983). Typically, river otter forage on abundant, slow-swimming fish in the shallow water (Toweill and Tabor 1982, Anderson and Woolf 1987, Melquist and Dronkert 1987, Reid et al. 1994a). Shoreline diversity, or the complexity of the shoreline, provides information about the shallow foraging area available to river otter (Dubuc et al. 1990). The selection of these particular habitats also may reflect a river otter's ability to obtain food and shelter (Reid et al. 1994b). Similar to Dubuc et al. (1990), Newman and Griffin (1994) and Reid et al. (1994b) also found that river otter habitat selection partially was based upon shoreline diversity. A measure of the curvilinearity of the stream channel potentially could provide information about the cutbanks and mud or sandbars that might exist along the channel and give evidence of shallow-dwelling fish habitat.

Vegetation types along channel banks also may be of potential value to river otter. Because they are not completely aquatic mammals, river otter rely on land for resting sites and shelter (Melquist and Dronkert 1987, Reid et al. 1994b). River otter tend to use, and sometimes modify, lodges and cavities built by aquatic and other semi-aquatic mammals, such as muskrats (*Ondatra zibethicus*) and beavers for escape cover and densites (Melquist and Dronkert 1987). In Idaho, abandoned and inhabited beaver dens were used more often than any other kind of den site by radio-collared river otters (Melquist and Hornocker 1983). Because wooded areas attract beaver to the source of forage and potential lodging, river otter therefore subsequently might be attracted to these areas (Melquist and Dronkert 1987). Therefore, riparian vegetation both directly and indirectly might be important to river otters in Kansas. In Alberta, Canada, Reid et al. (1988) concluded that river otters dug trenches through beaver dams to ensure a passage between water bodies during the winter when ice has formed on the surface. Although river otter typically inhabit streams and rivers, they also will reside in marshes or areas where there are many lakes and ponds (Bluett 1984). Microhabitat requirements of river otter in riverine systems are reported to be similar; however, mesohabitat characteristics, which encompass the entire home range seem to differ from the northeast to the northwest.

The mesohabitat level, which lies between the micro- and macrohabitat scale, recently has become more studied when analyzing habitat use of wildlife. Focus on the mesohabitat scale of black-throated green warblers (*Dendroica virens*) has shown areas where their densities are clustered (Robichaud and Villard 1999). Similarly, aquatic studies of the mesohabitat of brown trout (*Salmo trutta*) populations in France and spotfin shiner (*Cyprinella spiloptera*) in Virginia have demonstrated the diversity of mesohabitat types used by different size classes and species of fish (Vadas 1992; Baran et al. 1997). Certainly what is considered micro-, meso-, or macrohabitat of a species can be defined differently, particularly between researchers, therefore the habitat level and the description of the habitat characteristics included in that level must be determined for each study. The microhabitat of river otter would include for example, the presence of rock formations, logs, and steep sloping banks found specifically at a latrine site. Habitat characteristics at the regional or even continental scale would be considered the macrohabitat of river otter. Rivers within forested areas primarily consisting of conifers in the northeast would be considered a mesohabitat characteristic used by river otter in Pennsylvania (Swimley et al. 1998). In my study, which also focuses on the mesohabitat level, habitat characteristics that potentially are used by river otter might include the general vegetation, general stream characteristics, and land use patterns surrounding the channels where river otter inhabit. These characteristics fit into the mesohabitat level because they describe the overall habitat a river otter might use seasonally, or its home range, which differ between sexes and range across North America from 8 to 231 km (Melquist and Hornocker 1983; Reid et al. 1994b). By studying the mesohabitat characteristics used by river otter, much information can be gathered regarding its distribution, population trends, potential expansion, and delineation of locations for reintroductions. The more recent focus on the mesohabitat scale rather than the microhabitat scale by researchers has created a need for the use of computers to efficiently study habitat and population trends.

Within the field of wildlife management, computers have been used for all aspects of research and resource planning. With the increased use of Geographic Information Systems (GIS), population and habitat analyses can be conducted with improved efficiency. A GIS includes all the maps, databases, software programs, and personnel used in the analysis of geographic data. Geographic Information Systems have been used to determine home ranges of many species and to study characteristics, distribution, and connectivity of habitats (Schumaker 1996; Knick and Dyer 1997; Stone et al. 1997). Specifically, GIS applications were used to determine suitable habitat for the reintroduction of bighorn sheep (*Ovis canadensis*) in Utah (Mahoney 1991). The level of detail incorporated into databases used in GIS lends itself to be most useful at the meso- to macroscale.

The objectives of my study were to (1) determine the current distribution of river otter in eastern Kansas during 1999 and 2000 by conducting surveys for river otter sign at bridge crossings in addition to mapping previously reported sightings and (2) develop a method of analyzing the mesohabitat characteristics of areas inhabited by river otter in eastern Kansas by using a GIS that includes the locations of survey sites and habitat data obtained from wetland, stream, and landcover databases. To analyze the potential availability of food to river otter, I wanted to determine if areas providing shallow habitat to fish were located in areas where river otter were present. By creating a GIS that incorporates the distribution of river otter as well as mesohabitat characteristics, comparisons can be made between habitat characteristics present at locations inhabited by river otter and locations where river otter sign is not detected.

METHODS

Study Area

My study area included most of eastern Kansas (Fig. 1). The area within which all surveyed sites are located, is contained within an area bounded by these coordinates: 97°18′ 00″, 95°12′ 00″, 40°01′ 15″, and 36°58′ 30″. Within these coordinates in eastern Kansas, the northeastern portion is considered the glaciated region. The substrate contains finely ground silt, and in some areas consists of exposed bedrock. The southeastern portion of the study boundary is within the Osage Cuestas and primarily is characterized by areas that have steep slopes on one side and gentler slopes on the other. Within the Osage Cuestas there are rolling hills and flat areas as well. The substrate is composed of a layering of sandstone, limestone, and shale. The westernmost portion of the study boundary is located within the Flint Hills Uplands, which is known for its rolling grasslands and the flint rock found within the resistant limestone layers that form the hill tops (Kansas Geological Survey; http://www.gisdasc.kgs.ukans.edu). The portion of the study area that I personally surveyed included the Neosho River, which divides eastern Kansas in the north-south direction, the Marais des Cygnes River, which crosses Kansas in the east-west direction, and tributaries of the Neosho River that are part of the Flint Hills National Wildlife Refuge.

Landuse primarily is agricultural, dominated by row crops including soybean, sorghum, wheat, and corn, as well as hayfields and pastures with grazing livestock. The riparian areas along the rivers and streams are of varying widths ranging from zero to greater than 100 m. Tree species that are found in eastern Kansas consist mainly of osage orange (*Maclura pomifera*), juniper (*Juniperus* sp.), cottonwood (*Populus deltoides*), ash (*Fraxinus* sp.), maple (*Acer* sp.), willow (*Salix* sp.), and oak (*Quercus* sp.), with sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), black walnut (*Juglans nigra*), and common hackberry (*Celtis occidentalis*) being locally abundant.

Site Selection

I surveyed 33 bridge sites extending from White City in Morris County to the Kansas/Oklahoma border on the Neosho River and 15 sites extending from east of Melvern Lake to the Kansas/Missouri border on the Marais des Cygnes River (Figs. 1, 2). The focus of the surveys was on county road bridges. County roads often are less traveled than state or interstate highways which results in less disturbance and the greater potential for the occupancy of river otters in that area. The survey sites also were chosen based on landowner permission and accessibility. Because county roads have less vehicular traffic than highways, accessing the survey site can be accomplished more safely. Accessibility to the streambanks on foot often was not a problem due to the lack of vegetation growth during October through March when the surveys were conducted; however, the presence of cliff-like banks occasionally made accessibility on foot too dangerous to proceed.

A total of 239 additional surveys also were conducted by volunteer surveyors during 1999 and 2000 (Figs. 1, 2). Additional sites surveyed were not selected randomly

Fig. 1. Counties, major cities, and major reservoirs, lakes, and streams within study area searched for river otter bridge surveys during 1999 and 2000.

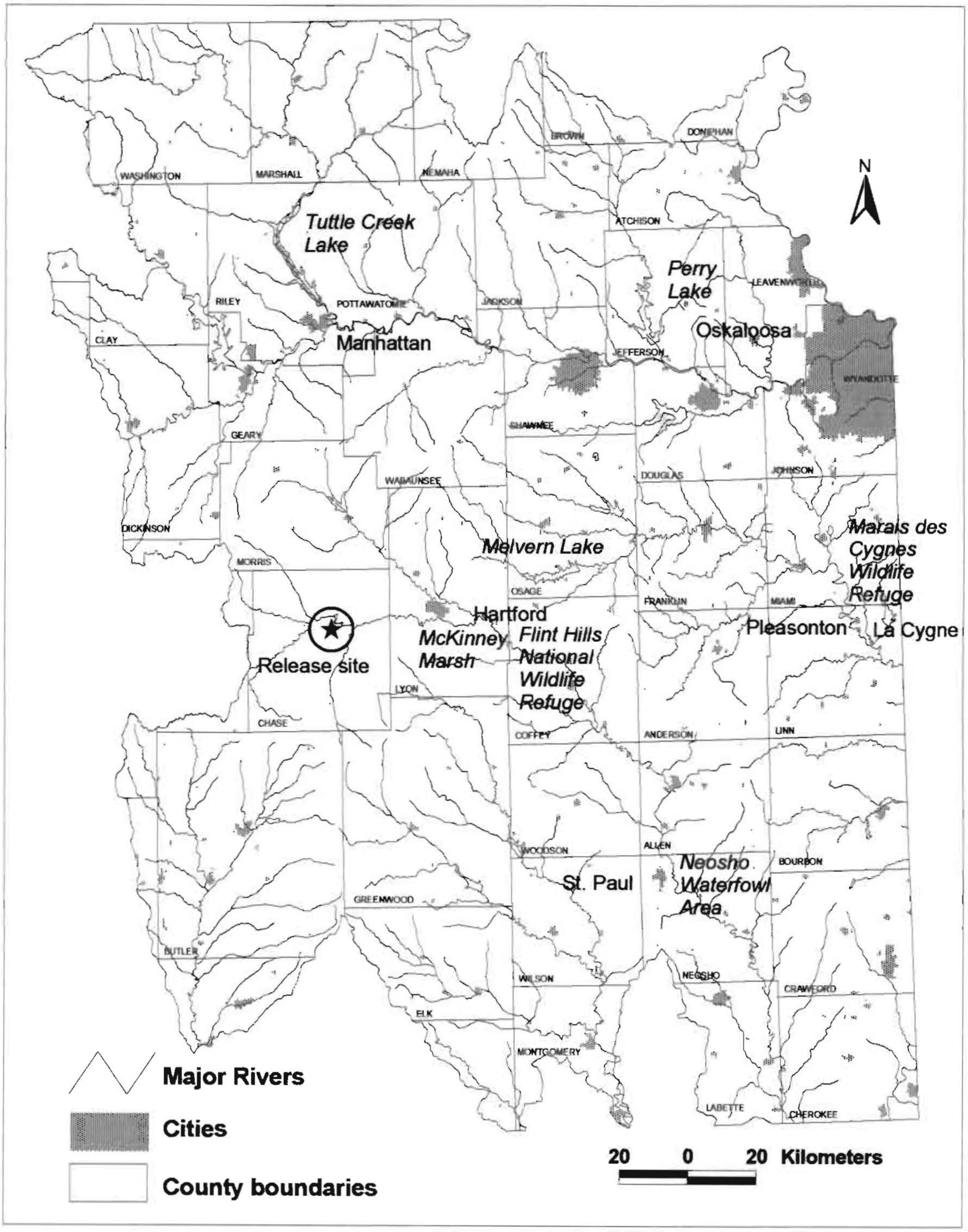
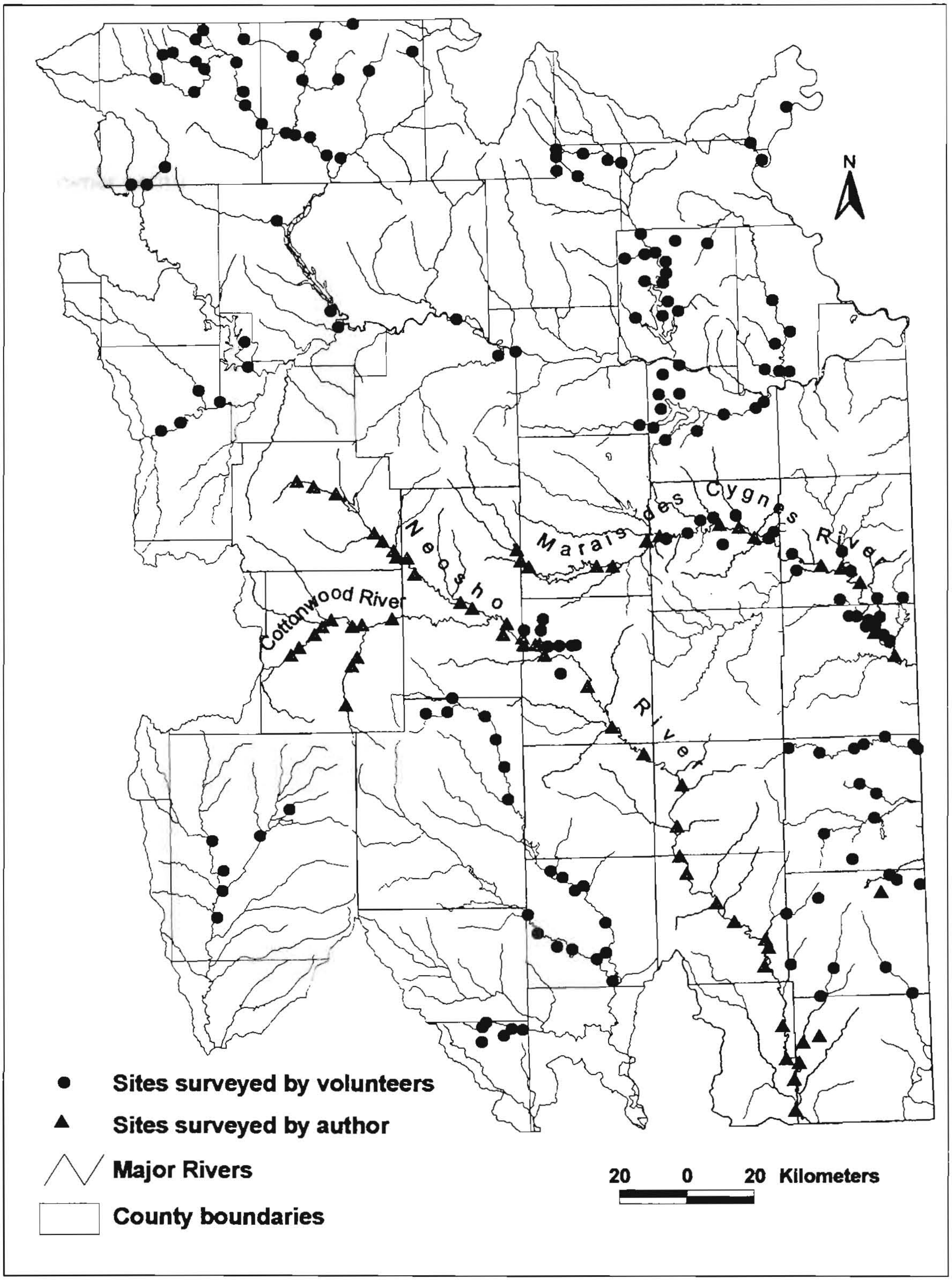

WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
ATCHISON
Tuttle Creek Lake
Perry Lake
LEAVENWORTH
RILEY
POTTAWATOMIE
JACKSON
CLAY
Manhattan
Oskaloosa
JEFFERSON
WYANDOTTE
GEARY
SHAWNEE
WABAUNSEE
DOUGLAS
JOHNSON
DICKINSON
Marais des Cygnes Wildlife Refuge
Melvern Lake
MORRIS
OSAGE
FRANKLIN
MIAMI
Hartford
Pleasonton
La Cygne
McKinney Marsh
Flint Hills National Wildlife Refuge
Release site
LYON
CHASE
COFFEY
ANDERSON
LINN
WOODSON
ALLEN
Neosho Waterfowl Area
BOURBON
St. Paul
GREENWOOD
BUTLER
WILSON
NEOSHO
CRAWFORD
ELK
MONTGOMERY
LABETTE
CHEROKEE
N
Major Rivers
Cities
County boundaries
20 0 20 Kilometers

Fig. 2. All sites surveyed by myself, volunteer furharvesters, and volunteer Kansas Department of Wildlife and Parks employees during 1999 and 2000.


N
Neosho River
Marais des Cygnes River
Cottonwood River
Sites surveyed by volunteers
Sites surveyed by author
Major Rivers
County boundaries
20 0 20 Kilometers

and depended upon the county the volunteer preferred to survey. Thus, sites were scattered across several counties and included locations along both creeks and rivers. Landowner permission occasionally was an obstacle for volunteers as well; however, many volunteers had previous agreements with landowners for use of their land for furharvesting purposes. In addition to prior landowner permission, the knowledge of the area that volunteers preferred to survey often aided in their selection of survey sites.

Bridge Survey Methods

The surveys I conducted along the Neosho and Marais des Cygnes rivers took place from 14 to 27 March 1999, 20 October to 7 November 1999, 10 March to 12 April 2000, and 23 October to 27 November 2000. The surveys conducted by volunteers were completed between 1 March and 15 April for both 1999 and 2000. Sign surveys were accomplished by searching riverbanks at bridge crossings for river otter sign. A search for sign, either on foot or by canoe, was conducted for a total stream segment of 600 meters. The stream segment was selected by pacing 300 m both upstream and downstream of the bridge. Banks on both sides of the channel were searched for sign. Because easement of bridges only extends 15.24 m in Kansas, permission to access the land was necessary to survey 600 m. When it rained during the scheduled time for surveys to take place, an overnight waiting period before survey of the banks was used to allow time for river otters to leave tracks. I followed the survey protocol used by the Missouri Department of Conservation to monitor the river otter population following its reintroduction efforts (Hamilton 1998). Presence or absence of river otter sign was recorded for each bridge site surveyed in addition to selected habitat variables.

The habitat variables were chosen based upon their potential significance to river otter use. Variables analyzed were measured from both ground surveys and from maps and databases supplied by the Data Access and Support Center (DASC) of the Kansas Geological Survey. Measurements collected from ground surveys included the presence of river otter and beaver sign. Measurements collected from DASC databases included: stream order, number of tributary streams, a measure of curvilinearity of the stream segment, proximity to wetlands and/or farm ponds, size characteristics of wetlands and/or farm ponds, shoreline diversity of water bodies, and percentage of land cover types.

Recruitment of Volunteers

With the assistance of Christiane Roy, a biologist from the KDWP, I recruited volunteer furharvesters to expand the survey workforce. Each volunteer followed the same protocol described above for surveying bridge crossings to evaluate the population distribution of river otter, as well as record the presence of beaver, raccoon, mink (*Mustela vison*), and muskrat. The furharvesters were asked to survey at least 10 bridge crossings in their county of preference within eastern Kansas.

The 225 furharvesters, who indicated in the 1997-1998 Furbearer Harvest Survey questionnaire that they were interested in assisting with a furbearer field survey, were contacted by letter mailed on 19 January 1999 (Appendix A). A pre-addressed, postage-paid postcard was included with the letter to encourage a response. The response card included a place to indicate whether or not the individual would like to participate, spaces for name, address, phone number, and preferred county to survey along with a few questions about furharvesting experience (Appendix B).

After responses were received, an instructional package was sent to each of the participating volunteers on or about 15 February 1999. The package included: a letter of appreciation (Appendix C), a map of the county the respondent indicated as their preference, a data sheet with a copy of the furbearer tracks on the reverse side (Appendix

D), a description of the protocol (Appendix E), a ruler, and a pre-addressed, postage-paid envelope for the respondent to return the data sheets.

On 29 January 2000, I sent out another letter (Appendix F) requesting participation of the 72 individuals, who indicated they were interested in January 1999, regardless of whether or not they completed the bridge surveys the previous year. The letter requested their field assistance for bridge surveys to be conducted 1 March through 15 April 2000. The letter also inquired whether the individual would be interested in attending a track-training session to become familiar with tracks of river otter and other furbearers. If interested in the track-training session, the person was instructed to fill out the interest form (Appendix G) and return to me. The same mailing protocol was followed from the previous year. In addition, letters were sent to 117 KDWP employees. The letters requested information regarding river otter sightings in their region that have occurred in the past 5 years as well as a request for volunteer assistance to conduct bridge surveys (Appendix H). After responses were collected, 2 track-training sessions were organized to accommodate participants.

Field confirmation personally was attempted at sites that were reported by volunteers as having river otter sign present. The date of the attempted field confirmation depended upon the time the survey data sheets were returned, many of which occurred within 2 weeks of receipt of the data sheets. Some sites that were unable to be confirmed as having river otter present during March and April 2000 were re-visited in October and November 2000.

Geographic Information System Analysis

A total of 239 survey sites were digitized by using ArcView® (ESRI 1996) to create a spatial record of the bridge surveys conducted. Of these, corresponding field and digital information for 129 of the surveyed sites were used in the habitat analysis including 31 otter sites and 98 non-otter sites (Fig. 2). In order for a surveyed site to be included in the habitat analysis, the site must have been surveyed during both 1999 and 2000 bridge survey periods unless river otter sign was detected either year. The databases that served as the base coverages were obtained through DASC. The coverages used include: the Surface Water Information Management System (SWIMS) water network and water bodies coverages, Tiger Line database of the roads network, the Hydrologic Unit Code (HUC) boundaries, and Digital Orthophoto Quarter Quadrangles (DOQQs). A list of the DOQQs used for habitat analysis are in Appendix I.

All the SWIMS and Tiger Line coverage files that encompassed eastern Kansas were joined together by using ArcInfo® (ESRI 1996). The original Tiger Line files are available in the longitude and latitude coordinate system measured in decimal degrees, while the SWIMS coverage was projected in a Lambert Conformic Conic projection with distance units of meters. Therefore, the Tiger Line files needed to be projected to the Lambert projection before the two databases could be used together. The SWIMS database was overlaid onto the Tiger roadway network coverage to locate and plot bridge crossings of survey sites. Survey sites along the Neosho and Marais des Cygnes rivers that I conducted and additional sites surveyed by all volunteers were plotted by creating a point coverage in ArcInfo® (ESRI 1996; Fig. 2). Sites included in the habitat analysis are shown on a separate map (Fig. 3). The HUC boundaries were used to clip the map of the survey sites to the outlines of their drainage. The resulting outline represents the total study area boundary.

Associated with each survey site in the database is a location identification including county and town names, the surveyor's name who surveyed the site, the date the site was surveyed, and whether river otter or beaver sign was detected at the time the survey was completed. The remaining information associated with each surveyed site was generated from the existing coverages obtained from DASC. These other habitat variables include stream order, the number of tributary streams, the curvilinear distance of the channel per the straight-line valley length, the number, area, and perimeter of water bodies near the survey sites, shoreline diversity of the water bodies, and the proportion of riparian/woodland, grassland, cropland, and urban-developed areas around each site (Table 1).

A series of buffers were created around each survey site (Fig. 4). To accomplish this, a line segment was drawn digitally along the channel of the surveyed site. Each segment was 2400 m long, centered on the bridge, and was drawn following any route along adjoining streams that a river otter could potentially swim if it inhabited the area.

Fig. 3. Locations of survey sites included in the habitat analysis.

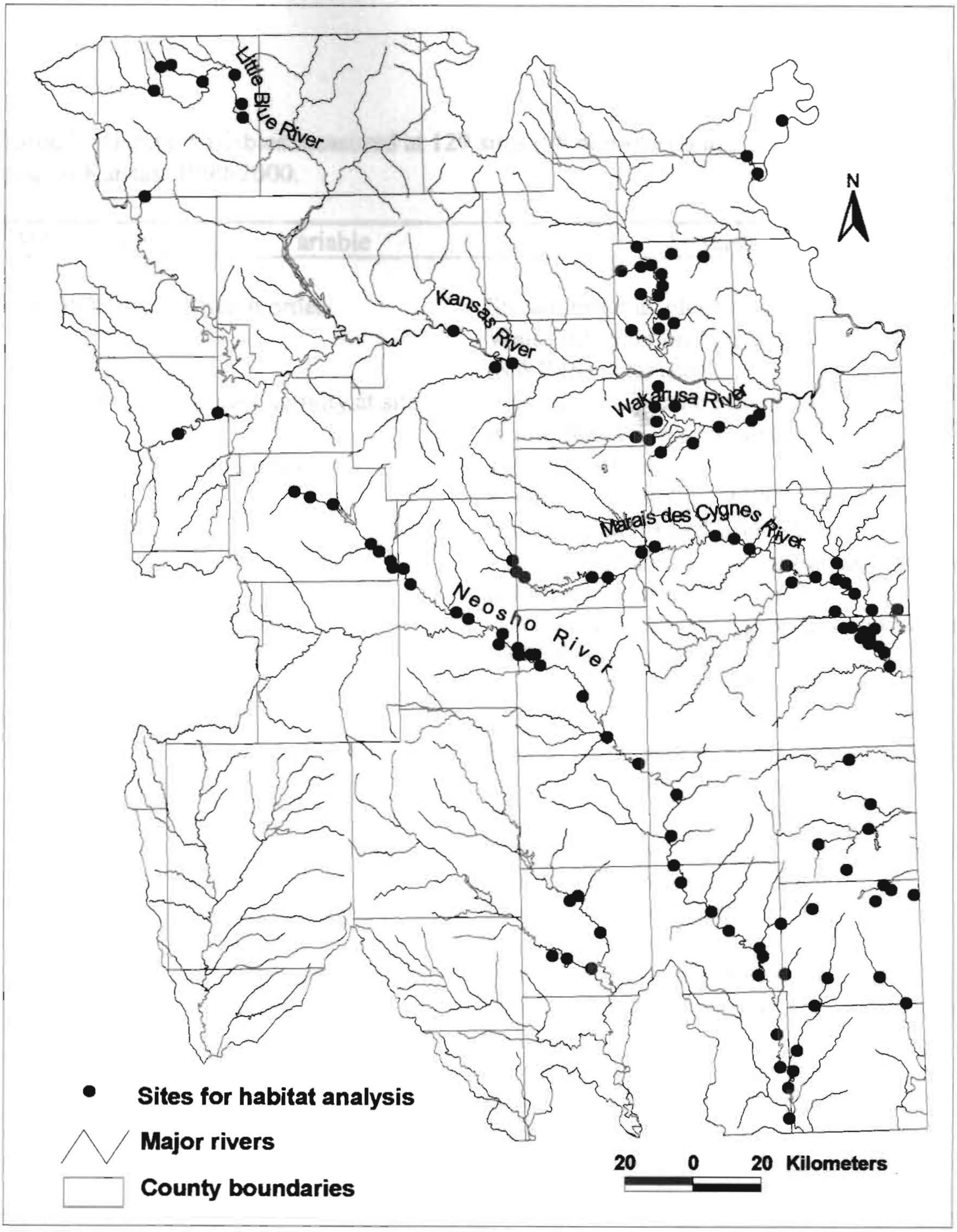
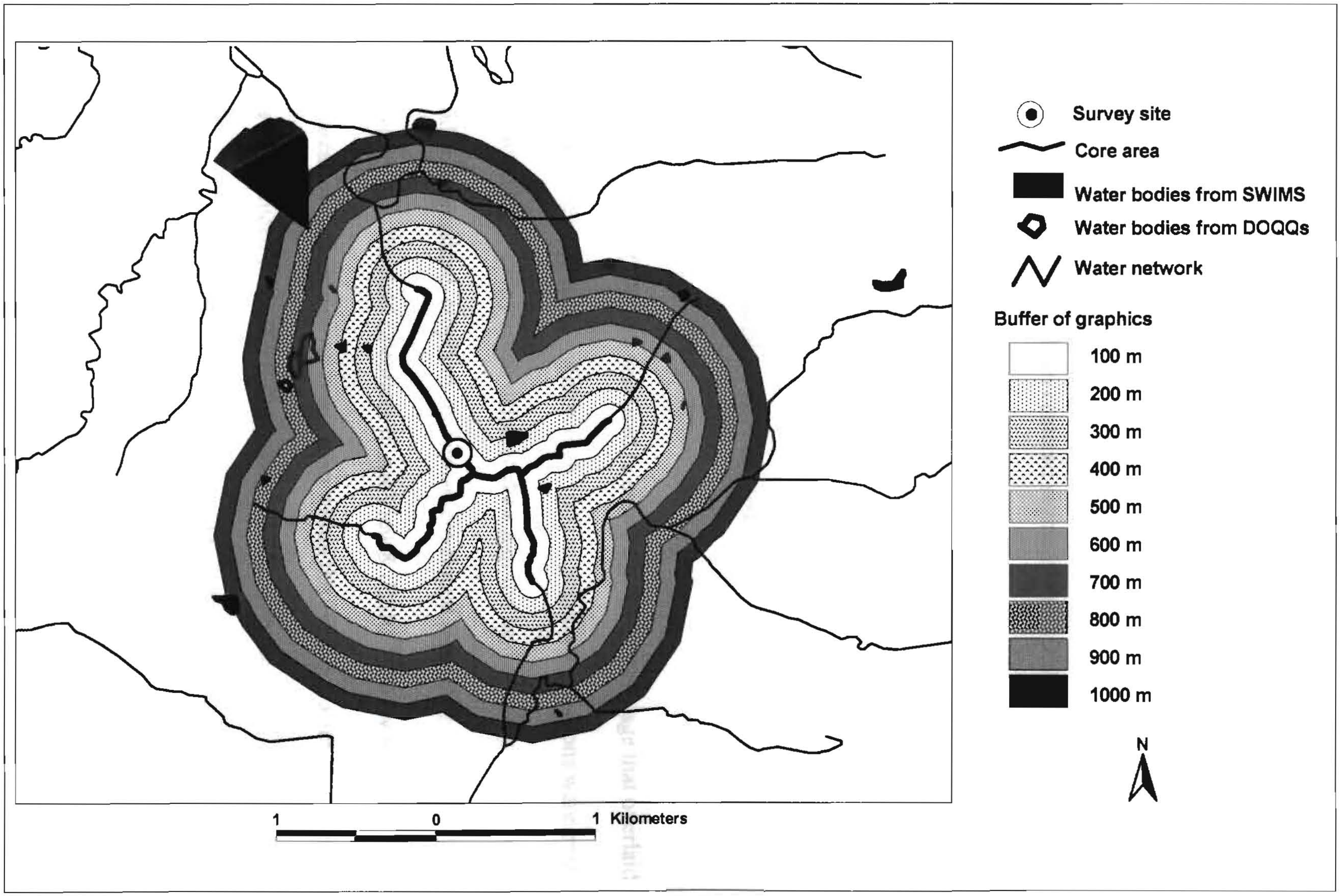

