NORTH DAKOTA GAME AND FISH DEPARTMENT

FINAL REPORT

Evaluating the Distribution and Abundance of River Otters and Other Meso-carnivores in Eastern North Dakota Drainage: Applications of GIS, Genetic and Digital Technologies for Conservation Planning

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North Dakota Department of Game and Fish

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EXECUTIVE SUMMARY

We assessed the current population status, distribution, and relative abundance of river otters (*Lontra Canadensis*), fishers (*Martes pennanti*), and American martens (*Martes americana*) in North Dakota, as well as survey techniques for documenting further range expansion and/or monitoring population trends. We also conducted a preliminary population assessment for other select carnivores in the state. Survey questionnaires were sent to wildlife professionals from state and federal agencies to obtain opinions regarding species' presence in North Dakota and we examined verified reports of otters and fishers from the recent past (2005 – May 2009). Furthermore, we conducted population surveys in the Red River Basin (2006 – 2009) and Turtle Mountains (2007) of eastern and northcentral North Dakota. To aid in enhancing effectiveness and efficiency of otter and fisher field surveys, we 1) examined monthly variation in scat marking by otters, 2) identified characteristics that could distinguish otter and raccoon scats when both were comprised of crayfish, and 3) compared the efficacy of track-plate-boxes and remote cameras to detect fishers. In addition to surveys, we established the population origin of otters through a genetic analysis of animals from North Dakota, South Dakota, Minnesota, and Manitoba. We also documented food habits of otters based on an analysis of scats and evaluated the applicability of scales for estimating size of fish prey.

Based on field surveys and verified reports, we determined that otters, fishers, and martens had recolonized portions of their former ranges in North Dakota. The current distribution of the otter occurred in drainages of northeast and eastcentral North Dakota. Otters also were documented in the southeastern part of the state but their presence was limited in the region. Fishers were distributed primarily in wooded riparian habitat in the northeastern part of the state, but also were documented in these areas in eastcentral and southeastern North Dakota

at low frequencies. For martens, we verified that the species occurred in North Dakota and was distributed throughout the Turtle Mountains although detections in this region were greater east of U.S. Highway 281. While all three mustelids were detected with sufficient frequency to verify their presence in the state and document current distributions, detections were rare compared to the raccoon (*Procyon lotor*), which was the most common carnivore documented during all field surveys. Other non-target carnivores detected (≥ 1 time) included the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), striped skunk (*Mephites mephitis*), mink (*Neovison vison*), weasel (*Mustela* spp.), badger (*Taxidea taxus*), bobcat, and black bear (*Ursus americanus*). We had hoped to detect the eastern spotted skunk (*Spilogale putorius*) in southeastern North Dakota but this carnivore was not documented during any of our surveys.

Based on survey questionnaires to wildlife professionals, by jurisdictional region coyotes, red foxes, striped skunks, and mink were the most common carnivores reported to occur in North Dakota. Less commonly reported species included bobcats, mountain lions (*Puma concolor*), otters, and fishers. Gray wolves (*Canis lupus*), gray foxes (*Urocyon cinereoargenteus*), swift foxes (*Vulpes velox*), martens, and lynx (*Lynx canadensis*) also were reported, but at low frequencies; eastern spotted skunks and wolverines (*Gulo gulo*) were not reported to occur in the state. The written survey provided baseline information on most of the state's carnivores. For rare carnivores, information could be supplemented with other data to more fully understand the current occurrence of these species in North Dakota. For the common furbearers, the written survey provided information that could be used as an independent dataset for management purposes.

For future monitoring of the otter population, the best time-period to conduct surveys depends on research objectives and availability of personnel. If objectives include documenting species presence/absence in given drainages, surveys any time of year are sufficient as we detected otter sign all months surveyed. Summer months also may be the desired time to conduct population surveys due to availability of personnel. However, summer was the most problematic time-period for detecting scats due to decreased marking by otters at this time. Additionally, in summer, diets of otters and raccoons were most similar making it more difficult to distinguish between otter and raccoon crayfish-dominated scats. Nevertheless, we found that scats of the two species could be distinguished with some degree of confidence by examining a combination of characteristics (e.g., documenting mucous associated with the scat, examining the scat for presence of plant material, assessing percentage of fish remains in the scat, counting the number of scat segments, and assessing percentage of larger fragments in the scat) to exclude one or the other animal from final assessment. If objectives include collecting large numbers of scats (i.e., for determining density estimates via genetic analyses), surveys conducted during fall may be preferred over other seasons as we documented increased marking by otters and reduced dietary overlap with raccoons at this time. Additionally, unlike spring (the other time-period in which we documented increased marking by otters), during fall, it was less likely that flooding would wash away scats from the shoreline, reducing opportunities to detect this rare carnivore.

Overall, fish and crayfish were the primary prey items of otters. Fish of Cyprinidae (carp and minnows) were the most prominent fish in the diet. Other relatively common fish included ictalurids (catfish), catostomids (suckers), and centrarchids (sunfish). The diet of river otters changed seasonally, including a decline in the frequency of fish in the summer diet and a corresponding increase in occurrence of crayfish. Fish prey ranged 3.5 – 71.0 cm, but fish 10.1 – 20.0 cm were the most frequently consumed size class by otters. We determined that scales were effective anatomical structures for estimating size of fish prey. Typically, lateral line scales produced better relationships than random scales, and overall, scale length and height were the best scale measurements for estimating fish length.

For fishers and martens, track-plate-boxes and remote cameras were effective at detecting presence of the two species. Both devices enabled the documentation of occurrence, provided information on the current distribution, and facilitated the collection of binomial data to conduct other statistical analyses (e.g., documentation of habitat use). For fishers, we found that detection devices placed for 11 days were sufficient for detecting the species if they were present at survey sites. However, devices left out in the field for at least seven days could detect most fisher presence in a given drainage. Furthermore, although the initial cost of cameras was greater than that of track-plate-boxes, cameras detected a greater percentage of fishers and provided additional behavioral information (e.g., activity patterns, documentation of family groups) at survey sites. Cameras also provided a more robust dataset to develop an occupancy model, which yields a more accurate analysis of population status.

Knowledge gained from our study provided a strong foundation that can be built upon to more fully understand the ecology and demography of these populations in the upper Midwest for conservation, education, and management purposes. Other than continuing to provide educational material to North Dakota residents and deal with occasional 'nuisance' individuals, otter, fisher, and marten populations likely require little management at this time. For otters and fishers, our findings indicated the two species probably still are in the process of recolonizing suitable habitat in North Dakota, and maintaining closed seasons on these populations would facilitate further population growth and range expansion at the fastest rate. For martens, based on their current distribution in the Turtle Mountains and potential distribution in the Pembina Gorge, this species likely will remain a rare animal state-wide as these regions in North Dakota comprise only 0.6% and 0.1% of the state's land area, respectively.

The re-establishment of otters, fishers, and martens underscored the importance of populations and their management in adjacent states and provinces to the North Dakota populations. For otters, our genetic analysis revealed that North Dakota otters originated from Minnesota. However, we found that North Dakota otters experienced a loss of heterozygosity presumably due to inbreeding of initial immigrants. We also documented some degree of gene flow between the North Dakota/Minnesota population and the newly establishing South Dakota population. Thus gene flow that is encouraged among populations in these states would maintain the genetic health of the North Dakota population. Additionally, while the origins and genetic statuses of the fisher and marten populations have not yet been verified, fishers probably originated from the westward-expanding fisher population in Minnesota, and most likely, the marten population originated from translocated animals that had been released into Turtle Mountain Provincial Park, Manitoba, Canada in the late 1980s. These peripheral North Dakota populations most likely are, and will continue to be, influenced by adjacent populations in Minnesota and Manitoba, respectively.

Although there is not an apparent need for active management prescriptions on otter, fisher, and marten populations in North Dakota, members of the North Dakota Fur Takers Association and North Dakota Fur Hunters and Trappers Association have indicated interest in trapping the three species for recreational purposes and/or commercial harvest of their fur. Ideally, obtaining additional demographic information on a sample of live animals would not only aid in assessing feasibility of opening trapping seasons and establishing initial harvest rates through population modeling, but also in understanding factors affecting these species in the upper Midwest. For otters and fishers, the information would be helpful for determining the extent that additional mortality from trapping at this time would impede continued range expansion by these species.

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CHAPTER 1

CHAPTER 1

Assessment of the Current Distribution of River Otters (*Lontra Canadensis*), Fishers (*Martes pennanti*) and other Carnivores in North Dakota

Abstract

We assessed the current distribution of river otters (*Lontra Canadensis*) and fishers (*Martes pennanti*) in North Dakota. Written surveys were sent to wildlife professionals from state and federal agencies to obtain opinions regarding species' presence in the state, and including other select carnivores. A database containing recent verified reports (2005 – May 2009) was obtained from the North Dakota Game and Fish Department. Field surveys were conducted periodically (2006 – 2009) along drainages in the Red River Basin of eastern North Dakota; riparian, bridge, and aerial surveys were conducted for otters and track-plate-box and camera-station surveys were conducted for fishers and other meso-carnivores. Based on 114 returned surveys, coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), and mink (*Neovison vison*) were the most common carnivores reported to occur in North Dakota. Less common species included bobcats (*Lynx rufus*), mountain lions (*Puma concolor*), otters, and fishers. Gray wolves (*Canis lupus*), gray foxes (*Urocyon cinereoargenteus*), swift foxes (*Vulpes velox*), American martens (*Martes americana*), and lynx (*Lynx canadensis*) also were reported, but at low frequencies; spotted skunks (*Spilogale putorius*) and wolverines (*Gulo gulo*) were not reported to occur in the state. By jurisdictional region, the greatest percentage of respondents' reports of otters (57%) occurred in eastern North Dakota; for fishers, the greatest percentage (67%) occurred in the northeast. Based on verified reports, the greatest number of reports for otters occurred in eastcentral North Dakota, in Grand Forks (n = 9; 22%) and Cass (n = 8; 19%) Counties. For fishers, the majority of reports occurred in the northeast, in Walsh (*n* = 14; 27%) and Grand Forks (*n* = 17; 33%) Counties. Sex ratios of animal mortalities (*n* = 24 otters; *n* = 28 fishers) were 0.84:1.0 and 1.0:1:0 for otters and fishers, respectively. Riparian surveys revealed otter presence in northeast and eastcentral North Dakota, along the Pembina, Park, Forest, Turtle, Red, and Sheyenne Rivers. Bridge surveys indicated additional otter occurrence in the northeast, along the Tongue and Little Pembina Rivers, and southeast, along the Sheyenne River. Potential otter den sites (based on an aerial survey of beaver activity) were distributed throughout 11 rivers surveyed. Based on the track-plate-box and camera-station surveys, raccoons were the most common carnivore detected all years surveyed. Fishers were detected in northeast and eastcentral North Dakota, along the Pembina, Tongue, Park, Forest, Turtle, Red, Goose, and Sheyenne Rivers. However, a greater number of detections occurred in northeastern region of the state than in the southeast. Findings of this study indicated that otters and fishers both recently have recolonized portions of their former ranges in North Dakota. The primary range of the otter occurred in northeast and eastcentral North Dakota, and that of the fisher, in the northeastern part of the state. Fishers also were documented in eastcentral North Dakota and both species, in the southeastern part of the state, but their presence in these regions was limited.

Introduction

River otters (*Lontra canadensis*) and fishers (*Martes pennanti*) are native to North Dakota (Adams 1961, Bailey 1926). Bailey (1926) provided a historic account of the two species based on a summary of trapping records and other writings during the 1800s and early 1900s. According to Bailey (1926), in the 1800s otters were documented throughout North Dakota in the Missouri, Little Missouri, Yellowstone, Red, Park, Pembina, Salt (present-day Forest), Turtle, Sheyenne, and Heart Rivers, as well as in Devils Lake and waterbodies of the

Turtle Mountains (Figure 1). Bailey (1926) noted that in the early 1900s the animals were not as abundant as in the 1800s but still could be found in the principal streams and some of the larger lakes; at that time, the species was documented in the Missouri River near Buford, the Sheyenne River, and Antelope and Shell Creeks. It is not known if otters ever were extirpated from North Dakota. But, a combination of factors, including unregulated trapping, loss of wetlands and riparian habitat, and susceptibility to pollutants have been attributed to the near-extirpation of the state's population (Gerads 2001). In the early 1800s fishers were documented in eastern North Dakota, along the Park, Pembina, Turtle, and Salt (Forest) Rivers, and in Grand Forks and the Hair Hills (present-day Pembina Hills; Figure 2). Bailey (1926) speculated that in the early 1830s fisher skins brought to Fort Union (present-day Buford, North Dakota) could have come from the Turtle Mountains and along the Souris and Mouse Rivers of northcentral North Dakota. He further noted that fishers no longer occurred in the state and attributed their extirpation to over-trapping due to their high fur value (Bailey 1926).

In the recent past, the number of sightings of otters and fishers in North Dakota has increased. From 1958 – 2004, 22 verified reports of otters or otter sign were documented in water bodies of Williams, Renville, Montrail, McLean, Grand Forks, Cass, and Ransom Counties (NDGF, unpublished data). Half of the reports occurred from 2002 – 2004 and the majority, were from the eastern part of the state. In 2004, NDGF listed the otter as a species having a moderate level of conservation priority in North Dakota (Dyke et al. 2004). For fishers, from 1976 – 2004, 17 verified reports of the species were documented in Pembina, Cavalier, Grand Forks, Traill, Richland, Ransom, Rollette, and Barnes Counties. Similar to otters the majority of reports occurred from 2002 – 2004 and with the exception of one report in northcentral North Dakota, all reports occurred in eastern part of the state.

The objective of this research was to assess the current distribution of otters and fishers in North Dakota to aid in determining if viable populations existed in the state as well as provide baseline data to document range expansion, relative abundance, and offer insight into habitat requirements of the two species. Research was accomplished through 1) a written survey questionnaire sent to wildlife professionals in state and federal agencies, 2) records of recent verified reports obtained from NDGF, and 3) field surveys (riparian, bridge, and aerial surveys for otters; track-plate-box and camera-station surveys for fishers). To take advantage of the written survey, additional questions were added on other select carnivores in North Dakota to gain cursory information on their status.

Methods

Written surveys

Written surveys designed to assess the distributions of otters, fishers, and other select carnivores in North Dakota [gray wolf (*Canis lupus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), swift fox (*Vulpes velox*), gray fox (*Urocyon cinereoargenteus*), mountain lion (*Puma concolor*), lynx (*Lynx canadensis*), bobcat (*Lynx rufus*), feral domestic cat (*Felis catus*), American marten (*Martes americana*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), eastern spotted skunk (*Spilogale putorius*), wolverine (*Gulo gulo*), and mink (*Mustela vison*)] were sent to wildlife professionals from various state and federal agencies [North Dakota Game and Fish Department (NDGF), North Dakota Parks and Recreation Department (NDPR), United States Department of Agriculture Wildlife Services (WS), United States Department of the Interior Bureau of Land Management, United States Army Corps of Engineers, and United States Department of the Interior Fish and Wildlife Service (FWS)] in the state (Appendix I). Individual opinions regarding a species presence ("yes" response) or absence ("no" response) in North Dakota were tabulated for each of the carnivores; responses for all of the select carnivores also were tabulated by jurisdictional region of survey respondents (northeast, east, southeast, northcentral, central, southcentral, northwest, west, south, and southwest). Responses for otters and fishers were tabulated at three spatial scales: 1) statewide, 2) by jurisdictional region, and 3) by county. Only respondents with statewide areas of responsibility (e.g., Directors, Assistant Directors, etc.) were included in the statewide tabulation. We used responses from WS field personnel, NDGF game wardens, and representatives of NDPR to assess distributions at the county level. Respondents with areas of responsibility >1 county provided a response for each county within that jurisdiction. By-county responses were tabulated independently for each county in the respondent's area of responsibility. In cases where the respondent's area of responsibility included part of a county, the response was tabulated as including the whole county.

Verified reports of river otters and fishers

To evaluate records of otters and fishers in North Dakota from the recent past, a database containing verified reports (2005 – May 2009) for both species was obtained from NDGF. Reports included sightings by credible witnesses (e.g., wildlife professionals, trappers, etc.), photographs from hand-held cameras and remote trail cameras, and carcasses of dead animals. Cause of mortality was classified as road-kill, incidental trapping, legal-shooting, illegal shooting, other, or unknown cause. Records included the date of the report, location (county and township, range section), and if known, sex of animals.

Field surveys

Field surveys for river otters

Field surveys for otter sign or scat (Figures 2 – 4; see Chapter 5 for a description of sign and scat survey techniques) were conducted June – November 2006, March – November 2007, and May – August 2008 in drainages of the Red River Basin of eastern North Dakota (Figure 3). In addition, surveys at bridges were conducted throughout winter, spring, and fall months of 2007. Objectives of surveys were to 1) obtain basic distribution information on the species, 2) evaluate techniques for their ability to detect otters in North Dakota [i.e., sign versus scat surveys, on-foot versus by canoe/motor boat, and season conducted (Chapter 5)], and 2) facilitate the collection of samples for other research purposes (e.g., documenting food habits, etc.; Chapters 2 – 4). Locations [Universal Transverse Mercator (UTM) or Latitude Longitude] where otters were detected were recorded using a Global Position System (GPS) unit and subsequently entered into a Geographic Information System (GIS) for spatial analysis.

June – November 2006 sign and scat surveys – Sign surveys for otters were conducted 2 June 2006 – 2 August 2006. Surveys were systematically conducted along the Red River and its tributaries (Pembina, Tongue, Forest, Turtle, Goose, Maple, Sheyenne, and Rice Rivers), approximately every 10 – 15 km of river, access permitting, and in the best available habitat. Surveys were started at bridges and were 1 km in length as determined by a GPS unit in tracking mode. The survey direction from the bridge (upstream or downstream) was chosen randomly and both river banks were surveyed simultaneously by ≥1 researcher per bank. From September – November 2006 surveys for otter latrine sites (scat surveys) were conducted by motor boat and canoe on the Red, Pembina, Forest, Turtle, Park, and Sheyenne Rivers.

In a GIS, a 1-km^2 grid layer encompassing North Dakota was created and overlaid onto a other spatial layers, including roads, county outlines, cities, and perennial waters. All grid cells intersecting perennial waters visibly connected to flowing water were selected as “available” for surveying from the following rivers in eastern North Dakota: Bois de Sioux, Wild Rice, Sheyenne, Maple, Rush, Elm, Goose, Turtle, Forest, Park, Tongue, Pembina, and Red Rivers. The western boundary of the study area was the 550000 East (UTM’s) meridian. Start and end

UTM coordinates for each survey reach and UTM coordinates for otter latrines and other sign were digitized into a GIS layer. We determined the proportion of sampled to available 1-km^2 grid cells in our defined study area.

March – May 2007 sign surveys – Sign surveys for otters were conducted 19 March 2007 – 1 May 2007 along stream sections (3 – 5 km) of the Park, Forest, Turtle, and Red Rivers; most of the sites started and ended at bridges.

April – November 2007 and May – August 2008 scat surveys – To facilitate the collection of otter scats and documentation of latrines for other research purposes (See Chapters 2 – 5), scat surveys for otters were conducted along both shorelines of three, 5-km sections of the Forest, Red, and Turtle Rivers in northeastern North Dakota with known otter use (based on 2006 surveys). Sites occurred in Grand Forks (Sites 1 and 2) and Walsh (Site 3) Counties. Site 1 was located along the Red River, in Grand Forks, North Dakota within city limits; Site 2, occurred along the Turtle River, approximately 3 km northwest of Manvel, North Dakota; and Site 3 was located along the Forest River, approximately 8 km southeast of Minto, North Dakota.

Bridge sign surveys – Otters are known to mark at prominent landscape features, including bridges. To gain additional distribution information on the species, sign surveys at bridges were conducted throughout 2007 on the Pembina, Little Pembina, Tongue, Turtle, Forest, Park, and Sheyenne Rivers in eastern North Dakota. In winter months area immediately surrounding bridges was surveyed for presence of otter tracks, slides, or scat (Figures 4 – 6). During spring and fall months an additional 100 m upstream and downstream on both sides of the river was searched for otter sign.

Aerial survey for beaver activity – Because otters often are associated with beaver activity (abandoned beaver lodges and bank dens provide den sites to otters), we wished to document beaver activity to provide baseline data for indexing the otter population. Beavers build food caches (cut branches of woody plant material deposited in relatively deep water) that they access from their lodges or bank burrows under the ice during winter (Baker and Hill 2003); food caches are easily seen by fixed-wing aircraft flying at low altitudes. We conducted an aerial survey for beaver food caches 8 – 9 November 2006 along selected reaches of river in eastern North Dakota. The survey was conducted using an American Champion Scout fixed-wing aircraft carrying a pilot and one observer. River reaches were >20 km in length and systematically located within the study area. Bridges or obvious natural features were used as visual start and end markers for each sample reach. We calculated the number of caches per kilometer within each reach. Mean beaver caches per km was calculated for each river with more than one surveyed reach.

Field surveys for survey for fishers and other meso-carnivores

Track-plate-box and camera-station surveys (See Chapter 7 for a description of survey methods) for fishers, eastern spotted skunks, and other meso-carnivores were conducted 25 July – 14 August 2006, June – August 2008, and June – August 2009 in the Red River basin of eastern North Dakota (Figure 3). In addition to collecting presence/absence data for distribution information, another objective included comparing the efficacy of the two devices at assessing the presence and activity patterns of fishers (Chapter 7). Similar to otters, locations at each site were recorded using a GPS unit and a database was developed to create a GIS for spatial analysis.

9 August – 14 August 2006 track-plate-box/camera-station survey – Track-plate-boxes and camera stations were used to systematically survey riparian areas in southeastern North Dakota for the presence of fishers and eastern spotted skunks from 9 August 2006 through 25 August 2006. Stations were established in the best available riparian habitat approximately every 10 km, not more than 100 m from a road, and where landowner permission could be gained along the Wild Rice, Bois de Sioux, and Red Rivers. Camera stations were substituted for track-plate-boxes approximately every fifth station. Stations were baited with approximately 2.25 oz (e.g., half a can) of meat-based and wet cat food and skunk essence were used as attractants. Stations were checked after seven days as weather permitted. At stations with track-plate-boxes tracks were recorded and the station was reset and re-baited. Stations with remote cameras were re-baited when checked, but the number of frames taken by the camera dictated whether the roll of film was replaced.

In addition to systematic sampling in the southeast, we deployed two camera stations in Turtle River State Park, two in Icelandic State Park, and one in the town of Cavalier on 25 July 2006. All stations were established in areas with prior fisher sightings. The Turtle River and Icelandic State Park stations were baited with "Bonanza Mild," a commercial food lure, whereas the station in Cavalier was baited with beaver castor. Skunk essence was used as an attractant at all stations. Stations were checked and re-baited after one week and removed the following week (8 August 2006).

June – August 2008 and 2009 track-plate-box/camera-station survey – During the summers of 2008 and 2009 (June – August), we surveyed drainages in eastern North Dakota for fishers using camera stations and track-plate-boxes baited with beaver meat and lured with beaver castor and skunk essence. Surveys in 2008 involved systematic sampling sites (nine-day sampling period per site) located approximately 10 km apart on the Turtle, Red (north of Grand Forks), Pembina, and Tongue Rivers. To cover as much area possible during the survey period, portions of additional rivers [Forest, Park, Red (south of Grand Forks), and Sheyenne Rivers] were surveyed, but less intensively. In 2009 sampling was conducted along the Goose, Pembina, Red (north of Grand Forks), Tongue, and Turtle Rivers. Systematic sampling (13-day sampling period per site) at 20 km intervals was completed on the Sheyenne, Red (south of Grand Forks), Park, and Forest Rivers and from Pembina Hills to Devils Lake.

Results

Written Surveys

We received 113 completed surveys for all species (Table 1) and one survey completed only for otters and fishers. Coyotes, red foxes, striped skunks, and mink were the most common carnivores reported to occur in North Dakota (Tables 2 and 3). Less common species included bobcats, mountain lions, otters and fishers. Gray wolves, gray foxes, swift foxes, martens, and lynx also were reported to occur in North Dakota, but at low frequencies; spotted skunks and wolverines were not reported to occur in the state. Twenty-two respondents indicated that otters were present in their jurisdictional region; 15 respondents indicated that fishers were present (Table 2). Of eight respondents at the statewide level, two indicated that river otters occurred in North Dakota and one responded that fishers occurred in the state. By jurisdictional region, the greatest percentage of respondents indicating otters were present occurred in eastern North Dakota (57%), followed by the southeast (50%) and the northeast (42%; Table 3). The greatest percentage of respondents indicating fishers were present occurred in northeastern North Dakota (67%), followed by the east (29%) and the northcentral (27%) part of the state (Table 3). Of 54 counties, otters were reported by ≥1 respondent in 15 counties in eastern and central North Dakota and fishers were reported by ≥1 respondent in 9 counties in northeast, east central and northcentral North Dakota (Table 4; Figures 7 and 8, respectively).

Verified reports of river otters and fishers

From 2005 to May 2009, there were 41 verified reports of river otters in North Dakota. By county, the greatest number of records occurred in eastcentral North Dakota, in Grand Forks (n = 9) and Cass (n = 8) Counties (Figure 9). Other counties where verified otter records occurred were Traill (*n* = 4), Richland (*n* = 4), Steele (*n* = 3), Pembina (*n* = 2), Walsh (*n* = 2), Ransom (*n* = 2), Wells, (*n* = 1), Burleigh (*n* = 1), Morton/Sioux County line (*n* = 1), Burke (*n* = 1), and Williams (*n* = 1) Counties; locations of two animals were unknown. By classification, 17 records were from animals incidentally captured in body-gripping traps, one record was from a road-killed animal, one animal drowned in a fish-sampling net, five records were mortalities from unknown causes, 14 records were sightings of the animals or its sign by credible witnesses, and three records were from photographs. Twenty-four river otter carcasses were examined by NDGF Biologists; 11 animals were males and 13, were females.

From 2005 to May 2009 there were 51 verified reports of fishers in North Dakota. By County, the greatest number of records occurred in northeastern part of the state, in Grand Forks (*n* = 17) and Walsh (*n* = 14) Counties (Figure 10). Other counties where verified fisher records occurred were Pembina (*n* = 4), Cavalier (*n* = 3), Ransom (*n* = 1), Richland (*n* = 1), Benson (*n* = 2), Traill (*n* = 2), Steele (*n* = 1), Griggs (*n* = 2), Nelson (*n* = 1), Ramsey (*n* = 1), Stutsman (*n* = 1) and Bottineau (*n* = 1) Counties. By classification, twenty-two records were from road-killed animals, seven records were from animals incidentally trapped or snared, two records were from animals that had been shot (one legal and one illegal shooting), nine records were sightings by credible witnesses, and 11 records were from photographs. Twenty-eight fisher carcasses were examined by NDGF biologists. Fourteen animals were males, and 14 were females.

Field surveys

<u>*Field surveys for river otters*</u>

June – November 2006 scat surveys – During summer 2006 (2 June – 2 August), we sampled 45 stream sections (Appendix II) and recorded three locations with river otter sign in northeast and eastcentral North Dakota, along the Sheyenne River in Barnes County, the Red River in Traill County, and along the Pembina River in Pembina County (Appendix III). Our survey routes intersected 145 of 3,421 available grid cells (4.24%, Figure 11). During fall (September – November) 2006, we surveyed 43 reaches of river in eastern North Dakota for river otter latrine sites and sign. Surveyed reaches intersected 423 of 3421 available 1-km^2 grid cells (12.36%, Figure 12). We documented 13 latrine sites in eastcentral North Dakota, on the Red (n = 3), Turtle (n = 4) and Forest (n = 6) Rivers (Figure 13; Appendix III).

March – May 2007 sign surveys – We detected otter sign in northeastern North Dakota along nine stream sections in the Park, Forest, Turtle, and Red Rivers of Walsh and Grand Forks Counties (Appendix IV).

April – November 2007 and May – August 2008 scat surveys – During monthly scat surveys in 2007 and 2008 (See Chapter 5), we counted a total of 1,019 scats at 202 latrine sites on the three 5-km survey sites of the Forest, Red and Turtle Rivers (See Appendix V for locations of unique latrine sites). Fewer latrines and/or scats were found along the Red River, than the other rivers [Forest River in 2007 (n = 24, $F_{2, 21}$ = 7.926, P = 0.003); and Turtle River in 2008 (n = 11, $F_{2, 8}$ = 5.271, P = 0.035)]. Between years, a greater number of scats was recorded for the Forest River in 2008 than in 2007.

Bridge sign surveys – We surveyed 140 bridges for otter sign, along the Pembina, Little Pembina, Tongue, Turtle, Park, Forest, Red, North Marais, and Sheyenne Rivers (Table 5; Appendix VI). We detected otter sign at 11 (7.8%) bridges, on the Tongue (n = 4; 22.2%), Turtle (n = 3; 8.8%), Red (n = 1; 100%), North Marais (n = 2; 50%) and Sheyenne (n = 44; 4.5%) Rivers, in Pembina, Grand Forks, and Richland Counties of eastern North Dakota.

Aerial survey for beaver activity – Based on the aerial survey of beaver activity, potential otter den sites were distributed throughout the 11 rivers surveyed in eastern North Dakota (Table 6). We counted 162 beaver caches along nearly 530 km of river in 23 sampled reaches. The range of beaver caches/km was 0.09 – 0.59 for individual reaches (Table 6). Among rivers with

>1 surveyed reach, the highest mean caches/km (±SE) was 0.49 ± 0.10 (*n* = 2) along the Pembina River (Table 7).

<u>*Field surveys for fishers and other meso-carnivores*</u>

August 9 – 14 2006 track-plate-box/camera-station survey – Track-plate-boxes were active for 349 trap nights and remote cameras for 49 trap nights during the systematic survey. The raccoon was the most common carnivore detected at track-plate-boxes ([*n* = 24 (96%) boxes; Table 8)]. Other carnivores detected at boxes included domestic cats [*n* = 17 (68%) boxes], striped skunks [*n* = 2 (8%) boxes], and unknown Mustela species [*n* = 2 (8%) boxes]. Seven species of carnivores were detected at camera stations over a total of 96 trap nights (Table 9). Similar to the track-plate-boxes, raccoons were the most common species detected at camera stations (*n* = 6; 67%). Other species detected at camera stations included the fisher (*n* = 1), striped skunk (*n* = 1), badger (*n* = 1), coyote (*n* = 1), domestic dog (*n* = 1), and domestic cat (*n* = 1).

June – August 2008 and 2009 track-plate-box/camera-station survey – During the 2008 survey, eight species of carnivores were detected at 184 survey sites (Table 10). Raccoons had the highest detection rate (66%), followed by fishers (29%), striped skunks (8%) and domestic cats (7%). Other species detected at low rates (1%) included mink, weasel, red fox, and domestic dog. Fishers were detected at 54 of the survey sites, along the Pembina, Tongue, Forest, and Red Rivers in northeast and eastcentral North Dakota (Figure 14; Appendix VII). Detection rates of fishers were 0.23 for the Pembina, 0.43 for the Red (north of Grand Forks), 0.27 for the Tongue, and 0.20 for the Turtle (Table 11).

In 2009, 11 species of carnivores were detected at 172 survey sites (Table 10). Similar to 2008, raccoons had the highest detection rate (73%), followed by fishers (45%), coyotes, stripe skunks and domestic cats (11%), and red foxes (6%). Other species detected at lower rates included the domestic dog (4%), weasel spp. (2%), river otter (1%), black bear (1%), and bobcat (1%). Fishers were detected at 78 of the survey sites, along the Pembina, Tongue, Park, Forest, Turtle, Red, Goose, and Sheyenne Rivers in northeast and eastcentral North Dakota (Figure 15; Appendix VIII). In general, rivers in the northeast [Forest, Park, Pembina, Red (north of Grand Forks), Tongue, and Turtle Rivers] had many fisher detections, whereas rivers in the southeast (Goose, Sheyenne, and Red (south of Grand Forks) Rivers) had very few detections. Detection rates of fishers were 0.81 for the Pembina, 0.89 for the Red (north of Grand Forks), 0.82 for the Tongue, and 0.25 for the Turtle River (Table 11). By river, the Red River (north of Grand Forks) had the highest detection rates both years surveyed and the Turtle River had the lowest detection rates both years.

Discussion

Findings of this study indicated that otters and fishers both recently have recolonized portions of their former ranges in North Dakota (Figures 1 and 2). Based on verified reports and field surveys, we documented continued presence of the two species over a 5-year period in the Red River Basin of eastern North Dakota. Additionally, both sexes were equally represented in reported mortalities, multiple otters traveling together were detected during sign surveys and verified reports of the species, and family groups of fishers were documented on photographs of remote cameras (See Chapter 7). The primary range of the otter occurred in northeast and eastcentral North Dakota, and that of the fisher, in the northeastern part of the state. Fishers also were documented in eastcentral North Dakota and both species, in the southeastern part of the state, but their presence in these regions was limited. For example, bridge surveys in 2007 indicated otter presence along the Sheyenne River, although at relatively low occurrence [n = 2 (4.5%) of 44 bridges surveyed on this river]. Also, during the 2006 surveys, otter sign was only detected at one (4.7%) of 21 stream sections surveyed on the Sheyenne River (Appendix III) and was not detected on the Wild Rice (*n* = 2 stream sections), Bois de Sioux (*n* = 5 stream sections) or Maple (*n* = 6 stream sections) Rivers (Appendix II). Additionally, fishers were documented along rivers in eastcentral and southeastern North Dakota [Goose, Sheyenne, and Red (south of Grand Forks) Rivers], but compared to northeastern North Dakota, there were notably fewer detections.

In addition to the Red River Basin of eastern North Dakota, written surveys and a limited number of verified reports indicated fishers and otters may be present in other regions of the state. Written surveys indicated otters occurred in Wells County of central North Dakota, and fishers occurred in Bottineau and Rollette Counties of northcentral North Dakota (Figures 7 and 8, respectively). Single verified reports of otters occurred in Wells and Burleigh Counties, along the Morton/Sioux County line, and Burke and Williams Counties of central, southcentral, and northwestern North Dakota (Figure 9). One report of a fisher occurred in the Turtle Mountains (Bottineau County) of northcentral North Dakota (Figure 10). Additional field surveys are needed to determine if these sightings are isolated incidences or if the animals' have expanded their ranges further into the central and western part of the state. In the case of the fisher, field surveys were conducted in the Turtle Mountains during the summer of 2007 (Chapter 6) and fishers were not detected at that time; although, American martens were well-documented in the area. Although fisher presence was not verified during the 2007 survey, this wooded region offers the potential for range expansion of the species.

The written survey provided baseline information on most of the state's carnivores. For the rare carnivores, this information could be supplemented with other data to more fully understand current occurrence of these species in the state. For example, by jurisdictional region, the greatest percentage of respondents' reports of wolves (where *n* = >1 respondent) occurred in the northwest (27%), northcentral (18%) and northeastern (17%) regions of North Dakota (Table 3). Currently in the state, the gray wolf is considered an endangered species west of U.S. Highway 83 to the south shore of Lake Sakakawea and west of the Missouri River, but a protected state furbearer (under the jurisdiction of NDGF) east of the boundary line, in central and eastern North Dakota (NDGF 2008). Verified reports of wolves (NDGF unpublished data) combined with on-the-ground surveys in northcentral and northeastern North Dakota would aid in assessing the current status of this protected furbearer for management purposes. Similar work could be done with the swift fox where the greatest percentage of respondents' reports for this canid (11%) occurred in the southwest. Two species believed to be rare or extirpated from the state, the spotted skunk and wolverine, also were included in the survey, and our findings supported this status; both species were not reported to occur in the state by any respondents, and neither species was detected during our field surveys. Conversely, the black bear (*Ursus americanus*), was not included in the survey although NDGF receives sporadic reports of the species, primarily in the eastern part of the state (NDGF unpublished data). We also documented one black bear during the 2009 survey (Table 10), although our methods were not designed specifically to detect large carnivores. For the common furbearers, the written survey provided information that could be used as an independent dataset for management purposes. For example, regional data obtained for most of the common furbearers (e.g., coyotes, red foxes, striped skunks, and mink) could be compared to NDGF datasets (annual rural mail carrier and trapper surveys; NDGF unpublished data) for the same time-period and our survey could be repeated periodically to obtain trend data. However, for long-term spatial trend data, two common furbearers would need to be added to the survey as we did not include badgers (*Taxidea taxus*) and raccoons which are ubiquitous in North Dakota. In fact, raccoons were the most common carnivore detected at track-plate-boxes and camera stations during the 2006 – 2009 field surveys.

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Table 1. Number of carnivore distribution surveys returned by state and federal agencies in North Dakota.

Agency	Surveys returned
US Army Corps of Engineers	1
USDI Bureau of Land Management	1
North Dakota Parks and Recreation Department	9
USDA Wildlife Services	9
USDI Fish and Wildlife Service	12
North Dakota Game and Fish Department	81
Total	113

Table 2. Number and percent of respondents who observed selected carnivore species in the last year in North Dakota during 2005.

Species	Yes	No	% Yes
Coyote	112	1	99.1
Red fox	110	3	97.3
Striped skunk	108	5	95.6
Mink	107	6	94.7
Long-tailed weasel	95	18	84.1
Feral cat	93	20	82.3
Bobcat	29	84	25.7
Mountain lion	28	85	24.8
River otters	22	92	23.9
Fishers	15	99	13.2
Gray wolf	12	101	10.6
Gray fox	4	109	3.5
Swift fox	2	111	1.8
American marten	2	111	1.8
Canada lynx	2	111	1.8
Spotted skunk	0	113	0
Wolverine	0	113	0

Table 3. Number of respondents of a carnivore distribution survey who indicated the presence of select carnivores in the region of their jurisdiction in North Dakota. Percentages are in parentheses.

Species	Northeast	East	Southeast	Northcentral	Central	Southcentral	Northwest	West	South	Southwest	All
	n = 12	*n* = 7	*n* = 12	*n* = 11	*n* = 19	*n* = 9	*n* = 11	*n* = 5	*n* = 1	*n* = 18	*n* = 8
Coyote	12(100)	7(100)	12(100)	11(100)	18(95)	9(100)	11(100)	5(100)	1(100)	18(100)	8(100)
Red fox	12(100)	7(100)	11(92)	11(100)	18(95)	9(100)	11(100)	5(100)	1(100)	18(100)	7(87)
Striped skunk	11(92)	7(100)	12(100)	11(100)	17(89)	9(100)	10(91)	5(100)	1(100)	18(100)	7(87)
Mink	11(92)	7(100)	12(100)	11(100)	17(89)	8(89)	10(91)	5(100)	1(100)	17(94)	8(100)
Long-tailed weasel	7(58)	7(100)	9(75)	10(91)	14(74)	9(100)	10(91)	5(100)	1(100)	16(89)	7(87)
Feral cat	9(75)	7(100)	10(83)	9(82)	14(74)	8(89)	10(91)	5(100)	1(100)	14(78)	6(75)
Bobcat	1(8)	0(0)	0(0)	3(27)	0(0)	3(33)	2(18)	4(80)	0 (0)	14(78)	2(25)
Mountain lion	3(25)	1(14)	0(0)	3(27)	2(10)	0(0)	4(36)	3(60)	0 (0)	11(61)	1(12)
River otter	5(42)	4(57)	6(50)	0(0)	0(0)	1(11)	2(18)	1(20)	0 (0)	0(0)	2(25)
Fisher	8(67)	2(29)	0(0)	3(27)	1(5)	0(0)	0(0)	0(0)	0 (0)	0(0)	1(12)
Gray wolf	2(17)	1(14)	0(0)	2(18)	1(5)	0(0)	3(27)	1(20)	0(0)	1(5)	2(25)
Gray fox	0(0)	0(0)	2(17)	1(9)	0(0)	0(0)	0(0)	0(0)	0 (0)	0(0)	1(12)
Swift fox	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0 (0)	2(11)	0(0)
American marten	0(0)	0(0)	0(0)	2(18)	0(0)	0(0)	0(0)	0(0)	0 (0)	0(0)	0(0)
Canada lynx	0(0)	0(0)	0(0)	1(9)	0(0)	0(0)	0(0)	0(0)	0 (0)	0(0)	1(12)
Spotted skunk	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0 (0)	0(0)	0(0)
Wolverine	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0 (0)	0(0)	0(0)

Table 4. Responses indicating the presence (Yes) or absence (No) of river otters and fishers by county in North Dakota. Bold indicates a positive response for that county.

County	River otters			Fishers			County	River otters			Fishers		
	Yes	No	Total	Yes	No	Total		Yes	No	Total	Yes	No	Total
Adams	0	2	2	0	2	2	McLean	**1**	5	6	**1**	5	6
Barnes	**2**	1	2	0	3	3	Mercer	0	3	3	0	3	3
Benson	0	5	5	**1**	4	5	Montrail	**1**	1	2	0	2	2
Billings	0	2	2	0	2	2	Morton	**1**	5	6	0	6	6
Bottineau	**1**	3	4	**2**	2	4	Nelson	**3**	1	4	**3**	1	4
Bowman	0	2	2	0	2	2	Oliver	0	2	2	0	2	2
Burke	**1**	1	2	0	2	2	Pembina	**1**	2	3	**3**	0	3
Burleigh	0	2	2	0	2	2	Pierce	0	2	2	**1**	1	2
Cass	**2**	0	2	0	2	2	Ramsey	0	3	3	**1**	2	3
Cavalier	**1**	2	3	**2**	1	3	Ransom	**2**	1	3	0	3	3
Dickey	**1**	1	2	0	2	2	Renville	**1**	2	3	**1**	2	3
Divide	0	1	1	0	1	1	Richland	**2**	0	2	0	2	2
Dunn	**1**	2	3	0	3	3	Rollette	0	4	4	**2**	2	4
Eddy	**2**	1	3	**1**	1	2	Sargent	**2**	0	2	0	2	2
Emmons	0	2	2	0	2	2	Sheridan	**1**	2	3	**1**	2	3
Foster	**2**	1	3	**1**	2	3	Sioux	**1**	1	2	0	2	2
Golden Valley	0	2	2	0	2	2	Slope	0	2	2	0	2	2
Grand Forks	**4**	1	5	**4**	1	5	Stark	0	4	4	0	4	4
Grant	**1**	1	2	0	2	2	Steele	**4**	0	4	**2**	2	4
Griggs	**2**	1	3	**1**	2	3	Stutsman	**2**	2	4	**1**	3	4
Hettinger	0	3	3	0	3	3	Towner	0	2	2	**1**	1	2
Kidder	0	2	2	0	2	2	Traill	**4**	0	4	**2**	2	4
LaMoure	**1**	1	2	0	2	2	Walsh	**2**	1	3	**3**	0	3
Logan	0	3	3	0	3	3	Ward	**1**	5	6	**1**	5	6
McHenry	0	2	2	**1**	1	2	Wells	**2**	1	3	**1**	2	3
McIntosh	0	3	3	0	3	3	Williams	0	2	2	0	2	2
McKenzie	**1**	0	1	0	1	1							

Table 5. Number of bridges where river otter sign was detected during sign surveys conducted in eastern North Dakota (2007). Percentages are in parantheses.

	Bridges	
River	Number surveyed	Number with otter sign
Pembina	4	0 (0)
Little Pembina	10	0 (0)
Tongue	18	4 (22.2)
Park	9	0 (0)
Forest	18	0 (0)
Red	1	1 (100)
Sheyenne	44	2 (4.5)
Turtle	34	3 (8.8)
North Marais	2	1 (50.0)
	140	11 (7.8)

Table 6. Counts of beaver caches for river reaches in eastern North Dakota on 8 – 9 November 2006.

Reach ID	River	Length (km)	Beaver caches	Caches per km
1	Sheyenne	30.95	7	0.23
2	Sheyenne	20.12	6	0.30
3	Sheyenne	21.61	3	0.14
4	Sheyenne	23.59	11	0.47
5	Maple	21.39	7	0.33
6	Wild Rice	21.23	2	0.09
7	Wild Rice	21.23	6	0.28
8	Red	28.59	7	0.24
9	Elm	22.29	3	0.13
10	Goose	21.17	7	0.33
11	Goose	21.62	8	0.37
12	Red	29.04	13	0.45
13	Turtle	20.72	7	0.34
14	Turtle	20.29	6	0.30
15	Red	30.37	13	0.43
16	Forest	21.43	2	0.09
17	Forest	22.42	5	0.22
18	Park	20.90	9	0.43
19	Red	22.75	5	0.22
20	Red	23.13	2	0.09
21	Tongue	20.58	11	0.53
22	Pembina	20.53	8	0.39
23	Pembina	23.90	14	0.59

Table 7. Mean number of beaver caches per kilometer (km) for rivers in eastern North Dakota on 8 – 9 November 2006.

River	*n*	Mean caches/km	SE
Elm	1	0.13	---
Forest	2	0.16	0.06
Goose	2	0.35	0.02
Maple	1	0.33	---
Park	1	0.43	---
Pembina	2	0.49	0.10
Red	5	0.29	0.07
Sheyenne	4	0.28	0.07
Tongue	1	0.53	---
Turtle	2	0.32	0.02
Wild Rice	2	0.19	0.09

Table 8. Number of species detected with track-plate-boxes (*n* = 25) over a two-week period (9 – 14 August 2006) along the Wild Rice, Bois de Sioux, and Red Rivers of North Dakota. Percentages are in parentheses.

Species	No. Sites with a Detection	
	Week 1	Week 2
Raccoon	21(84)	24(96)
Domestic cat	10(40)	17(68)
Stripped skunk	0(0)	2(8)
Weasel spp.	0(0)	2(8)

Table 9. Number of species detected with camera stations (n = 9; 25 July – 8 August 2006) in eastern North Dakota. Percentages are in parentheses.

Species	No. Sites with a Detection
Raccoon	6 (67)
Fisher	1 (11)
Striped skunk	1 (11)
Badger	1 (11)
Coyote	1 (11)
Domestic dog	1 (11)
Domestic cat	2 (22)

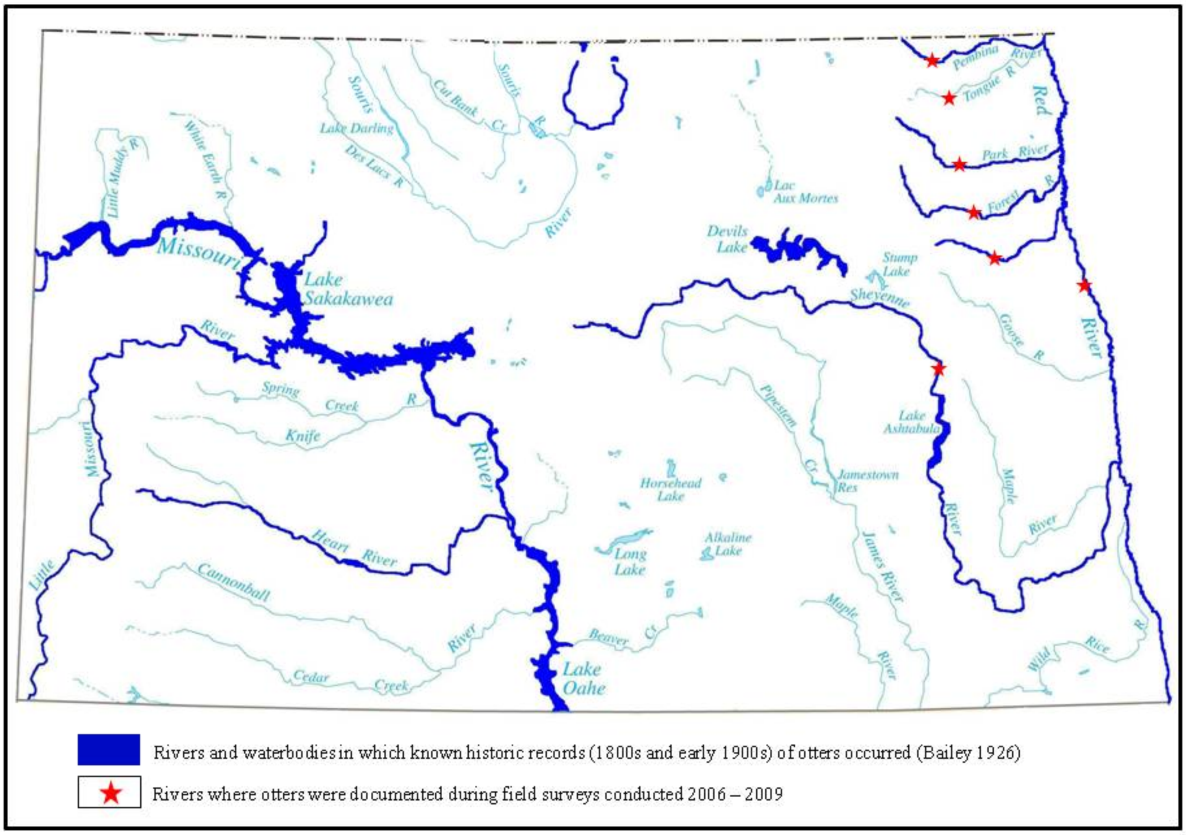
Table 10. Carnivore species detected during track-plate-box/camera-station surveys conducted in eastern North Dakota (May – August 2008; *n* = 184 survey sites; and May – August 2009; *n* = 172 survey sites).

Species	2008 No. of Detections	2008 Detection Rate	2009 No. of Detections	2009 Detection Rate
Fisher	54	0.29	78	0.45
River otter	---	---	1	0.01
Striped skunk	14	0.08	19	0.11
Mink	2	0.01	---	---
Weasel spp.	2	0.01	3	0.02
Coyote	---	---	31	0.18
Red fox	1	0.01	11	0.06
Raccoon	122	0.66	125	0.73
Black bear	---	---	1	0.01
Bobcat	---	---	1	0.01
Domestic dog	1	0.01	7	0.04
Domestic cat	13	0.07	19	0.11

Table 11. Comparison of detection rates for fishers surveyed in 2008 and 2009 using track-plate-boxes and camera stations placed along the Red, Pembina, Tongue and Turtle Rivers of northeastern North Dakota.

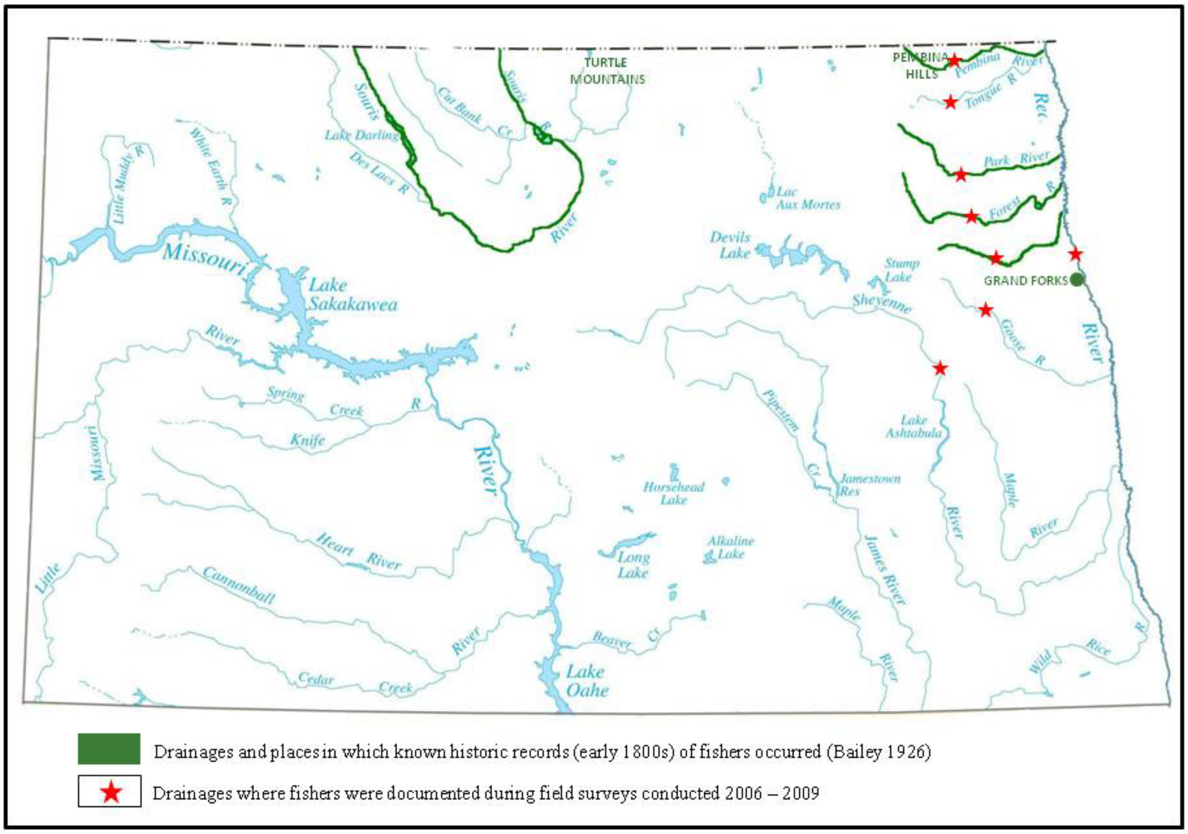
River	2008		2009	
	n	Detection Rate	*n*	Detection Rate
Red (N. of Grand Forks, ND)	56	0.43	35	0.89
Pembina	22	0.23	16	0.81
Tongue	22	0.27	11	0.82
Turtle	44	0.20	20	0.25

Figure 1. Rivers and waterbodies in North Dakota in which known historic records of river otters were documented by Bailey (1926) and where otter sign was detected during field surveys (2006 – 2009).



Map Source prior to modification: http://www.nationalatlas.gov/printable/reference.html#list

Figure 2. Drainages and places (Pembina Hills, Turtle Mountains, and Grand Forks) in North Dakota in which known historic records of fishers were documented by Bailey (1926) and where fishers were detected during field surveys (2006 – 2009).



Map Source prior to modification: http://www.nationalatlas.gov/printable/reference.html#list

Figure 3. Red River Basin of eastern North Dakota where field surveys for river otters, fishers and other meso-carnivores were conducted (2006 – 2009).

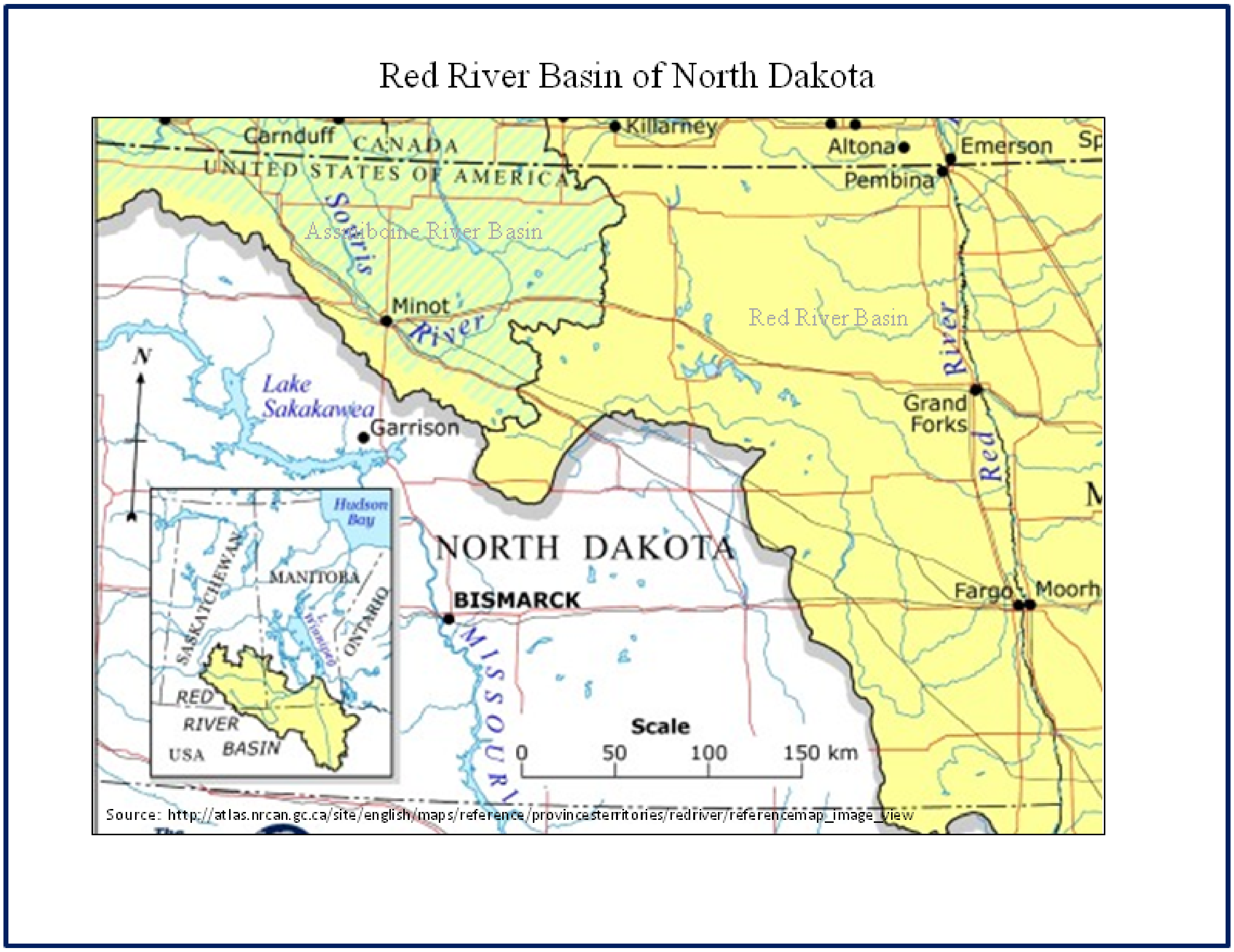


Figure 4. Tracks of river otters detected during sign surveys in eastern North Dakota.

Figure 5. Tracks and slides of multiple river otters detected during sign surveys in eastern North Dakota.

Figure 6. Scat of river otters detected during field surveys in eastern North Dakota.

Figure 7. Counties in North Dakota in which river otters were reported to occur by ≥1 respondent of a carnivore distribution survey.

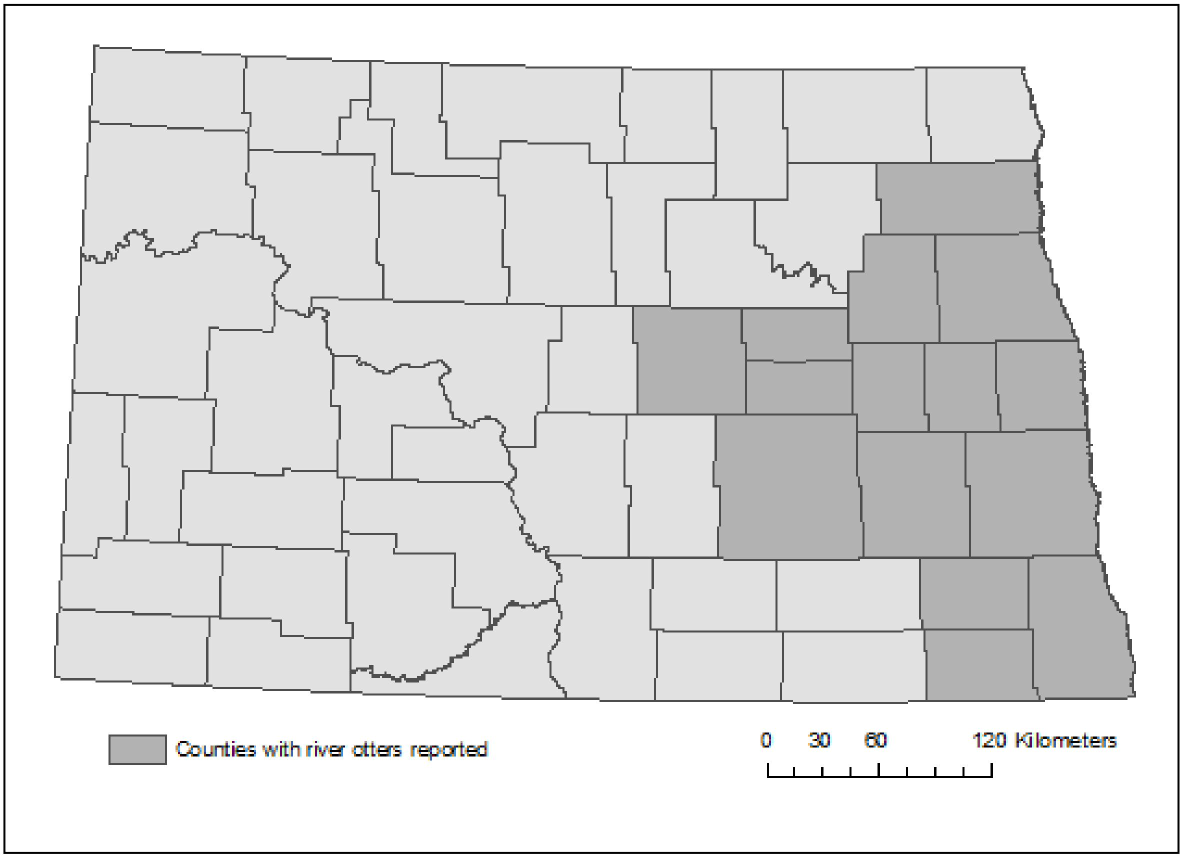


Figure 8. Counties in North Dakota in which fishers were reported to occur by ≥1 respondent of a carnivore distribution survey.

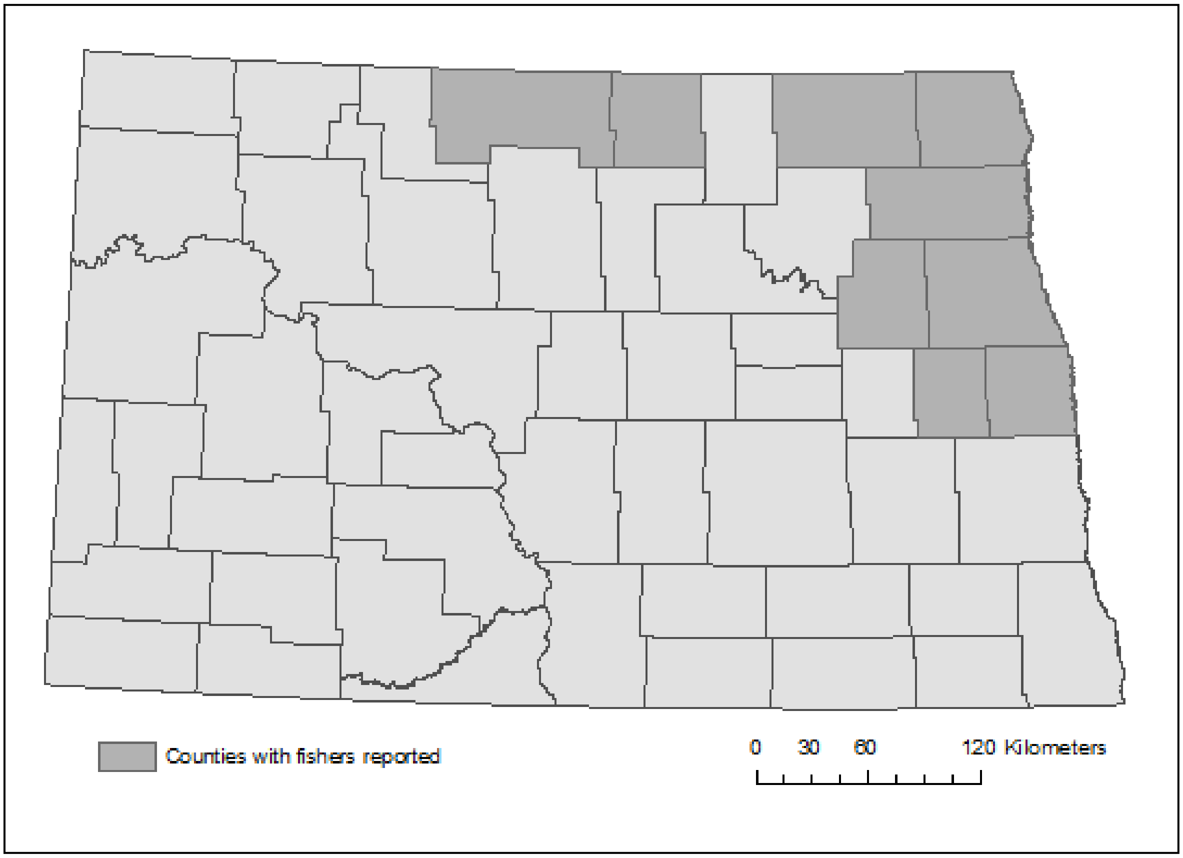


Figure 9. Counties in North Dakota in which verified reports of river otters were documented by the North Dakota Game and Fish Department (2005 – May 2009; *n* = 39 reports).

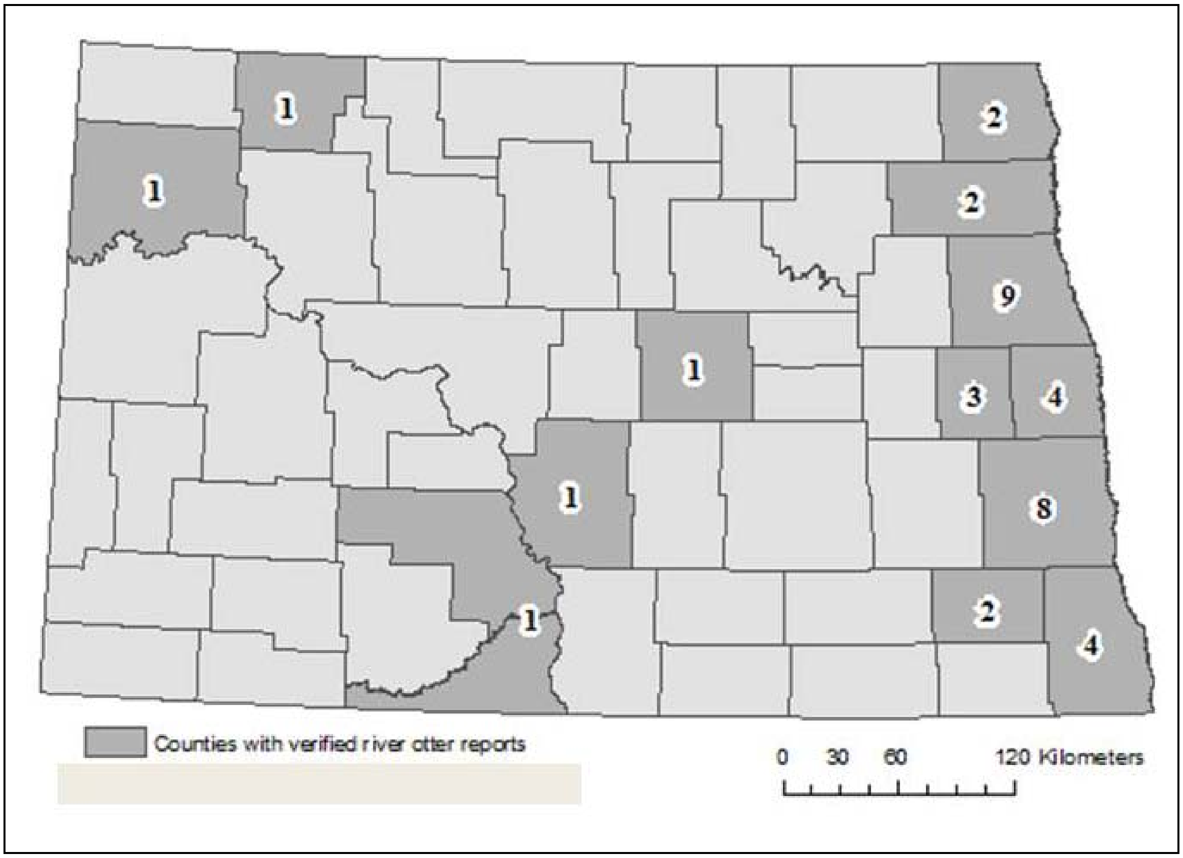


Figure 10. Counties in North Dakota in which verified reports of fishers were documented by the North Dakota Game and Fish Department (2005 – May 2009; *n* = 51).

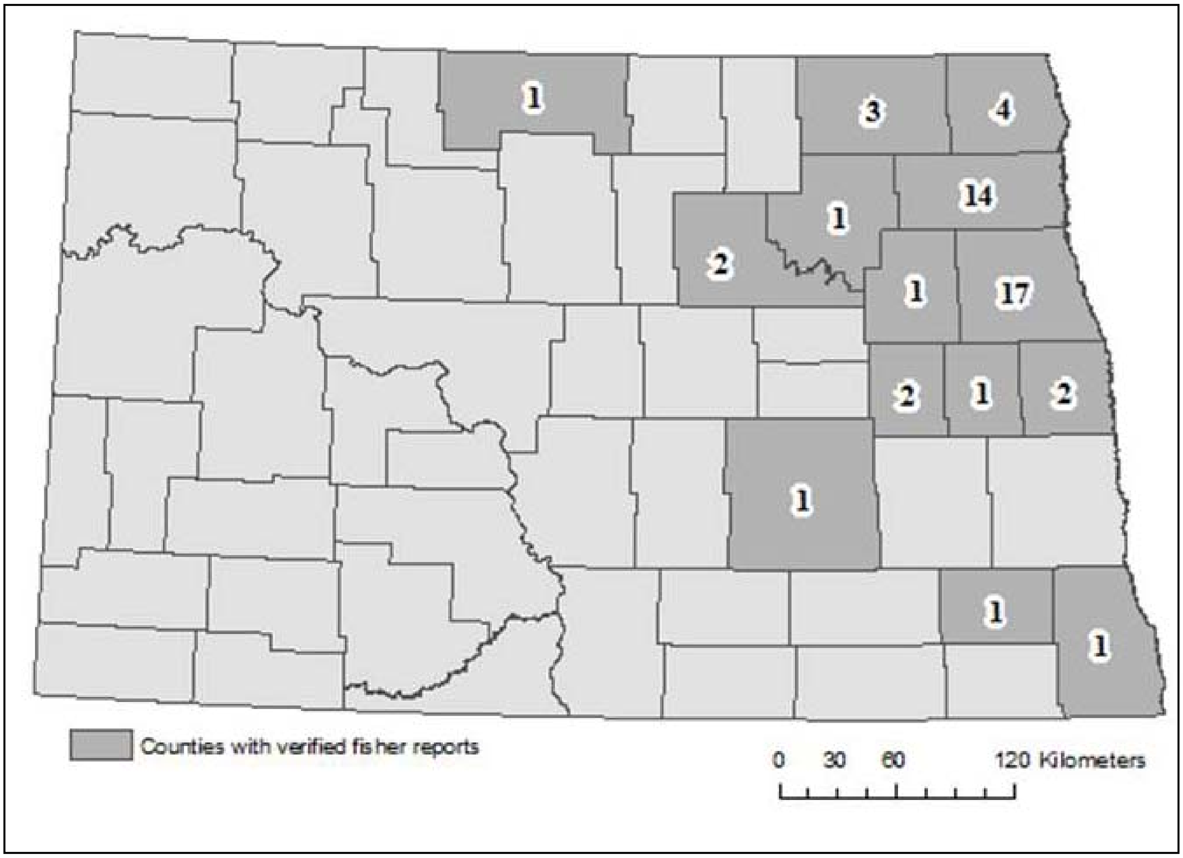


Figure 11. Dispersion of 1-km^2 grid cells sampled versus those available during river otter sign surveys conducted from 2 June 2006 through 2 August 2006 in the Red River drainage of eastern North Dakota.