Little Blue River
Kansas River
Wakarusa River
Marais des Cygnes River
Neosho River
N
Sites for habitat analysis
Major rivers
County boundaries
20 0 20 Kilometers

Table 1. Habitat variables measured at 129 sites (98 non-otter and 31 otter) across eastern Kansas, 1999-2000.

Abbreviation	Variable	Description
ORDER	Stream order	Stream order as identified on the Surface Water Information Management System (SWIMS) database.
BEAVER	Beaver activity at site	Presence or absence of beaver activity within the 600 m surveyed at the site.
TRIB (1-10)	Tributaries	Tributaries present within each 10 100-m buffered area along a 4400 m stretch of channel; determined from SWIMS data.
PN (1-10)	Pond number	Number of water bodies within each 10 100-m buffered area around site.
PA (1-10)	Pond area	Sum of areas of all water bodies within each 10 100-m buffered area around site.
PP (1-10)	Pond perimeter	Sum of perimeters of all water bodies within each 10 100-m buffered area around site.
SD (1-10)	Shoreline diversity	Sum of perimeters of water bodies divided by the sum of areas of water bodies within each 10 100-m buffered area around site.
CDI	Curvilinear diversity index	Measure of distance along stream divided by straight line distance across land.
PERCAG	Percent agriculture	Percentage of total buffered area that is encompassed by cropland.
PERCWD	Percent riparian and woodland	Percentage of total buffered area that characterized as riparian or encompassed by woodland.
PERCGR	Percent grassland	Percentage of total buffered area that is encompassed by grass or pasture land.
PERCDEV	Percent developed	Percentage of total buffered area that is urban development.

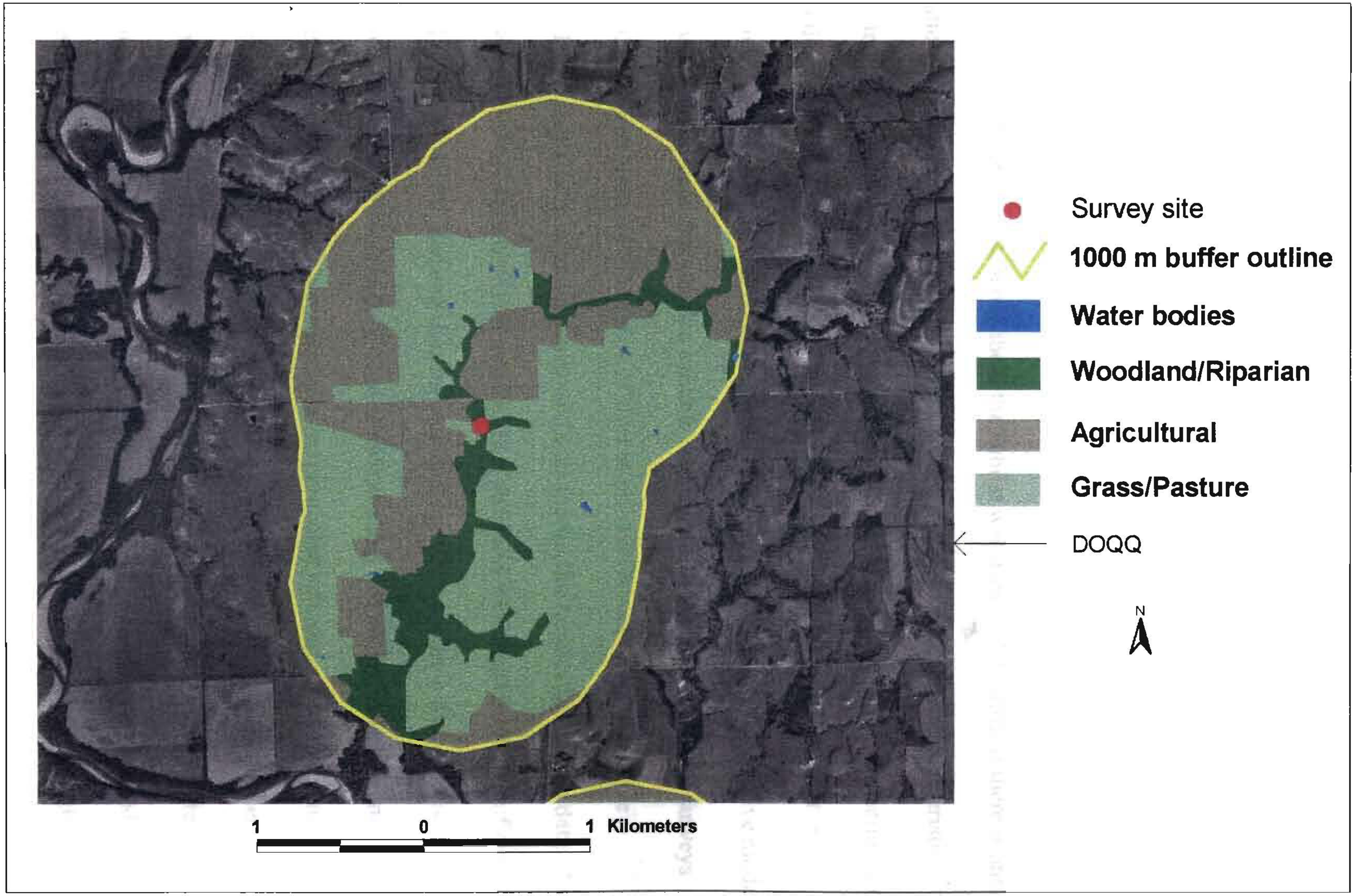
Fig. 4. Example of a site used in the habitat analysis showing 10 100-m buffers created around a 2400-m segment measured within the core area of a survey site.


Survey site
Core area
Water bodies from SWIMS
Water bodies from DOQQs
Water network
Buffer of graphics
100 m
200 m
300 m
400 m
500 m
600 m
700 m
800 m
900 m
1000 m
N
1
0
1 Kilometers

Therefore, on either side of the bridge, the length of the segment was 1200 m. Ten 100-m buffers were then created around the drawn line for each segment by using ArcView® (ESRI 1996). The total buffer distance of 1000 m was chosen so that the total encompassed area for each survey site would include the river distance used daily by a river otter. In other words, the 2400 m centered segment plus 1000 m both upstream and downstream of the segment would equal 4.4 km, which is the average daily movement of a male river otter (Melquist and Hornocker 1983). The male's average daily movement was chosen so that it would naturally overestimate the potential daily movement of any females or young inhabiting the area. These buffers then were used to determine the distance category that habitat variables were located from the bridge and the channel segment.

The largest buffer (1000 m) was used to create a polygon coverage that overlaid the DOQQs to serve as an outline. Within each 1000 m boundary, polygons were created within ArcView® (ESRI 1996) which delineated each of the land cover types including riparian/woodland, grassland, cropland, and urban-developed areas (Fig. 5). After the polygons were created, the field calculator in ArcView® (ESRI 1996) was used to compute the areas of each land cover type. Also within the 1000-m buffer, any additional water bodies not included in the SWIMS coverage visible at the scale of 1:6,000 m digitally were traced on the DOQQs. After these additional polygons were created, the field calculator again was used to calculate the area and perimeter of each water body. The number, areas, and perimeters of water bodies included in the SWIMS coverage within each buffer also were recorded. If a water body overlapped 2 buffer zones, it was

Fig. 5. Example of a site used in the habitat analysis showing land use characterization within 1000-m buffer.


Survey site
1000 m buffer outline
Water bodies
Woodland/Riparian
Agricultural
Grass/Pasture
DOQQ
N
1
0
1 Kilometers

recorded for the smaller buffer. The assumption was, if a river otter were to use the water body, it most likely would encounter the body of water on the side nearest the core area along the river.