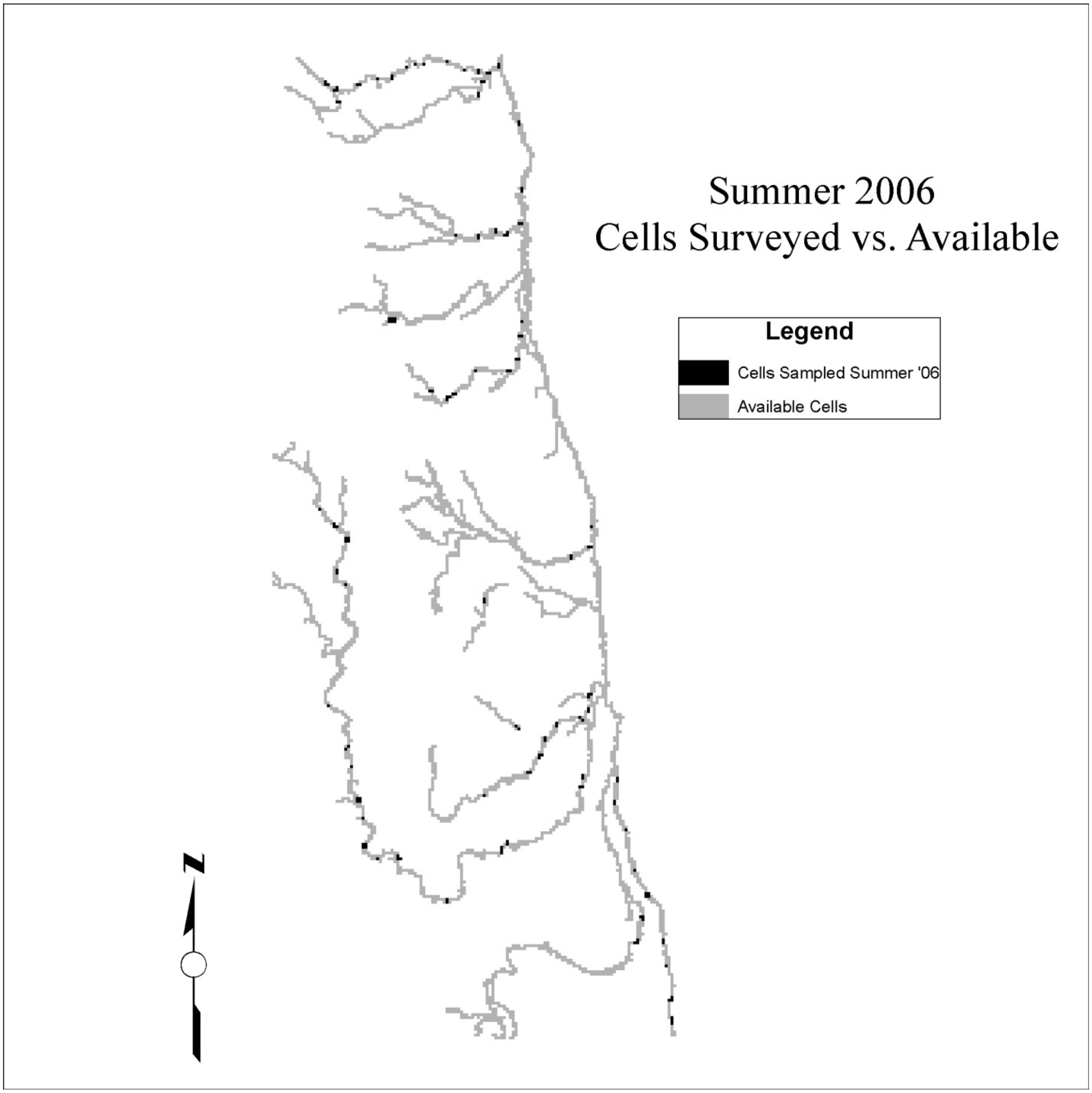


Figure 12. Dispersion of 1-km^2 grid cells sampled vs. those available during river otter sign surveys conducted via motor boat and canoe September – November 2006 in the Red River drainage of eastern North Dakota.

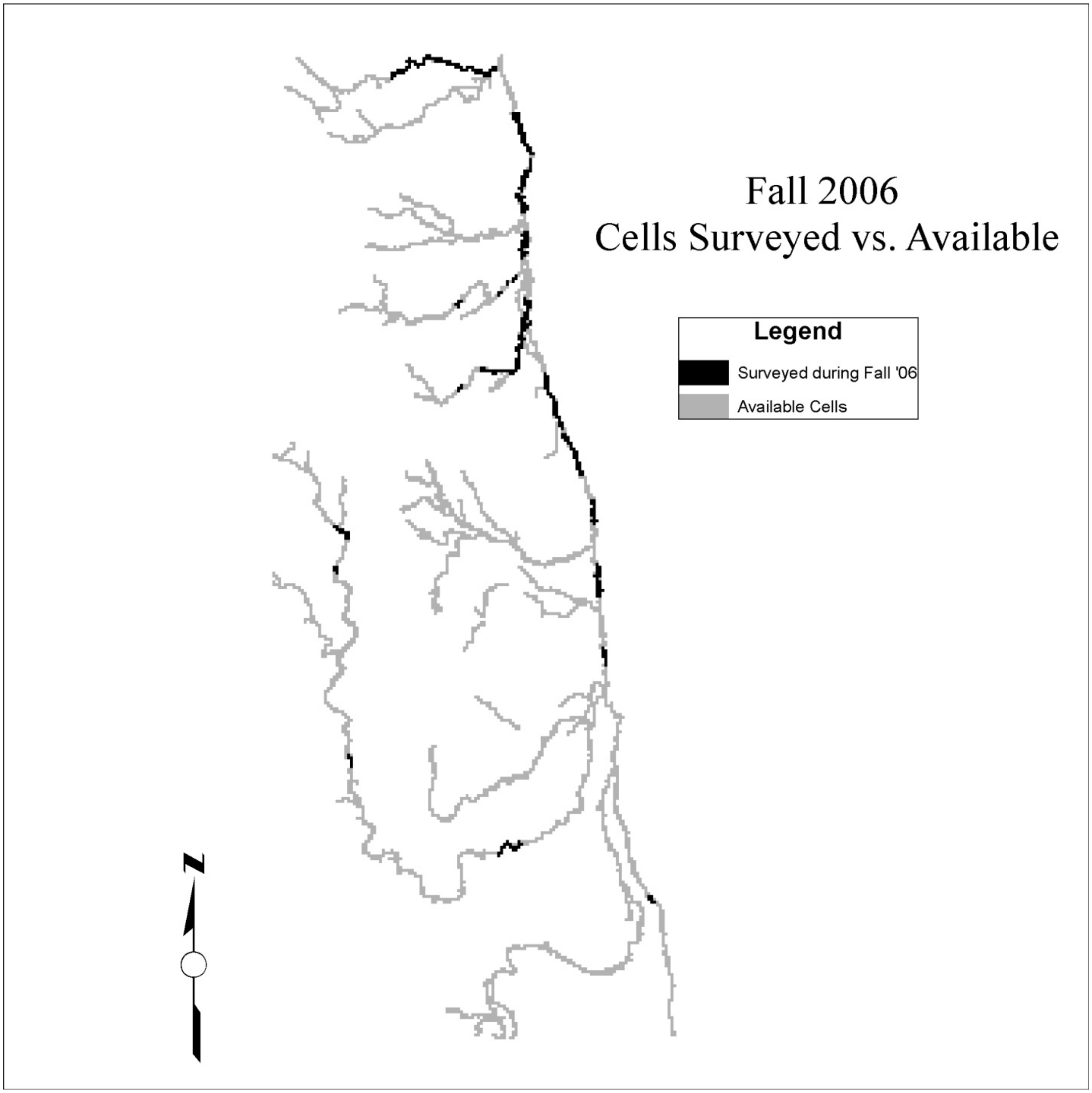


Figure 13. Locations of river otter latrine sites and other sign documented during motor boat and canoe surveys conducted September – November 2006 in the Red River drainage of eastern North Dakota.

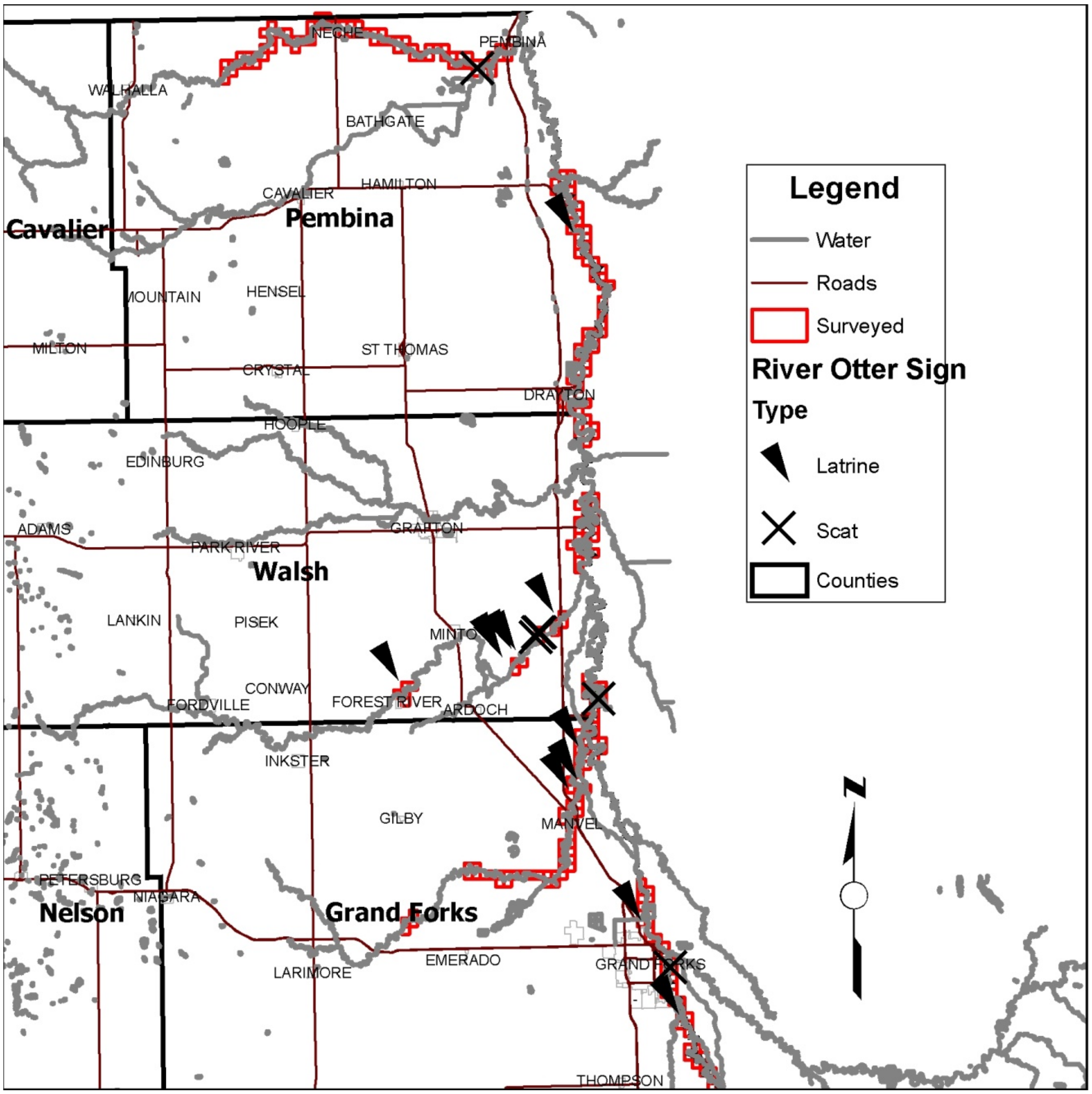


Figure 14. Survey sites and fisher detections during a track-plate-box/camera station survey conducted June – August 2008. Black dots represent survey sites and red stars represent sites with fisher detections. All rivers surveyed in 2008 are indicated by blue lines. The focal rivers [Pembina, Red (north of Grand Forks), Tongue, and Turtle Rivers], which were intensively surveyed in 2008 and 2009, are indicated by bold blue lines.

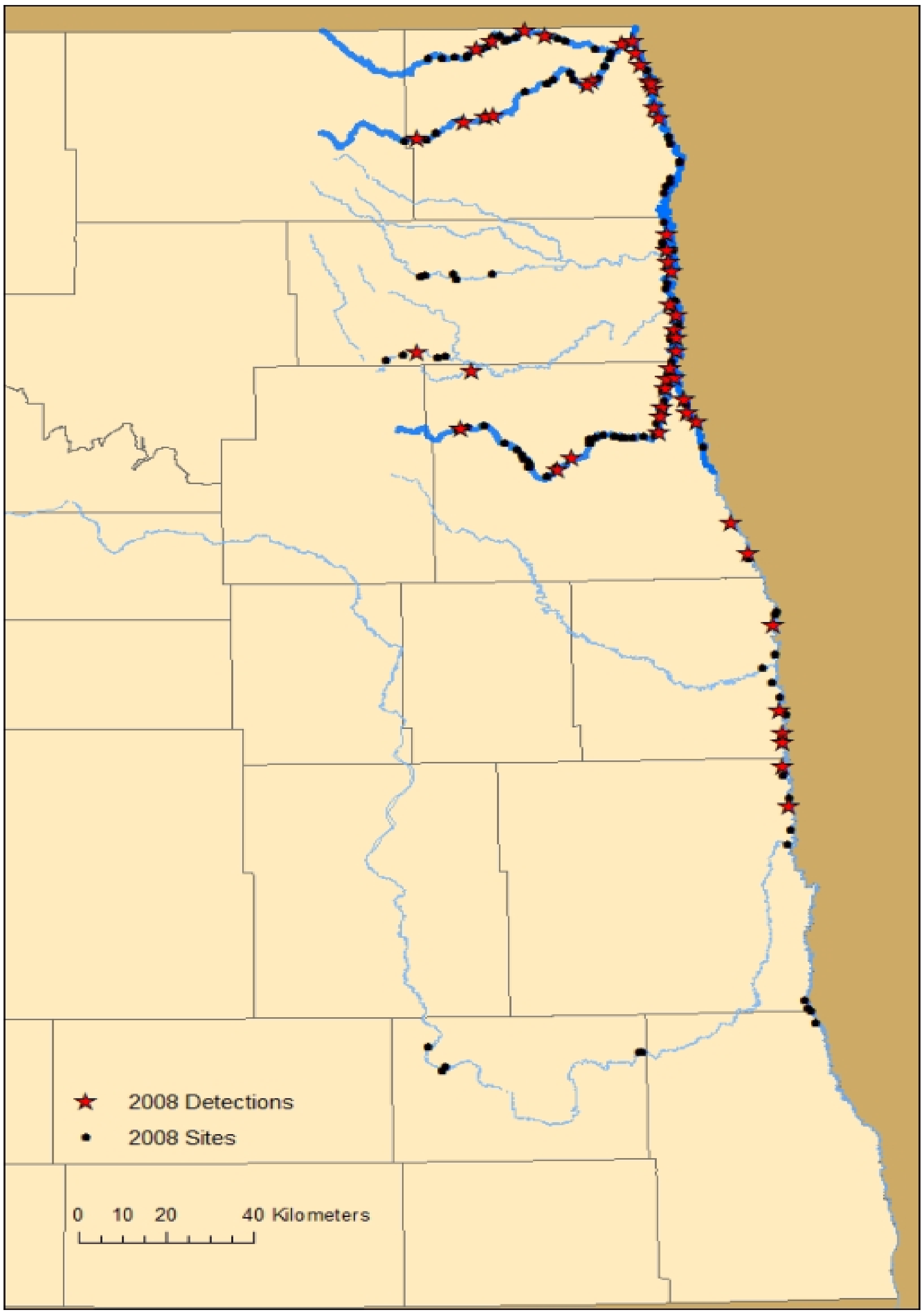
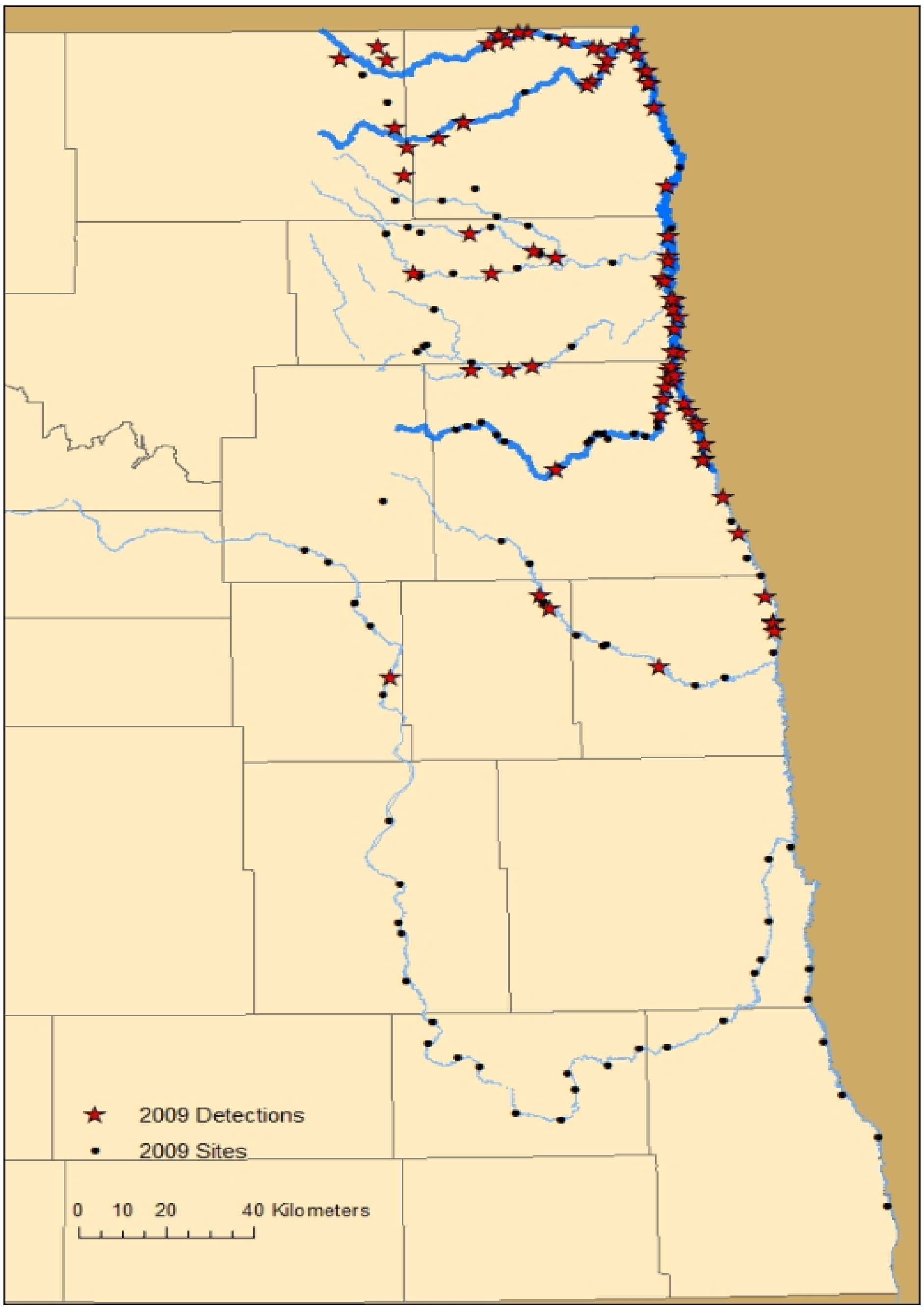


Figure 15. Survey sites and fisher detections during a track-plate-box/camera station survey conducted June – August 2009. Black dots represent survey sites and red stars represent sites with fisher detections. All rivers surveyed in 2009 are indicated by blue lines. The focal rivers [Pembina, Red (north of Grand Forks), Tongue, and Turtle Rivers], which were intensively surveyed in 2008 and 2009, are indicated by bold blue lines.



Appendix I. Survey of Carnivore Distribution designed to determine the distribution of a select group of carnivores, with special emphasis on river otters and fishers.

Survey of Carnivore Distribution

Name: ______________________________ **Date:**_______________ **Phone:** _________________
Name of Area: ____
County/Counties: ____

Section 1
General Carnivore Information

1) Indicate the carnivore(s) you or your staff have observed in your area in the last year

Please indicate by placing an X next to any observed carnivore
(include observations of sign and transient individuals)

__ Wolf	__ Mountain Lion	__ River Otter	__ Striped Skunk
__ Coyote	__ Lynx	__ Fisher	__ Spotted Skunk
__ Red Fox	__ Bobcat	__ Marten	__ Wolverine
__ Swift Fox	__ Feral Domestic Cat	__ Long-tailed weasel	__ Mink
__ Gray Fox			

2) In the above list, bold the carnivores that are probably residents

Section 2
Species Specific Information

1) Describe the occurrence of river otters in your area:
Place an X next to the appropriate statement

__ No observations or reports

__ Observations or reports, but a population is not established. Year of first observation: _____

__ Established population present. Year of first observation: _____Year established:_______

2) Estimate the number of river otters occurring in your area: (if wildlife personnel census the otter population, how many individuals would they find?) Bold the appropriate selection

0 1-5 6-10 11-20 21-30 31-50 50+

If you answered "0" in question 2, please skip to QUESTION 4

3) How was the occurrence of river otters in your area determined?

(X every category that applies & estimate the number of occurrences for **2005-present**)

Personal Observations	Reports
__ River otter sighting(s); how many? _____ __ Incidental capture by trappers Otters dead ____ Otters released _____ __ Capture by personnel Otters euthanized ____ Otters relocated _____ __ Roadkill _____ __ River otter sign sightings (scat, scrapes, slides, tracks, etc.) _____	__ River otter sighting(s); how many? _____ __ Incidental capture by trappers Otters dead ____ Otters released _____ __ Capture by personnel Otters euthanized ____ Otters relocated _____ __ Roadkill _____ __ River otter sign sightings (scat, scrapes, slides, tracks, etc.) _____
Additional comments:	

4) Describe the occurrence of fishers in your area:

Place an X next to the appropriate statement

__ No observations or reports

__ Occasional observations or reports, but a population is not established. Year of first observation: _____

__ Established population is present. Year of first observation: _____

Year established: _____

5) Estimate the number of fishers occurring in your area: (if wildlife personnel census the otter population, how many individuals would they find?) Bold the appropriate selection

0 1-5 6-10 11- 20 21-30 31-50 50+

6) How was the occurrence of fishers in your area determined?

(X every category that applies & estimate the number of occurrences for **2005-present**)

Personal Observations	Reports
__ Fisher sighting(s); how many? _____ __ Incidental capture by trappers Fishers dead ____ Fishers released _____ __ Capture by personnel Fishers euthanized ___ Fishers relocated ____ __ Roadkill _____ __ Fisher sign sightings (scat, tracks, etc.) _____	__ Fisher sighting(s); how many? _____ __ Incidental capture by trappers Fishers dead ____ Fishers released _____ __ Capture by personnel Fishers euthanized ____ Fishers relocated _____ __ Roadkill _____ __ Fisher sign sightings (scat, tracks, etc.) _____
Additional comments:	

Thank You!

Appendix II. Locations (UTM coordinates) of 45 stream sections sampled on foot during sign surveys for river otters 2 June – 2 August 2006 in eastern North Dakota.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix III. Locations (UTM coordinates) of river otter sign documented during sign surveys conducted on foot during summer (2 June – 2 August 2006) and by motor boat and canoe during fall (September – November 2006) on the Sheyenne, Turtle, Forest, Park, Pembina, and Red Rivers in eastern North Dakota.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix IV. Locations (UTM coordinates) of nine stream sections in which river otter sign was detected during sign surveys for the species (19 March – 1 May 2007) in eastern North Dakota.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix V. Locations (UTM and Latitude, Longitude) of unique river otter latrines found during monthly scat surveys (April – November 2007 and May – August 2008) conducted along both sides of three, 5-km stream sections of the Forest, Red, and Turtle Rivers of northeastern North Dakota.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix VI. Locations (UTM coordinates) of bridges in eastern North Dakota surveyed for river otter sign (2007). 'Yes' responses for presence of river otter sign are in bold.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix VI. (cont.)

Redacted. N.D.C.C. § 20.1-02-29.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix VII. Locations (Latitude, Longitude) of survey sites where fishers were detected during track-plate-box/camera station surveys conducted June – August 2008 in eastern North Dakota.

Redacted. N.D.C.C. § 20.1-02-29.

Appendix VIII. Locations (Latitude, Longitude) of survey sites where fishers were detected during track-plate-box/camera station surveys conducted June – August 2009 in eastern North Dakota.

Redacted. N.D.C.C. § 20.1-02-29.

CHAPTER 2

Food habits and fish prey size selection of a newly colonizing population of river otters (*Lontra canadensis*) in eastern North Dakota

Abstract

The food habits of river otters (*Lontra canadensis*) in the Red River drainage of eastern North Dakota were evaluated using an analysis of 665 scats collected between 26 July 2006 and 26 November 2007. Overall, fish and crayfish were the primary prey items, occurring in 75.8% and 57.6% of scats, respectively. Other prey included insects (27.2%), amphibians (7.1%), birds (7.1%), mammals (5.6%), and freshwater mussels (0.2%). Fish of Cyprinidae (carp and minnows) were the most prominent fish in the diet, occurring in 55.9% of scats. Other relatively common fish in the diet included ictalurids (catfish, 17.0% frequency of occurrence), catostomids (suckers, 11.4%), and centrarchids (sunfish, 10.1%). The diet of otters changed seasonally, including a decline in the frequency of fish in the summer diet and a corresponding increase in the occurrence of crayfish. Consumed fish ranged from 3.5 – 71.0 cm total length, with a mean of 20.7 cm (SE ± 0.5, n = 671). Fish 10.1 – 20.0 cm were the most frequently consumed size class (36.5% relative frequency), with the majority of other consumed fish being ≤ 10.0 cm (24.5%), 20.1 – 30.0 cm (13.1%), 30.1 – 40.0 cm (13.7%), or 40.1 – 50.0 cm (8.2%). The size of fish consumed changed seasonally, with spring having the largest mean prey size.

Introduction

Historically, the nearctic river otter (*Lontra canadensis*) occurred on most rivers in North Dakota, and was relatively common into the 1890's (Bailey 1926, Adams 1961). River otters still occurred in the 1920s along the major rivers and some lakes, but had become rare by the

1960s, and were considered extirpated soon after (Bailey 1926, Adams 1961). However, in recent years reports of river otters have increased, with most coming from the Red River drainage, and Lake Sakakawea in the Missouri river drainage (Hagen et al. 2005).

River otters are opportunistic aquatic predators. Although the diet is diverse, most dietary analyses have shown fish to be the primary prey (e.g., Greer 1955, Melquist and Hornocker 1983, Serfass et al. 1990). River otters are presumed to select fish in proportion to their abundance, and in inverse proportion to swimming speed and agility (Ryder 1955). Therefore, the most abundant and slowest swimming fishes tend to be taken more often than other fishes. Catostomidae (suckers), Centrarchidae (sunfish and bass), Cyprinidae (carp and minnows), and Ictaluridae (catfish) are usually among the most frequently occurring fish families detected in river otter diet studies (e.g., Wilson 1954, Greer 1955, Hamilton 1961, Griess 1987, Serfass et al. 1990, Noordhuis 2002, Giordano 2005). When available, crayfish usually are the second most important prey item, and in a few studies have occurred most frequently in the diet (Grenfell 1974, Griess 1987, Noordhuis 2002). Other organisms consumed by river otters include amphibians, insects and other invertebrates, birds, mammals, and reptiles (Ryder 1955, Melquist and Hornocker 1983, Serfass et al. 1990).

Despite many previous food studies on river otters, rarely have studies been conducted to assess the size of their fish prey. Previous studies have made general inferences about prey size, indicating that fish prey ranges from 2 – 80 cm, and that most fish consumed are probably 10 – 30 cm in length (Lagler and Ostenson 1942, Greer 1955, Ryder 1955, Hamilton 1961, Toweill 1974, Melquist and Hornocker 1983, Stenson et al. 1984, Griess 1987, Tumlison and Karnes 1987, Noordhuis 2002, Giordano 2005). However, these studies typically did not indicate the methods used in their assessments, or establish predictive relationships between anatomical structures (that are recoverable from the digestive tracts or scats, such as bones and scales) and the length of the fish. Also, inferences have been limited to one or a few species (occasionally only a few individuals), and only provided information on the size range (maximum and minimum) or common prey sizes. This study was part of a larger project determining the distribution of river otters in the Red River drainage of eastern North Dakota, and was the first research conducted on the reestablishing population. The objectives of this aspect of the study were to: 1) assess the food habits of river otters in recolonized areas, 2) determine the size of fish preyed on by river otters, and 3) evaluate seasonal variation in the diet and prey size.

Study Area

The Red River forms at the convergence of the Bois de Sioux River and the Ottertail River at Wahpeton, ND and Brackenridge, MN (46°15.84'N, 96° 35.92'W). The river flows north forming the boundary between North Dakota and Minnesota for nearly 640 km before entering Manitoba, Canada (Koel and Peterka 1998). The landscape of the Red River drainage has low relief, and mostly occurs within the former lake bed of Lake Agassiz (Stoner et al. 1993). The majority of the Red River valley (about 80%) is cropland, but pasture also is present (Stoner et al. 1993). Forested regions mostly are confined to narrow riparian strips (Stoner et al. 1993). Riparian areas consist of strips of grass or trees, but in some areas agricultural fields extend to the river banks (Stoner et al. 1993). The North Dakota tributaries of the Red River are very similar in physical structure, meandering, and typically have low gradients and high turbidity (Copes and Tubb 1966, Stoner et al. 1993). In spring 2007, study areas were established on the Red River in Grand Forks, ND, and East Grand Forks, MN, Forest River in Ardoch township (Walsh County), and Turtle River in Turtle River township (Grand Forks County; Figure 1). Although the Red River study site was located in an urban area, both cities have a protected riparian greenway providing abundant riparian vegetation. The study areas on the Forest and Turtle rivers occurred within agricultural landscapes. There was a narrow forested riparian strip in the Turtle River study area. But, there was little riparian vegetation in the Forest River study area because agricultural fields extend to its banks. However, the western border of the Forest River study area was Ardoch National Wildlife Refuge, which provided river otters access to lacustrine and wetland habitats.

In addition to the three primary study areas, the study also included the Tongue River, a tributary of the Pembina River (a tributary of the Red River). A study site was not established on the Tongue River, because river otters were not detected there until after primary study areas were established. After their discovery, the latrine sites on the Tongue River were monitored (primarily in summer 2007). These latrines were located in the townships of Akra and Bathgate (Cavalier County).

Methods

The diet of river otters was assessed by analyzing scats collected between 26 July 2006 and 26 November 2007. Initially, scats were collected during sign surveys (surveys along river banks to detect scats, tracks, or other sign) or during checks of latrine sites. Beginning in spring 2007, the primary study areas were surveyed on foot at least monthly. Scats were collected on the Tongue River during sporadic checks of latrine sites. A total of 665 scats were analyzed, including 142 scats from the Red River, 245 from the Forest River, 182 from the Turtle River, and 89 scats from the Tongue River. Additionally, six scats were collected from the Pembina River and one from the Park River.

Scats were collected in individual plastic bags, which subsequently were labeled with identifying information (i.e., date, river, and site), and frozen until analysis. In preparation for analysis, scats were washed by soaking over night in soapy water, and then rinsed through a

0.125 mm mesh sieve to eliminate small organic material and other debris. After drying, food particles were separated to facilitate identification. Fish remains were identified to species or to as small of an identifiable group as possible using Daniels' (1996) scale identification key, and reference collections of scales and other bony structures. We used Spiers (1973) to identify mammalian prey, and other remains (e.g., amphibian bones) were identified using reference collections.

The diet was assessed using frequency of occurrence, determined by tabulating the number of scats the prey occurred in and dividing by the total number of scats. Seasonal variation in the diet was evaluated by assigning scats to a season depending on their collection date. Scats collected from 1 March – 31 May were defined as spring, from 1 June – 31 August as summer, 1 September – 30 November as fall, and 1 December – 28 February as winter. Due to seasonal variation in river otter scent marking, and in our sampling effort there was considerable variation in the number of scats collected among seasons, ranging from 22 in winter to 275 in fall (Table 1).

The size of fish consumed by river otters was estimated using body-scale relationships (relating fish total length to scale size) established from samples collected throughout the North Dakota tributaries of the Red River, June -November 2007. The samples were collected in collaboration with researchers from South Dakota State University, and were obtained through electrofishing, and the use of seines and clover leaf traps. The size of fish prey was estimated by inserting the measurements of scales sorted from river otter scats into species-specific or group models. Lateral line scales were preferred for size estimation (because they provide more precise body-scale regressions; see Stearns (2008) for the regression models used), and always were used when present in a scat. When a lateral line scale could not be located within a scat, a representative non-lateral line scale of the species (or group) was used in models constructed with non-lateral line scales. If scales of distinctly different sizes (but the same species) were present within a scat, multiple scales were taken and used for size estimation. Fish size estimates were obtained for each of the scales, and 95% prediction intervals were constructed around the estimates. Doing so allowed multiple individuals of the same species to be identified in a single scat when the prediction intervals did not overlap. When multiple individuals were detected within a scat each individual was included in prey size estimates. Prey size was evaluated using relative frequency (number of prey detections divided by total prey detections), and by categorizing fish prey into six size (total length) classes: ≤10.0 cm, 10.1 – 20.0 cm, 20.1 – 30.0 cm, 30.1 – 40.0 cm, 40.1 – 50.0 cm, and >50.0 cm. Ten cm was chosen as the upper limit of the smallest size class because it is approximately the maximum length of small cyprinid species (minnows). Due to their lack of scales the size of ictalurid prey was not analyzed. Furthermore, due to inadequate scale samples to construct body-scale regressions the size of mooneyes (*Hiodon* spp.), quillback (*Carpiodes cyprinus*), and *Ictiobus* spp. was not estimated, but these species comprised a very small portion of the diet (Table 1).