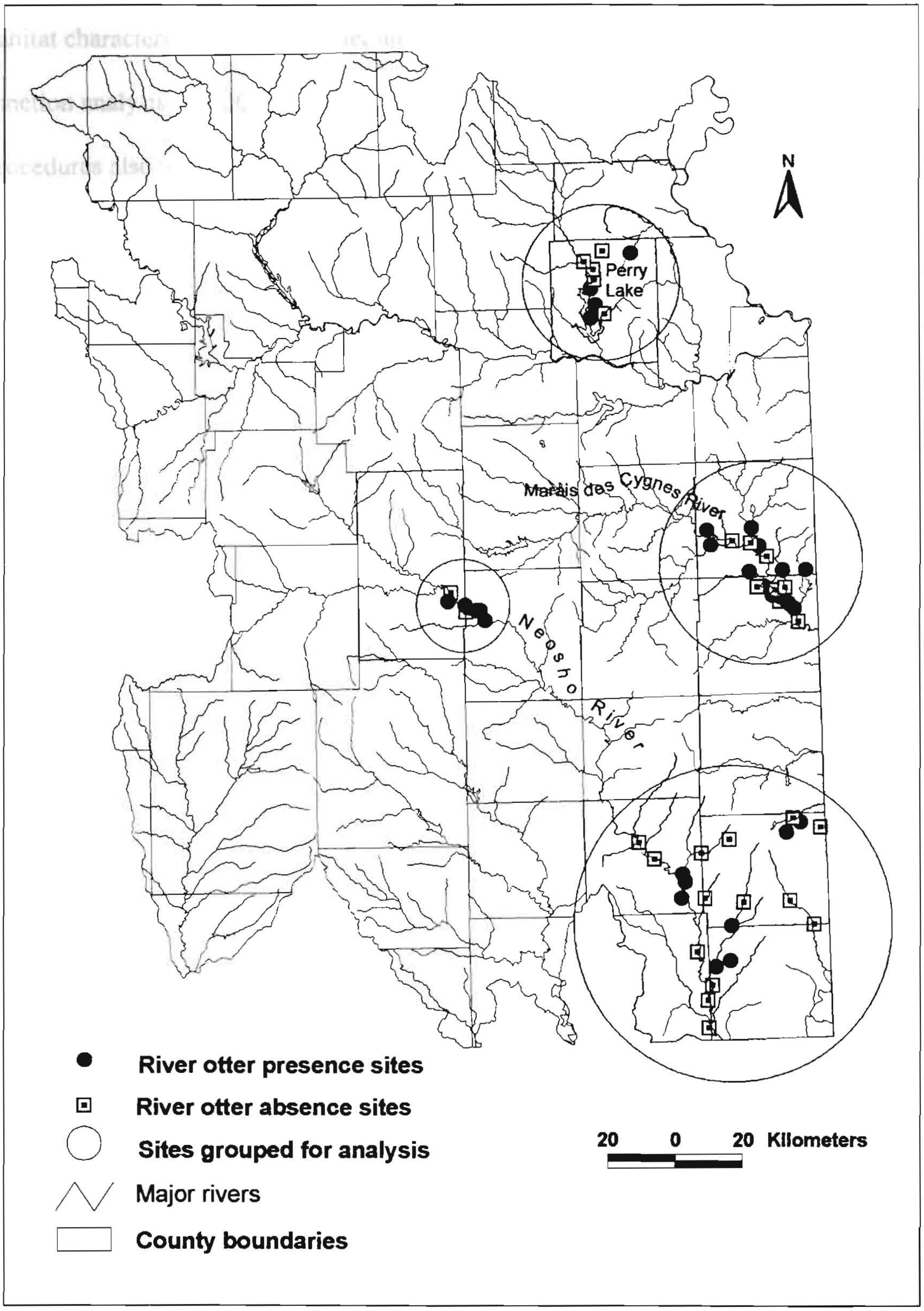
Data Analysis

The information gathered about the habitat was used to determine if there is any relationship between river otter use or distribution and the mesohabitat characteristics of the stream channels. Using the Statistical Analysis System (SAS), stepwise discriminant function analysis (SAS Inst., Inc. 1988) was applied by using PROC STEPDISC to determine which mesohabitat features should be included in the habitat predictive model. Stepwise discriminant analysis is a variable reduction technique. Because the surveys only determined presence or absence of river otters and did not measure relative abundance, stepwise discriminant analysis is an appropriate application for the data. The stepwise selection continued until no additional variables were statistically significant, based on F ($\alpha = 0.15$). Because discriminate analysis does not test a formal hypothesis, an alpha level of 0.15 is often applied to allow variables that are potentially significant to be included in the model. This was a concern particularly during my study because river otter recently have been reintroduced and most likely have not dispersed completely. The analysis was first applied to all 129 sites. In the program, statements were written so that the number of tributary streams, pond number, pond area, pond perimeter, and shoreline diversity were calculated cumulatively for each of the 10 buffers. In other words, the number of ponds in the first 100-m buffer was applied as a variable, then the number of ponds in the first 2 100-m buffers (200 m) were summed for the second variable, and continued until buffers 1-10 were summed together. I chose this procedure based on the assumption that a river otter would use water bodies that were in closest proximity to the core habitat area. In order for an individual to use a water body 300 m away, I assumed the river otter also would use the closer water bodies to forage. These methods of summing the data on a cumulative basis among the delineated buffers has not been reported previously and might or might not be a valid assumption for analysis of these data.

The habitat variables determined significant with the stepwise discriminant function analysis then were applied subsequently to a discriminant analysis procedure (PROC DISCRIM, SAS Inst., Inc. 1988) to determine the proportion of sites the model correctly predicted river otter presence or absence. A t-test (PROC TTEST, SAS Inst., Inc. 1988) also was applied to determine if there was a significant difference between the habitat variables found at locations where river otter sign was present versus where river otter sign was not detected.

Based on the assumption that river otter have not dispersed completely in eastern Kansas, a second set of analyses were applied to a smaller subset of data. These data, which are included in the habitat analysis of 129 total sites, were compiled from 59 (30 non-otter and 29 otter) sites selected from areas where sites of river otter presence appear to be concentrated (Fig. 6). By analyzing a subset of the survey sites, the number of otter and non-otter sites are more equal and are located in similar areas of the state, which might increase the potential of the discriminant analysis to detect differences in the

Fig. 6. Fifty-nine sites (30 non-otter and 29 otter) from concentrated areas of river otter occurrence used for second set of habitat data analyses.


N
Perry
Lake
Marais des Cygnes River
Neosho River
River otter presence sites
River otter absence sites
Sites grouped for analysis
Major rivers
County boundaries
20 0 20 Kilometers

habitat characteristics between otter and non-otter sites. The stepwise discriminant function analysis (PROC STEPDISC) and discriminant analysis (PROC DISCRIM) procedures also were applied to these 59 sites.

RESULTS

Bridge Surveys

During March 1999, I found no indication of river otter activity on the Cottonwood River or the South Fork of the Cottonwood River, where the river otter release took place in 1983 and 1984 (Fig. 1). The tracking conditions along that river were very rocky and poor for reading tracks. I decided not to continue surveying the Cottonwood River or its South Fork in subsequent seasons.

Results from my bridge surveys of 1999 indicated that river otters were present on the Flint Hills National Wildlife Refuge, just east of Hartford, Kansas (T20S, R13E, S13), on Eagle, Lebo, and Troublesome creeks (Figs. 1, 7; Table 2). I also found river otter sign along the Marais des Cygnes River on the land of the Marais des Cygnes Wildlife Refuge near LaCygne, Kansas (T20S, R24E, S23), which is located about 16.09 km (10 miles) from the Kansas/Missouri border (Figs. 1, 7; Table 2). A third location on the Marais des Cygnes River was located about 4.83 km (3 miles) west of New Lancaster, Kansas (T18S, R24E, S28; Figs. 1, 7; Table 2).

Many locations where river otter presence was not documented previously were recorded during the spring 2000 season. River otter sign was found for the first time at 2 locations south of St. Paul, Kansas. One site was located approximately 1.6 km (1 mile) south of St. Paul and 1.9 km (1.18 miles) west of Neosho Waterfowl Area (T29S, R20E, S25; Figs. 1, 7; Table 2). The other was located approximately 2.8 km (1.75 miles) south of St. Paul, 1.6 km (1 mile) west of Neosho Waterfowl Area, and approximately 1.6 river-

Fig. 7. Distribution of river otter in eastern Kansas based on bridge surveys conducted during 1999 and 2000.

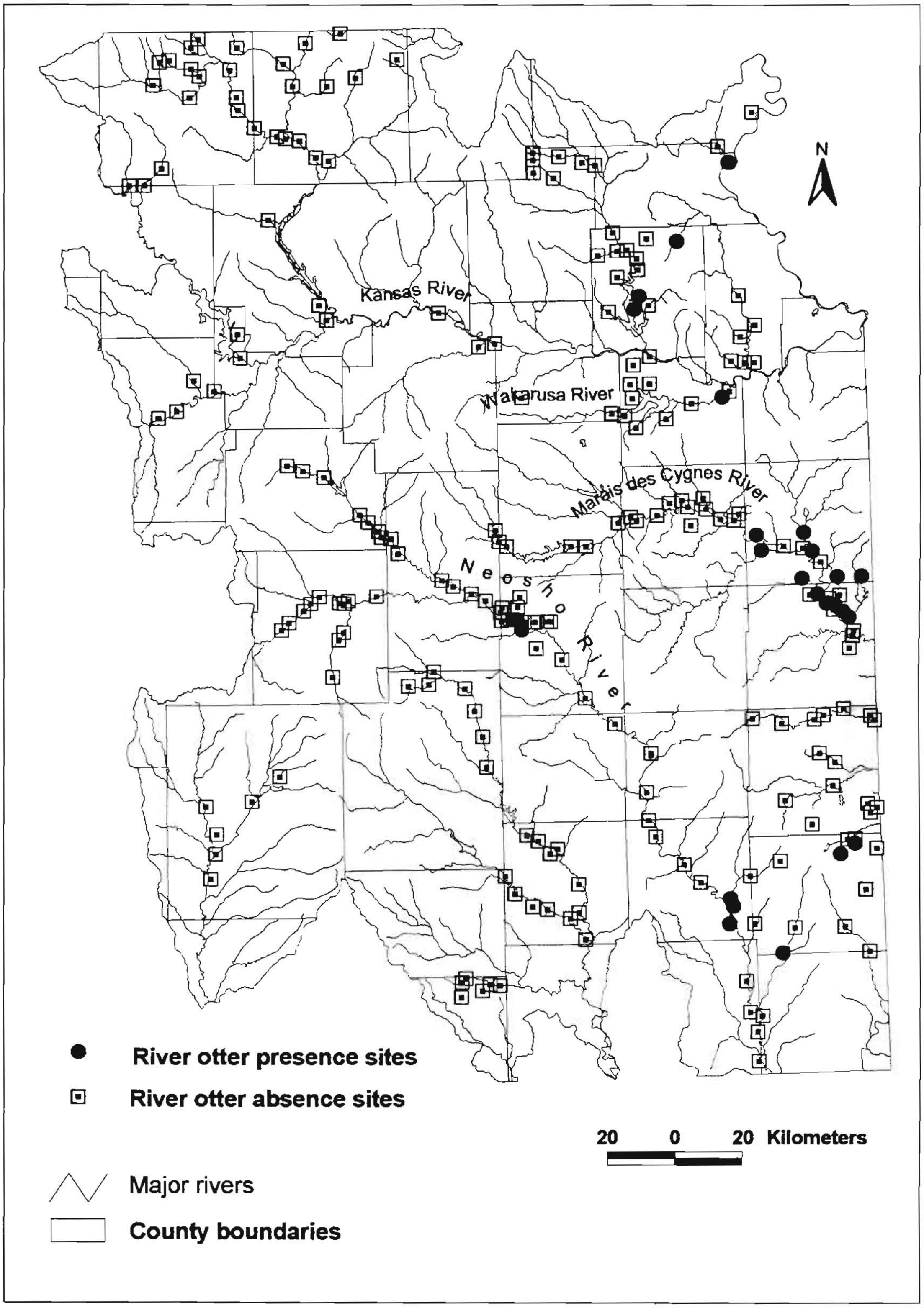

Kansas River
Wakarusa River
Marais des Cygnes River
Neosho River
N
River otter presence sites
River otter absence sites
20 0 20 Kilometers
Major rivers
County boundaries

Table 2. List of sightings reported from 1989 through 2000.

Date	Location	Location Description	Type of Sighting
12 June 1989	T13S, R14E, S15	east of Dover, KS	live animal
30 January 1995	T27S, R24E, S10	northwest of Arma, KS	1 captured
9 March 1995	T34S, R25E, S3	Galena, KS	1 captured
12 March 1995	T19S, R12E, S15	east of Emporia, KS	1 capture
10 February 1997	T27S, R25E, S11	southeast of Ft. Scott	3 captured
8 April 1997	T20S, R13E, S9	Flint Hills National Wildlife Refuge, Hartford, KS	vehicle kill
20 November 1997	T20S, R24E, S2	north of Pleasanton, KS	1 captured
3 January 1998	T20S, R13E, S6	McKinney Marsh, southwest of Neosho Rapids, KS	1 captured
10 January 1999	T32S, R22E, S33	Mined Land Wildlife Area, north of Pittsburg, KS	live animal
7 March 1999	T13S, R2E, S25	southeast of Abilene, KS	tracks
15 March 1999	T20S, R13E, S13	Flint Hills National Wildlife Refuge, Hartford, KS	tracks, latrine
20 March 1999	T8S, R19E, S10	north of Winchester, KS	tracks
20 March 1999	T9S, R18E, S8	Perry Lake, south of Valley Falls, KS	tracks
21 March 1999	T10S, R18E, S17	Perry Lake, southwest of Oskaloosa, KS	tracks
21 March 1999	T20S, R24E, S23	Marais des Cygnes Wildlife Refuge, near La Cygne, KS	tracks, latrine
21 March 1999	T18S, R24E, S28	west of New Lancaster, KS	tracks
27 March 1999	T19S, R23E, S36	west of La Cygne, KS	tracks
28 March 1999	T20S, R24E, S5	southwest of La Cygne, KS	tracks
28 March 1999	T20S, R24E, S14	south of La Cygne, KS	tracks
10 October 1999	T19S, R8E, S28	east of Cottonwood Falls, KS	live animal
17 October 1999	T55N, R21E, S18	northeast of Atchison, KS	live animal
23 January 2000	T20S, R24E, S36	north of Pleasanton, KS	1 captured
6 February 2000	T20S, R13E, S6	McKinney Marsh, southwest of Neosho Rapids, KS	3 captured
1 March 2000	T20S, R13E, S6	McKinney Marsh, southwest of Neosho Rapids, KS	latrine
10 March 2000	T27S, R25E, S31	west of Arcadia, KS	tracks
10 March 2000	T29S, R20E, S25	west of Neosho Waterfowl Area, south of St. Paul, KS	tracks

Table 2 cont.

Date	Location	Location Description	Type of Sighting
13 March 2000	T19S, R24E, S15	south of New Lancaster	latrine
17 March 2000	T29S, R25E, S15	north of Pittsburg, KS	live animal
28 March 2000	T13S, R21E, S13	southeast of Eudora, KS	tracks
28 March 2000	T18S, R23E, S14	south of Henson, KS	tracks
28 March 2000	T19S, R23E, S9	southeast of Fontana, KS	tracks
29 March 2000	T32S, R22E, S18	south of Sherman, KS	vehicle kill
2 April 2000	T18S, R22E, S19	south of Osawatomie, KS	tracks
2 April 2000	T17S, R22E, S31	west of Osawatomie, KS	latrine
2 April 2000	T17S, R23E, S26	south of Paola, KS	tracks
2 April 2000	T19S, R25E, S9	east of Jingo, KS	tracks
6 April 2000	T31S, R22E, S15	southeast of McCune, KS	tracks
9 April 2000	T12S, R4E, S13	north of Chapman, KS	tracks
13 April 2000	T20S, R13E, S3	Flint Hills National Wildlife Refuge, Hartford, KS	live animal
10 November 2000	T9S, R18E, S33	Little Slough Creek into Perry Lake, Oskaloosa, KS	tracks

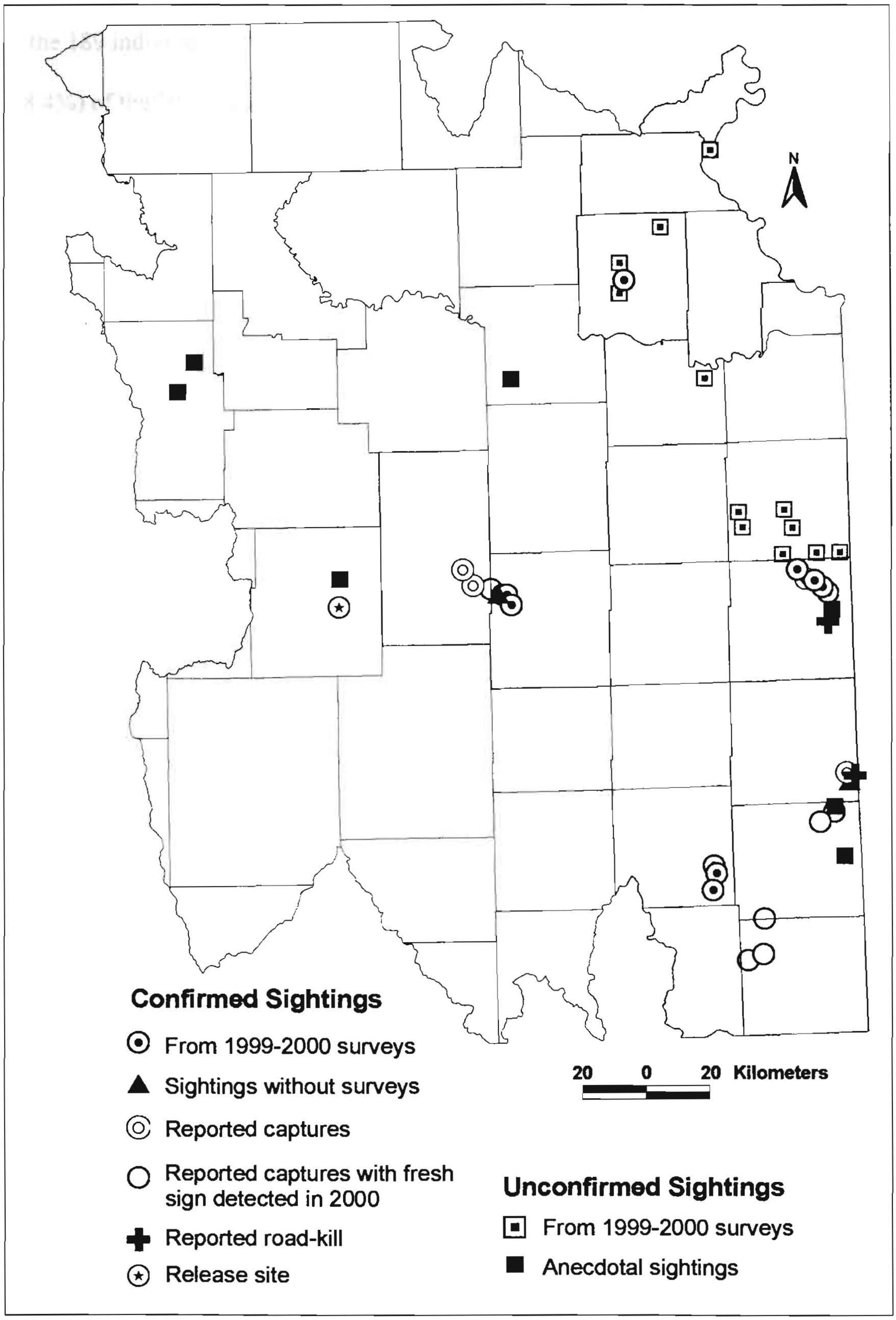
km (1 river-mile) southwest of the junction of the Neosho River and the Neosho River Cutoff (T29S, R21E, S31; Figs. 1, 7; Table 2).

In order to compare methods of the 1999-2000 bridge survey protocol to other sighting information, the distribution based upon the bridge surveys were plotted separately (Fig. 7). Distribution of river otter in eastern Kansas is reported by including results from the bridge surveys conducted by myself, volunteer furharvesters, and KDWP volunteers, sites by volunteers that personally were confirmed, reported captures, anecdotal sightings reported via phone calls, letters, or e-mail, and reports of road-kill since 1989 (Table 2; Fig. 8).

Recruitment of Volunteers

Sixty-eight (30.2%) of the 225 individuals contacted were able to participate in conducting the survey during March 1999. Surveys were returned by 26 (38.2%) of the 68 individuals who showed interest. Twenty-three of those included usable data. Returned data sheets were determined usable if there was at least one survey site reported that corresponded to a clearly marked location on the enclosed map. The 23 usable surveys included data collection from the following counties: Bourbon, Butler, Chautauqua, Coffey, Douglas, Franklin, Geary, Greenwood, Jackson, Jefferson, Leavenworth, Linn, Marshall, Riley, Washington, and Wilson. Seven (30.4%) trappers completed a survey of all 10 bridges indicated in the protocol. Nine (39.1%) trappers completed a survey of 5 to 9 bridges and 7 volunteers (30.4%) completed between 1 and 4 bridge surveys. In March 2000, of the furharvesters and KDWP employees, 19 (10.0%)

Fig. 8. Distribution of river otter in eastern Kansas based upon bridge surveys, sightings not associated with bridge surveys, anecdotal sightings, road-kill reports, and reported captures, between 1989 and 2000.


N
20 0 20 Kilometers
Confirmed Sightings
From 1999-2000 surveys
Sightings without surveys
Reported captures
Reported captures with fresh sign detected in 2000
Reported road-kill
Release site
Unconfirmed Sightings
From 1999-2000 surveys
Anecdotal sightings

of the 189 individuals contacted were able to participate in the bridge surveys. Thirteen (68.4%) of the 19 individuals completed some portion of the bridge surveys between March and April 2000. Three (23.1%) volunteers completed a survey of all 10 bridges indicated in the protocol. Seven (53.9%) volunteers completed a survey of 5 to 9 bridges and 3 volunteers (23.1%) completed between 1 and 4 bridge surveys.

Volunteer Surveys

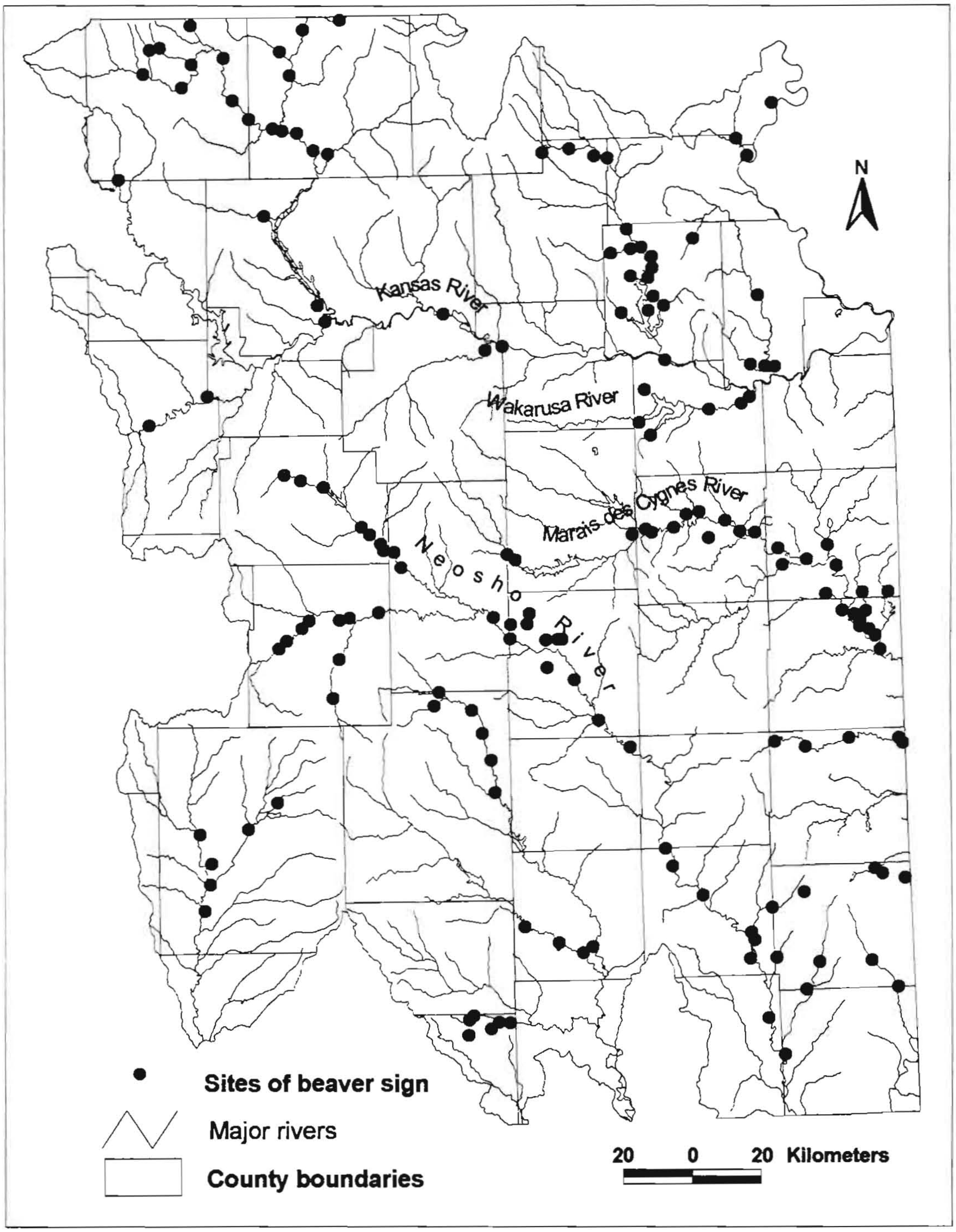
Locations of sighting information that were sent to me from KDWP employees and volunteer surveyors were visited to attempt to confirm the sighting location. However, due to the time lapse between the original date the sighting was recorded to the time the locations were revisited, not all sites could be confirmed successfully. Several locations where river otter sign were detected in Miami and Linn counties were recorded by volunteers and KDWP employees (Figs. 1, 7). A volunteer detected river otter sign in March 2000 along Little Slough Creek that feeds into Perry Lake, which is located 9.6 km (6 miles) from Oskaloosa, Kansas (T9S, R18E, S33; Figs. 1, 8; Table 2). The site was confirmed when otter tracks were found in the sandy creek bottom in November 2000. Tracks also were confirmed at 2 non-river locations in southeast Kansas 2.4 km (1.5 miles) south of Sherman (T32S, R22E, S18; Figs. 1, 8; Table 2) and also 19.2 km (12 miles) north of Pittsburg in a matrix of ponds, which were formerly strip mining pits (T32S, R22E, S15; Figs. 1, 8; Table 2). On 13 April 2000, a river otter was observed crossing a grassy path and swimming into a wetland just west of K130 approximately 0.8

km (0.5 miles) south of the north entrance to the Flint Hills National Wildlife Refuge (T20S. R13E, S3; Figs. 1, 8; Table 2).

In February 2000, a local trapper incidentally trapped 3 river otters in his beaver traps set within McKinney Marsh, which is located 3.2 km (2 miles) southwest of Neosho Rapids and approximately 1.2 km (0.75 miles) west of the Flint Hills National Wildlife Refuge boundary (T20S, R13E, S6; Figs 1, 8; Table 2). Visiting the site 3 weeks later, I found fresh river otter scat in a path crossing between 2 adjacent marsh pits at the same location.

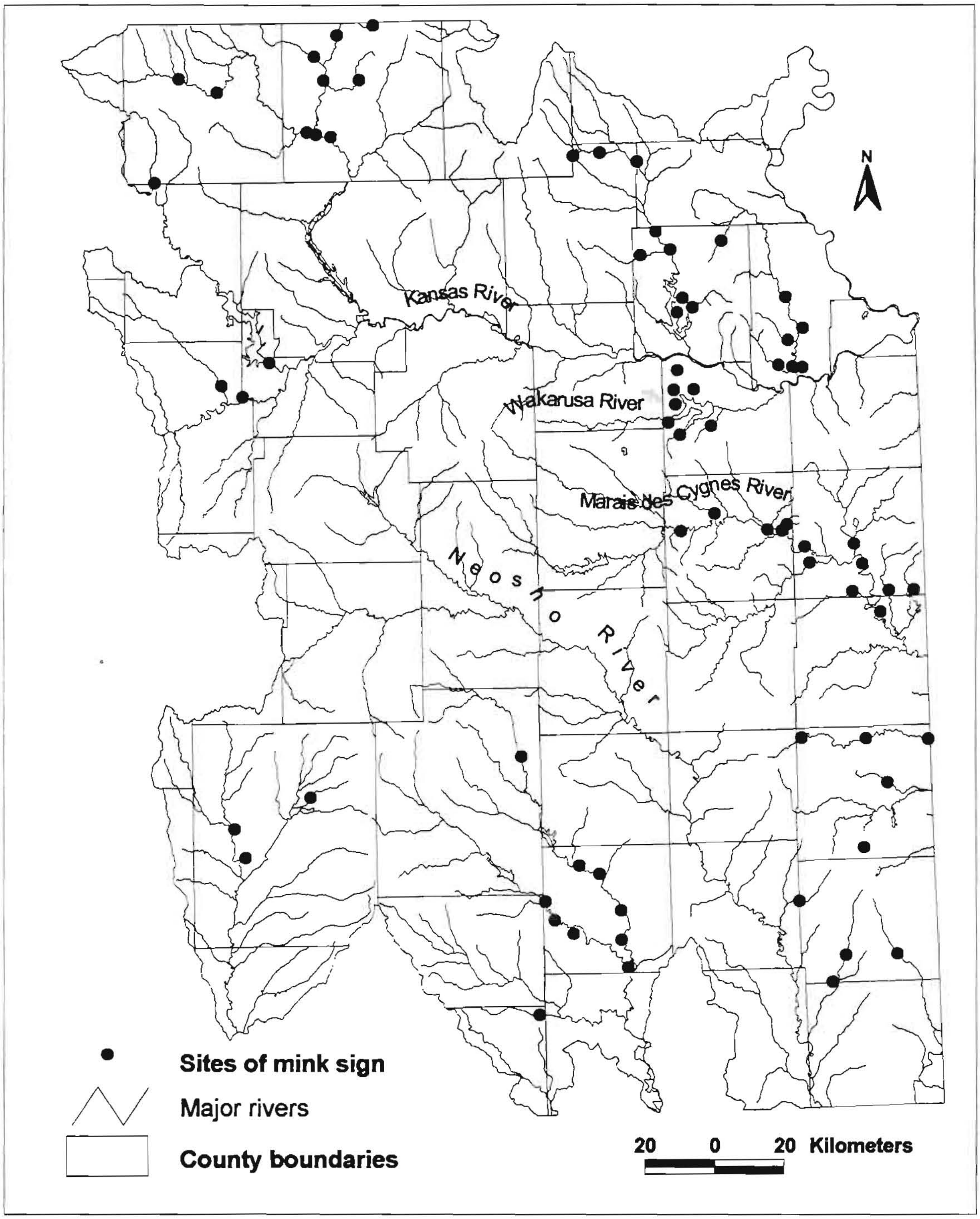
Volunteer surveyors also recorded other furbearer tracks detected while surveying their sites. Raccoon tracks were identified at every location surveyed in each county listed (Figs. 1, 4). Beaver tracks were identified in each county surveyed except Geary (Figs. 1, 9). Mink tracks were identified in Bourbon, Butler, Chautauqua, Dickinson, Douglas, Franklin, Geary, Greenwood, Jackson, Jefferson, Leavenworth, Linn, Marshall, Washington, and Wilson (Figs. 1, 10). Muskrat tracks were identified in Bourbon, Butler, Chautauqua, Dickinson, Douglas, Franklin, Jackson, Jefferson, Leavenworth, Marshall, Washington, and Wilson (Figs. 1, 11).