Seasonal variation in the diet was assessed by comparing the frequency of occurrence of each prey item between seasons using chi-square (χ^2) analyses. Chi-square analyses also were used to assess the seasonal variation in the relative frequency of prey size categories. Additionally, mean prey sizes were compared among seasons and study areas using F-tests through ANOVA. All statistical analyses were conducted using Minitab (Minitab Version 14, Minitab Inc., State College, Pennsylvania).

Results

Fish and crayfish were the primary foods of river otters in eastern North Dakota, occurring in 75.8% and 57.6% of all scats, respectively (Table 1). Insects also were relatively common in the diet, occurring in 27.2% of scats. Other prey included amphibians (7.1%), birds (7.1%), mammals (5.6%), and freshwater mussels (0.2%). Cyprinids were the most common fishes consumed (55.9%), and carp (*Cyprinus carpio*) (48.0%) was the most frequently consumed species (Table 1). Other fishes that were relatively common in the diet included ictalurids (17.0 %), catostomids (11.4 %), and centrarchids (10.1%). Other fish prey included: percids (4.8%), northern pike (*Esox lucius*, 4.4%), white bass (*Morone chrysops*) or freshwater drum (*Aplodinotus grunniens*, 4.1%), and mooneyes (2.1%).

The diet of river otters changed seasonally in eastern North Dakota (Table 1, Figure 2). Fish were the most important prey item in spring, fall, and winter, but became less important in summer ($\chi^2 = 70.04$, 3 df, $P < 0.001$; Table 1). The frequency of occurrence of most fish families varied seasonally, with the relatively common families (i.e., cyprinids, ictalurids, and catostomids) in the diet tending to occur most often in fall or winter, and families rarely consumed occurring at highest frequencies in spring (Table 1). In contrast to fish, crayfish increased in importance in summer when they became the prey item with the highest frequency of occurrence ($\chi^2 = 27.20$, 3 df, $P < 0.001$; Table 1). Seasonal differences also were detected in the occurrence of insects ($\chi^2 = 21.72$, 3 df, $P < 0.001$), amphibians ($\chi^2 = 28.64$, 3 df, $P < 0.001$), and birds ($\chi^2 = 10.65$, 3 df, $P = 0.014$; Table 1).

The size of fish prey ranged from 3.5 (a carp) to 71.0 cm (a northern pike), with a mean of 20.7 cm (SE ± 0.5, $n = 671$). Northern pike ($\bar{x} = 36.3$ cm, SE ± 2.2, $n = 35$) and darters (*Etheostoma* spp. or *Percina* spp.) ($\bar{x} = 6.0$ cm, SE ± 0.2, $n = 17$) were on average the largest and smallest fish prey, respectively. The size category with the highest relative frequency (36.5%) in the diet was 10.1 – 20.0 cm total length. In order of relative frequency the remaining fish were ≤10.0 cm (24.5%), 30.1 – 40.0 cm (13.7%), 20.1 – 30.0 cm (13.1%), 40.1 – 50.0 cm (8.2%), and >50.0 cm (2.7%).

The size of fish consumed by river otters changed seasonally, with all but the largest fish (>50.0 cm) varying across seasons (Table 2, Figure 3). In summer, most fish prey (45.6%) were small (≤10.0 cm). With increasing frequency of fish in the diet in fall and winter, there was a shift towards fish 10.1 – 20.0 cm in length. In spring, fish 30.1 – 40.0 cm reached their seasonal maximum in relative frequency, and were the most frequent size in the diet (25.3%). Similarly, fish 20.1 – 30.0 cm, 40.1 – 50.0 cm, and >50.0 cm peaked in relative frequency in spring (Table 2). Also, the mean estimated length of fish prey differed among seasons ($F_{3, 667} = 25.62$, $P <$ 0.001), with the highest average occurring in spring ($\bar{x}$ = 27.8 cm, SE ± 1.0, n = 178).

The size of fish preyed on by river otters differed among study areas (Tables 3 – 5, Figure 4). Fish 10.1 – 20.0 cm in total length composed the largest component of the diet on the Forest and Red Rivers, and occurred in similar proportions on the Turtle River (Tables 3 – 5). However, on the Turtle River fish ≤10.0 cm comprised the largest proportion of consumed fish, with fish >20.0 cm being less frequently consumed than on other rivers (Tables 3 – 5). The Red River had the largest mean prey size ($\bar{x}$ = 25.5, SE ± 0.8, n= 234), and was followed by the Forest River ($\bar{x}$ = 20.2 cm, SE ± 0.8, n = 262), and Turtle River ($\bar{x}$ = 14.5 cm, SE ± 0.8, n = 163) ($F_{2, 655}$ = 39.08, $P < 0.001$; Figure 4).

Red River

Fish were the predominant prey item in the diet of river otters on the Red River, occurring in 96.5% of scats (Table 6). The fish family with the highest frequency of occurrence was Cyprinidae (58.7%), with carp being the most frequent species consumed (54.2%). Other families that were relatively common in the diet included Centrarchidae (32.2%), Ictaluridae (21.0%), Catostomidae (18.9%), Moronidae or Sciaenidae (17.5%), and Esocidae (10.5%; Table 6). Crayfish (42.7%), insects (32.2%), and mammals (12.7%) also were common prey items. Amphibians (4.2%) and birds (2.1%) were less frequently occurring prey.

Seasonal comparisons are restricted to comparing spring with fall, because of an inadequate sample size in summer (0 scats) and winter (11 scats). Fish overall, catostomids, cyprinids, and insects occurred more frequently in fall than spring (Table 6). Conversely, white bass or freshwater drum occurred much more frequently in spring. The frequency of occurrence of other prey did not differ among seasons (Table 6).

Among length categories, fish 10.1 – 20.0 cm had the highest relative frequency (33.1%) (Table 3). Fish 20.1 – 30.0 cm (21.2% relative frequency), 30.1 – 40.0 cm (20.8%), and 40.1 – 50.0 cm (14.4%) made up relatively large proportions of the diet, with fish ≤10.0 cm (8.9%), and >50.0 cm (1.7%) comprising small components. The size of fish consumed did not differ between spring and fall in relative frequency or mean prey size ($F_{2,\,233} = 0.11$, $P = 0.892$; Table 3).

Forest River

The diet of river otters on the Forest River was largely comprised of fish (83.3% frequency of occurrence; Table 7). However, crayfish (34.7%), insects (29.4%), birds (15.9%), and amphibians (11.0%) also were common in the diet. Mammals (2.0%) and freshwater mussels (0.4%) were rarely preyed upon. Among fish, cyprinids (mostly carp) were the dominant family, occurring in 74.3% of scats. Catostomids (8.6%) and centrarchids (5.3%) occurred much less frequently than cyprinids, but were the second and third most frequently occurring fish families (Table 7).

The frequency of occurrence of fish ($\chi^2 = 14.3$, 3 df, $P = 0.002$) varied among seasons, although they were the most frequent prey item year round. However, they occurred more often in winter (100%) and fall (93.4%) than spring (73.8%) and summer (79.6%). Similarly, cyprinids, centrarchids, and ictalurids were most frequently consumed in fall (Table 7). The occurrence of crayfish, birds, and amphibians also varied among seasons. Crayfish were most frequent in the diet in summer (42.9%), and were not detected in winter. Birds were most commonly consumed in spring (31.1%), and much less common in other seasons (Table 7). Amphibians were most frequent in the diet during summer (23.7%) and were not detected in fall or winter (Table 7). No seasonal differences were detected in the frequency of occurrence of insects or mammals.

Fish 10.1 – 20.0 cm had the highest relative frequency of fish with estimated sizes (39.1%; Table 4). In order of relative frequency the other size categories were ≤10.0 cm (25.2%), 30.1 – 40.0 cm (13.2%), 20.1 – 30.0 cm (12.4%), 40.1 – 50.0 (6.2%), and >50.0 cm (3.9%). The length of the fish prey of river otters changed seasonally, with spring having a larger mean prey size ($\bar{x}$ = 30.8 cm, SE ± 1.9, n = 54), than summer ($\bar{x}$ = 19.4 cm, SE ± 1.7, n = 77), fall ($\bar{x}$ = 16.1 cm, SE ± 1.0, n = 106), and winter ($\bar{x}$ = 17.9 cm, SE ± 1.7, n = 21) ($F_{3, 254}$ = 17.95, P <0.001). In spring, fish 20.1 – 30.0, 30.1 – 40.0 (which was the most common prey size), 40.1 – 50.0, and >50.0 cm had their respective highest seasonal relative frequencies in the diet. But, in summer fish ≤10.0 cm was the most common size in the diet, and in both fall and winter 10.1 – 20.0 cm was the size category most frequently consumed (Table 4).

Turtle River

Crayfish and fish were the most prominent prey items in the diet of river otters on the Turtle River, occurring in 79.4% and 71.4 % of scats, respectively (Table 8). Other prey included insects (18.7%), mammals (6.0%), amphibians (2.7%), and birds (1.6%). Cyprinid remains occurred in 56.6% of scats, the most of any fish family, and was followed by ictalurids (32.4%), catostomids (14.3%), and percids (8.2%), with other families occurring only rarely (Table 8).

The diet of river otters changed seasonally on the Turtle River (Table 8). Crayfish increased in importance during summer, and there was a corresponding decline in fish consumption. As a result, crayfish surpassed fish (which were the most frequent prey item in spring, fall, and winter) as the most frequently occurring prey item. Cyprinids occurred in similar frequencies in spring (64.3%) and fall (67.0%), but less frequently in summer (30.8%). Ictalurids were much more frequent in fall, and catostomids had a lower frequency of occurrence in summer than other seasons (Table 8). Seasonal variation also was documented for insects, mammals, and amphibians. Insects were common in the diet in spring (28.6%) and fall (24.3%), but rare in summer (1.9%), mammals were only consumed in fall (9.6%), and amphibians occurred in 7.7% of scats in summer, but none in fall (Table 8).

The ≤10.0 cm size category had the highest relative frequency in the diet (46.3%) of river otters on the Turtle River (Table 5). Most of the remaining fish were 10.1 – 20.0 cm (37.2%) in total length (Table 5). The size of consumed fish varied seasonally, with spring having a much larger mean prey length ($\bar{x}$ = 33.4 cm, SE ± 3.3, *n* = 18) than summer ($\bar{x}$ = 13.8 cm, SE ± 4.4, *n* = 12), and fall ($\bar{x}$ = 11.7 cm, SE ± 0.6, *n* = 134) ($F_{2, 161}$ = 51.52, P <0.001). Fish ≤10.0 cm were the primary size category consumed during summer (58.3%) and fall (50.0%), but comprised a much lower proportion of fish consumed in spring (11.1%). In contrast, fish 30.1 – 40.0 cm in total length were not detected in scats collected in summer, and were rare in fall (2.2%), but had the largest relative frequency of any size category in spring (33.3%).

Tongue River

Crayfish were the dominant prey item on the Tongue River, occurring in 96.6% of scats (Table 9). Insects (31.5%), fish (29.2%), and amphibians (10.1%) also were common prey, but birds (2.2%) and mammals (1.1%) were rare in the diet. The most frequently occurring fish family was Ictaluridae (9.0%), and the occurrence of fish was otherwise infrequent (Table 9).

Seasonal comparisons of prey items on the Tongue River were restricted to comparing spring and summer because of an inadequate sample size in fall (8 scats) and winter (0 scats).

The frequencies of insects, fish, and amphibians all differed between spring and summer, with crayfish occurring slightly more often in summer, whereas insects, fish, and amphibians occurred more frequently in spring (Table 9).

Discussion

The food habits of river otters in North Dakota are similar to those reported in studies elsewhere, with fish and crayfish being the primary prey items (e.g., Greer 1955, Melquist and Hornocker 1983, Serfass et al. 1990). For instance, in the primary study areas (Forest, Red, and Turtle rivers), the occurrence of fish ranged from 71.4% to 96.5%, values typical of most previous studies. Nonetheless, there were some results that differed from what would be expected based on previous studies. Fish, for example, occurred in only 29.2% of scats on the Tongue River, with only Grenfell (1974) reporting a lower frequency of occurrence. Crayfish were the most frequent prey item in two study areas (Tongue and Turtle rivers), which has been reported in only a few previous studies (Grenfell 1974, Griess 1987, Noordhuis 2002). Also, birds were relatively frequent in the diet on the Forest River (15.9%), whereas in most previous studies (and in the other study areas in this study) occurrence is <5%.

River otters have been reported to capture prey in proportion to the prey's availability, and inversely with the prey's swimming ability (Ryder 1955). Accordingly, the most important fish in the diet (i.e., cyprinids, ictalurids, catostomids, and centrarchids) are relatively slow swimmers, and were the most numerous fishes (in the same order of importance) in fish sampling we conducted in the Forest and Turtle river study areas (Table 1). Similarly, these fishes are typically reported as the most frequently occurring fishes in the diet of river otters in other studies. However, cyprinids have been reported as the most frequently occurring fish family in relatively few studies (i.e., Wilson 1954, Hamilton 1961, Griess 1987).

Seasonal variation in the diet of river otters likely reflects changes in the availability and vulnerability of prey. This and previous studies have shown fish decreasing in occurrence in summer, with a corresponding increase in the occurrence of crayfish (Tumlison and Karnes 1987, Serfass et al. 1990, Noordhuis 2002, Giordano 2005). Changes in the catchability of fish and crayfish may contribute to this transition in diet. For instance, fish are probably more difficult to capture in summer, because fish swimming speeds increase as water temperature increases (Erlinge 1968, Wardle 1980). Also, and perhaps a greater contributing factor, crayfish activity and overall availability increases in warmer water temperatures, potentially making them more vulnerable to predation in summer (Flint 1977). This shift in the vulnerability of prey likely contributed to the dominance of crayfish (and relative scarcity of fish) in the diet on the Tongue River, because the majority of scats analyzed from the Tongue River were collected in summer.

The breeding season of potential prey likely influences their vulnerability. For example, fish become concentrated during spawning, and therefore are probably more vulnerable to predation. In this study, despite total fish consumption being higher in fall, fish that were consumed relatively rarely (e.g., centrarchids, northern pike, and percids) occurred more often in spring, which is during their spawning period (Lee et al. 1980, Koel and Peterka 2003, Werner 2004). More commonly consumed fishes (i.e., carp, ictalurids, and catostomids) also spawn at this time, but because they are the most abundant fishes in the study area they were consumed relatively frequently throughout the year (Lee et al. 1980, Koel and Peterka 2003, Werner 2004). Similarly, birds and amphibians were consumed most frequently in spring and summer, which corresponds to seasonally high abundance, and with higher activity levels associated with the breeding season. The higher frequency of occurrence of birds in the Forest River study area in comparison to the other study areas and previous studies (only Grenfell (1974) and Gilbert and

Nancekivell (1982) have reported higher) is likely the result of a high abundance of breeding waterfowl in the area.

The fish prey of river otters in eastern North Dakota ranged from 3.5 to 71.0 cm total length, with most being ≤30.0 cm, which is similar to the few previous reports of river otter prey size (Lagler and Ostenson 1942, Greer 1955, Ryder 1955, Hamilton 1961, Melquist and Hornocker 1983, Griess 1987, Giordano 2005). The only other study to thoroughly examine prey size (Giordano 2005) reported similar relative frequencies as this study, including fish 10.1 – 20.0 cm as the most frequent prey size. Also, fish 30.1 – 40.0 cm, 40.1 – 50 cm, and >50.0 cm occurred in similar proportions in both studies. However, Giordano (2005) reported a much lower frequency of fish ≤10.0 cm (10.3%, compared with 24.4% here), and a higher frequency of fish 20.1 – 30.0 cm.

Many factors influence the likelihood that a fish of a particular length will be consumed. In particular, the abundance and species composition of the size class may play an important role. For instance, more abundant size classes of a fish species would suggest greater encounter rates with river otters. Also, if a size class is dominated by slow swimming species it also would be expected to be more vulnerable to predation by river otters (Ryder 1955). Other factors that could influence the likelihood of a fish being taken include its nutritive value, swimming speed, and detectability. Large individual fish have more nutritive value than smaller individuals of the same species, therefore making it more profitable to catch the larger fish, if catchability is similar. But, fish of different sizes likely do have differential catchability, because large fish swim at faster speeds than smaller individuals of the same species (Rowe-Rowe 1977, Videler 1993). Detectability also likely plays a role in determining the size of the fish that a river otter will pursue while foraging. Because of their size, small fish are less readily detectable and therefore may be less likely to be pursued. Furthermore, there are probably more hiding spaces available to small fish seeking refuge from predation, possibly making small fish less available to river otters than what their abundance would suggest. Accordingly, Adrian and Delibes (1987) reported European otters capturing small fish less than expected based on their abundance, and Erlinge (1968) noted captive European otters taking fish ≤10.0 cm with difficulty.

A limitation of using scales to estimate prey size is another possible explanation for the observed relative frequencies. Knowing the actual number of fish of a particular species a scat contains is difficult, because of the wide prediction intervals around fish size estimates. Therefore, remains of multiple individuals occurring in a scat generally could only be differentiated for species that attain large sizes (e.g., carp and northern pike). Consistently underestimating the number of small fish within a scat (i.e., not detecting all fish present) would cause an overall overestimation of mean prey size, and conversely overestimating the number of small fish (i.e., detecting more fish than the actual amount) would lead to an underestimation of mean prey size. In our study, the relative frequency of fish ≤10.0 cm is likely underestimated, leading to an overestimation of the importance of larger size classes and mean prey size. This potential bias also is a reason we partitioned fish prey by size category and portrayed the occurrence of various sizes by relative frequency.

Previous studies on the diet of river otters and European otters have shown that prey size is largest in spring or winter (Erlinge 1968, Carss et al. 1990, Kozena et al. 1992, Dolloff 1993, Giordano 2005). Similarly, in eastern North Dakota, river otters consumed larger prey in spring than in other seasons. The increased vulnerability of large fish during spawning is a potential contributing factor to the observed increase in river otter prey size. Swimming speed also may be an influence on prey selection. Large fish may be more easily captured and handled during periods of colder water because of lowered activity levels (i.e., their metabolism is lowered and swimming speed reduced; Wardle 1980).

Differences in fish prey size among study areas are likely reflections of differences in the composition of fish populations among study sites (e.g., species and age class). For instance, the frequency of occurrence of small cyprinid species was much higher on the Turtle than on the other rivers, and correspondingly the relative frequency of fish ≤10.0 cm was much higher. Similarly, the Turtle River had the smallest occurrence of carp (the most frequently occurring large fish in the study area), and lowest relative frequency of the larger size classes in the river otters' diet.

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Table 1. Seasonal comparison of the food habits of river otters in the Red River drainage of eastern North Dakota, using frequency of occurrence (%) in scats collected July 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 June – 30 August as summer, 1 September – 30 November as fall, and 1 December – 28 February as winter. Bold indicates a significant difference ($P < 0.05$).

Prey Item	Spring (n = 169)	Summer (n = 199)	Fall (n = 275)	Winter (n = 22)	Total (n = 665)	χ^2	*P*
Crayfish	47.3	71.4	55.6	36.4	57.6	27.2	**<0.001**
Insects	33.1	15.6	32.7	18.2	27.2	21.7	**<0.001**
Freshwater Mussels	0.6	0.0	0.0	0.0	0.2	---	---
Amphibians	8.3	14.1	1.5	4.5	7.1	28.6	**<0.001**
Birds	11.8	7.5	4.4	0.0	7.1	10.7	**0.014**
Mammals	4.7	3.5	7.6	4.5	5.6	4.1	0.251
Fish	74.6	56.8	88.4	100	75.8	70.0	**<0.001**
Catostomidae (suckers)	9.5	2.5	18.5	18.2	11.4	31.0	**<0.001**
Catostomus commersoni (white sucker)	6.5	1.5	6.1	4.5	5.1		
Moxostoma sp. (redhorses)	1.2	0.5	7.5	9.1	4.4		
Ictiobus spp. or *Carpiodes cyprinus*	0.6	0.5	2.4	4.5	1.2		
Centrarchidae (sunfish)	14.8	2.0	11.3	31.8	10.1	30.4	**<0.001**
Pomoxis spp. (crappie)	1.8	0.5	2.1	9.1	2.1		
Ambloplites rubestris or *Lepomis* spp.	10.7	1.5	5.9	27.3	6.2		
Unknown centrarchids	3.6	0.0	4.3	4.5	2.9		
Cyprinidae (carp and minnows)	42.6	42.2	73.5	63.6	55.9	62.2	**<0.001**
Cyprinus carpio (carp)	36.7	28.6	67.7	59.1	48.0		
Rhinichthys spp. (dace)	0.6	0.0	0.3	0.0	0.3		
Large non-carp cyprinid[1]	0.6	0.5	1.6	0.0	1.2		
Small cyprinid[2]	0.0	6.5	8.5	4.5	6.0		
Esocidae *Esox lucius* (northern pike)	7.1	1.5	4.0	13.6	4.4	7.4	**0.025**[3]
Hiodontidae (mooneyes)	3.6	1.0	2.2	0.0	2.1	2.8	0.249[3]
Ictaluridae (catfish)	12.4	3.0	31.3	0.0	17.0	74.3	**<0.001**
Percidae (perches)	7.1	1.5	5.8	4.5	4.8	33.7	**<0.001**[3]
Etheostoma spp. or *Percina* spp. (darters)	4.1	0.0	3.2	4.5	2.7		
Perca flavescens or *Sander* spp.	3.6	1.5	3.2	0.0	2.3		
Moronidae/Sciaenidae *Morone chrysops* (white bass) or *Aplodinotus grunniens* (freshwater drum)	11.2	0.5	1.8	9.1	4.1	7.3	0.063

[1] Includes non-carp cyprinids with scale lengths ≥2.50 mm.
[2] Includes cyprinids with scale lengths <2.50 mm, excluding *Cyprinus carpio* and *Rhinichthys* spp.
[3] Comparison excluded winter.

Table 2. Seasonal comparison of total length (cm) categories of fish consumed by river otters in the Red River drainage of eastern North Dakota, July 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 June - 30 August as summer, 1 September - 30 November as fall, and 1 December – 28 February as winter. Bold indicates a significant difference ($P < 0.05$).

Total Length (cm)	Spring (n = 178)	Summer (n = 90)	Fall (n = 362)	Winter (n = 41)	Total (n = 671)	χ^2	P
≤10.0	7.9	45.6	28.7	12.2	24.4	55.1	**<0.001**
10.1 – 20.0	24.7	23.3	44.5	46.3	36.5	29.0	**<0.001**
20.1 – 30.0	24.2	6.7	11.0	17.1	14.3	21.8	**<0.001**
30.1 – 40.0	25.3	12.2	7.7	19.5	13.7	32.4	**<0.001**
40.1 – 50.0	13.5	7.8	6.4	4.9	8.3	8.7	**0.034**
>50.0	4.5	4.4	1.7	0.0	2.7	5.9	0.117

Table 3. Seasonal comparison of total length (cm) categories of fish consumed by river otters on the Red River, North Dakota and Minnesota, October 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 September – 30 November as fall, and 1 December – 28 February as winter. Bold indicates a significant difference ($P < 0.05$).

Total Length (cm)	Spring ($n = 99$)	Fall ($n = 117$)	Winter ($n = 20$)	Total ($n = 236$)	χ^2	P
≤10.0	5.1	11.1	15.0	8.9	3.4	0.180
10.1 – 20.0	32.3	34.2	30.0	33.1	0.2	0.916
20.1 – 30.0	28.3	15.4	20.0	21.2	5.4	0.069
30.1 – 40.0	21.2	19.7	25.0	20.8	0.3	0.853
40.1 – 50.0	10.1	18.8	10.0	14.4	3.6	0.162
>50.0	3.0	0.9	0.0	1.7	1.4	0.237[1]

[1] Comparison excluded winter.

Table 4. Seasonal comparison of total length (cm) categories of fish consumed by river otters on the Forest River, North Dakota, October 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 June – 30 August as summer, 1 September – 30 November as fall, and 1 December – 28 February as winter. Bold indicates a significant difference ($P < 0.05$).

Total Length (cm)	Spring ($n = 54$)	Summer ($n = 77$)	Fall ($n = 106$)	Winter ($n = 21$)	Total ($n = 258$)	χ^2	*P*
≤10.0	9.3	44.2	22.6	9.5	25.2	25.1	**<0.001**
10.1 – 20.0	14.8	20.8	60.4	61.9	39.1	49.0	**<0.001**
20.1 – 30.0	20.4	7.8	11.3	14.3	12.4	4.9	0.184
30.1 – 40.0	33.3	14.3	1.9	14.3	13.2	31.1	**<0.001**
40.1 – 50.0	14.8	9.1	0.9	0.0	6.2	14.4	**0.002**
>50.0	7.4	3.9	2.8	0.0	3.9	1.9	0.390[1]

[1] Comparison excluded winter.

Table 5. Seasonal comparison of total length (cm) categories of fish consumed by river otters on the Turtle River, North Dakota, October 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 June – 30 August as summer, and 1 September – 30 November as fall. Bold indicates a significant difference (*P* < 0.05).

Total Length (cm)	Spring (*n* = 18)	Summer (*n* = 12)	Fall (*n* = 134)	Total (*n* = 164)	χ^2	*P*
≤10	11.1	58.3	50.0	46.3	10.4	**0.006**
10.1 – 20	11.1	33.3	41.0	37.2	6.2	**0.046**
20.1 – 30	11.1	0.0	6.7	6.7	0.5	0.499[1]
30.1 – 40	33.3	0.0	2.2	5.5	27.5	**<0.001[1]**
40.1 – 50	27.8	0.0	0.0	3.0	---	---
>50	5.6	8.3	0.0	1.2	---	---

[1] Comparison excluded summer.

Table 6. Seasonal comparison of the food habits of river otters on the Red River, North Dakota and Minnesota, using frequency of occurrence (%) in scats collected October 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 September – 30 November as fall, and 1 December – 28 February as winter. Bold indicates a significant difference (P < 0.05). The statistical comparisons were between only spring and fall.

Prey Item	Spring (*n* = 58)	Fall (*n* = 73)	Winter (*n* = 11)	Total (*n* =142)	χ^2	*P*
Crayfish	44.8	38.4	63.6	42.7	0.6	0.455
Insects	24.1	42.5	9.1	32.2	4.8	**0.028**
Amphibians	1.7	5.5	9.1	4.2	1.2	0.265
Birds	1.7	2.7	0.0	2.1	0.6	0.438
Mammals	13.8	12.3	9.1	12.7	0.1	0.804
Fish	93.1	100	100	96.5	5.2	**0.023**
Catostomidae (suckers)	10.3	28.8	0.0	18.9	6.7	**0.010**
Centrarchidae (sunfish)	39.7	26.0	36.4	32.2	2.8	0.097
Cyprinidae (minnows)	39.7	76.7	45.5	58.7	18.5	**<0.001**
Esocidae *Esox lucius* (northern pike)	10.3	8.2	27.3	10.5	0.2	0.675
Hiodontidae (mooneyes)	5.2	6.8	0.0	5.6	0.2	0.691
Ictaluridae (catfish)	19.0	24.7	9.1	21.0	0.6	0.436
Percidae (perches)	6.9	2.7	9.1	4.9	1.3	0.258
Moronidae/Sciaenidae *Morone chrysops* (white bass) or *Aplodinotus grunniens* (freshwater drum)	32.8	6.8	9.1	17.5	14.5	**<0.001**

Table 7. Seasonal comparison of the food habits of river otters on the Forest River, North Dakota, using frequency of occurrence (%) in scats collected October 2006 - November 2007. Scats collected 1 March – 31 May were considered as spring, 1 June – 30 August as summer, 1 September – 30 November as fall, and 1 December – 28 February as winter. Bold indicates a significant difference ($P < 0.05$).

Prey Item	Spring ($n = 61$)	Summer ($n = 98$)	Fall ($n = 76$)	Winter ($n = 10$)	Total ($n = 45$)	χ^2	P
Crayfish	26.2	42.9	35.5	0.0	34.7	10.1	**0.017**
Insects	29.5	27.6	32.9	20.0	29.4	1.0	0.793
Amphibians	6.6	23.5	0.0	0.0	11.0	27.4	**<0.001**
Birds	31.1	12.2	10.5	0.0	15.9	15.1	**0.002**
Mammals	0.0	4.1	1.3	0.0	2.0	2.5	0.284[1]
Fish	73.8	79.6	93.4	100	83.3	14.3	**0.002**
Catostomidae (suckers)	9.8	3.1	10.5	40.0	8.6	4.4	0.112[1]
Centrarchidae (sunfish)	0.0	2.0	10.5	30.0	5.3	11.2	**0.004**[1]
Cyprinidae (minnows)	63.9	69.4	88.2	80.0	74.3	14.1	**0.003**
Esocidae *Esox lucius* (northern pike)	1.6	3.1	6.6	0.0	3.7	2.5	0.285[1]
Hiodontidae (mooneyes)	1.6	0.0	1.3	0.0	0.8	---	---
Ictaluridae (catfish)	3.3	0.0	11.8	0.0	4.5	13.8	**0.001**[1]
Percidae (perches)	4.9	1.0	2.6	0.0	2.4	2.3	0.317[1]
Moronidae/Sciaenidae *Morone chrysops* (white bass) or *Aplodinotus grunniens* (freshwater drum)	0.0	1.0	0.0	10.0	0.8	---	---

[1] Comparison excluded winter.

Table 8. Seasonal comparison of the food habits of river otters on the Turtle River, North Dakota, using frequency of occurrence (%) in scats collected October 2006 – November 2007. Scats collected 1 March – 31 May were considered as spring, 1 June – 30 August as summer, and 1 September – 30 November as fall. Bold indicates a significant difference ($P < 0.05$).

Prey Item	Spring ($n = 14$)	Summer ($n = 52$)	Fall ($n = 115$)	Total[1] ($n = 182$)	χ^2	P
Crayfish	42.9	98.1	75.7	79.7	23.6	**<0.001**
Insects	28.6	1.9	24.3	18.7	13.2	**0.001**
Amphibians	7.1	7.7	0.0	2.7	9.1	**0.003**[2]
Birds	0.0	1.9	1.7	1.6	---	---
Mammals	0.0	0.0	9.6	6.0	5.3	**0.021**[2]
Fish	85.7	44.2	81.7	71.4	26.2	**<0.001**
Catostomidae (suckers)	21.4	3.8	18.3	14.3	6.7	**0.036**
Centrarchidae (sunfish)	14.3	1.9	0.0	2.7	---	---
Cyprinidae (minnows)	64.3	30.8	67.0	56.6	28.8	**<0.001**
Esocidae *Esox lucius* (northern pike)	28.6	0.0	0.0	2.2	---	---
Hiodontidae (mooneyes)	7.1	3.8	0.0	1.6	---	---
Ictaluridae (catfish)	7.1	1.9	49.6	32.4	42.8	**<0.001**
Percidae (perches)	7.1	3.8	10.4	8.2	3.3	0.189

[1] Includes 1 scat from winter.
[2] Comparison excluded spring.

Table 9. Seasonal comparison of the food habits of river otters on the Tongue River, North Dakota, using frequency of occurrence (%) in scats collected May 2007 – October 2007. Scats collected 1 March – 31 May were considered as spring, 1 June – 30 August as summer, and 1 September – 30 November as fall. Bold indicates a significant difference ($P < 0.05$). The statistical comparisons were between only spring and summer.

Prey Item	Spring (n = 35)	Summer (n = 46)	Fall (n = 8)	Total (n = 89)	χ^2	P
Crayfish	91.4	100	100	96.6	4.1	**0.043**
Insects	57.1	6.5	62.5	31.5	25.1	<**0.001**
Amphibians	22.9	2.2	0.0	10.1	8.6	**0.003**
Birds	0.0	4.3	0.0	2.2	---	---
Mammals	0.0	2.2	0.0	1.1	---	---
Fish	40.0	19.6	37.5	29.2	4.1	**0.043**
Catostomidae (suckers)	2.9	0.0	12.5	2.2	---	---
Centrarchidae (sunfish)	0.0	2.2	25.0	3.4	---	---
Esocidae *Esox lucius* (northern pike)	2.9	0.0	0.0	1.1	---	---
Ictaluridae (catfish)	17.1	4.3	0.0	9.0	3.7	0.056
Percidae (perches)	8.6	0.0	0.0	3.4	4.1	**0.043**

Figure 1. Map of North Dakota showing the Red River and its tributaries in eastern North Dakota. The stars indicate the location of the four study areas used in the analysis of river otter food habits conducted July 2006 – November 2007.

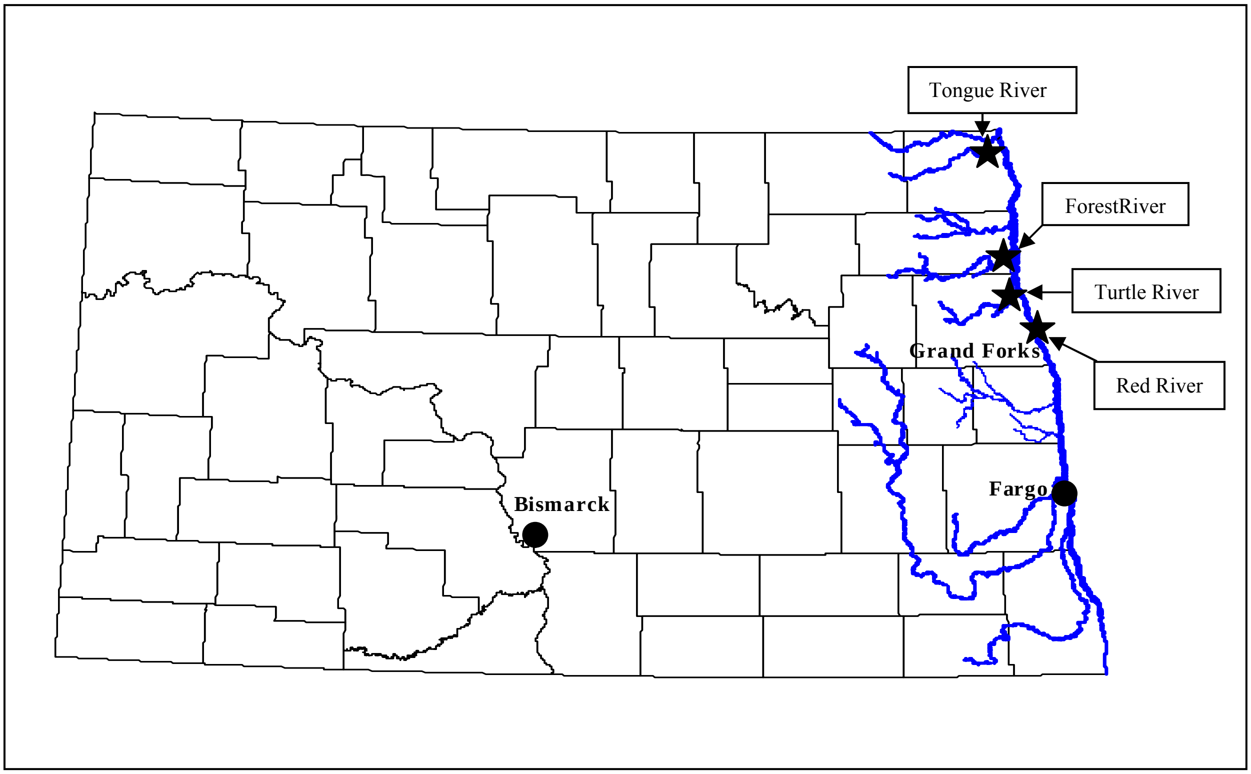


Figure 2. Seasonal variation in the frequency of occurrence of the most common prey items in the diet of river otters in the Red River drainage of eastern North Dakota, July 2006 – November 2007.

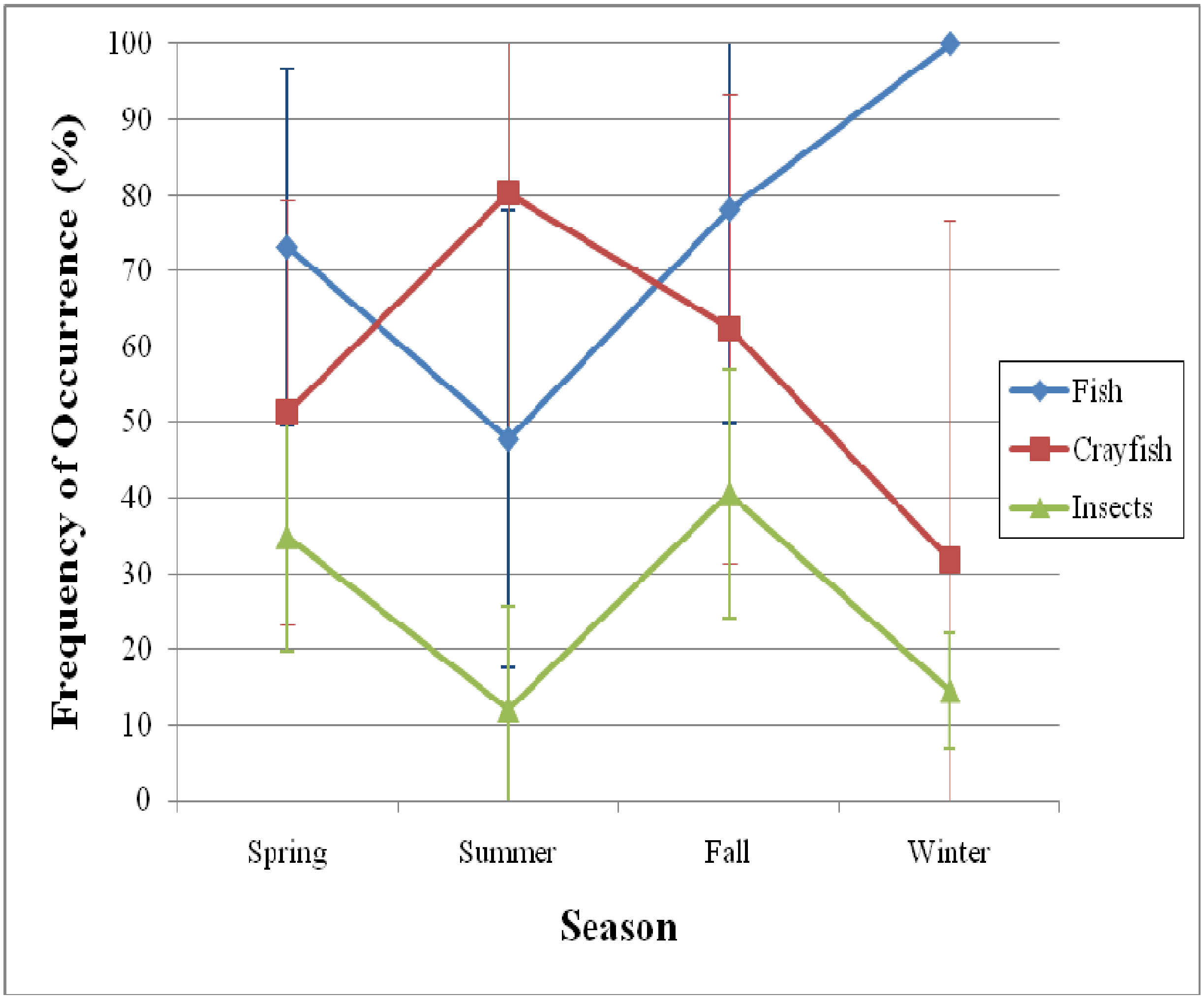


Figure 3. Seasonality of mean prey length of four fish groups in the diet of river otters in the Red River drainage of eastern North Dakota, July 2006 – November 2007.

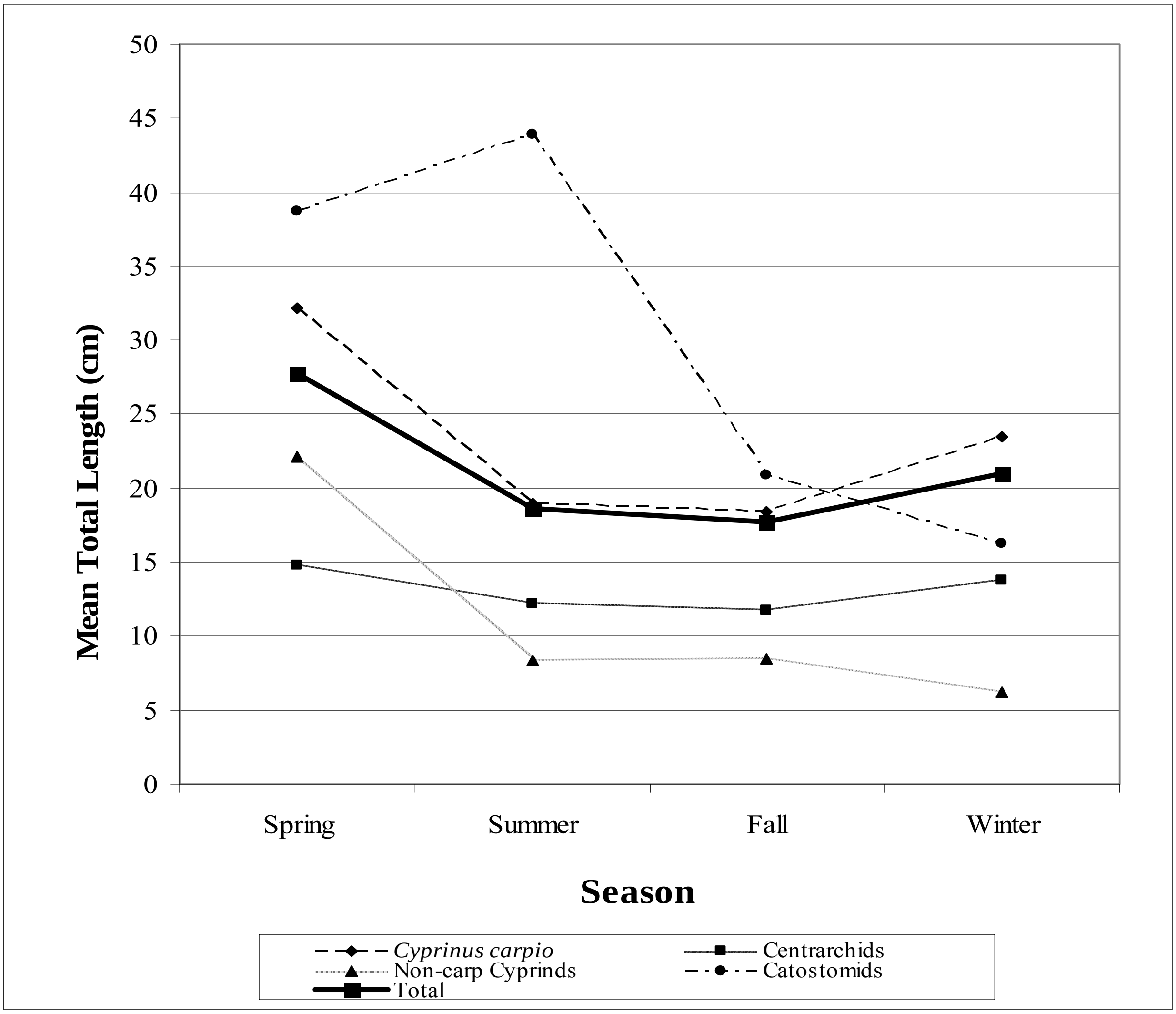
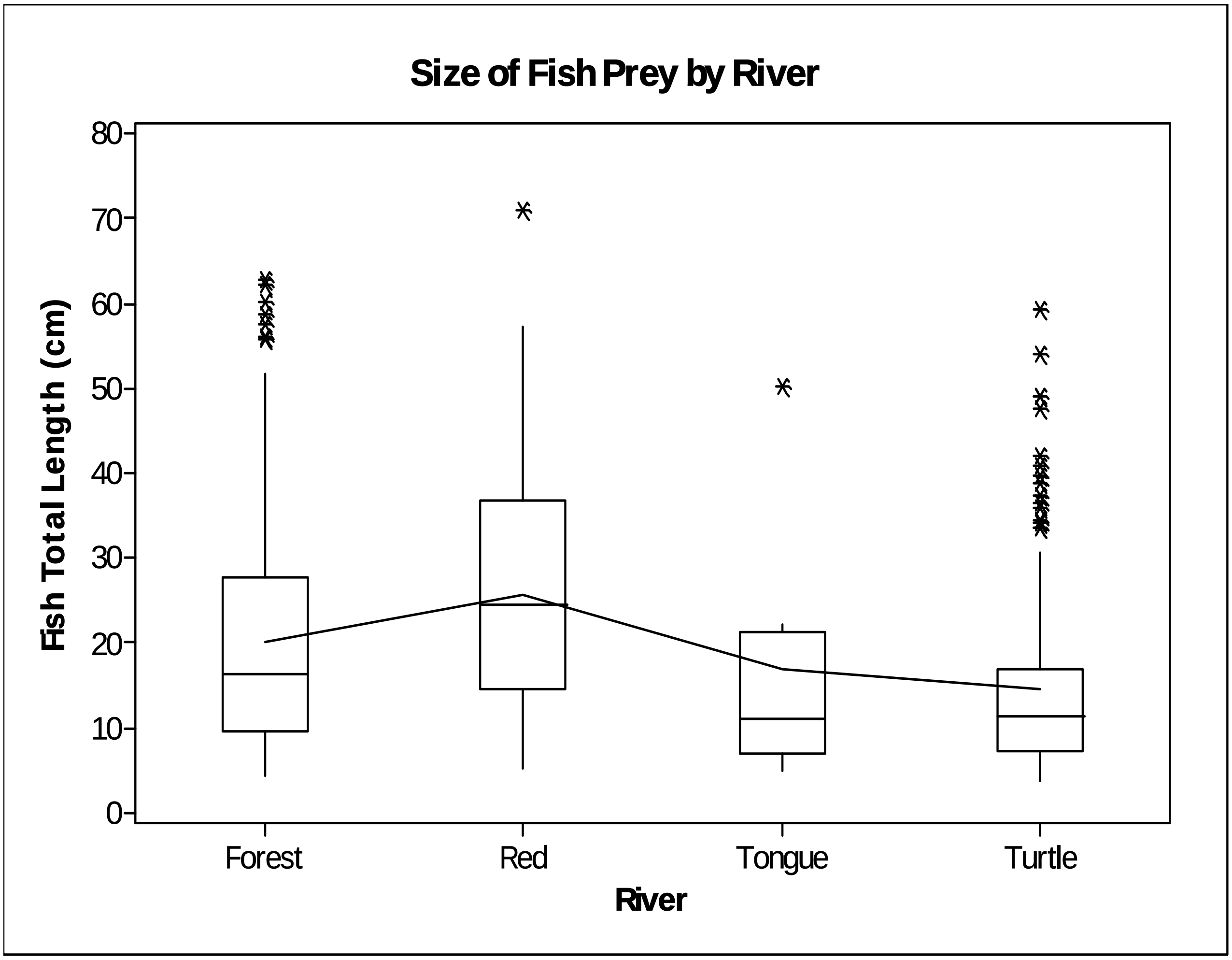


Figure 4. Comparison of the size of fish prey of river otters among rivers in the Red River drainage of eastern North Dakota, July 2006 – November 2007. The line connects mean prey size.



CHAPTER 3

The Use of Scales to Estimate the Size of the Fish Prey of Nearctic River Otters (*Lontra canadensis*)

Abstract

Estimating the size of the fish prey of nearctic river otters (*Lontra canadensis*) requires the use of relationships between the size of hard anatomical fish structures (recovered in scats or digestive tracts) and fish length. We evaluated the applicability of scales for estimating the size of fish prey of otters from tributaries of the Red River in eastern North Dakota. We conducted a linear regression analysis of scale size and fish length for 22 species and six multi-species groups. Analyses included six scale measurements and separate models were constructed for lateral line and non-lateral line (random) scales. Single and multiple regression models were considered and the best models were determined by maximizing the adjusted coefficient of determination (r^2) and maintaining the simplicity of the model. Our findings suggested scales were effective anatomical structures for estimating the size of fish prey. Positive relationships existed between a single scale dimension and fish length in most (42 of 44) single species models; body-scale relationships also existed when including multiple species in a model. Multi-variable models usually had higher adjusted R^2 than single variable models but improvements by including >1 variable were small. Typically, lateral line scales produced better relationships than random scales, and overall, scale length and height were the best scale measurements for estimating fish length. Limitations of using scales for estimating the size of fish prey of river otters included the fact that not all fish prey possessed scales and that multiple small cyprinid individuals could not be distinguished within a scat using scales.

Introduction

Estimating the size of fish consumed by nearctic river otters (*Lontra canadensis*) requires the use of relationships between the size of hard anatomical fish remains (recovered from scats or digestive tracts) and fish length. These positive relationships result from growth of the structures as the fish grow in length (Lagler 1956, Daniels 1996). Previous studies of the European otter (*Lutra lutra*) used relationships between fish length and the dimensions of vertebrae to estimate prey length (Wise 1980, Adrian and Delibes 1987, Carss et al. 1990, Kemenes and Nechay 1990). Scales also have been used to estimate prey size of the European otter (Kozena et al. 1992). Other structures that have been suggested include cleithra, jaw bones (i.e., dentary, premaxillary, and maxilla), pectoral spines, pharyngeal teeth, opercula, and otoliths (Hamilton 1961, Hansel et al. 1988, Prenda and Granado-Lorencio 1992, Dellinger and Trillmich 1999, Granadeiro and Silva 2000, Noordhuis 2002, Copp and Kovac 2003, Hajkova et al. 2003, Ross et al. 2005). However, there are disadvantages to using most of these structures for estimating prey size. In the case of vertebrae, otoliths, and other bony structures, the fish must be sacrificed and dissected for predictive relationships can be established. Additionally, potential breakage or other degradation as vertebrae or other bones pass through the digestive system could reduce effectiveness of size estimation (Carss and Nelson 1998). Moreover, using structures associated with the heads or vertebrae of larger fish could result in an underestimation of prey size because otters may not consume the heads of larger fish (Erlinge 1968, Rowe-Rowe 1977). A further complication of using vertebrae is that the size of vertebrae within a fish differs among regions along the vertebral column (Wise 1980). Therefore, specific vertebrae may be required for size estimation, but determining the region of origin of vertebrae is complicated and time consuming. Conversely, using scales may be less complicated and more efficient for estimating prey size than developing models from other anatomical structures. A particular advantage is the ability to collect samples without killing fish. Scales easily can be removed from fish that are captured alive and subsequently the fish can be released. Another advantage is that keys for identifying scales to the family level are available (Daniels 1996). While scales vary by shape and size over the body of an individual fish, resulting in criticism of their use for size estimation (Phillips 1948, Joeris 1956, Scarnecchia 1979, Wise 1980, Daniels 1996, Miranda and Escala 2007, Roberts et al. 2007), lateral line scales are easily distinguished from other scales by a pore or line on the scale (Daniels 1996, Roberts et al. 2007). Therefore, constructing regression models using dimensions of lateral line scales may reduce the amount of variation in the model and thereby, provide more precise estimates of prey size. We evaluated the applicability of scales for estimating the size of fish prey by conducting a linear regression analysis of scale size and fish length for 22 species and six multi-species groups from tributaries of the Red River in eastern North Dakota.

Study Area

The Red River of the North forms at the convergence of the Bois de Sioux River and the Ottertail River at Wahpeton, North Dakota and Brackenridge, Minnesota. The river flows north forming the boundary between North Dakota and Minnesota for nearly 640 km before entering Manitoba, Canada (Koel and Peterka 1998). The landscape of the Red River drainage has low relief, and mostly occurs within the former lake bed of Lake Agassiz (Eddy et al. 1972, Stoner et al. 1993). The majority (80%) of the Red River valley is cropland, but pasture also occurs, and forested regions mostly are confined to riparian strips (Stoner et al. 1993). Riparian areas consist of strips of grass or trees. But, in some areas agricultural fields extend to the river banks (Stoner et al. 1993). The Red River has ten major tributaries in North Dakota which are all similar in appearance, typically having low gradients, frequent meanders, and high turbidity (Copes and Tubb 1966, Stoner et al. 1993). Samples were obtained from most of the tributaries, although the majority of samples were obtained from the Forest and Turtle Rivers.

Methods

Scale samples were collected 12 June 2007 – 16 August 2007 in collaboration with researchers from South Dakota State University during surveys of fish communities in the North Dakota tributaries of the Red River. Sampling was conducted using a backpack electrofishing unit, seine, and cloverleaf and minnow traps. From 28 September to 2 November 2007 additional scale samples were obtained during sampling we conducted using fyke nets and minnow traps in the Forest and Turtle Rivers and associated wetlands. The total length (from snout to the tip of the tail) of each fish was recorded following its capture. Ten equal-sized regions were visually imposed down the length of the fish, and a random lateral line scale was taken from one of the regions. Then, ten regions were visually imposed along the height of the fish on top of the length regions, thereby forming a 10 x 10 grid over the fish. Thereafter, a random non-lateral line scale (hereafter called random scales) was selected from one cell within the grid. After collection, six scale measurements (length, height, diagonal, anterior radius, posterior radius, and antero- or posterolateral radius) were taken using calipers accurate to 0.01 mm (Figure 1). An anterolateral radius was measured for most species. However, a posterolateral radius was measured for cyprinids other than carp (*Cyprinus carpio*).

From fish length and scale measurements a linear regression analysis was performed (Minitab Version 14, Minitab Inc., State College, Pennslvania) to determine if a linear relationship existed between fish length and scale size for each species. The analysis included 22 species that included ≥10 lateral line and random scale samples (most contained 20 – 40), and single and multiple regression models were constructed independently for both scale types. The best models for each species were determined by maximizing the adjusted coefficient of determination (r^2 for single variables models, R^2 for multivariable models) while maintaining simplicity of the model. For single variable models, the mean adjusted r^2 of the best lateral line and random models (averaging across the 22 species) was compared using a paired t-test.

For species that could not reliably be distinguished by the morphology of their scales, multi-species models were constructed. In such models, all samples collected from each of the species in the group were included. Therefore, multi-species models included samples from species that were evaluated individually, and from species that lacked adequate sample sizes to be analyzed independently. Sample sizes varied for each species, and were not standardized before constructing models.

In a companion study (Chapter 2; Stearns 2008), food habits of otters in eastern North Dakota were evaluated using scat analysis with the size of the fish prey being estimated using the body-scale relationships established here. To assess the utility of using scales for size estimation, the proportion of scats containing scales usable for size estimation was determined. For comparison, the proportion of scats with pharyngeal teeth was determined for scats containing catostomid (sucker) and cyprinid (carp and minnow) remains. The ability to distinguish multiple individuals of a particular species (or group) within a scat was assessed by using 95% prediction intervals of fish length based on the size of scales within the scat. Also, to evaluate if lateral line scales alone could be used for prey size estimation, the proportion of length estimates obtained using lateral line scales was calculated.

Results

For most individual species positive relationships existed between a single scale dimension and fish total length using lateral line and random scales (Table 1). Generally, relationships had high r^2 values, with 28 of 44 of the best (the lateral line and random model with the highest r^2 for each species) single variable models having adjusted $r^2 \geq 0.70$ (Table 1). Using lateral line scales, the best model for all 22 species was significant, with adjusted r^2 ranging from 0.264 for sand shiners (*Notropis ludibundus*) to 0.994 for bluegill (*Lepomis macrochirus*) (Table 1). The best random scale model was significant for 20 of 22 species, with adjusted r^2 ranging from 0.061 to 0.954 for largescale stonerollers (*Campostoma oligolepis*) and freshwater drum (*Aplodinotus grunniens*), respectively (Table 1). Lateral line models usually were better estimators of fish total length than random models, with 20 of 22 species having higher adjusted r^2 for the best lateral line model than the best random model (Table 1). The mean adjusted r^2 of the best single variable lateral line models (averaging across the 22 species) ($\bar{x}$ = 0.825, SE = 0.038, n = 22) was significantly higher than that for the best random models ($\bar{x}$ = 0.651, SE = 0.055, n = 22) (paired t_{21} = 4.94, P < 0.001).

For most species specific models, including >1 variable increased the adjusted R^2 in comparison with single variable models. The maximum adjusted R^2 was attained for most models (33 of 44) by including 2 – 4 variables. However, because the variables were highly correlated, in most cases there was not a substantial increase in adjusted R^2 by adding variables to the model. Only eight (four lateral line and four random) of the 44 models improved ≥0.05 in adjusted R^2 by including >1 variable. Because many of the models improved little, the mean improvement by using >1 variable was 0.027 (SE = 0.01, n = 22) and 0.042 (SE = 0.01, n = 22) for lateral line and random models, respectively.

Positive relationships did exist when including multiple species in a model (Table 2). Usually, the r^2 of a multi-species model was slightly lower than that of the species in the group with the lowest individual r^2 (Tables 1 and 2). However, for some groups (e.g., centrarchids) r^2 still was high. As with single species models, lateral line scales on average provided significantly better models than random scales (paired T_5 = 2.89, P = 0.035). Also, including >1 variable yielded little improvement in adjusted R^2 ($\bar{x}$ = 0.026, SE = 0.010, n = 6; $\bar{x}$ = 0.027, SE = 0.015, n = 6, for lateral line and random models, respectively).

Scale length was the measurement that resulted in the highest mean adjusted r^2 using both lateral line ($\bar{x}$ = 0.774, SE = 0.05, n = 22) and random ($\bar{x}$ = 0.595, SE = 0.06, n = 22) scales, and provided the best fit for nine species using lateral line scales, the most of any measurement

(Tables 1 and 3). However, scale height provided the best fit for the most species (eight) using random scales (Table 1). The majority of multi-species groups attained their best fit using scale length for lateral line models (Table 2). Random scale multi-species models reached their maximum r^2 using the length, height, or posterior radius measurement (Table 2). For regression coefficients of all models, correlations between variables, and other analyses refer to Stearns (2008).

In the companion river otter diet study, 88.2% of scats (n = 504) containing fish remains (and lacking ictalurid remains, which lack scales) contained scales usable for fish size estimation. Of scats containing catostomid remains (n = 76) 97.4% contained usable scales, whereas only 23.7% contained pharyngeal teeth. Usable scales were included in 92.2% of scats with cyprinid remains (n = 372), and only 40.0% contained pharyngeal teeth. Using 95% prediction intervals of fish length based on the size of scales sorted from scats, multiple fish of the same species (or group) were detected in 71 (out of 665) scats (66 with two individuals, and five with three individuals). Lateral line scales were used to estimate 57.0% of fish for which size estimation was possible (n = 671), with the remainder being estimated using random scales.

Discussion

The body-scale relationship is well known in fisheries literature, so it was not surprising that there were positive relationships (in most cases) between scale size and fish total length (Whitney and Carlander 1956, Hile 1970, Carlander 1982, Francis 1990, Pierce et al. 1996). However, while other studies typically reported r^2 >0.85 (Pierce et al. 1996, Giordano 2005, Miranda and Escala 2007), for many species in this study values were lower (particularly using random scales). This could be due to the fact that in previous studies scales typically were taken from a specific location (e.g., at the tip of the pectoral fin when it is flattened against the body) on the fish to minimize variation, thereby maximizing r^2 (Regier 1962, Scarnecchia 1979, Carlander 1982, Pierce et al. 1996). But, since scales vary in size and shape over the body of the fish, and the exact location on the body where the scale originated can't be determined from the scale itself, this method would inaccurately estimate the size of fish prey (Phillips 1948, Joeris 1956, Scarnecchia 1979, Daniels 1996, Roberts et al. 2007). Therefore, predictive relationships need to be established using scale samples from the entire body. This study documented that at least in most cases there still were positive relationships between scale size and fish total length. Furthermore, constructing models using only lateral line scales restricts the area from which scales are selected. As a result, lateral line models have higher r^2 than random models, and thereby provide more precise estimates of prey size (Tables 1 and 2). Therefore, when available lateral line scales should be used (when possible) to estimate the size of fish prey.

Using multi-variable models typically resulted in higher adjusted R^2 values than single variable models, suggesting that using more than one scale measurement would provide more precise fish size estimation. However, the variables were highly correlated, causing improvements by including additional variables to be small (≤0.05 in adjusted R^2). Because there were not substantial improvements in predictive capabilities by including >1 variable, to maintain simplicity, and for time efficiency, using single variable models are preferable for prey size estimation.

In general, the best scale measurement for estimating fish size was scale length. Accordingly, length was the most frequently used measurement used, and in some cases, the best scale measurement reported in other studies (Daniels 1996, Pierce et al. 1996, Giordano 2005, Miranda and Escala 2007). Scale height also was a good measurement for estimating prey size for many species, and previously has been shown to be a better measurement than scale length for white suckers (*Catostomus commersoni*; Giordano 2005). However, for single species models height, on average, was only the third best estimator using lateral line scales and fourth using random scales (Table 3). The low mean r^2 for scale height was the result of it being generally a poor predictor of fish length for cyprinids [except for dace (*Rhinichthys* spp.) for which it was a good predictor]. Thus, while scale length and height usually were the best measurements and the easiest to measure, because the variable that resulted in the best model varied by species (and group) several measurements would ensure that the most precise measurement was used for prey size estimation.

The companion river otter diet study revealed that scales were the most numerous fish remains in scats, far outnumbering pharyngeal teeth (Stearns 2008). The frequency of vertebrae (and other structures) was not determined but they clearly were not as common as scales (though vertebrae may have been more common than pharyngeal teeth). Regardless of the abundance of scales, many lacked lateral line scales. Therefore, models using non-lateral line scales need to be constructed and used extensively to thoroughly evaluate prey size.

Despite its advantages, using scales for estimating the size of fish prey of otters and other piscivores had limitations. Perhaps the largest limitation was that not all fish possessed scales. Ictalurids lack scales and commonly are reported as prey in otter diet studies (Field 1970, Serfass et al. 1990, Noordhuis 2002, Giordano 2005, Stearns 2008). Therefore, by only using scales for size estimation, the size of some fish in the diet (occasionally a large portion) can not be evaluated. The utility of other structures should be assessed for size estimation of ictalurids and other species that lack scales. For example, pectoral spines are distinct from other fish structures and previously have been reported to have a relationship with fish length (Klaasen and Townsend 1973). Another limitation of using scales was that it is difficult to determine the actual number of fish consumed. Occasionally, it was possible to document multiple individuals of the same species (or group) within a scat by having non-overlapping 95% prediction intervals of fish size based on the size of scales in the scat. When foraging, piscivores probably are more likely to consume multiple small fish than multiple large individuals. But, since predicted lengths need to be several centimeters apart to separate individual fish, multiple individuals of small fish species could not be differentiated. For example, multiple small cyprinid individuals could not be distinguished within a scat using scales. But, remains of at least 25 individuals were documented in one scat based upon the number of pharyngeal teeth it contained.

This study documented the utility of scales for estimating the prey size of river otters and other piscivores. However, further research on assessing prey size using scales is needed in several areas. First, more research should be conducted on body-scale relationships to evaluate relationships for species and groups (e.g., salmonids) that were not evaluated in this study. Additionally, because the sample size and size range for some species was limited (e.g., largescale stonerollers, and sand shiners) these species should be re-assessed to determine if our results were typical. Secondly, further study is needed in scale identification. Currently, scales can be identified to at least the family level (in most cases). But, because single species models produce better body-scale relationships than multi-species models, the ability to distinguish between additional species would allow for more precise estimates of prey size. Finally, future studies are needed to determine if body-scale relationships are affected by passage through the digestive system. In passage, scales may become degraded, potentially completely. Therefore, research is needed to determine if scale size changes in passage and if some scales become more degraded than others (i.e., scales of large fish passing through, but smaller scales being digested). However, because of their abundance in scats, the existence of identification keys to the family level, the positive relationships between scale size and fish length, and the noninvasive method of establishing predictive relationships, scales were the structure best suited for use in fish prey size estimation.

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Table 1. The adjusted coefficient of determination of the best single variable (r^2) and overall model (R^2) of body-scale relationships for 22 fish species in tributaries of the Red River in eastern North Dakota using samples collected June – November 2007, by scale type. Variables include: A = anterior radius, B = anterolateral radius, C = posterolateral radius, D = diagonal, H = height, L = length, P = posterior radius. *Indicates an insignificant relationship. For regression coefficients refer to Stearns (2008).

	Tot. Length Range (cm)	Lateral Line					Random				
			Single		Overall			Single		Overall	
		n	Var.	r^2	Var.	R^2	*n*	Var.	r^2	Var.	R^2
Catostomidae											
Shorthead Redhorse (*Moxostoma macrolepidotum*)	7.1-24.6	16	P	0.840	A H L	0.882	15	P	0.873	A D L P	0.923
White Sucker (*Catostomus commersoni*)	6.4-44.9	82	D	0.902	A B H L P	0.912	84	H	0.815	A B D H L	0.839
Centrarchidae											
Black Crappie (*Poxomis nigromaculatus*)	2.9-18.3	18	H	0.979	B H P	0.980	16	L	0.933	D H L	0.938
Bluegill (*Lepomis macrochirus*)	4.4-21.0	29	D	0.994	B D	0.995	28	L	0.954	A B D H L	0.987
Cyprinidae											
Bigmouth Shiner (*Notropis dorsalis*)	4.7-7.3	22	P	0.541	C L	0.562	26	C	0.531	C D L P	0.573
Blacknose Dace (*Rhinichthys atratulus*)	3.5-9.4	21	H	0.611	A C H L	0.628	26	H	0.645	H	0.645
Bluntnose Minnow (*Pimephales notatus*)	2.7-8.6	35	L	0.786	H L	0.851	37	C	0.642	D H L	0.670
Carp (*Cyprinus carpio*)	3.0-68.9	125	L	0.963	All	0.971	128	L	0.914	All	0.944
Common Shiner (*Luxilus cornutus*)	3.3-16.8	64	L	0.957	A L P	0.958	56	P	0.608	A D L	0.688
Creek Chub (*Semotilus atromaculatus*)	3.5-23.7	59	L	0.941	D H L P	0.948	64	C	0.778	C	0.778
Fathead Minnow (*Pimephales promelas*)	3.4-7.4	13	C	0.932	C L	0.933	21	D	0.594	D L P	0.621
Horneyhead Chub (*Nocomis biguttatus*)	3.2-15.8	43	L	0.964	All	0.972	48	H	0.856	C H	0.864
Largescale Stoneroller (*Campostoma oligolepis*)	8.9-12.9	13	H	0.684	A H L P	0.865	13	H	0.061*	H L	0.322*
Longnose Dace (*Rhinichthys cataractae*)	5.8-10.9	18	H	0.734	A C H	0.752	17	C	0.355	C D L	0.378
Sand Shiner (*Notropis ludibundus*)	4.8-7.5	15	P	0.264	D H L P	0.318	19	C	0.085*	D H	0.128*
Spotfin Shiner (*Cyprinella spiloptera*)	5.3-8.6	17	L	0.787	L	0.787	14	L	0.563	H P	0.606
Esocidae											
Northern Pike (*Esox lucius*)	13.2-55.0	39	H	0.951	B D H L	0.971	44	L	0.774	A D H L	0.816
Moronidae											
White Bass (*Morone chrysops*)	5.8-15.3	25	H	0.949	B H L P	0.963	30	H	0.817	B D H L P	0.863
Percidae											
Blackside Darter (*Percina maculata*)	3.4-9.0	44	L	0.868	A B H L	0.873	43	H	0.463	H P	0.485
Johnny Darter (*Etheostoma vitreum*)	2.6-7.3	36	L	0.726	A H P	0.809	55	H	0.429	B H L P	0.485

Table 1. (cont.)

		Lateral Line					Random				
		Single			Overall		Single			Overall	
		n	Var.	r^2	Var.	R^2	*n*	Var.	r^2	Var.	R^2
Yellow Perch (*Perca flavescens*)	6.5-21.9	43	L	0.793	D P	0.816	44	L	0.679	D L	0.716
Sciaenidae											
Freshwater Drum (*Aplodinotus grunniens*)	3.6-43.5	10	P	0.988	A D L P	0.995	12	H	0.954	A B D	0.976
Mean				0.825		0.852			0.651		0.693

Table 2. The adjusted coefficient of determination of the best single variable (r^2) and overall model (R^2) of body-scale relationships for six multi-species groups of fish in tributaries of the Red River of eastern North Dakota using samples collected June – November 2007, by scale type. Variables include: A = anterior radius, B = anterolateral radius, C = posterolateral radius, D = diagonal, H = height, L = length, P = posterior radius. *Indicates an insignificant relationship. For regression coefficients refer to Stearns (2008).