Fig. 9. Distribution of beaver in eastern Kansas based upon volunteer bridge surveys conducted during 1999 and 2000.



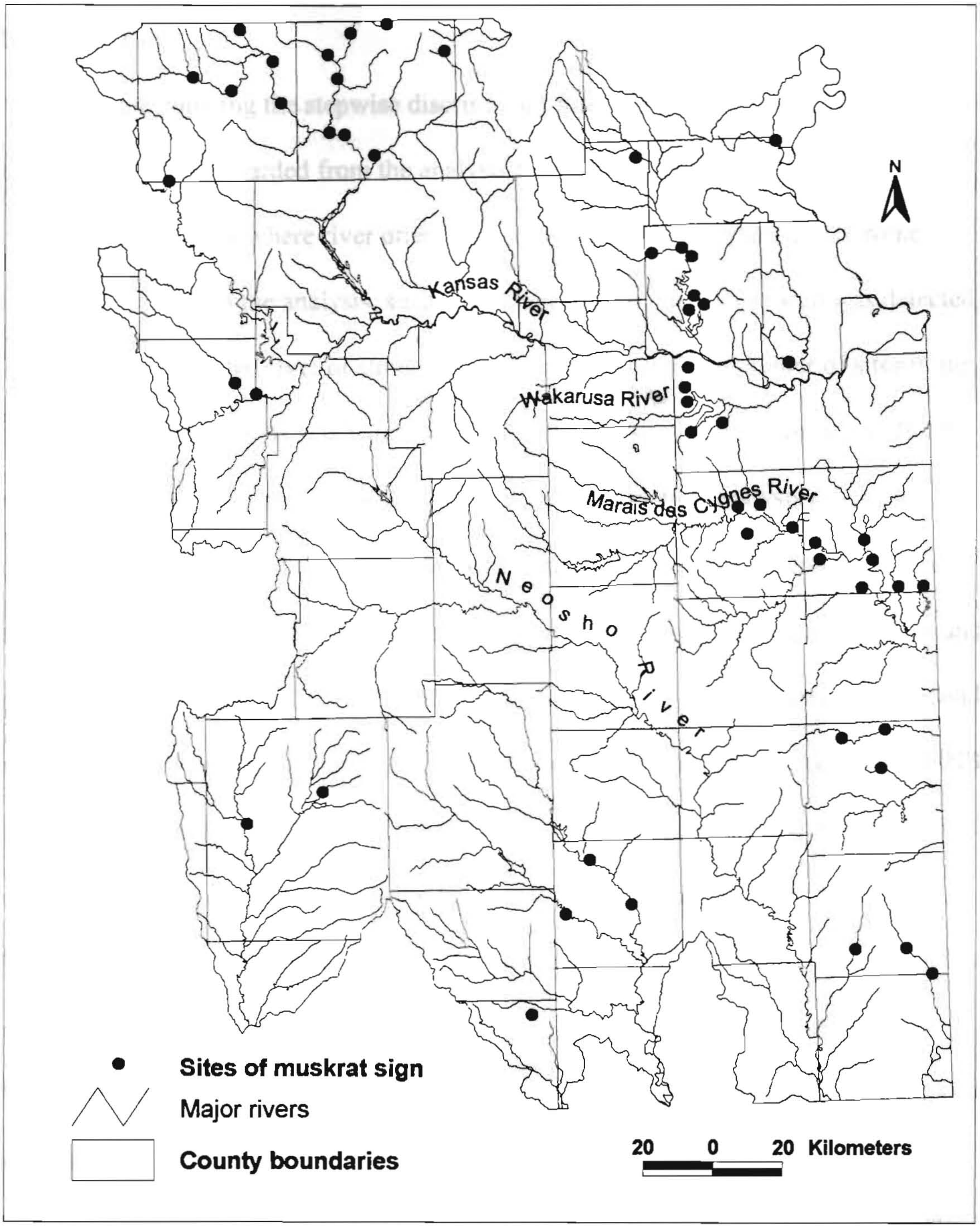
N
Kansas River
Wakarusa River
Marais des Cygnes River
Neosho River
Sites of beaver sign
Major rivers
County boundaries
20 0 20 Kilometers

Fig. 10. Distribution of mink in eastern Kansas based upon volunteer bridge surveys conducted during 1999 and 2000.



N
Kansas River
Wakarusa River
Marais des Cygnes River
Neosho River
Sites of mink sign
Major rivers
County boundaries
20 0 20 Kilometers

Fig. 11. Distribution of muskrat in eastern Kansas based upon volunteer bridge surveys conducted during 1999 and 2000.


N
Kansas River
Wakarusa River
Marais des Cygnes River
Neosho River
Sites of muskrat sign
Major rivers
County boundaries
20 0 20 Kilometers

Data Analysis

While applying the stepwise discriminant function analysis to the 129 surveyed sites, 9 sites were discarded from the analysis because of missing values. Because I included all locations where river otter were detected during 1999 and 2000, some locations included in the analysis, such as wetlands and ponds where sign was detected, did not have associated river or stream data. Therefore, the total number of sites in the first discriminant analysis was reduced from 129 to 120 sites (94 non-otter and 26 otter). As explained earlier, during the stepwise discriminant function analysis procedure, a significance level of $\alpha = 0.15$ must have been met for a variable to be entered and to remain in the model. The first variable to be entered was the percentage of riparian and woodland cover (PERCWD; $P < 0.0003$) within the 1000-m buffered area. The second variable added was the number of tributary streams within the first 100-m buffer (TRIB1; $P < 0.1493$). Finally, the number of water bodies, or pond number, within the first 3 100-m buffers (PN13; $P < 0.0850$) was the last variable entered into the model (Table 3). Results from the t-test show a significantly greater total amount of riparian and woodland cover (PERCWD; $P < 0.0004$) and number of water bodies within the first 3 100-m buffers (PN13; $P < 0.0004$) at sites where river otter sign were present than where river otter sign was not detected. However the number of tributary streams within the first 100-m buffer ($P < 0.007$; Table 4) was significantly greater in sites where river otters were absent.

Table 3. Results of stepwise discriminant analysis using habitat data[a] from 94 non-otter sites and 31 otter sites in eastern Kansas.

Variable entered	Partial R^2	*P*-Value > F
PERCWD *	0.1044	0.0003
TRIB1 *	0.0177	0.1493
PN13 *	0.0254	0.0850
Beaver	0.0001	0.8981
Order	0.0084	0.3269
TRIB12	0.0163	0.1698
TRIB13	0.0080	0.3389
TRIB14	0.0028	0.5717
TRIB15	0.0044	0.4760
PN1	0.0001	0.9254
PN12	0.0002	0.8709
PN14	0.0037	0.5158
PN15	0.0037	0.5160
PA1	0.0076	0.3506
PA12	0.0076	0.3494
PA13	0.0074	0.3550
PA14	0.0075	0.3526
PA15	0.0075	0.3532
PP1	0.0043	0.4839
PP12	0.0044	0.4789
PP13	0.0044	0.4770
PP14	0.0046	0.4660
PP15	0.0044	0.4778
CDI	0.0020	0.6345
PERCAG	0.0125	0.2309
PERCGR	0.0002	0.8730

[a] Variable abbreviations are described in Table 1.
* Variables entered and remained in model.

Table 4. Results of a t-test comparing the habitat variables[a] found significant through stepwise discriminant analysis out of variables measured at 129 sites surveyed in eastern Kansas.

	River Otter Presence		River Otter Absence			
Variable	Mean ± SE	*n*	Mean ± SE	*n*	*t*	*P*
PERCWD	0.313 ± 0.027	31	0.224 ± 0.011	98	-3.67	< 0.0004
PN13	1.774 ± 0.337	31	0.816 ± 0.105	98	-3.61	< 0.0004
TRIB1	1.000 ± 0.186	31	1.663 ± 0.123	98	2.74	< 0.0071

[a] Variable abbreviations are described in Table 1.

Discriminant analysis was applied by using the 3 variables, PERCWD, TRIB1, and PN13, to determine the percentage of sites classified correctly as either "otter" or "non-otter" sites. The discriminant analysis used a total of 125 observations (94 non-otter and 31 otter) in the procedure. Only 4 survey sites were eliminated for missing values because sites at wetlands/ponds were able to be classified during this analysis. Seventy-four of the 94 (78.72%) non-otter sites were classified correctly as non-otter sites, and 19 of 31 (61.29%) of the otter sites were classified correctly based on the above habitat variables entered (Table 5).

When the analysis was performed on the 59 sites among the areas of concentrated river otter sites, the stepwise discriminant analysis removed 5 observations with missing data, and 54 sites were used to develop the model. The only variable entered into the model was the number of water bodies in the first 3 100-m buffers (PN13; $P < 0.0192$; Table 6). When PROC TTEST was applied to the data set of 59 sites, it showed a significant difference between the number of ponds within the first 3 100-m buffers at otter sites when compared to non-otter sites (PN13; $P < 0.007$; Table 7). Discriminant analysis of PN13 when analyzed with the 59 concentrated sites classified 23 of 30 (76.67%) non-otter sites correctly and only 12 of 29 (41.38%) otter sites correctly (Table 8).

Table 5. Percentage of sites classified correctly as "otter" or "non-otter" through discriminant analysis determined by using habitat data from 94 non-otter sites and 31 otter sites in eastern Kansas.

From PRES_ABS[a]	0[b]	1[c]	Total
0	*n* = 74 78.72%	*n* = 20 21.28%	*n* = 94 100.00%
1	*n* = 12 38.71%	*n* = 19 61.29%	*n* = 31 100.00%
Total Percent	*n* = 86 68.80%	*n* = 39 31.20%	*n* = 125 100.00%

[a] PRES_ABS = Presence or absence of river otter.
[b] 0 = Absence of river otter.
[c] 1 = Presence of river otter.

Table 6. Results from stepwise discriminant analysis using habitat data[a] from 59 sites (30 non-otter and 29 otter) from areas of concentrated river otter occurrence in eastern Kansas.

Variable entered	Partial R^2	*P*-value > F
PN13 *	0.1010	0.0192
Beaver	0.0062	0.5750
Order	0.0207	0.3036
TRIB1	0.0100	0.4759
TRIB12	0.0004	0.8934
TRIB13	0.0009	0.8310
TRIB14	0.0002	0.9197
TRIB15	0.0041	0.6504
PN1	0.0054	0.6027
PN12	0.0003	0.9011
PN14	0.0034	0.6783
PN15	0.0235	0.2727
PA1	0.0379	0.1625
PA12	0.0378	0.1630
PA13	0.0365	0.1703
PA14	0.0368	0.1688
PA15	0.0367	0.1691
PP1	0.0369	0.1684
PP12	0.0362	0.1724
PP13	0.0351	0.1791
PP14	0.0360	0.1735
PP15	0.0346	0.1825
CDI	0.0268	0.2416
PERCAG	0.0007	0.8466
PERCWD	0.0040	0.6509
PERCGR	0.0157	0.3711

[a] Variable abbreviations are described in Table 1.

* Variable entered and remained in model.

Table 7. Results of a t-test comparing habitat variables[a] found significant through stepwise discriminant analysis out of variables measured at 59 (30 non-otter sites and 29 otter sites) surveyed in eastern Kansas.

	River Otter Presence		River Otter Absence			
Variable	Mean ± SE	*n*	Mean ± SE	*n*	*t*	*P*
PN13	1.897 ± 0.349	29	0.542 ± 0.159	24	-3.30	< 0.002

[a] Variable abbreviations are described in Table 1.

Table 8. Percentage of sites classified correctly as "otter" or "non-otter" determined by discriminant analysis using habitat data from 30 non-otter sites and 29 otter sites from areas of concentrated river otter occurrence in eastern Kansas.

From PRES_ABS[a]	0[b]	1[c]	Total
0	$n = 23$ 76.67%	$n = 7$ 23.33%	$n = 30$ 100.00%
1	$n = 17$ 58.62%	$n = 12$ 41.38%	$n = 29$ 100.00%
Total Percent	$n = 40$ 67.80%	$n = 19$ 32.20%	$n = 59$ 100.00%

[a] PRES_ABS = Actual presence or absence of river otter.
[b] 0 = Model prediction as absence of river otter.
[c] 1 = Model prediction as presence of river otter.