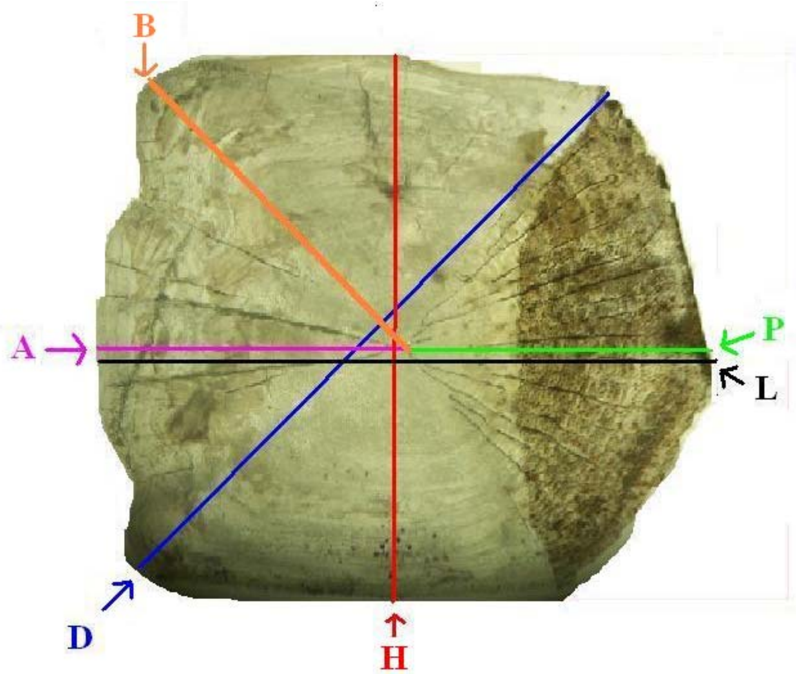
Lateral Line				Random			
Single		Overall		Single		Overall	
Variable	r^2	Variables	R^2	Variable	r^2	Variables	R^2
Centrarchidae[1]							
H	0.975	B H L	0.978	L	0.916	B L	0.944
Cyprinidae							
Dace: Blacknose Dace (*Rhinichthys atratulus*) and Longnose Dace (*Rhinichthys cataractae*)							
D	0.582	H P	0.647	H	0.521	C H	0.535
Large (>10 cm) Cyprinids, excluding Carp (*Cyprinus carpio*) and Dace (*Rhinichthys* spp.)[2]							
L	0.480	A H P	0.516	L	0.274	A D H P	0.291
Small (≤10 cm) Cyprinids, excluding Carp and Dace[3]							
L	0.549	A B D H L	0.582	P	0.353	P	0.353
Moronidae/Sciaenidae							
White Bass (*Morone chrysops*) and Freshwater Drum (*Aplodinotus grunniens*)							
L	0.979	A B D H P	0.984	H	0.930	D H	0.934
Percidae							
Darters: Blackside Darters (*Percina maculata*) and Johnny Darter (*Etheostoma vitreum*)							
L	0.802	A H L P	0.817	P	0.399	B L P	0.499
Mean	**0.728**		**0.754**		**0.566**		**0.593**

[1, 2, 3] Includes species evaluated individually (Table 1) and:
[1] Green sunfish (*Lepomis cyanellus*, $n_{LL} = 1$, $n_R = 1$), orangespotted sunfish (*Lepomis humilis*, $n_{LL} = 4$, $n_R = 4$), and rock bass (*Amploplites rupestris*, $n_{LL} = 6$, $n_R = 6$).
[3] Brassy minnow (*Hybognathus hankinsoni*, $n_{LL} = 1$, $n_R = 1$), emerald shiner (*Notropis atherinoides*, $n_{LL} = 4$, $n_R = 4$), and pearl dace (*Margariscus margarita*, $n_{LL} = 0$, $n_R = 2$)

Table 3. Mean adjusted coefficient of determination (r^2) of body-scale relationships of 22 fish species and six multi-species groups from tributaries of the Red River in eastern North Dakota established from samples collected June – November 2007, by scale measurement.

	Single Species r^2		Multi-Species r^2	
Scale Measurement	Lateral Line	Random	Lateral Line	Random
Length	0.774	0.595	0.720	0.537
Height	0.723	0.576	0.561	0.452
Diagonal	0.742	0.590	0.620	0.500
Anterior Radius	0.573	0.431	0.556	0.387
Antero- or Posterolateral Radius	0.702	0.586	0.625	0.511
Posterior Radius	0.712	0.556	0.624	0.509

Figure 1. Scale measurements used in assessing body-scale relationships of 22 fish species and six multi-species groups of fish of the Red River tributaries of eastern North Dakota. A = anterior radius, B = anterolateral radius, D = diagonal, H = height, L = length, P = posterior radius.



CHAPTER 4

A Quantitative Approach for Assessing Physical Differences between River Otter (*Lontra canadensis*) and Raccoon (*Procyon lotor*) Scats Comprised Primarily of Crayfish

Abstract

River otter (*Lontra canadensis*) scats can be confused with those of raccoons (*Procyon lotor*) due to similar seasonal diets and marking behavior along riparian habitats. The purpose of this research was to identify physical characteristics of scats that could be used to distinguish otter and raccoon scats when both were comprised primarily of crayfish. Scat samples were collected from captive otters and raccoons (107 scats from four otters and 91 scats from four raccoons) fed a controlled diet of crayfish. Additionally, scats from wild otters (n = 457) and raccoons (n = 272) were collected during sign surveys conducted in northeastern North Dakota. Clean, dry scats were sifted through sieves to separate crayfish exoskeleton pieces into size classes. Weight and size measurements, association with mucous, and segment number were recorded for scats of captive animals. For scats of wild animals, percent frequency of occurrence (PFOC) of food remains was determined for a six-month period (May – October 2007), and for scats containing crayfish, percentages of fish and crayfish remains were calculated. When compared, scats of captive and wild otters contained higher percentages of crayfish pieces in the larger (4 and 2 mm) size classes than those of raccoons ($P < 0.05$). Mucous only was associated with otter scats, and for captive otters, 10 – 15% of the time. For captive raccoons, there were fewer observations of scats with 0 – 2 segments and more, with 3 – 5 segments than expected ($P < 0.05$). Otter scats with crayfish contained a greater percentage of fish remains than those of raccoons ($P < 0.05$). Additionally, PFOC of crayfish remains in otter scats remained relatively high (Min., Max. = 69.2, 100%) for the six-month period, whereas, for raccoons, PFOC was

highest during July (48.1%) and lowest in October (9.8%). Otter scats never contained plant material but plant material was detected in raccoon scats all months (Min., Max. PFOC = 38.5, 90.2%), increasing throughout the six-month period. Summer months (especially July) appeared to be the most problematic time-period for distinguishing otter and raccoon crayfish-dominated scats. Our research indicated that scats of otters and raccoons comprised of crayfish remains can be distinguished with some degree of confidence by examining a combination of characteristics, to exclude one or the other animal from final assessment. Key characteristics may be most useful on occasions when surveys are conducted during summer months and/or when single crayfish-dominated scats are found outside of well-established otter latrine sites.

Introduction

Field surveys for river otters (*Lontra canadensis*) based on detecting the animal's sign have been used to gather information on species distribution and for monitoring populations (Macdonald and Mason 1983, Bas et al. 1984, Serfass et al. 1993). Occurrence of otters is documented via detection of tracks, scat, slides, rolling places, sign heaps, and latrines that are found along shorelines and on frozen, snow-covered water bodies (Grinnell 1939, Liers 1951, Melquist and Hornocker 1979). Scat surveys, in particular, have been used to detect otter presence as latrine sites of the species are fairly conspicuous. Otter latrines are areas along the shoreline where one or multiple animals periodically deposit scat, urine and anal sac secretions (Figure 1). This 'marking behavior' is thought to be used as a means of communication among conspecifics. Latrines commonly occur on fallen trees, logjams, large boulders, elevated banks, and on or near beaver lodges (Greer 1955, Melquist and Hornocker 1983). Scat surveys are conducted by walking along, or in some cases canoeing kilometer-sections of stream or lake shore and searching for latrine sites. Although scat surveys are labor intensive, they can be performed at any time of year and are cost-effective.

Researchers have noted that otter scat can be confused with scats of other species, especially raccoons (*Procyon lotor*; Greer 1955, Swimley and Hardisky 2000, Davison et al. 2002). Distinguishing otter scats from those of raccoons can be difficult because of similar summer diets and marking behavior along riparian habitats by both species (Grinnell et al. 1937, Giles 1939, Yeager and Rennels 1943, Tevis 1947). Like otters, raccoons frequently use latrines as a mode of communication (Gehrt 2003) and during the summer months crayfish are an important component of both species diet (Schoonover and Marshall 1955, Knudsen and Hale 1968). The goal of this research was to identify specific characteristics of scats that distinguished otter and raccoons scats when both were comprised primarily of crayfish. Differentiating scat characteristics of otters and raccoons would enable wildlife managers to more reliably and confidently determine the presence or absence of otters in a drainage based on scat surveys. Specific objectives included to: 1) assess effectiveness of physical characteristics of scats (e.g., size and shape of scats, number of scat segments, association with mucous, size of exoskeleton fragments within scats) in distinguishing between otters and raccoons, and 2) document monthly occurrence of crayfish and other key food items in otter and raccoon scats to determine when both species most frequently consume crayfish.

Study Area

Scats were collected from captive otters and raccoons that were fed a controlled diet of crayfish. Of four otters, one male (ROM1) was housed at Connecticut's Beardsley Zoo in Bridgeport, Conneticut; one male (ROM2) was housed at Maritime Aquarium in, in Norwalk, Connecticut; and two otters [one male (ROM4) and one female (ROF3)] were housed at Chahinkapa Zoo in Wahpeton, North Dakota. Four captive raccoons [two males (RAM2 and RAM4) and two females (RAF1 and RAF3)] were housed at T & D's Big Cats of the World animal refuge in Penns Creek, Pennsylvania.

Scats from wild otters and raccoons were collected at three survey sites in northeastern North Dakota, in Grand Forks (Sites 1 and 2) and Walsh (Site 3) Counties (May – October 2007). Sites ranged 5 – 9 km in length and occurred along rivers with known otter and raccoon use based on previous work in 2006 (B. Curry, Frostburg State University, unpublished data). Site 1 was located along the Red River, in Grand Forks, ND, within city limits, Site 2, along the Turtle River, approximately 3 km northwest of Manvel, ND, and Site 3 was located along the Forest River, approximately 8 km southeast of Minto, ND.

Methods

Captive river otter and raccoon scats

Scats were collected from captive otters (three males, one female) and captive raccoons (two males, two females) that had been fed a controlled diet of crayfish. Initial feedings of crayfish were provided to each animal to clear their digestive tracts of other food items and provide a period to acclimate to the new diet. This generally last four days; the proportion of crayfish in the diet was increased by 25% each of those days. When two individuals were housed together (i.e., two otters at Chahinkapa Zoo), cake dye was placed in one of the animal's food to differentiate scats of individuals. Captive animals were fed the crayfish diet until 20 – 30 scats were obtained for each animal. Each deposited scat was measured for total length and width, and the number of segments was determined. Diameter was measured for three segments; if three or more segments were not produced, diameter was measured for as many segments that were produced. Presence or absence of mucus at the scats also was recorded. Scats were placed in a zip-lock bag, weighed (wet weight) to the nearest gram and frozen pending further processing.

Frozen scats were processed first by soaking them in soapy water to clean the scats and emulsify any mucus and then by washing through a US standard 120 sieve to remove fecal residue; raccoon scats were autoclaved prior to washing to kill any parasites. Scats were air dried and weighed (dry weight) to the nearest gram. Dried scats were sifted through four sieves (US standard sieve sizes 5, 10, 18, and 35) to separate crayfish pieces into four size classes (4, 2, 1, and 0.5 mm). Average weights, lengths, widths, heights, scat segment diameter, and percentages of crayfish pieces in the four size classes of scats were compared for otters and raccoons s using Mann-Whitney U tests (Program SYSTAT 12, Systat Software, Inc., Chicago, Illinois). Additionally, association of scats with mucous was determined and numbers of segments per scat for the two species were compared using Chi-Square tests (Conover 1999).

Wild river otter and raccoon scats

Scats of otters and raccoon were collected April – November 2007 during sign surveys for otters conducted at the end of each month. Scats were placed in individual zip-lock bags, dated, labeled and frozen. Frozen scats were processed similar to those of captive animals. Percent frequency of occurrence (PFOC) of food remains (Crayfish, Fish, Plant, Invertebrate, Mollusk, Amphibian, Bird, Mammal) was determined for both species. Scats containing crayfish were sifted through three sieve sizes (US standard sieves 5, 10, and 35) to separate remains into three size classes (4, 2, and 0.5 mm). Contents from each sieve were sorted into three categories: 1) fish scales and bones, 2) crayfish remains, and 3) 'other' remains. Percentages of crayfish remains for otters and raccoons in three size classes, and percentages of fish and crayfish remains in scats of otters and raccoons by month (May – October 2007) were compared using the Mann-Whitney U Test (Program SYSTAT 12, Systat Software, Inc., Chicago, Illinois).

Results

Captive river otter and raccoon scats

Weight and size measurements were obtained for 107 scat samples collected from captive otters and 91 scat samples, from captive raccoons (Tables 1 and 2). Average weights, lengths, widths, heights, and diameters of scats did not differ between captive otters and raccoons ($P > 0.05$). However, scats of captive otters contained higher percentages of crayfish pieces in the Sieve 5 (4 mm) and Sieve 10 (2 mm) size classes than those of captive raccoons ($\chi2 = 4.083$ and 5.333; $n = 4$; $P < 0.05$; Table 3); otter scats also contained lower percentages of crayfish pieces in the Sieve 18 (1 mm) and Sieve 35 (0.5 mm) size classes that those of raccoons ($\chi2 = 5.333$; $n = 4$; $P = 0.021$).

Physical characteristics (association with mucous and number of segments) were described for 104 otter and 20 raccoon scats (Table 4). For otters, overall, mucus was associated with 14 (13.5%) of the scats (Figure 2). Individually, mucus was associated with 1 (10.0%), 2 (9.1%), 5 (13.5%) and 6 (15%) scats deposited by the four otters. None of the raccoon scats were associated with mucous. While the number of otter scats in each segment category did not differ from expected values, raccoon scats had fewer observations of scats in the 0-2 segment category and a greater number of observations of scats in the 3-5 segment category than expected ($\chi2 = 8.427$; $P < 0.05$; Figure 3).

Wild river otter and raccoon scats

A total of 457 otter and 272 raccoon scats were collected along the Turtle, Forest and Red River drainages from March – November 2007 (Table 5). For otters, 263 scats contained crayfish remains, of which 61 were comprised entirely of crayfish parts. For raccoons, 95 scats contained crayfish remains, of which 26 were comprised entirely of crayfish parts. Other prey remains found in varying amounts in remaining scats included insects, fish, amphibians, birds, mammals, and plant material (Tables 6 and 7).

When scats of wild otters and raccoons containing 100% crayfish were compared, significant differences did not occur among the percentages of pieces representing three size classes [Sieve 5 (4 mm), Sieve 10 (2 mm), and Sieve 35 (0.5 mm)]. However, when all of the scats that contained any amount of crayfish were analyzed, similar to captive animals, scats of wild otters contained a higher percentage of crayfish pieces in the larger size classes (4 mm and 2 mm) than those of raccoons ($\chi 2$ = 7.789 and 7.450; n = 264 otter scats; n = 82 raccoon scats; $P < 0.05$; Table 8).

Percent frequency of occurrence (PFOC) of food remains and percentages of fish and crayfish remains in scats containing crayfish were determined for otter and raccoon scats collected May – October 2007 (Tables 6, 7, and 9). Crayfish and fish remains were detected in scats of both species all months. Overall, PFOC of fish remains in scats was 73.8% for otter scats and 3.7% for raccoon scats; PFOC of crayfish in scats was 94.3% and 34.9% for otter and raccoon scats, respectively. Otter scats contained a greater percentage of fish remains than raccoon scats ($\chi 2$ = 85.492; n = 202 otter scats; n = 82 raccoon scats; P = 0.000; Table 10; Figure 4); mean percent of fish remains in otter scats was 39.1% ± 40.1%, whereas for raccoons, the mean percent was 1.4% ± 10.8%.

By month, for otters, PFOC for crayfish remains in scats remained relatively high for the six–month period (96.3%, 100%, 89.3%, 100%, 69.2% and 95.0% for May – October 2007, respectively). For raccoons, PFOC for crayfish remains in scats was highest during July (48.1%) and August (46.5%), and lowest (9.8%) in October. During July, raccoon scats also had greater percentage of crayfish remains in scats than river otter ($\chi 2$ = 6.64; n = 28 otter scats; n = 23 raccoon scats; P = 0.010; Table 11); although in August, the percentage of crayfish remains in scats was higher for otters ($\chi 2$ = 16.693; n = 40 otter scats; n = 37 raccoon scats; P = 0.000; Table 11). Unlike otter scats, which never contained plant material, plant material was detected in raccoon scats all months surveyed, and at relatively high percent occurrence (Figure 5). Furthermore, percent occurrence of plant material in scats of raccoons increased throughout the six-month period (38.5%, 57.1%, 72.2%, 72.3%, 83.3%, and 90.2% for May – October 2007, respectively).

Discussion:

Based on our results, October may be the best time-period to distinguish scats of otters and raccoons that contain crayfish remains due to the high PFOC of plant material in raccoon scats at this time. Conversely, summer months (especially July) appeared to be the most problematic time-period for distinguishing scats as both species consumed crayfish at a relatively high frequency. Still, we found that scats dominated by crayfish could be distinguished with some degree of confidence by examining a combination of characteristics that excluded one or the other animal from final assessment, including: 1) documenting mucous associated with the scat, 2) examining the scat for presence of plant material, 3) determining percentage of fish remains in the scat, 4) counting the number of scat segments, and 5) determining percentage of larger (4 and 2 mm) fragments in the scat. However, not all characteristics measured were useful for distinguishing scats. For example, among the physical characteristics tested, we found no difference in scat weight, length, height, and diameter between the two species.

Examining key characteristics may be most helpful in distinguishing otter and raccoon scats when surveys are conducted during summer months and/or when single crayfish-dominated scats are found outside of well-established otter latrine sites. On occasions when crayfish-dominated scats are associated with mucous, observers can conclude with a high degree of confidence that the scat was deposited by an otter (Figure 2) because mucous was not documented at any of the raccoon scats (captive or wild). The association of mucous with otter scats also was noted by other researchers (Geer 1955, Modafferi 1980). However, otter scats in our study only were associated with mucous 10 – 15% of the time based on the captive animals, so presence of mucous should not be relied upon as the sole distinguishing characteristic.

Our results suggested that when plant material occurs in a crayfish-dominated scat there is a high likelihood it was not deposited by an otter. Scats of otters in our study never contained plant material, but plant material was documented in raccoon scats all months surveyed (Figure

5). Other studies have documented plant material in otter scats, but attributed it to incidental consumption by animals while feeding on other prey items (Knudsen and Hale 1968). However, Skyer (2006) believed otter scats with plant material actually were raccoon scats that had been misidentified. We found that PFOC of plant material in raccoon scats with crayfish gradually increased over the six-month survey period and was highest in October. This pattern also was reported by Schoonover and Marshall (1951) where raccoons showed a gradual shift from crayfish consumption in early-to-mid summer, to berries, corn, and acorns in late summer and fall reflecting changes in seasonal food availability. Conversely both species consumed fish during the survey period, although fish consumption was greater for otters, reflected by the relatively high PFOC and greater percentage of fish remains in otter scats (Figure 4); raccoons generally consume fish as secondary a food source (Gerht 2003, Dorney 1954). Therefore, assessing relative percentages of fish remains in scats containing crayfish remains could aid in determining species because the average percentage of fish remains in otter scats was 39.1% ± 40.1%, whereas for raccoons, average percentage was only 1.4% ± 10.8%.

We found no difference in the number of scat segments (0 – 2, 3 – 5, and >5) for scats for captive otters. However, raccoons had more observations of scats in the 3-5 segment category than expected, with zero observations occurring in the 0-2 segment category (Figure 3). Sample sizes were small for captive data and could have influenced findings. Nevertheless, results could be helpful in discerning between species when available evidence suggests a scat could be from either animal, such as when a crayfish-dominated scat is not associated with mucous, does not contain plant material, and is comprised of about 10% fish remains; in this case, if the scat were comprised of 1 or 2 segments it more likely would have been deposited by an otter based on our findings.

Significant differences among the three size classes of crayfish fragments did not occur when only the scats of wild otters and raccoons containing 100% crayfish were compared.

However, when all of the scats that contained any amount of crayfish were analyzed, findings were significant and supported those of captive animals. Otter scats with crayfish contained a higher percentage of fragments in larger size classes (4 and 2 mm) when compared to raccoons. We speculate that the discrepancy could have been due to a small number of misclassification errors during the collection of scats. Most scats were collected from well-established latrine sites which easily were distinguished in the field, but some single scats containing 100% crayfish were collected sporadically outside of those sites. Several otter scats collected during the same time-period for a companion study on food habits of otters (Chapter 2) were discarded when it was determined that they were, in fact, raccoon scats. It is possible that data from a small number of misclassified scats were analyzed and could have masked true fragment size of crayfish remains for those scats; that, and the smaller sample size could have resulted in the non-significant finding. But, when all of the data were included in the analyses the larger number of scats could have muted the effects of scats with species misclassifications. Nevertheless, our findings are similar to those of other studies. Other researchers have noted that fragment remains in wild otter scats and digestive tracts (all prey) ranged 6.3 – 12.7 mm (0.25 – 0.5 in.; Lager and Ostenson1942) and 3.2 – 6.3 mm (0.12 – 0.25 in.) in dimension, or smaller (Ginnell et al. 1937). Differences in dentition and mastication between the two species likely were the causes of the larger fragments seen in otter scats. Raccoons are omnivores and possess two additional premolars and molars than the carnivorous otter, which aid in crushing and grinding, and result in smaller food particles entering the esophagus (Gehrt 2003, Melquist et al. 2003). In fact, the mucous associated with otter scats probably serves to protect the digestive tract from sharp, relatively large bone fragments that the animals consume. However, we found that collecting scats and determining the percentage of crayfish fragments by size class in the laboratory was labor intensive, and assessing percentages of various sized classes in the field is subjective and may be difficult, especially for a novice field technician. Thus, this characteristic should be used cautiously or in conjunction with other supporting evidence to discern scats of the two species.

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Table 1. Mean and median weight (g) and size (mm) measurements of scats collected from four captive river otters.

	Captive River Otters											
Measurements	ROM1			ROM2			ROF3			ROM4		
	n	Mean ± SD	Med.	*n*	Mean ± SD	Med.	*n*	Mean ± SD	Med.	*n*	Mean ± SD	Med.
Weight	10	76.2 ± 29.2	76	22	42.0 ± 31.9	28.0	34	59.2 ± 39.9	49.0	42	39.6 ± 17.8	39
Dry Dirty Weight	9	17.2 ± 5.1	18.5	19	9.7 ± 7.9	7.2	35	23.1 ± 20.5	14.6	41	14.0 ± 18.6	11.5
Clean Dry Weight	8	10.1 ± 4.7	9.0	20	6.2 ± 5.0	4.5	35	16.5 ± 16.2	10.5	41	8.7 ± 10.8	7.2
Length	10	123.6 ± 29.5	133.2	23	111.5 ± 34.2	100.8	31	120.0 ± 34.2	123.5	42	113.8 ± 31.0	107.3
Width	10	77.4 ± 36.6	87.4	23	68.5 ± 34.4	71.7	30	87.6 ± 115.3	62.8	42	65.4 ± 31.0	55.9
Height	10	21.8 ± 7.4	20.6	23	23.5 ± 10.0	19.1	31	21.2 ± 7.3	19.1	42	22.4 ± 7.8	21.4
Random Diameter 1	7	14.3 ± 1.7	15.0	23	15.6 ± 1.4	15.7	31	15.3 ± 2.6	14.9	35	15.6 ± 2.7	15.8
Random Diameter 2	7	13.6 ± 1.8	13.7	19	16.4 ± 2.6	16.2	28	15.4 ± 3.3	14.8	33	15.4 ± 2.3	15.9
Random Diameter 3	5	14.1 ± 1.9	14.1	14	15.4 ± 1.9	15.3	26	15.2 ± 1.9	15.3	28	15.2 ± 2.1	14.8
Random Height	---	---	---	---	---	---	23	12.4 ± 2.8	12.7	23	13.7 ± 2.2	12.7
Weight Sieve 5 (4 mm)	9	0.7 ± 0.6	0.4	19	1.3 ± 1.1	1.1	35	1.7 ± 2.0	1.0	41	0.6 ± 0.8	0.5
Weight Sieve 10 (2 mm)	9	5.9 ± 2.8	5.1	19	2.7 ± 2.3	2.1	35	8.4 ± 8.0	5.7	41	4.9 ± 5.3	4.1
Weight Sieve 18 (1 mm)	9	2.1 ± 0.8	2.1	19	1.0 ± 0.9	0.7	35	4.0 ± 3.5	2.3	41	2.0 ± 2.8	1.6
Weight Sieve 35 (0.5 mm)	9	0.9 ± 0.4	0.8	19	0.3 ± 0.2	0.2	35	1.2 ± 1.3	0.7	41	0.6 ± 1.0	0.4
Weight Remaining	9	0.5 ± 0.2	0.5	19	0.3 ± 0.2	0.2	35	1.0 ± 1.2	0.5	41	0.5 ± 0.9	0.3
Sieve Total Weight	9	10.1 ± 4.3	10.5	19	5.7 ± 4.7	4.4	35	16.4 ± 15.9	10.6	41	8.7 ± 10.7	7.2
Total II Weight	9	9.6 ± 4.1	9.8		5.4 ± 4.4	4.1	35	15.4 ± 14.7	10.1	41	8.2 ± 9.8	6.9
% Total II Sieve 5 (4 mm)	9	7.0 ± 3.2	7.0	19	24.7 ± 8.4	24.0	35	10.4 ± 3.6	10.8	41	7.5 ± 3.8	7.0
% Total II Sieve 10 (2 mm)	9	60.3 ± 4.8	60.3	19	49.4 ± 4.7	50.5	35	54.3 ± 3.7	53.5	41	61.4 ± 5.4	60.5
% Total II Sieve 18 (1 mm)	9	23.3 ± 5.0	23.3	19	18.9 ± 6.1	17.8	35	27.5 ± 3.6	27.1	41	23.9 ± 4.2	23.7
% Total II Sieve 35 (0.5 mm)	9	9.4 ± 3.1	8.9	19	6.9 ± 2.2	6.4	35	7.6 ± 1.8	7.4	41	7.2 ± 1.8	67.3

RO = river otter; M = male; F = female; SD = standard deviation; Med. = median value
Total II = Sieve Total Weight – Weight Remaining

Table 2. Mean and median weight (g) and size (mm) measurements of scats collected from four captive raccoons.

Measurements	Captive Raccoons											
	RAF1			RAM2			RAF3			RAM4		
	n	Mean ± SD	Med.	*n*	Mean ± SD	Med.	*n*	Mean ± SD	Med.	*n*	Mean ± SD	Med.
Weight	5	33.8 ± 13.0	30.0	5	56.2 ± 7.5	55	3	31.3 ± 5.1	30.0	3	45.7 ± 8.1	42.0
Dry Dirty Weight	31	12.4 ± 5.3	11.1	20	16.5 ± 10.3	14.7	20	19.4 ± 11.4	15.8	20	15.5 ± 5.5	15.6
Clean Dry Weight	31	5.0 ± 3.8	4.0	20	4.7 ± 2.3	4.2	20	6.7 ± 2.9	5.6	20	6.8 ± 3.4	5.8
Length	5	78.7 ± 17.2	86.9	5	128.4 ± 15.4	126	3	93.4 ± 11.9	95.4	3	97.9 ± 20.9	109.9
Width	5	77.6 ± 7.4	74.6	5	80.2 ± 15.9	73.4	3	82.4 ± 10.6	78.7	3	74.3 ± 40.9	57.7
Height	5	14.6 ± 6.2	12.7	5	26.0 ± 9.2	25.4	3	21.7 ± 9.0	19.0	3	19.0 ± 2.7	17.5
Random Diameter 1	5	17.3 ± 4.5	16.1	5	18.5 ± 3.8	19.4	3	16.2 ± 3.6	15.3	3	17.6 ± 3.2	17.8
Random Diameter 2	5	15.7 ± 4.5	13.5	5	17.9 ± 2.8	17.0	3	19.3 ± 5.2	20.1	3	12.3 ± 7.0	12.6
Random Diameter 3	5	16.1 ± 3.5	14.4	5	12.1 ± 7.4	13.8	3	19.1 ± 3.9	18.5	3	12.4 ± 3.9	14.0
Random Height	5	11.4 ± 2.8	12.7	5	13.6 ± 3.5	12.7	3	12.7 ± 2.7	14.3	3	16.9 ± 3.6	18.9
Weight Sieve 5 (4 mm)	31	0.2 ± 0.3	0.1	20	0.1 ± 0.1	0.05	20	0.2 ± 0.2	0.1	20	0.5 ± 0.6	0.3
Weight Sieve 10 (2 mm)	31	1.5 ± 1.6	0.7	20	1.0 ± 0.6	0.8	20	2.0 ± 0.8	1.9	20	2.2 ± 1.9	1.7
Weight Sieve 18 (1 mm)	31	1.5 ± 1.4	1.2	20	1.4 ± 0.7	1.4	20	2.3 ± 1.0	2.1	20	1.8 ± 1.0	1.6
Weight Sieve 35 (0.5 mm)	31	0.8 ± 0.7	0.6	20	1.0 ± 0.6	0.8	20	1.3 ± 0.6	1.1	20	0.8 ± 0.3	0.7
Weight Remaining	31	0.6 ± 0.5	0.6	20	1.2 ± 0.8	1.0	20	0.9 ± 0.9	0.5	20	1.5 ± 0.8	1.6
Sieve Total Weight	31	4.6 ± 3.8	3.4	20	4.7 ± 2.3	4.2	20	6.7 ± 2.8	5.7	20	6.8 ± 3.3	5.7
Total II Weight	31	4.0 ± 3.7	2.7	20	3.5 ± 1.7	3.3	20	5.8 ± 2.2	5.1		5.3 ± 3.5	4.4
% Total II Sieve 5 (4 mm)	31	4.1 ± 5.5	2.7	20	2.7 ± 4.2	1.6	20	3.8 ± 3.8	2.8	20	7.4 ± 5.8	7.1
% Total II Sieve 10 (2 mm)	31	30.2 ± 12.1	31.4	20	28.3 ± 9.6	28.1	20	34.2 ± 8.1	34.4	20	37.4 ± 11.0	39.2
% Total II Sieve 18 (1 mm)	31	41.0 ± 7.7	40.5	20	40.5 ± 5.1	39.6	20	39.8 ± 5.3	38.8	20	36.1 ± 7.0	35.4
% Total II Sieve 35 (0.5 mm)	31	24.7 ± 12.8	22.6	20	28.4 ± 9.3	26.9	20	22.1 ± 6.7	21.9	20	19.1 ± 8.9	17.1

RA = raccoon; M = male; F = female; SD = standard deviation; Med. = median value
Total II = Sieve Total Weight – Weight Remaining

Table 3. Comparison of median percentages (%) of crayfish remains in four size classes [Sieve 5 (4 mm), Sieve 10 (2 mm), Sieve 18 (1 mm), and Sieve 35 (0.5 mm)] for 104 scats from four captive river otters and 91 scats from four captive raccoons using the Mann-Whitney U Test (Program SYSTAT 12.0).

Size Class	Mean Median % Crayfish Remains		Rank Sum		Mann–Whitney U Test Statistic	*P* – value	Chi-square Approximation; df = 1
	Otter $n = 4$	Raccoon $n = 4$	Otter	Raccoon			
Sieve 5 (4 mm)	12.3	3.5	25	11	15	0.043*	4.083
Sieve 10 (2 mm)	56.2	33.3	26	10	16	0.021*	5.333
Sieve 18 (1 mm)	22.5	38.6	10	26	0.0	0.021*	5.333
Sieve 35 (0.5 mm)	7.5	22.1	10	26	0.0	0.021*	5.333

* = Statistical significance ($P \leq 0.05$)

Table 4. Physical characteristics of scats collected from captive river otters (n = 4) and raccoons (n = 4). Data are counts associated with presence of mucous and three scat segment categories (0 – 2, 3 – 5, and >5 segments). Percentages are in parentheses.

		Captive River Otters					Captive Raccoons				
Physical Characteristic		ROM1 n = 10	ROM2 n = 22	ROF3 n = 32	ROM4 n = 40	Total n = 104	RAF1 n = 5	RAM2 n = 5	RAF3 n = 5	RAM4 n = 5	Total n = 20
Association with Mucous		1 (10.0)	2 (9.1)	5 (13.5)	6 (15.0)	14 (13.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Segment Category	0 – 2	6 (60.0)	8 (36.4)	5 (13.5)	16 (40.0)	35 (33.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	3 – 5	0 (0.0)	11 (50.0)	14 (43.7)	15 (37.5)	40 (38.5)	4 (80.0)	3 (60.0)	2 (40.0)	2 (40.0)	11(55.0)
	>5	4 (40.0)	3 (13.6)	13 (40.6)	9 (22.5)	29 (27.9)	1 (20.0)	2 (40.0)	1 (20.0)	1 (20.0)	5 (25.0)

RO = River otter; RA = Raccoon; M = male; F = female

Table 5. Numbers of wild river otter (RO) and raccoon (RA) scats collected along three drainages (Forest, Red, and Turtle Rivers) in eastern North Dakota from March – November 2007.

	Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Total	
River	RO	RA	RO	RA	RO	RA	RO	RA	RO	RA	RO	RA	RO	RA	RO	RA	RO	RA	RO	RA
Forest	8	0	22	0	50	4	25	3	46	6	16	28	18	9	9	19	12	0	206	69
Red	2	0	37	0	19	1	0	1	0	44	0	54	2	14	41	22	7	13	108	149
Turtle	0	0	5	0	8	8	8	1	32	5	12	19	30	13	43	8	5	0	143	54
Total	10	0	64	0	77	13	33	5	78	55	28	101	50	36	93	49	24	13	457	272

Table 6. Frequency of occurrence of food remains in river otter scats collected along three drainages (Forest, Red and Turtle Rivers) in eastern North Dakota (May – October 2007). *n* = number of scats collected. Percentages are in parentheses.

River		May	June	July	August	September	October	Total
Forest	*n*	8	15	20	5	12	5	65
	Crayfish	8 (100)	15 (100)	17 (85.0)	5 (100)	8 (66.7)	5 (100)	58 (89.2)
	Fish	2 (25.0)	7 (46.7)	17 (85.0)	5 (100)	10 (83.3)	4 (80.0)	45 (69.2)
	Plant	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Invertebrate	2 (25.0)	3 (20.0)	11 (55.0)	2 (40.0)	1 (8.3)	2 (40.0)	21 (32.2)
	Mollusk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Amphibian	2 (25.0)	3 (20.0)	13 (65.0)	1 (20.0)	2 (16.7)	0 (0.0)	21(32.3)
	Bird	1 (12.5)	3 (20.0)	1 (5.0)	0 (0.0)	1 (8.3)	1 (20.0)	7 (10.8)
	Mammal	0 (0.0)	0 (0.0)	1 (5.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.5)
Red	*n*	16	---	---	---	1	17	34
	Crayfish	15 (93.7)	---	---	---	1 (100)	17 (100)	33 (97.0)
	Fish	15 (93.7)	---	---	---	1 (100)	17 (100)	33 (97.0)
	Plant	0 (0.0)	---	---	---	0 (0.0)	0 (0.0)	0 (0.0)
	Invertebrate	2 (12.5)	---	---	---	1 (100)	8 (47.1)	11 (32.3)
	Mollusk	0 (0.0)	---	---	---	0 (0.0)	0 (0.0)	0 (0.0)
	Amphibian	0 (0.0)	---	---	---	0 (0.0)	1 (5.9)	1 (2.9)
	Bird	0 (0.0)	---	---	---	0 (0.0)	0 (0.0)	0 (0.0)
	Mammal	3 (18.7)	---	---	---	0 (0.0)	5 (29.4)	8 (23.5)
Turtle	*n*	3	7	8	35	---	58	111
	Crayfish	3 (100)	7 (100)	8 (100)	35 (100)	---	54 (93.1)	107 (96.4)
	Fish	2 (66.7)	2 (28.6)	8 (100)	12 (34.3)	---	53 (91.4)	77 (69.4)
	Plant	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	---	0 (0.0)	0 (0.0)
	Invertebrate	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.9)	---	15 (25.9)	16 (14.4)
	Mollusk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	---	0 (0.0)	0 (0.0)
	Amphibian	0 (0.0)	3 (42.9)	4 (50.0)	1 (2.9)	---	0 (0.0)	8 (7.2)
	Bird	0 (0.0)	1 (14.3)	0 (0.0)	0 (0.0)	---	0 (0.0)	1 (0.9)
	Mammal	0 (0.0)	1 (14.3)	0 (0.0)	0 (0.0)	---	10 (17.2)	11 (9.9)
Total	*n*	27	22	28	40	13	80	210
	Crayfish	26 (96.3)	22 (100)	25 (89.3)	40 (100)	9 (69.2)	76 (95.0)	198 (94.3)
	Fish	19 (70.4)	9 (40.9)	25 (89.3)	17 (42.5)	11 (84.6)	74 (92.5)	155 (73.8)
	Plant	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Invertebrate	4 (14.8)	3 (13.6)	11 (39.3)	3 (7.5)	2 (15.4)	25 (31.2)	48 (22.8)
	Mollusk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Amphibian	2 (7.4)	6 (27.3)	17 (60.7)	2 (5.0)	2 (15.4)	1 (1.2)	30 (14.3)
	Bird	1 (3.7)	4 (18.2)	1 (3.6)	0 (0.0)	1 (7.7)	1 (1.2)	8 (3.8)
	Mammal	3 (11.1)	1 (4.5)	1 (3.6)	0 (0.0)	0 (0.0)	15 (18.7)	20 (9.5)

Table 7. Frequency of occurrence of food remains in raccoon scats collected along three drainages (Forest, Red and Turtle Rivers) in eastern North Dakota (May – October 2007). *n* = number of scats collected. Percentages are in parentheses.

River		May	June	July	August	September	October	Total
Forest	*n*	4	3	6	28	9	19	69
	Crayfish	0 (0.0)	1 (33.3)	3 (50.0)	9 (32.1)	0 (0.0)	1 (5.3)	14 (20.3)
	Fish	1 (25.0)	1 (33.3)	0 (0.0)	0 (0.0)	1 (11.1)	1 (5.3)	4 (5.8)
	Plant	2 (50.0)	0 (33.3)	4 (66.7)	25 (89.3)	8 (88.9)	18 (94.7)	57 (82.6)
	Invertebrate	3 (75.0)	3 (100)	2 (33.3)	9 (32.1)	1 (11.1)	1 (5.3)	19 (27.5)
	Mollusk	3 (74.0)	2 (66.7)	1 (16.7)	1 (3.6)	1 (11.1)	1 (5.3)	9 (13.0)
	Amphibian	0 (0.0)	0 (0.0)	1 (16.7)	1 (3.6)	0 (0.0)	0 (0.0)	2 (2.9)
	Bird	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Mammal	1 (25.0)	2 (66.7)	1 (16.7)	2 (7.1)	1 (11.1)	2 (10.5)	9 (13.0)
Red	*n*	1	3	43	54	14	34	149
	Crayfish	0 (0.0)	0 (0.0)	19 (44.2)	23 (42.6)	3 (21.4)	2 (5.9)	47 (31.5)
	Fish	0 (0.0)	0 (0.0)	1 (2.3)	2 (3.7)	0 (0.0)	1 (2.9)	4 (2.7)
	Plant	1 (100)	3 (100)	32 (74.4)	41 (75.9)	11 (78.6)	29 (85.3)	117 (78.5)
	Invertebrate	0 (0.0)	1 (33.3)	16 (37.2)	19 (35.2)	2 (14.3)	10 (29.4)	48 (32.2)
	Mollusk	0 (0.0)	0 (0.0)	4 (9.3)	5 (9.3)	2 (14.3)	1 (2.9)	12 (8.0)
	Amphibian	0 (0.0)	0 (0.0)	3 (7.0)	3 (5.5)	0 (0.0)	1 (2.9)	7 (4.7)
	Bird	0 (0.0)	0 (0.0)	6 (13.9)	7 (13.0)	1 (7.1)	0 (0.0)	14 (9.4)
	Mammal	0 (0.0)	1 (33.3)	1 (2.3)	1 (1.8)	0 (0.0)	1 (2.9)	4 (2.7)
Turtle	*n*	8	1	5	19	13	8	54
	Crayfish	3 (37.5)	1 (100)	4 (80.0)	15 (78.9)	8 (61.5)	3 (37.5)	34 (63.0)
	Fish	1 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (7.7)	0 (0.0)	2 (3.7)
	Plant	2 (25)	0 (0.0)	3 (60.0)	7 (46.7)	11 (84.6)	8 (100	31 (57.4)
	Invertebrate	7 (87.5)	0 (0.0)	0 (0.0)	9 (47.4)	4 (30.8)	2 (25.0)	22 (40.7)
	Mollusk	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.3)	1 (7.7)	2 (25.0)	4 (7.4)
	Amphibian	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Bird	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Mammal	0 (0.0)	0 (0.0)	0 (0.0)	2 (10.5)	1 (7.7)	0 (0.0)	3 (5.5)
Total	*n*	13	7	54	101	36	61	272
	Crayfish	3 (23.1)	2 (28.6)	26 (48.1)	47 (46.5)	11 (30.5)	6 (9.8)	95 (34.9)
	Fish	2 (15.4)	1 (14.3)	1 (1.8)	2 (2.0)	2 (5.5)	2 (3.3)	10 (3.7)
	Plant	5 (38.5)	4 (57.1)	39 (72.2)	73 (72.3)	30 (83.3)	55 (90.2)	206 (75.7)
	Invertebrate	10 (76.9)	4 (57.1)	18 (33.3)	37 (36.6)	7 (19.4)	13 (21.3)	89 (3.3)
	Mollusk	3 (23.1)	2 (28.6)	5 (9.3)	7 (6.9)	4 (11.1)	4 (6.5)	25 (9.2)
	Amphibian	0 (0.0)	0 (0.0)	4 (7.4)	4 (4.0)	0 (0.0)	0 (0.0)	9 (3.3)
	Bird	0 (0.0)	0 (0.0)	7 (12.9)	7 (6.9)	1 (2.8)	0 (0.0)	15 (5.5)
	Mammal	1 (7.7)	3 (42.9)	2 (3.7)	5 (4.9)	2 (5.5)	3 (4.9)	16 (5.9)

Table 8. Comparison of median percentages of crayfish remains in three size classes [Sieve 5 (4 mm), Sieve 10 (2 mm), and Sieve 35 (0.5 mm)] using the Mann-Whitney U Test (Program SYSTAT 12.0) for 264 river otter and 82 raccoon scats collected along three drainages (Forest, Red, and Turtle Rivers) in northeastern North Dakota from March – November 2007.

Size Class	Mean Median % Crayfish Remains		Rank Sum		Mann–Whitney U Test Statistic	*P* – value	Chi Square Approximation df = 1
	Otter *n* = 264	Raccoon *n* = 82	Otter	Raccoon			
Sieve 5 (4 mm)	10.1	4.6	48,010.5	12,020.5	13,030.5	0.005*	7.789
Sieve 10 (2 mm)	27.3	11.5	47,963.5	12,067.5	12,983.5	0.006*	7.450
Sieve 35 (0.5 mm)	10.1	5.1	46,234.0	13,797.0	11,797.0	0.587	0.296

* = Statistical significance ($P \leq 0.05$)

Table 9. Mean and median percentages of fish and crayfish remains in scats of river otters and raccoons collected May – October 2007 along three drainages (Forest, Red, and Turtle Rivers) in northeastern North Dakota.

Month	Percentage of Fish Remains in Scats						Percentage of Crayfish remains in Scats					
	River Otter			Raccoon			River Otter			Raccoon		
	n	Mean ± SD	Med.	*n*	Mean ± SD	Med.	*n*	Mean ± SD	Med.	*n*	Mean ± SD	Med.
May	27	49.7 ± 42.1	52.4	3	0.2 ± 0.3	0.0	27	48.0 ± 40.9	40.8	3	89.1 ± 11.1	94.8
June	22	13.6 ± 30.4	0.0	2	0.0 ± 0.0	0.0	22	81.2 ± 30.9	97.5	2	49.1 ± 65.5	49.1
July	28	53.3 ± 43.6	59.2	23	0.1 ± 0.3	0.0	28	30.0 ± 39.3	5.0	23	52.5 ± 38.7	53.2
August	40	13.7 ± 32.4	0.0	37	2.91 ± 6.2	0.0	40	86.0 ± 32.9	100	37	43.1 ± 43.4	27.1
September	9	69.2 ± 33.2	86.9	11	0.1 ± 0.4	0.0	9	26.1 ± 32.1	13.1	11	57.0 ± 45.9	84.6
October	76	47.3 ± 35.4	46.4	6	0.7 ± 1.8	0.0	76	47.7 ± 35.3	49.6	6	14.9 ± 29.6	3.2
May – October	202	39.1 ± 40.1	25.4	82	1.4 ± 10.8	0.0	202	55.6 ± 40.7	59.8	82	47.4 ± 42.2	37.9
May/June	49	33.5 ± 41.2	2.6	5	0.1 ± 0.2	0.0	49	62.9 ± 40.1	84.3	5	73.1 ± 40.1	94.8
July/August	68	30.0 ± 42.0	1.9	60	1.81 ± 2.7	0.0	68	62.9 ± 45.0	96.7	60	46.7 ± 41.5	34.4
September/October	85	49.7 ± 35.7	50.2	17	0.3 ± 1.1	0.0	85	45.5 ± 35.4	43.1	17	42.1 ± 44.9	6.2

n = Number of scats that contain crayfish remains; SD = standard deviation; Med. = median value

Table 10. Comparison of median percentages of fish remains in scats of river otters and raccoons by month (May – October 2007) using the Mann-Whitney U Test (Program SYSTAT 12). Scats were collected along three drainages (Forest, Red, and Turtle Rivers) in northeastern North Dakota.

Month	Median Percentage of Fish Remains				Rank Sum		Mann–Whitney U Test Statistic	*P*–value	Chi Square Approximation; df = 1
	Otter		Raccoon						
	n	Med.%	*n*	Med.%	Otter	Raccoon			
May	27	52.4	3	0.0	443	22	65.0	0.084	2.978
June	22	0.0	2	0.0	282	18	29.0	0.363	0.828
July	28	59.2	23	0.0	989	337	583.0	0.000*	28.674
August	40	0.0	37	0.0	1,844	1,159	1,024.0	0.000*	14.150
September	9	86.9	11	0.0	138	72	93.0	0.000*	13.087
October	76	46.4	6	0.0	3,347	56	421.0	0.001*	11.857
May – October	202	25.4	82	0.0	34,264	6,206	13,761	0.000*	85.492
May/June	49	2.6	5	0.0	1,401	84	176.0	0.088	2.913
July/August	68	1.9	60	0.0	5,518.5	2,737.5	3,172.5	0.000*	40.767
September/October	85	50.2	17	0.0	5,004.5	248.5	1,349.5	0.000*	32.114

n = Number of scats that contain crayfish remains; * = Statistical significance ($P \leq 0.05$)

Table 11. Comparison of median percentages of crayfish remains in scats of river otters and raccoons by month (May – October 2007) using the Mann–Whitney U Test (Program SYSTAT 12). Scats were collected along three drainages (Forest, Red, and Turtle Rivers) in northeastern North Dakota.

Month	Median Percentage of Crayfish Remains				Rank Sum		Mann–Whitney U Test Statistic	*P*–value	Chi Square Approximation; df = 1
	Otter		Raccoon						
	n	Med.%	*n*	Med.%	Otter	Raccoon			
May	27	40.8	3	94.8	403	62	25.0	0.281	1.163
June	22	97.5	2	49.1	288	12	35.0	0.159	1.987
July	28	5.0	23	53.2	592	734	186.0	0.010*	6.64
August	40	100	37	27.1	1,952	1,051	1,132	0.000*	16.693
September	9	13.1	11	84.6	80	130	35.0	0.270	1.217
October	76	49.6	6	3.2	3,277	126	351	0.029*	4.797
May – October	202	59.8	82	37.9	29,802.5	10,667.5	9,299.5	0.103	2.651
May/June	49	84.3	5	94.8	1,358	127	133.0	0.750	0.101
July/August	68	96.7	60	34.4	4,778.5	3,477.5	2,432.5	0.059	3.569
September/October	85	43.1	17	6.2	4,425	828	770.0	0.670	0.182

n = Number of scats that contain crayfish remains; * = Statistical significance ($P \leq 0.05$)

Figure 1. River otter latrine showing multiple river otter scats comprised of crayfish remains.

Figure 2. Scat of captive river otter with associated mucous. For otters, overall, mucus was associated with 14 (13.5%) of the scats.

Figure 3. Scat of captive raccoon with 3 segments. Captive raccoons had fewer observations of scats in the 0-2 segment category and a greater number of observations of scats in the 3-5 segment category than expected (*P* < 0.05).

Figure 4. River otter scat comprised primarily of fish remains. River otter scats contained a greater percentage of fish remains than raccoon scats ($P < 0.001$).

Figure 5. Raccoon scat with crayfish remains and plant material. Plant material was detected in raccoon scats all months surveyed (May – October 2007, respectively).

CHAPTER 5

Monthly Variation in Scat Marking by River Otters (*Lontra Canadensis*) along the Red, Forest, and Turtle Rivers of Northeastern North Dakota

Abstract

We examined monthly variation in scat marking by river otters (*Lontra canadensis*) for a newly-establishing population in northeastern North Dakota. We conducted scat surveys (April – November 2007 and May – August 2008) along both shorelines of three, 5-km sections of the Forest, Red, and Turtle Rivers to determine if scat-marking habits of otters differed throughout spring, summer, and fall months. Overall, we counted 1,019 scats at 202 latrines (sites where otters deposit scats). Scats were detected all months, but marking frequency and intensity fluctuated monthly, and by river and year. In 2007, on average, we documented the greatest number of scats in October, and the fewest, in April and May. In 2008, we detected the greatest number in May, and the fewest, in July and August. By river, on average, more latrines (P = 0.003) but fewer scats per latrine (P = 0.016) were documented on the Forest River than on the Red or Turtle Rivers in 2007. In 2008, more latrines were documented along the Turtle River than on the Red River (P = 0.035), and more scats per latrine were documented on this river than the Forest or Red Rivers (P = 0.011). Between years, a greater number of scats was recorded for the Forest River in 2008 than in 2007 (P = 0.045); by month, more scats were documented on this river in May 2008 than May 2007 (P = 0.05). Increased scat-marking by otters in spring and fall months coincided with the species breeding season and greater movements of mothers with older cubs. Variation in marking by otters between rivers and among years could have been due to differences in habitat characteristics, variability in spring thaw and flooding, and local

densities at these sites. Greater numbers of scats observed in 2008 for the Forest River could be indicative of further population growth by river otters in this drainage.

Introduction

Throughout the range of the river otter (*Lontra canadensis*) in North America, scat surveys have been used to document occurrence of the species (Clark et al. 1987, Dubuc et al. 1990, Mowbray et al. 1976, Newman 1990, Newman and Griffin 1994, Robson 1983, Serfass 1984, Swimley 1996, Swimley et al. 1998, Swimley et al. 1999). Scat surveys are conducted by walking the shorelines of waterways and visually searching for otter latrines (sites where river otters deposit scats). This approach is time consuming, but is a reliable method for detecting presence of otters and is cost effective (Clark et al. 1987). Understanding seasonal scat-marking habits of otters would aid managers in determining the best time-periods to conduct surveys to detect this rare carnivore. Foy (1984) reported that otters in Texas marked more frequently during winter and early spring than during summer months. Karnes and Tumlison (1984) noted that the greatest amount of marking by otters in Arkansas occurred during early summer and late winter. Serfass (1994) evaluated monthly marking habits of otters at specific latrine locations in northcentral Pennsylvania and found that scat-marking intensity peaked in the spring (March – April), and again in the fall (October – November). Carpenter et al. (In review) expanded upon the research by Serfass (1994) and conducted a systematic study of monthly otter marking along extended sections of riverine shoreline in northwestern Pennsylvania. The specific intent of Carpenter et al.'s (In review) study was to enhance effectiveness and efficiency of surveys to detect otter field sign. Their findings supported those of Serfass (1994); peak periods of scat deposition occurred during March – April and September – November. They attributed the peaks in marking to breeding activity by otters in the spring and increased traveling by family groups in the fall. Based on their research, Carpenter et al. (In Review) recommended future scat surveys for otters in Pennsylvania be conducted during spring and fall months. The purpose of this research was to formally evaluate seasonality in marking habits of otters to determine if scat-marking habits differed throughout spring, summer, and fall months in North Dakota. Specifically, we investigated if 1) the number of marked latrines and 2) number of scats deposited at latrines along both shorelines of three, 5-km sections of the Red, Forest, and Turtle Rivers in northeastern North Dakota differed among months, and by river and year.

Methods

Evaluation of otter marking patterns in northeastern North Dakota took place after rivers were free of ice cover, from April – November in 2007 and May – August in 2008. Scat surveys were conducted approximately at the end of each month along both shorelines of three, 5-km stream sections of the Forest, Red, and Turtle Rivers in Walsh (Forest River) and Grand Forks Counties (Red and Turtle River) of northeastern North Dakota (Figure 1). We defined a latrine as anywhere that a scat occurred. Numbers of latrines were counted each month and GPS locations were recorded at latrine sites. We defined a scat as a single connected strand (or pile if the scat had deteriorated) of excrement. Individual scats were identified by differences in age (assessed by smell, moistness, and extent of degradation), color, and proximity to other scats. All scats at each latrine were counted. Scats either were collected for other research purposes or destroyed (stomped by boot into the soil) to prevent recounting the same scats the following month. In some cases, otters deposited scats over several meters of shoreline. A latrine was defined as separate if it was >10 m from other scats.

Data were analyzed using SYSTAT version 12 (Systat Software, Inc., Chicago, Illinois, 60606). To assess marking intensity of otters, mean number of latrines by month, mean number of scats per latrine, and mean number of scats per latrine by month per 5-km stream section were compared overall, and by river in 2007 and 2008 using One-way ANOVA and Tukey's Honestly-Significant-Difference statistical tests. Comparisons between years were made using two-sample t-tests.

Results

2007 Scat Survey

From April – November 2007, we documented 440 river otter scats from 114 latrines along both shorelines of three, 5-km stream sections of the Forest, Red, and Turtle Rivers. Overall, average number of latrines located per month was 4.7 ± 3.8 latrines (Min., Max. = 0, 13) and average number of scats per latrine was 3.8 ± 4.1 scats (Min., Max. = 1, 28). By month, on average, we documented the greatest number of latrines (7.0 ± 5.32) in May and the fewest (2.3 ± 0.6), in November (Table 1). However, differences in numbers of latrines among months were not significant ($n = 24$, $F_{7, 16} = 0.515$, $P = 0.810$). Of scats, on average, we documented the greatest number in October (7.1 ± 8.1), and the fewest, in April and May (2.9 ± 2.6 and 2.9 ± 1.7; Table 2, Figure 2). Differences were significant between October and April (marginal significance $n = 116$, $F_{7, 108} = 1.79$, $P = 0.097$; marginal significance at $P = 0.063$; Tukey's Difference = -4.304; 95% CI = -8.728, -0.120), but not among other months.

By river, one hundred eighty-nine river otter scats were collected from 65 latrines in the Forest River, 106 scats were collected from 21 latrines in the Red River, and 145 scats were collected from 28 latrines in the Turtle River. Average number of latrines located per month was

8.1 ± 4.1 latrines (Min., Max. = 2, 13) for the Forest River; 2.5 ± 2.8 latrines (Min., Max. = 0, 8) for the Red River; and 3.5 ± 1.4 latrines (Min., Max. = 2, 6) for the Turtle River. Numbers of latrines located per month differed among the three rivers (n = 24, $F_{2, 21}$ = 7.926, P = 0.003). On average, more latrines were documented on the Forest River than on the Red (P = 0.003; Tukey's Difference = 5.625; 95% CI = 1.825 9.425) or Turtle (P = 0.015; Tukey's Difference = 4.625; 95% CI = 0.825 8.425) Rivers. Average number of scats per latrine was 2.9 ± 2.7 scats (Min., Max. = 1, 17) for the Forest River; 5.0 ± 5.9 scats (Min., Max. = 0, 28) for the Red River; and 5.2 ± 4.7 scats (Min., Max. = 1, 17) for the Turtle River. Numbers of scats collected at latrines differed among the three rivers (n = 114, $F_{2, 111}$ = 4.283, P = 0.016). On average fewer scats were detected on the Forest River than on the Turtle (P = 0.036; Tukey's Difference = -2.271; 95% CI = -4.420 -0.121) or Red (marginal significance at P = 0.088; Tukey's Difference = -2.140; 95% CI = -4.527 – 0.247) Rivers. By month, we documented the greatest number of otter scats at latrines in October for the Red and Turtle Rivers (Table 2, Figures 3 and 4). We documented the fewest number of scats for these rivers during summer months (June, July, and August) for the Red River, and in April, for the Turtle River. However, average number of scats recorded at latrines did not differ among months for any of the three rivers individually (n = 65, $F_{7, 57}$ = 1.044, P = 0.411 for the Forest River; n = 23, $F_{7, 15}$ = 1.786, P = 0.164 for the Red River; and n = 28, $F_{7, 20}$ = 1.341, P = 0.283 for the Turtle River). Furthermore, no definitive seasonal marking pattern by river otters was documented for the Forest River (Figure 5).

2008 Scat Survey

From May – August 2008, we documented 579 otter scats from 88 latrines in three, 5-km stream sections of the Forest, Red and Turtle Rivers. Both shorelines of each stream segment were surveyed all months for the Forest and Red River. For the Turtle River, both shorelines were surveyed during May and June, the east shoreline was surveyed in July and the stream segment was not surveyed in August. To allow comparisons to be made among months and by river, numbers of latrines and scats were estimated for the shoreline not surveyed in July for the Turtle River. To estimate numbers of latrines and scats, first, the ratio of latrines and scats for the east shoreline (ES) and west shoreline (WS) of the stream segment was determined for May (21 latrines ES:12 latrines WS = 1.75:1.0; 202 scats ES:124 scats WS 1.63:1.0) and June (9:4 latrines = 2.25:1.0; 78:27 scats = 2.89:1.0). Then, the average ratio for latrines and scats over the two-month period was determined (2.0:1.0 latrines; 2.26/1.0 scats). Finally, using the known number of latrines and scats on ES of the Turtle River in July (8 latrines, 22 scats), the numbers of latrines and scats on WS were estimated based on the average ratio (4 latrines, about 10 scats). Additionally, in 2008, the survey section for the Turtle River differed from that in 2007; the segment surveyed occurred in the adjacent square-mile section. Thus, comparisons between years were not made for data collected on this River.

Overall, average number of latrines located per month was 8.4 ± 7.8 latrines (Min., Max. = 0, 24) and average number of scats per latrine was 6.3 ± 5.9 scats (Min., Max. = 0, 26). By month, on average, we documented the greatest number of latrines (16.0 ± 10.6) in May and the fewest (2.0 ± 2.8), in August (Table 1). However, similar to 2007, differences in numbers of latrines among months were not significant (n = 11, $F_{3, 7}$ = 1.834, P = 0.229). Of scats, on average, we detected the greatest number at latrines in May (7.7 ± 6.3), and the fewest, in August (3.2 ± 2.9; Table 2, Figure 6). Numbers of scats per latrine differed among months in 2008 (n = 93, $F_{3, 89}$ = 2.901, P = 0.039); more scats were documented in May, than July (P = 0.046; Tukey's Difference = -4.153; 95% CI = -8.248 -0.058). Among years, more scats were collected in 2008, than in 2007 for the May – August time-period (marginal significance at n = 94, $T_{71.1}$ = -1.875, P = 0.065).

By river, one hundred eighty-six otter scats were collected from 36 latrines in the Forest River, 18 scats were collected from 7 latrines in the Red River, and 375 scats were collected from 45 latrines in the Turtle River. Average number of latrines located per month was 9.0 ± 7.6 latrines (Min., Max. = 4, 20) for the Forest River; 2.0 ± 1.6 latrines (Min., Max. = 0, 4) for the Red River; and 16.3 ± 6.7 latrines (Min., Max. = 12, 24) for the Turtle River. Numbers of latrines located per month differed among the three rivers (n = 11, $F_{2, 8}$ = 5.271, P = 0.035). On average, more latrines occurred on the Turtle River, than on the Red (P = 0.029; Tukey's Difference = -14.333; 95% CI = -26.981 -1.685) River. Average number of scats per latrine was 5.2 ± 4.8 scats (Min., Max. = 1, 26) for the Forest River; 2.2 ± 2.2 scats (Min., Max. = 0, 7) for the Red River; and 8.3 ± 6.6 scats (Min., Max. = 1, 24) for the Turtle River. Numbers of scats collected at latrines differed among the three rivers (n = 93, $F_{2, 90}$ = 4.705; P = 0.011). On average more scats were documented on the Turtle River than on the Forest (marginal significance at P = 0.079; Tukey's Difference = -2.690; 95% CI = -5.625 -0.244) or Red (P = 0.028; Tukey's Difference = -5.607; 95% CI = -10.705 – 0.509) Rivers. By month, we recorded the greatest number of otter scats at latrines in May for the Red and Turtle Rivers, and in July, for the Forest River (Table 2; Figures 7, 8, and 9). We collected the fewest number of scats for these rivers during June (Forest River), July (Turtle River), and August (Forest and Red Rivers; Table 2). Average number of scats collected at latrines did not differ among months for the Forest (n = 36, $F_{3, 32}$ = 0.539, P = 0.659) or Red (n = 8, $F_{3, 4}$ = 0.921, P = 0.507) Rivers. However, for the Turtle River, significantly more scats were documented at latrines in May and June, than in July (n = 49, $F_{2, 46}$ = 7.171, P = 0.02; May-July comparison: P = 0.001; Tukey's

Difference = -7.667; 95% CI = -12.574 -2.759; June-July comparison: marginal significance at *P* = 0.058; Tukey's Difference = -5.410; 95% CI = -10.967 0.146).

Between years, for the Forest River, more scats per latrine were collected in 2008, than in 2007 for the May – August time-period (n = 78, $T_{57.1}$ = -2.046, P = 0.045). By month, more scats were collected in May 2008 than May 2007 along this river (n = 33, $T_{22.3}$ = 2.04, P = 0.05), but the number of scats per latrine did not differ between years for the other months surveyed (n = 21, $T_{18.9}$ = -0.715, P = 0.484; n = 15, $T_{6.4}$ = -1.391, P = 0.211; and n = 9, $T_{5.4}$ = -0.516, P = 0.626 for June, July, and August, respectively). For the Red River, there was no difference in the number of scats collected between the two years (n = 16, $T_{13.7}$ = 0.104, P = 0.919).

Discussion

While variation in scat marking by otters occurred among the three sites and over the two sampling periods, data collected over the two-year period revealed marking patterns similar to those found in studies with established otter populations (Serfass 1994, Carpenter et al. In review). We observed peaks in scat-marking activity by otters during spring and fall months, and less marking during summer. These times coincided with breeding activity by adults, parturition and denning behavior of females with young nursing cubs (Hamilton and Eadie 1964, Melquist and Hornocker 1983), and increased movements of females with weaned older cubs (Olson et al. 2005). Carpenter et al. (In review) suspected the peak in spring marking primarily was associated with the attraction of mates for breeding. Following mating, however, males no longer needed to mark as part of breeding-related behaviors. Additionally, after parturition, females with nursing cubs would not be traveling long distances and also might mark less to avoid advertising den locations. Thus, marking along the shoreline would be expected to decrease during summer. The second marking peak in fall coincided with the highest annual density of otters traveling along waterways. At this time females would be marking to re-establish territories and older cubs traveling with their mothers would contribute to the marking (Carpenter et al. In review).

Variation in scat marking by otters between the three rivers and among years could have been due to a combination of factors including differences in habitat characteristics, variability in spring thaw and flooding, and local densities at these sites in this establishing population. For example, during the two-year period, fewer latrines and/or scats were found along the Red River, than the other rivers (Forest River in 2007 and Turtle River in 2008). The Red River section of stream is located within the city of Grand Forks. Adjacent habitat on both sides of the river is wooded shoreline interspersed with open public park areas (called the Greenway) that were created after a major flood event in 1997 and that span the length of the city. While otter presence appears to be persistent in the area, poorer habitat quality from increased human disturbance may be limiting access to otters for marking along this stream segment. Additionally, in 2007, the Red River crested twice, in early spring from snow melt and then again in early summer due to high rainfall. Water levels rose onto the Greenway and up to mowed grass. This rendered portions of the shoreline unsuitable for marking and likely underestimated marking activity for the Red River during June, July and August 2007 when zero scats were detected at this site. Furthermore, fewer scats observed along the Red River, which defines the border between North Dakota and Minnesota also could be due to the fact that the animals are trapped on the Minnesota side of the Red River and densities just may be lower on this river. Conversely, between years, a greater number of scats was recorded for the Forest River in 2008 than in 2007, and by month, more scats were documented on this river in May

2008 than May 2007. It is possible greater marking activity is indicative of further population growth in the Forest River drainage.

Based on the data, the efficiency of surveys for otters would be enhanced if they were conducted during peak periods of marking (spring and fall). In North Dakota, May and October appeared to be the best times for detecting relatively large numbers of otter scats at latrine sites. However, while a spring marking peak occurred in May in 2008, it was not seen the previous year, likely a result of high water and flooding from spring snow melt washing away scats along the shoreline. Variability in spring thaw and flooding may result in fewer scats being detected during this season and local conditions should be taken into account when planning spring surveys. Summer months, especially July and August appeared to be the most challenging months for detecting otter scats.

While the data support peak marking in spring and fall, otter scats were detected all months surveyed (except for the Red River in 2007; Table 2). For basic presence/absence data, surveys conducted any season can detect occurrence of otters. Carpenter et al. (In review) discussed advantages and disadvantages of surveying for otters during the various seasons of the year. They reported that detecting latrines generally was uncomplicated from mid-spring through summer. In spring, the low density of herbaceous vegetation along the shoreline allowed for easy walking and scats were not obscured by vegetation. In summer, otters compressed riparian vegetation or selected open areas to defecate, making detection of marking activity relatively straightforward. But, hot weather, dense riparian vegetation, and low levels of scat marking contributed to summer being the least desirable time of the year for surveying. They further noted that limitations in searching for scats associated with dense vegetative cover could be minimized if surveys were timed to occur after herbaceous plants are killed following periods of heavy frosts. Additionally, during fall, crossing streams by wading generally was more easily accomplished because stream levels were lower than during spring. However, scats being covered by leaves was a primary limitation for conducting surveys during portions of the fall in their study. Carpenter et al. (In review) suggested this limitation could be minimized by planning surveys to precede leaf fall or allowing sufficient time after the peak leaf fall for otters to re-mark latrines. Leaf fall in the prairie dominated landscape of North Dakota probably is less of a factor than in the eastern United States. Fewer trees and higher-velocity winds that bring leaves to the ground relatively quickly may negate negative impacts of leaf fall on visibility of otter scats during this season. Ultimately, research objectives and availability of personnel may dictate time-periods to conduct surveys. If objectives included collecting a large numbers of scats (i.e., for analysis of DNA to document individuals to assess density), having a greater number of scats from more latrines along drainages would be helpful and surveys should be conducted in October; more marking also provides a greater number of opportunities to detect sign for less-experienced field technicians. If objectives included documenting species presence/absence in given drainages, surveys any time of year may be sufficient with limited training to detect sign. Summer months may be desired time-periods to conduct population surveys due to availability of field technicians at this time. However, summer was the most problematic time-period for detecting otter scats.

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Table 1. Average (Mean ± SD) number of river otter latrines located by month (April – November 2007 and May – August 2008) for three, 5-km stream sections in the Forest, Red, and Turtle Rivers of northeastern North Dakota.

Month	Average number of latrine sites	
	2007	2008
April	6.7 ± 4.2	---
May	7.0 ± 5.3	16.0 ± 10.6
June	5.0 ± 7.0	7.7 ± 5.5
July	4.2 ± 4.6	6.0 ± 5.3
August	2.7 ± 2.5	2.0 ± 2.8
September	4.0 ± 1.7	---
October	4.3 ± 1.5	---
November	2.3 ± 0.6	---

SD = standard deviation

Table 2. Average (Mean ± SD) number of river otter scats at latrines by month (April – November 2007 and May – August 2008) for both sides of three, 5-km stream sections along the Forest, Red, and Turtle Rivers of northeastern North Dakota.

		Average number of river otter scats at latrine sites							
		Forest River		Red River		Turtle River		All	
Year		*n*	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD
2007	April	10	1.7 ± 1.2	8	4.6 ± 3.3	2	1.5 ± 0.7	20	2.9 ± 2.6
	May	13	2.5 ± 1.4	5	3.8 ± 2.2	3	2.7 ± 1.5	21	2.9 ± 1.7
	June	11	3.2 ± 3.0	0	---	2	4.0 ± 1.4	16	3.1 ± 2.8
	July	11	4.2 ± 4.6	0	---	6	5.3 ± 5.9	17	4.6 ± 5.0
	August	5	3.2 ± 1.9	0	---	3	4.0 ± 4.4	8	3.5 ± 2.8
	September	5	3.6 ± 2.1	2	1.0 ± 0.0	5	6.0 ± 4.8	12	4.2 ± 3.7
	October	6	1.5 ± 0.5	3	13.7 ± 12.5	4	10.7 ± 5.7	13	7.1 ± 8.1
	November	2	4.0 ± 4.2	2	3.5 ± 0.7	3	3.0 ± 1.7	7	3.4 ± 2.1
	Total	65	2.9 ± 2.7	21	5.0 ± 5.9	28	5.2 ± 4.7	114	3.8 ± 4.1
2008	May	20	5.4 ± 6.0	4	3.5 ± 2.6	23	10.4 ± 6.1	48	7.7 ± 6.3
	June	8	4.0 ± 1.9	1	2.0 ± 0.0	13	8.1 ± 7.5	22	6.3 ± 6.2
	July	4	7.5 ± 3.9	2	1.0 ± 0.0	8*	2.7 ± 1.5	14	3.9 ± 3.3
	August	4	4.0 ± 2.6	0	---		**	4	3.2 ± 2.9
	Total	36	5.2 ± 4.8	7	2.2 ± 0.8	44	8.3 ± 6.6	88	6.5 ± 0.6

n = Number of latrines; SD = standard deviation; * only one side of stream segment surveyed; ** Indicates no data collected.