DISCUSSION

There are several published accounts identifying habitat features associated with the occurrence of river otter for many different geographic regions of the United States (Dubuc et al. 1990, Reid et al. 1994b, Swimley et al. 1998). However, no published literature is currently available on the habitat of river otter in the Great Plains. Low population numbers of river otter in Kansas do not permit the use of harvest data to determine its distribution and population status. Sign surveys were needed for information on its distribution before evaluation of its habitat or future studies could take place.

Because sign surveys are conducted best from October through March, which corresponds with the river otter's breeding season, often times a greater number of tracks are detected in the spring. These tracks might be from male river otters looking for females in estrus (Melquist and Hornocker 1983). When evaluating actual habitat use, information from surveys conducted in the spring should be interpreted conservatively because many individuals may be transients rather than individuals permanently inhabiting the area. The movement of river otters, particularly males during the spring, could also be a reason why it was difficult to confirm sightings reported by volunteers during the March 1999 and 2000 survey periods. The time period between when the volunteer returned the data sheets and the actual time the site was surveyed often extended from 1 to 6 weeks.

The use of bridge surveys seem to be the most viable method for determining river otter distribution in Kansas. A preliminary attempt to use scent stations, which were used by Eccles (1989) and Humphrey and Zinn (1982), was not a feasible option for the large geographic area I wanted to survey. Low population numbers in Kansas are probably the reason for the little visitation to scent stations during the trials. Floating the river on a canoe also proved to be very time consuming. Also, locations where I had permission to access the water by boat were often too steep to lift the aluminum canoe. A light-weight boat that could be carried overhead to the water at each bridge location could be useful, however this was not an option with the limited funds for my research.

Precipitation was very low and the weather was very mild in the fall of 1999. Temperatures during mid-October and mid-November averaged 13.6°C (56.5°F) and the rainfall averaged 31.6 mm per day (http://www.ncdc.noaa.gov). Therefore, during the time the surveys were conducted, conditions for tracking were very poor. The riverbanks were very hard and cracked from the dryness. In these conditions, unless there are known latrine sites to visit and examine, finding traces of river otter is very difficult.

Habitat Analysis

In the northeastern United States, river otter latrines have previously been associated with mouths of tributaries, fallen logs, points of land, vertical banks, backwater, large conifers, and areas where beaver are present (Dubuc et al. 1990, Newman and Griffin 1994, Reid et al. 1994b, Swimley et al. 1998). In my study, I used mesohabitat measurements that could be evaluated from a larger scale, and from databases that are already available.

The analyses determined that the percentage of woodland/riparian area and the number of water bodies within the first 300 m of the channel were significantly greater in areas where river otters were present. The percentage of the buffered area that consisted of woodland/riparian area (PERCWD) only was found significant when all 129 sites were analyzed, not during analyses of the data subset. Others have determined that river otters used forested habitats more often than random sites (Newman and Griffin 1994, Swimley et al. 1998). Even though these studies found an association of river otter presence with large conifers, which are not predominant in the Great Plains, the common attractant is most likely the protective cover that wooded areas provide from land predators and weather. In addition, areas with more woody cover tend to attract beaver because of the availability of food and shelter (Melquist and Dronkert 1987). In Kansas, areas where permanent streams are located tend to be wooded. Beaver are therefore attracted to these areas and in turn create dens, which provide shelter for river otter. Therefore, woody cover is potentially important to river otter in eastern Kansas. The variable PERCWD could have been eliminated by stepwise discriminant analysis when applied to the data subset of 59 sites because of a low sample size or because the reduction of sites allowed the habitat characteristics to be more distinguishable between otter and non-otter sites.

The significance of the number of water bodies within the first 300 m (PN13) from the channel site, which also was determined significant in the analysis of the data subset of concentrated sites, is consistent with the first set of analyses of all 129 surveyed sites. These results might indicate the potential importance of water bodies in close proximity to rivers and streams as habitat for river otters in Kansas. Besides farm ponds, there are limited areas where water is supplied all year. The extended warm season that Kansas experienced in 1999 and 2000 might explain river otter use of water bodies. Many smaller order streams in Kansas were dried out completely which would force river otters to use an alternate habitat for foraging and shelter. To adapt, one possibility would be for individuals to move into the larger rivers, where the water supply is more reliable. However, because river otter often feed on slow-swimming fish in the shallow water especially in the warm season, an individual's foraging ability might be reduced significantly. The higher density of concentrated fish in sloughs, ponds, and wetlands in the warmer season most likely attact river otter to these locations. Ponds and wetlands may also attract river otter during the winter because smaller streams are frozen completely, eliminating them as a source of food.

The insignificance of the measure of curvilinearity of the stream channel (CDI) determined by stepwise discriminant function analysis might be due to the lack of detail in the SWIMS coverage. The SWIMS water network coverage is created by tracing streams at the 1:100,000-m scale, which may not be detailed enough to be reflected in the CDI measurement. The same reason might have contributed to the insignificance of the shoreline diversity (SD) measurement. The values of area and perimeter of the water bodies already included in the SWIMS coverage were taken from the SWIMS database. These values in turn are used to calculate shoreline diversity. Therefore, unlike the results of the study in Maine by Dubuc et al. (1990), my results show that shoreline diversity is not a significant habitat characteristic of river otter in eastern Kansas.

However, these results only can be concluded based upon the use of the databases provided by DASC.

The CDI and shoreline diversity measurements were used to incorporate the food requirement dimension indirectly through habitat description that could potentially be measured in the GIS. Ideally, stream surveys of fish species and abundances should be used to analyze food availability as a potential driving variable for distribution of a species. However, if associations between habitat and food requirements could be identified at a larger scale, analysis through GIS will be much more informative.

Population numbers of river otter in Kansas are low. Due to the recent reintroduction, river otter probably have not expanded fully to all potentially suitable habitats. Therefore, use of a habitat suitability model may not be functional. Incorrect classification of sites as having river otter present or absent by discriminant analysis of the habitat variables might have occurred simply because individuals have not expanded to those areas yet. Possibly river otters respond more to characteristics at the microhabitat level, and differences at the mesohabitat level are not detectable. Therefore, my results should be interpreted with caution and should not be used to classify suitable versus unsuitable habitat. Monitoring should continue and future analyses might be able to discriminate between habitat characteristics of river otter in Kansas after individuals have more time to expand geographically.

Mesohabitat Analysis and GIS

Many states have undergone reintroduction programs during the 1980s and 1990s. Few follow-up accounts have been published that record the establishment or expansion of populations in areas where river otters have been restocked (Johnson and Berkley 1999). Reintroduction and restoration programs also should have long-term monitoring programs. Developing a GIS could be used to record, update, and analyze data collected during monitoring programs.

By incorporating habitat characteristics from field observations and mesohabitat characteristics from landscape databases, analysis of habitat use can be conducted on a larger scale. Once the information of habitat use is determined and maintained in a GIS, future monitoring will become less labor intensive and more specific information about the species can be studied. By completing the database of river otter distribution in my study, KDWP will be able to take advantage of these benefits. The use of computers has helped these type of monitoring efforts considerably, and should be used to their fullest abilities. My study should make the continuation of monitoring the progress of river otter in Kansas an easier task if it is maintained properly.

Information gained from my study regarding the potential importance of nearby water bodies and the ability to easily identify these areas by using a GIS could also be useful to other Great Plains states planning a reintroduction of river otter. Such information could be used to designate areas where river otter potentially could thrive or habitat that might be inhabited in the near future as populations expand.

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APPENDIX A. Letters sent to 225 furharvesters in 1999 to request assistance with conducting bridge surveys between 1 March and 15 April 1999.

19 January 1999

Dear Sir or Madam:

I recently started my graduate research at Emporia State University. I will be studying the distribution and habitat use of river otter in eastern Kansas.

In the 1996-97 Kansas Department of Wildlife and Parks Furharvester Survey, you indicated that you were interested in participating in a river otter survey. We finally have a project started and I would like to request your participation for this coming spring.

One of the objectives of my research is to determine the abundance and distribution of river otter, beaver, mink, raccoon, and muskrat in eastern Kansas. The survey will be conducted by recording tracks of these furbearers at bridge crossings. Each tracker will search for tracks along the edge of a river or stream for a distance of 300 meters on each side of the bridge crossing and on each side of the river or stream. This survey has been conducted in Missouri for the past 2 years with excellent success. We anticipate that it will take approximately one hour to complete each bridge survey.

If you agree to assist us in our survey, you will be assigned approximately 10 bridge crossings to survey in the county you selected. The surveys must be conducted between March 1 and April 15, 1999. Your participation is essential. It will provide me and the Kansas Department of Wildlife and Parks with valuable population distribution information on river otters and other furbearer species. If you are interested in participating, please return your response card. If you have any questions, please contact either Andrea Ostroff (Graduate Student) at 316-340-0616, e-mail: ostroffa@emporia.edu, Dr. Elmer Finck at 316-341-5623, e-mail: finckelm@emporia.edu or Christiane Roy (Furbearer Biologist for KS Wildlife and Parks) at 316-342-0658 ext 202, e-mail: christir@wp.state.ks.us

If you agree to participate you will receive maps, record sheets, and instructions in the mail before February 15. This will give you some time to select bridges you will survey (some bridges may not be accessible).

Thank you very much for your consideration. We hope to hear from you very soon.

Sincerely,

Andrea Ostroff
ESU Graduate Student

APPENDIX B. Postage-paid response card sent with letter on 19 January 1999, which requested assistance with conducting bridge surveys between 1 March and 15 April 1999.

Stamp
affixed
here

Andrea Ostroff
Department of Biological Sciences
Campus Box 4050
Emporia State University
Emporia, KS 66801

[On reverse side]:

[ ] YES, I would like to participate in the furbearer survey.
Preferred county ________________

[ ] NO, I would not like to participate

How many years have you been trapping? _____ years
Have you ever seen a river otter? _____ Or river otter tracks? _____

Name ______________________________

Address ____________________________

City, State, Zip ______________________

Phone Number ______________________

APPENDIX C. Letter sent with protocol, maps, and data sheets to volunteers conducting bridge surveys between 1 March and 15 April 1999 and 2000. The same letter body was sent to volunteers in 1999 and 2000.

1 March 2000

Dear Mr. ______,

I want to thank you very much for participating in the furbearer survey this spring. With your help, I will be able to gather important information for my thesis research concerning the distribution of river otter and the relation to the presence of other furbearers in eastern Kansas. It is wonderful that you are willing to volunteer your time and effort.

I hope this package of materials will help make the survey go smoothly. A map of the county you indicated as your preference is included in your package. Since you know your area better than I do, I thought it would be best to have you choose what bridge sites you would like to survey. Please only choose bridges for which you have permission to access.

The survey should be completed between March 1 and April 15, 2000. There are data sheets printed on waterproof paper with the copies of track prints on the back for your convenience. The river otter prints are the only tracks drawn to scale. I have also enclosed a ruler marked with the average size of a river otter print for a quick reference.

After you complete the survey, please return your maps and data sheets to me in the enclosed envelope. If you do not have time to complete ten bridge locations, please still return the information on the bridges where you completed the survey. Any information will be helpful.

If you have any questions, please do not hesitate to contact me. My address is listed above, or I can be reached by e-mail: ostroffa@emporia.edu, or by telephone (office: 316-341-5339; home: 316-340-0616). You may also contact Christiane Roy (Furbearer Biologist for KS Department of Wildlife and Parks) at 316-342-0658 ext. 202 or christir@wp.state.ks.us if you have any questions.

Thank you again for your participation. Your assistance is greatly appreciated!

Sincerely,

Andrea C. Ostroff
Graduate Student
Emporia State University

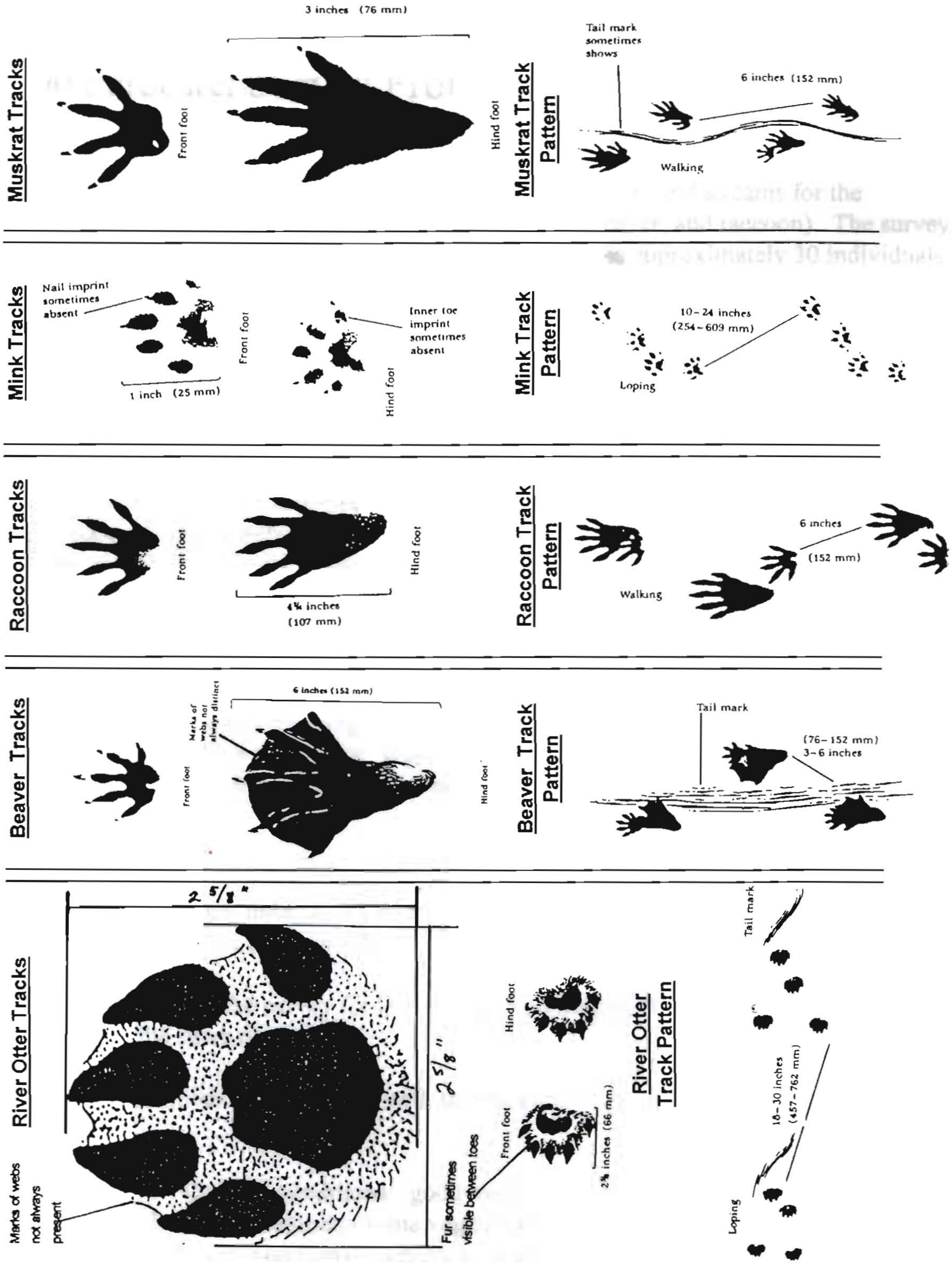
APPENDIX D. Sample data record sheet sent to volunteers to complete during bridge surveys conducted between 1 March and 15 April 1999 and 2000.

Name of Surveyor: ______________________ County: ______________________

Bridge Number	Date Surveyed	#of Days Since Rain	Tracking Condition	Start Time	End Time	River Otter Yes/No	# of Tracks Observed	Length	Width	Webbing Visible?	# of Toes Visible	Other Tracks Beaver Yes/No	Raccoon Yes/No	Mink Yes/No	Muskrat Yes/No
Example:															
4	3/2/99	3	1	8:00 am	10:00 am	Yes	6	2 3/4"	3"	No	5	Yes	Yes	No	No

Comments:

APPENDIX D cont. Reverse side of data record sheet with pictures of furbearer tracks for easy reference while conducting bridge surveys between 1 March and 15 April 1999 and 2000.



APPENDIX E. Bridge survey protocol sent to each volunteer for bridge surveys conducted between 1 March and 15 April 1999 and 2000. The same protocol was sent to volunteers in 1999 and 2000 with only the date changed.

2000 Furbearer Survey Protocol

This survey will require you to walk or boat the edge of rivers and streams for the presence of furbearer tracks (river otter, mink, muskrat, beaver, and raccoon). The survey will be repeated at a five year interval. This spring, there is approximately 30 individuals participating with each county having 1- 2 participants. We are trying to maximize our chances of finding river otters. If you have seen otters on some of the rivers in the county you are surveying, select the bridges closest to those observations. We have otters all along the Kansas - Missouri border due to the intensive reintroduction program held in Missouri. We also have animals coming in from Oklahoma and Nebraska, and have a good population around the Flint Hills National Wildlife Refuge. River otter tracks can be easily mistaken with raccoon and beaver tracks depending upon the tracking conditions. Their toes are quite distinctive (see diagrams on the data sheets) and not narrow and long like raccoon. The web between their toes is sometimes visible. Also, You can usually see five toes, and the foot prints are wide instead of long. If possible, bring a camera with you and take pictures of the tracks you see.

BRIDGE SELECTION

Write on the map provided a number (1-10) to identify the bridge you will survey. You cannot survey more then two bridges in a township. If you cannot access the larger rivers, select the first bridge on a tributary. It is preferable not to select two bridges on the same tributary. If 2 bridges are on the same river, they should be more then 4 miles apart.

DATA SHEET

1. Provide the bridge number that you are surveying. Make sure it corresponds with a matching number on the map. There is space for you to survey 10 bridges.

2. Record the date of the survey for that bridge. You may not have time to survey all 10 bridges on the same day.

3. Record the number that coincides with the tracking conditions for each bridge location:

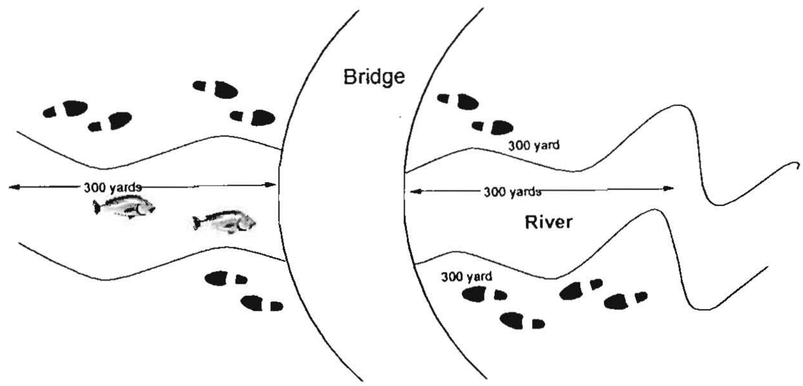
   1 - Optimal conditions - good mud, easy to read tracks
   2 - Fair conditions - some vegetation present, somewhat hard-to-see tracks
   3 - Poor conditions - very rocky, hard to find any tracks

APPENDIX E cont.

4. Indicate how many days ago it last rained. If it rains, you should wait at least one dry day to conduct surveys as tracks will be washed away by the rain or harder to identify afterwards.

5. Record how long each survey took by recording the time you started the each survey and the time you finished.

6. Survey 300 yards on each side of the bridge on each side of the river (see the diagram below). If you find tracks for all the species listed on the data sheet (otter, mink, muskrat, raccoon, and beaver) you can stop and move on to the next bridge.



7. In each appropriate column, indicate 'yes' if you find tracks of river otter, beaver, raccoon, mink, and muskrat at each bridge location. Indicate 'no' if you don't find any tracks.

8. If you find some river otter tracks along the bank:

    - Estimate the number of individual tracks you observed.
    - Measure the length and width of one track as shown on the diagrams behind the data sheet.
    - Indicate whether you saw webbing on the tracks you detected. (see diagram)
    - Record the number of toes that were visible on a good track.

9. A space is provided at the bottom for your comments.
    - Write down any bridge locations that you found were inaccessible, or substantial portions of banks along a river edge that you could not access.
    - Record any other information that you think may be helpful to the survey.

I would also appreciate any comments you may have to improve the survey for the future.

APPENDIX F. Letter sent to 72 individuals to request assistance with conducting bridge surveys between 1 March and 15 April 2000.

29 January 2000

Dear Madam or Sir:

You may recall I am researching the distribution of river otter in eastern Kansas for my thesis at Emporia State University. You expressed interest in conducting bridge surveys for furbearer tracks last spring. I especially want to thank those of you who helped with as many bridges as your schedule allowed. With your help we were able to cover portions of 19 counties in eastern Kansas. There is still a need to conduct more bridge surveys this spring, and I again am asking for your assistance.

I am in the process of compiling records of river otter sightings that have occurred in the last five years. I hope to survey those areas as well as others to determine if river otter still are living in those locations. The bridge surveys will again be conducted between March 1st and April 15th and will consist of searching the river banks for tracks for 300 meters on each side of the bridge crossing and on each side of the river or stream.

To become familiar with the locations river otter live, I need your help. If you would like to participate conducting bridge surveys in your area during March, your support and participation is greatly needed and appreciated. This year, Christiane Roy, from Department of Wildlife and Parks, and I will provide a track-training session to help you get aquainted with river otter tracks.

If you are interested in assisting with bridge surveys, please send your enclosed reply card indicating which county and area you are interested in surveying. If you have any questions, you can contact me via snail mail, via e-mail: ostroffa@emporia.edu, or by telephone. I can be reached in the office: 316-341-5339, or at home: 316-340-0616. You may also contact Christiane Roy (Furbearer Biologist for KS Department of Wildlife and Parks) at 316-342-0658 ext. 202 or christir@wp.state.ks.us if you have any questions.

I look forward to hearing from you very soon. Thank you in advance for your assistance. I greatly appreciate the information that will assist me with my thesis research.

Sincerely,

Andrea C. Ostroff
ESU Graduate Student

APPENDIX G. Interest form sent to individuals on 29 January 2000 that accompanied letters requesting assistance with conducting bridge surveys between 1 March and 15 April 2000.

Please fill out the information below and return in the envelope included if you would like to participate with the furbearer surveys this March. Also indicate which county and what part of that county you would like to survey.

Name: ______________________________

Address: ______________________________

____

Would you like to participate in the furbearer bridge surveys this March?

YES NO

What county would you like to survey? ____________________

What part of that county? (for example, NE quarter) ____________

Would you be interested in a one-day track training session?

YES NO

APPENDIX H. Letter sent to 117 Kansas Department of Wildlife and Parks employees to request sighting information and field assistance.

10 January 2000

Dear Madam or Sir:

I am a second-year graduate student at Emporia State University. In cooperation with Kansas Department of Wildlife and Parks, I have been studying the habitat and distribution of river otter in eastern Kansas by conducting bridge surveys in the spring and fall of 1999.

Field personnel are the best source of information for current river otter distribution. It would be helpful, and would contribute to my thesis research, if you could send me county maps or location information of river otter sightings for the past five years. Whether these sightings were live animals, road kill, how many animals were observed, and the dates of their occurrence would also be helpful information.

Last spring about 26 trappers across 19 counties in eastern Kansas assisted with bridge surveys that identified furbearer tracks. The survey consists of searching the river banks for tracks for 300 meters on each side of the bridge crossing and on each side of the river or stream. These survey methods have been used in Missouri for the past two years with great success. Because the river otter population numbers are so low in Kansas, it is difficult to construct an accurate distribution map of the locations river otters occur. This may only be possible with more individuals conducting bridge surveys. If you would like to participate conducting bridge surveys in your area during March, your support and participation is greatly needed and appreciated. Christiane and I will provide a track-training session to help you get acquainted with river otter tracks. The surveys will probably take 2 days of your time and do not require a boat or special equipment...just a keen eye sight!

Please send your maps and/or location information of river otter sightings to the above address. You can contact me via snail mail, via e-mail: ostroffa@emporia.edu, or by telephone to express interest in conducting bridge surveys this March. I can be reached in the office: 316-341-5339, or at home: 316-340-0616. You may also contact Christiane Roy (Furbearer Biologist for KS Department of Wildlife and Parks) at 316-342-0658 ext. 202 or christir@wp.state.ks.us if you have any questions.

I look forward to hearing from you very soon. Thank you in advance for your assistance. I greatly appreciate the information that will assist me with my thesis research.

Sincerely,

Andrea C. Ostroff
ESU Graduate Student

APPENDIX I. Digital Orthophoto Quarter Quadrangles used for calculation of the proportion of land uses within the 1000-m buffered area around each 129 sites in eastern Kansas.

County	Identification Number	Quarters Used
Allen	0854	NW, SW, NE
	0954	SW, SE
Atchison	2257	NW, NE
	2356	SE
	2357	SW
Bourbon	0759	NW, NE
	0858	SW
	0859	NE, SE
	0959	NW, SE
	1059	SW
Cherokee	0257	NW, SW
	0357	NW, SW, NE, SE
	0358	NW
	0457	SW, NE
	0458	NW
	0460	NE
Coffey	1152	NW, SW
	1250	NW, SW, SE
	1251	NW, SW
Crawford	0557	SW
	0558	SW, SE
	0559	SE
	0658	NW
	0659	NE
	0660	NW, NE
	0661	NW
	0760	SW, SE
Douglas	1654	NW, NE,
	1655	NW
	1754	NW, SW, NE, SE
	1755	SW, SE
	1756	SW, SE
	1757	NW, SW

APPENDIX I cont.

County	Identification Number	Quarters Used
Franklin	1350	SW
	1450	NW, SW, SE
	1452	SW, SE
	1453	NE
	1454	NW
	1455	NE
	1456	NW, NE
	1556	SW
Jefferson	1854	SW, SE
	1953	NE, SE
	1954	NW, SW, NE, SE
	1955	NW
	2053	NW, NE, SE
	2054	NW, SW, NE, SE
	2055	NE
	2153	SE
	2154	SW, SE
	2155	SE
Linn	1059	SW
	1160	NW, NE
	1259	NW, SW, NE, SE
	1260	NW, SW, SE
Lyon	1249	NE
	1347	NW, NE
	1348	NE, SE
	1349	NW, SW, SE
	1446	NW, NE, SE
	1447	NW, SW, SE
	1544	NW, NE
	1545	NW, NE
	1546	SW, SE
	1644	SW, SE
Miami	1357	NE
	1358	NW, NE, SE
	1359	NW, SW, NE, SE
	1360	SW, SE
	1457	SE
	1458	SW, SE
	1459	SW, SE

APPENDIX I cont.

County	Identification Number	Quarters Used
Neosho	0556	NE, SE
	0655	NW, NE, SE
	0656	SW, SE
	0657	NW, SW
	0754	NW, NE, SE
Washington	2240	NW, NE
	2343	NE
	2441	NE
	2442	NW, NE, SE
	2443	NW, SW
	2540	SE
	2541	SW, NE, SE
	2542	NW, SW, SE
	2543	SW
Wilson	0551	NW, NE
	0552	NW
	0652	NW, SW, SE
	0751	SW, SE
Woodson	1052	NE

I, Andrea Christina Ostroff, hereby submit this thesis to Emporia State University as partial fulfillment of the requirements for an advanced degree. I agree that the Library of the University may make it available to use in accordance with its regulations governing this document is allowed for private study, scholarship (including teaching), and research purposes of a nonprofit nature. No copying which involves potential financial gain, will be allowed without permission of the author.

Andrea C. Ostroff

Signature of Author

2 July 2001

Date

Distribution and mesohabitat characteristics of river otter in eastern Kansas

Title of Thesis

Dory Cooper

Signature of Graduate Office Staff

11-26-01

Date Received