Figure 1. River otter scat surveys were conducted April – November 2007 and May – August 2008 along both shorelines of three, 5-km sections of the Forest River (Walsh County), and Red and Turtle Rivers (Grand Forks County) in northeastern North Dakota.

Figure 2. Average number of river otter scats per latrine (± SE) detected during monthly surveys (April – November 2007) along both shorelines of three, 5-km sections of stream in the Forest, Red, and Turtle River of northeastern North Dakota.

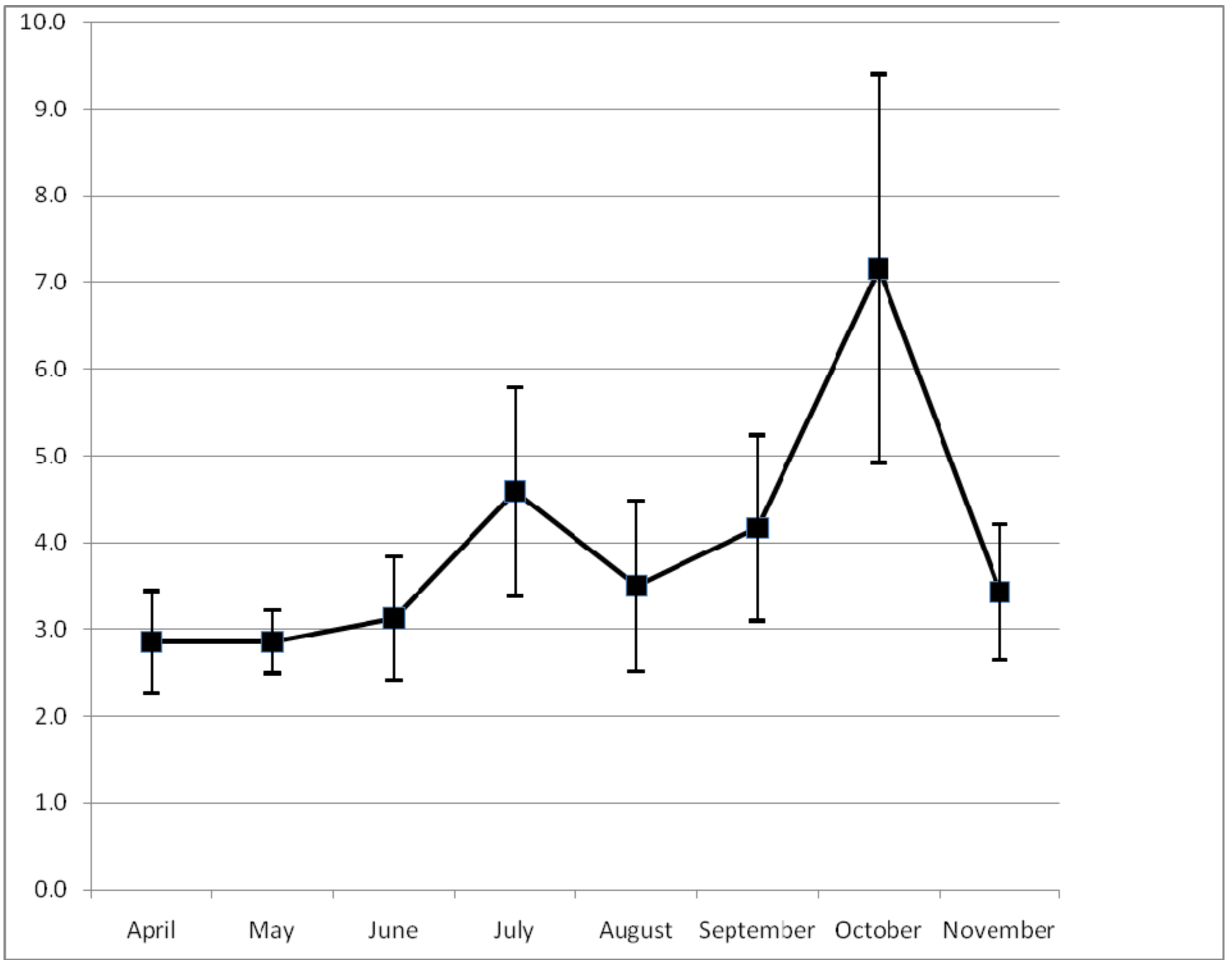


Figure 3. Average number of river otter scats per latrine (± SE) detected during monthly surveys (April – November 2007) along both shorelines of one, 5-km section of stream in the Red River of northeastern North Dakota.

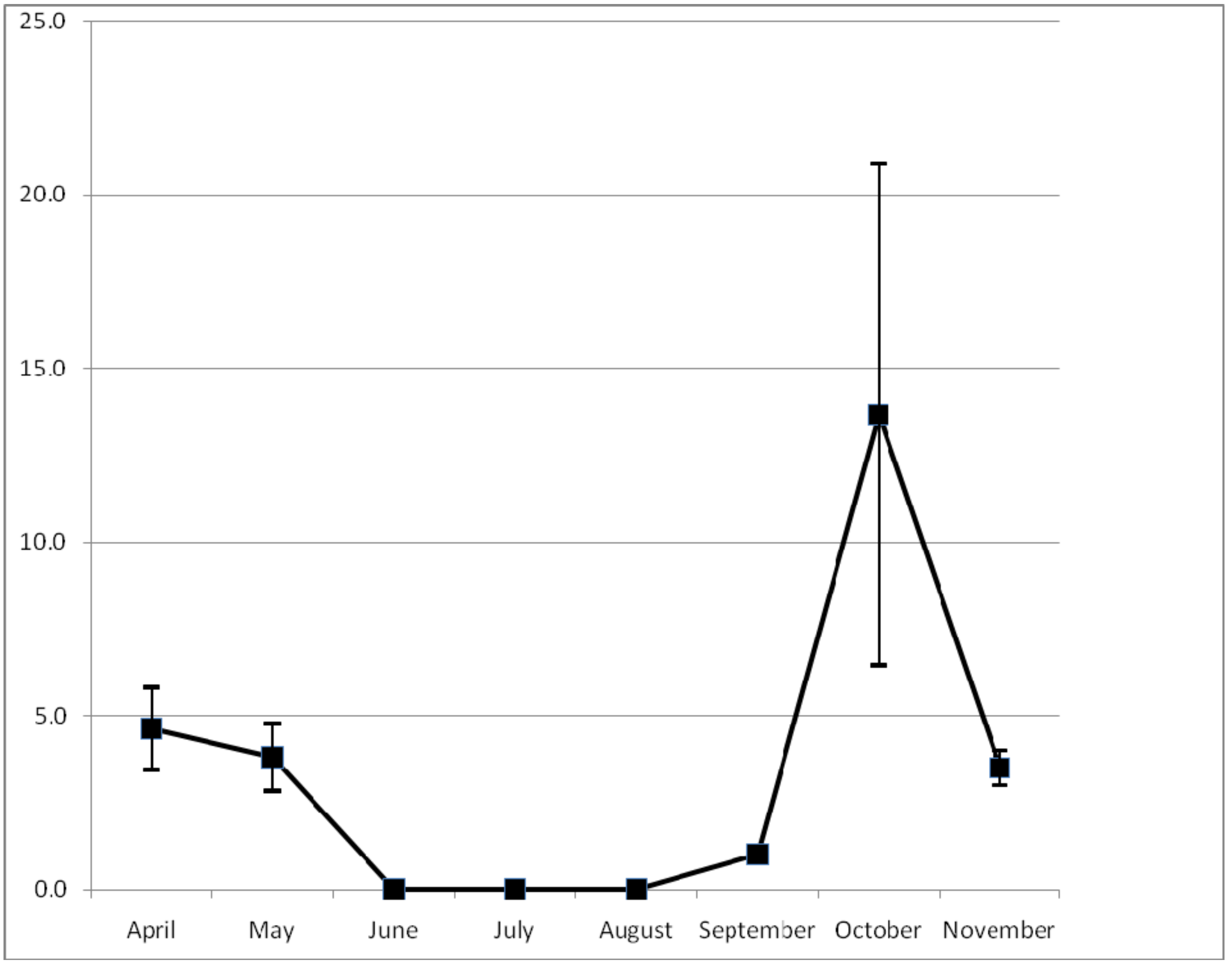


Figure 4. Average number of river otter scats per latrine (± SE) detected during monthly surveys (April – November 2007) along both shorelines of one, 5-km section of stream in the Turtle River of northeastern North Dakota.

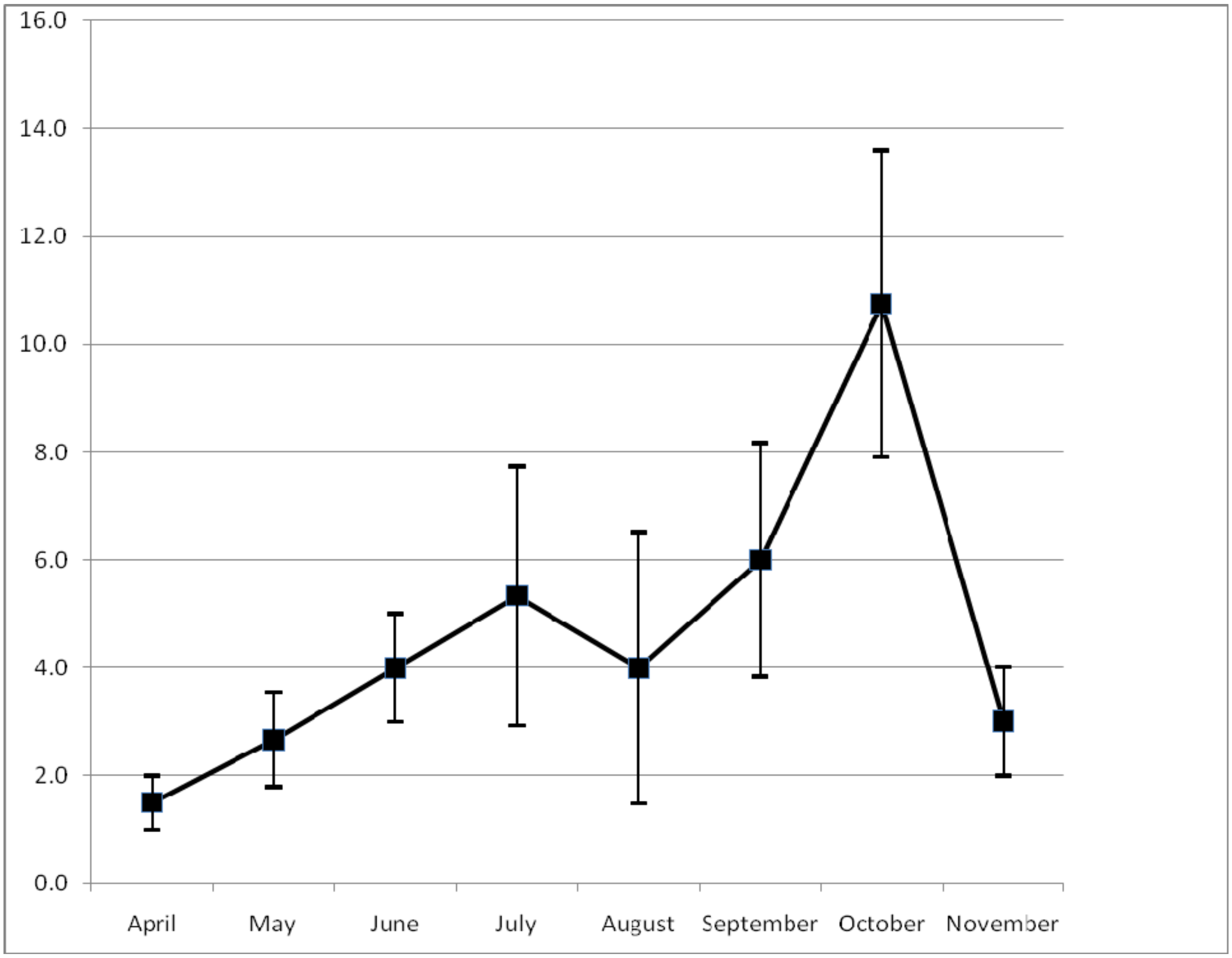


Figure 5. Average number of river otter scats per latrine (± SE) detected during monthly surveys (April – November 2007) along both shorelines of one, 5-km section of stream in the Forest River of northeastern North Dakota.

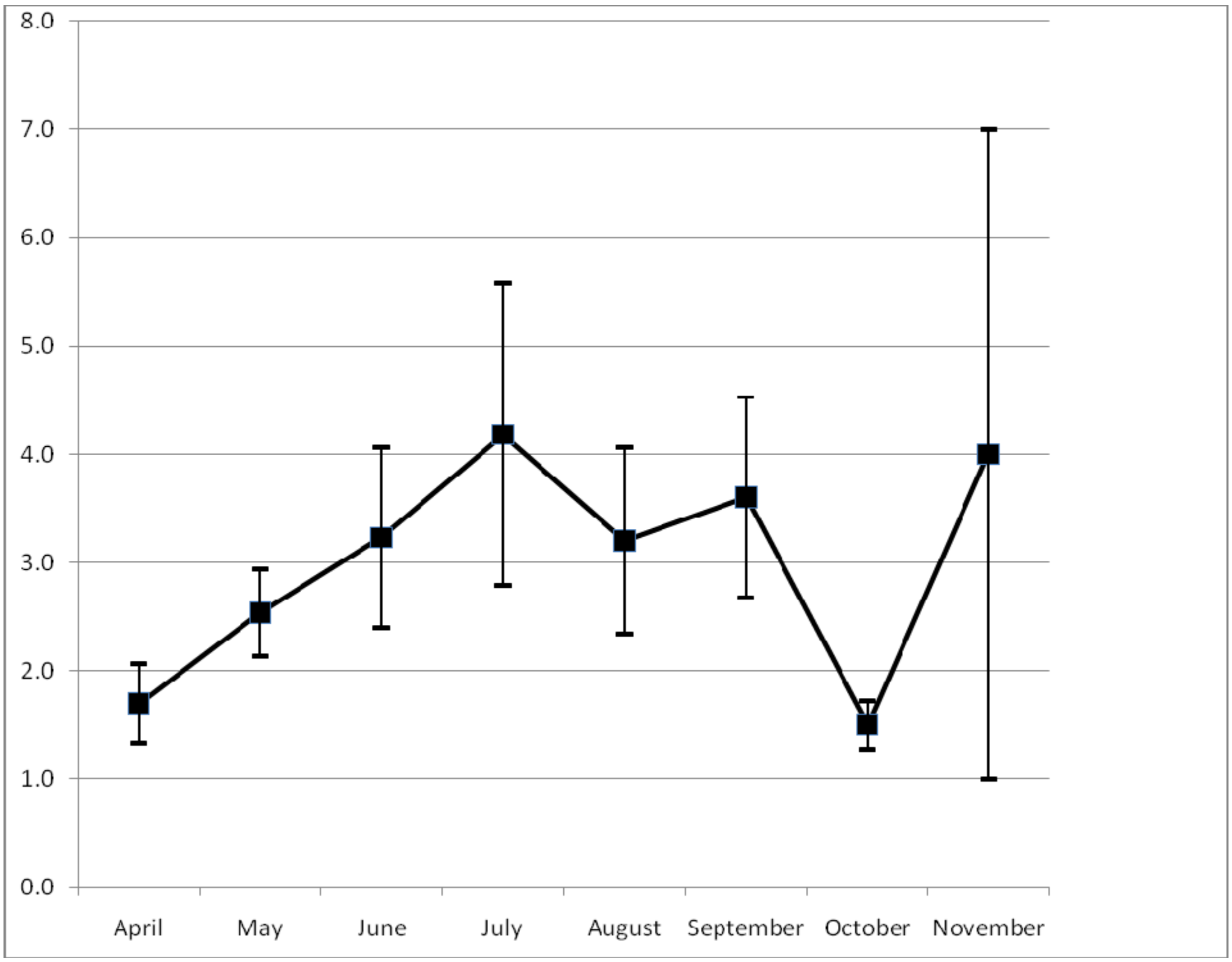


Figure 6. Average number of river otter scats per latrine (± SE) detected during monthly surveys (May – August 2008) along three, 5-km sections of stream in the Forest, Red, and Turtle Rivers of northeastern North Dakota.

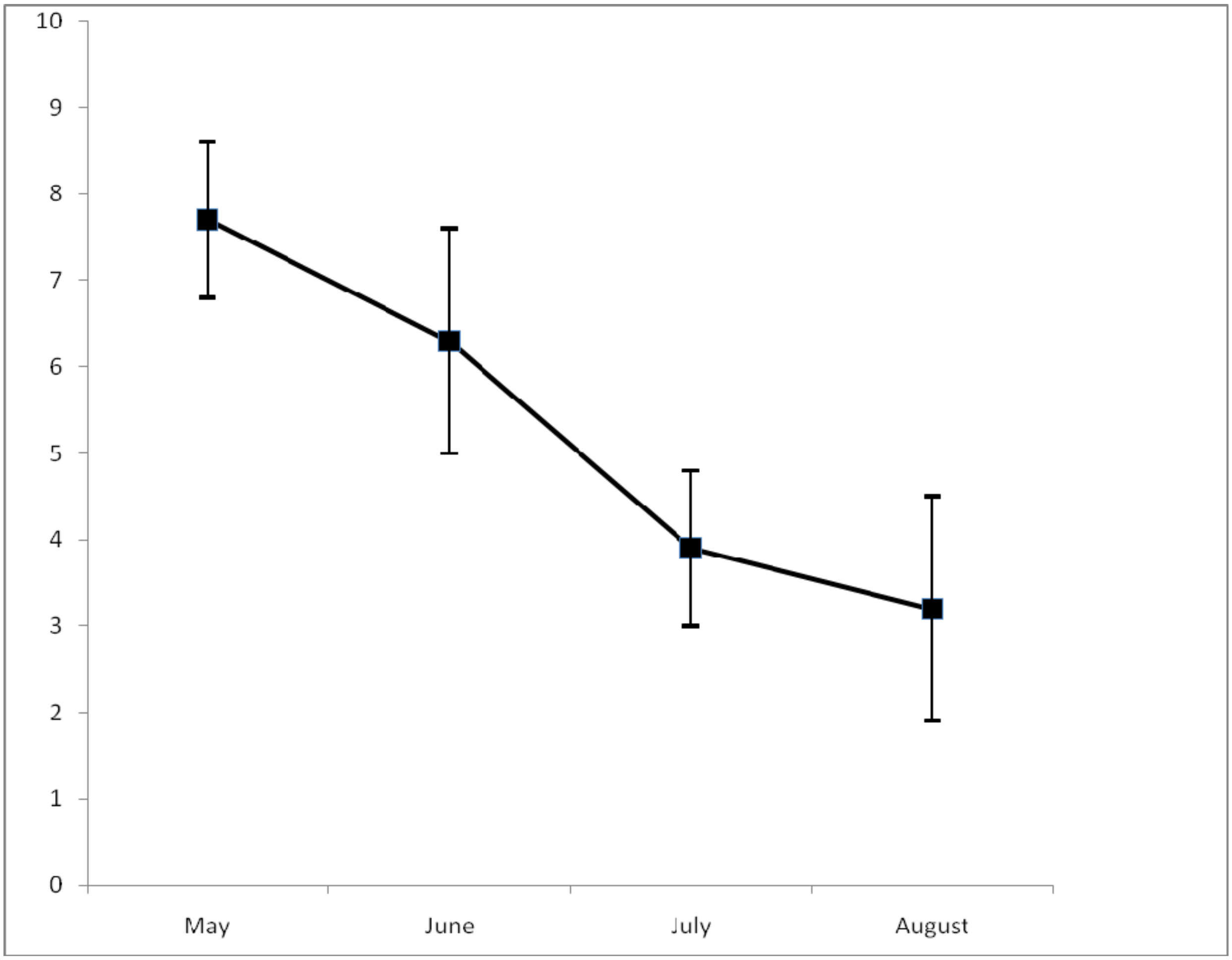


Figure 7. Average number of river otter scats per latrine (± SE) detected during monthly surveys (May – August 2008) along both shorelines of one, 5-km section of stream in the Red River of northeastern North Dakota.

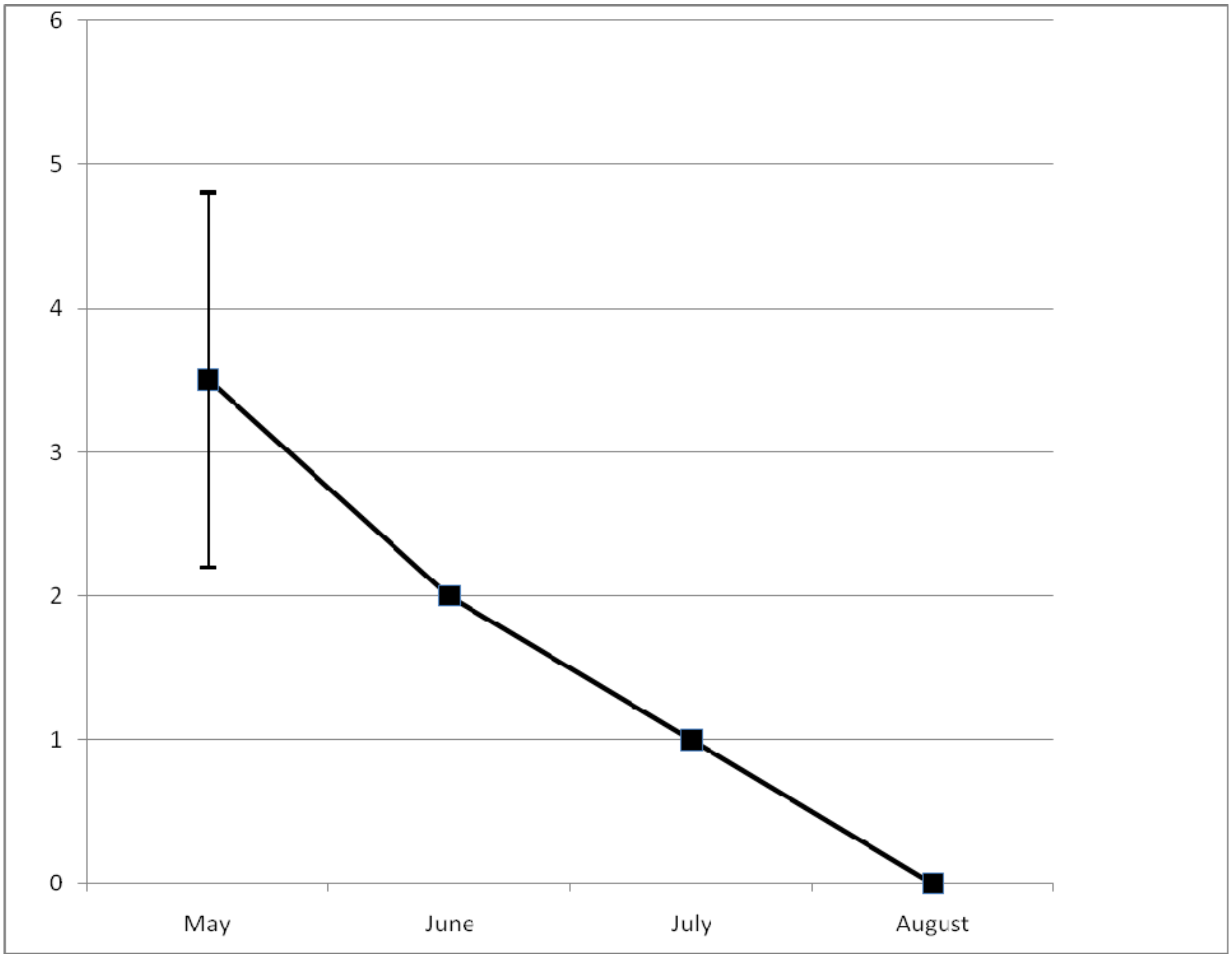


Figure 8. Average number of river otter scats per latrine (± SE) detected during monthly surveys (May – July 2008) along one, 5-km section of stream in the Turtle River of northeastern North Dakota. Both shorelines were surveyed in May and June and the east shoreline was surveyed in July.

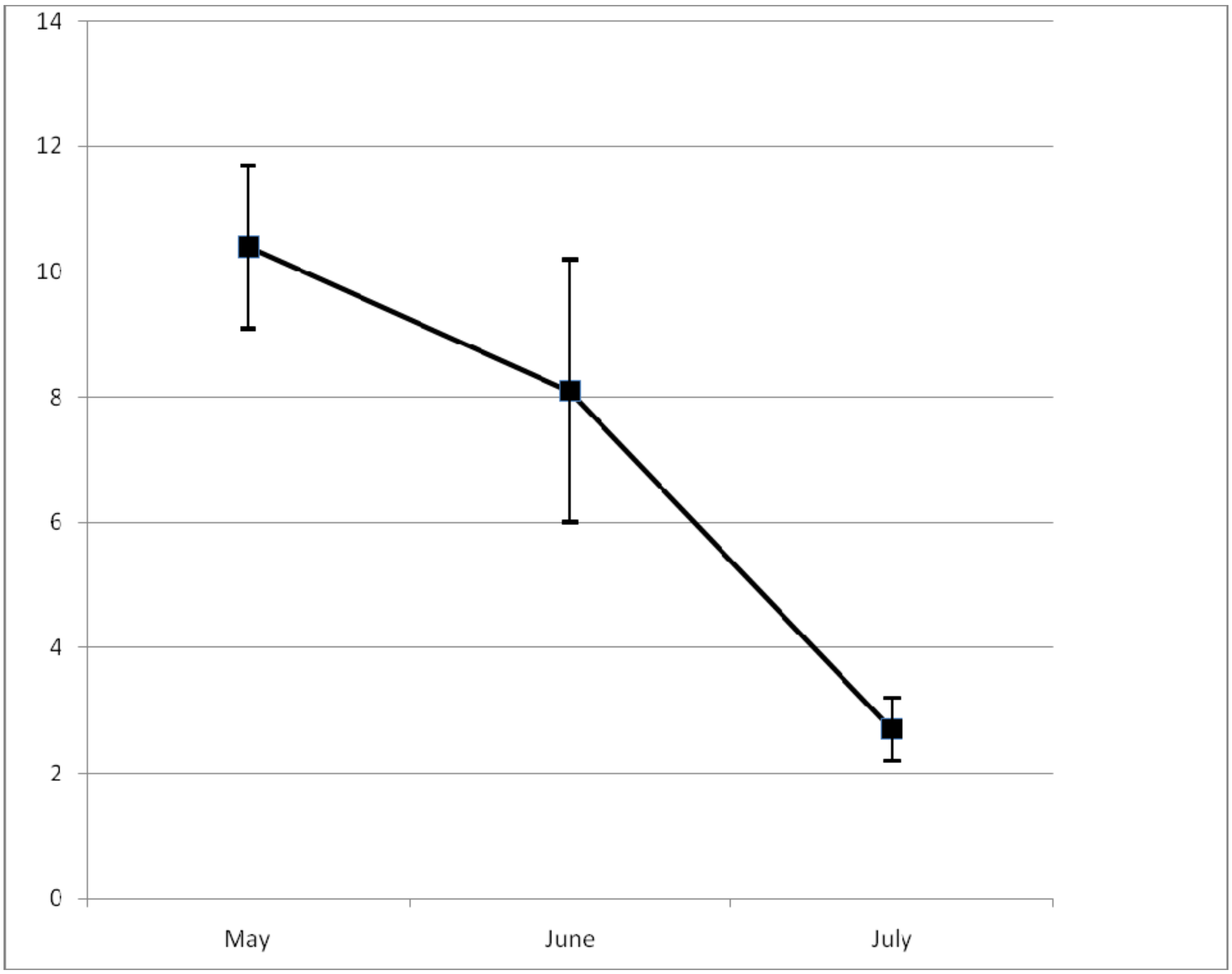
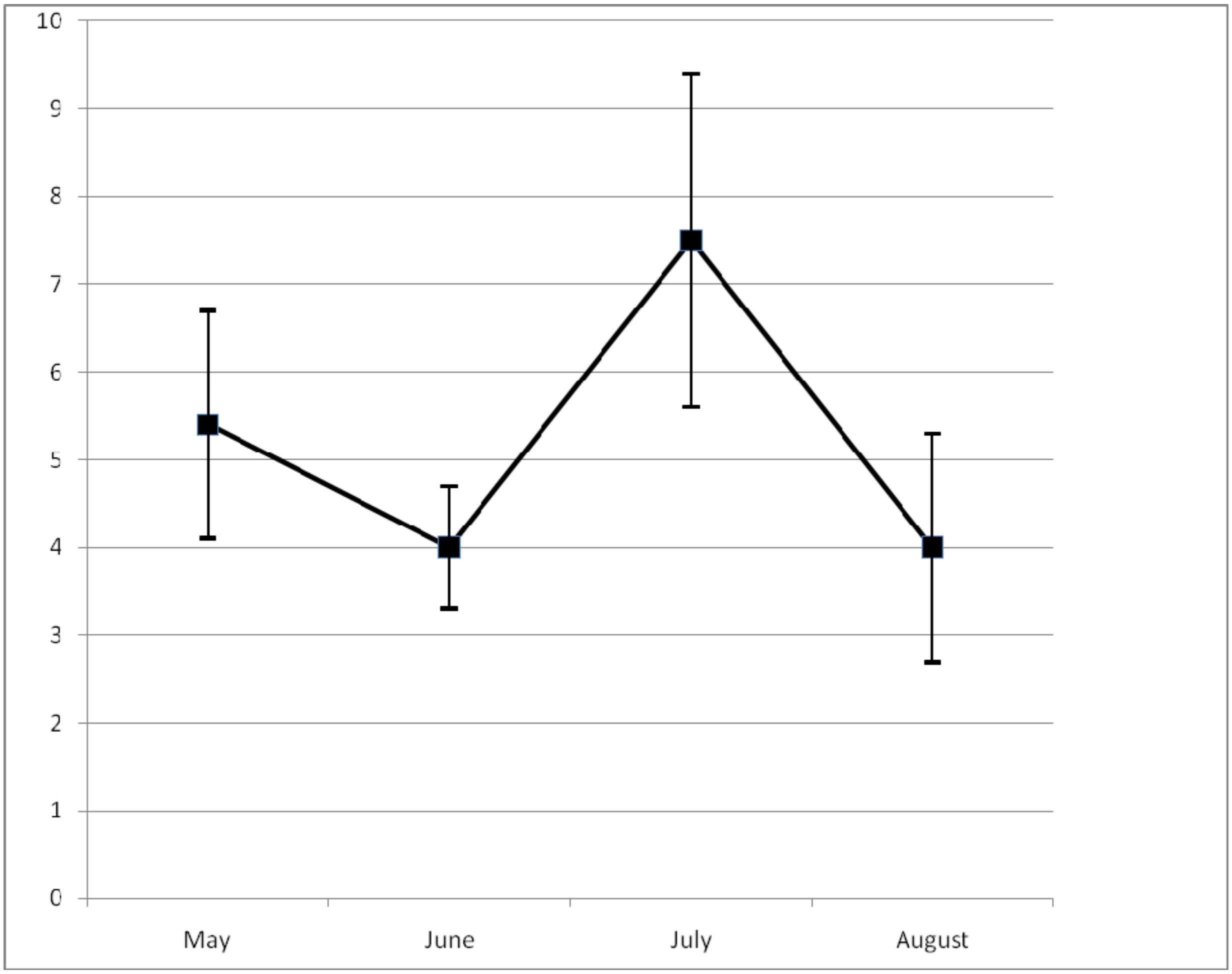


Figure 9. Average number of river otter scats per latrine (± SE) detected during monthly surveys (May – August 2008) along both shorelines of one, 5-km section of stream in the Forest River of northeastern North Dakota.



CHAPTER 6

Evidence of expansion of translocated American martens (*Martes americana*) into the Turtle Mountains of northcentral North Dakota

Abstract

The Turtle Mountains is a 1,680-km^2, heavily-wooded plateau located in northcentral North Dakota and southwestern Manitoba. American martens (*Martes americana*) are native to North Dakota but are not known to have historically occurred in the Turtle Mountains region of the state. However, martens apparently occurred in the Canadian Turtle Mountains until the 1940s. In 1989 and 1990, the Canadian Wildlife Service reintroduced 59 martens into Turtle Mountain Provincial Park. The objective of this research was to determine if martens from Manitoba had expanded into the Turtle Mountains of North Dakota. During the summer of 2007, we conducted a track-plate-box/camera station survey for martens. Survey sites were chosen based on a stratified random sampling design to focus efforts in areas with proportionally more forest cover (>50% forest cover per 1-km^2 survey cell). We surveyed 147 sites in 41, 1-km^2 cells. Martens were detected at 31 sites (21.1%) in 19, 1-km^2 cells that were distributed throughout the Turtle Mountains of North Dakota. Overall, marten detections occurred as early as the first day and no later than the ninth day of the 10 – 14-day cycles. Remote camera stations were deployed an average of 3.95 ± 2.76 nights before detecting a marten. Martens were detected during all time periods, but detection frequency was greatest for the 0801 – 1200 hour (26.5%) and 2001 – 0000 hour (23.5%) time periods. Our survey verified that martens have expanded their range into North Dakota through natural recolonization and provided baseline data from which the persistence of martens in the Turtle Mountains can be monitored. Track-

plate-boxes and remote cameras were effective devices for detecting marten presence, although the cameras enabled additional information to be collected on marten activity patterns.

Introduction

The Turtle Mountains of North Dakota and Manitoba (Figure 1) lies immediately west of the boundary delineating the historic distribution of American martens (*Martes americana*) in the upper Midwest (Strickland and Douglas 1987, Gibilisco 1994). Although there are no known historic records of martens occurring in the Turtle Mountains of North Dakota, the species is reported to have occurred in forested regions of northeastern North Dakota (Bailey 1926). Historic records indicated martens were trapped along the Park, Pembina, and Turtle Rivers, and in Grand Forks, Walhalla, and the Hair Hills (present-day Pembina Hills). Bailey (1926) further noted that the animals probably no longer occurred in North Dakota. In contrast, martens apparently occurred in the Canadian Turtle Mountains, including what today is known as the Turtle Mountain Provincial Park (TMPP, Fur Institute of Canada 2003; Figure 2). The TMPP was established in 1961 and covers an area of about 186 km^2 of forested land just north of the North Dakota - Manitoba border (Henderson et al. 2002). If true, the proximity of TMPP to North Dakota border provides evidence that the species also could have historically occurred in the Turtle Mountains of North Dakota. Regardless, by the 1940s martens were presumed be extirpated from the region largely because of forest fires in 1897, 1903, and 1921 (Fur Institute of Canada 2003, G. Armstrong, Manitoba Trappers Association, personal communication). The 1897 and 1903 fires burned almost all of the forest in TMPP, and in 1921, much of the Canadian forest was burned from a fire originating in North Dakota (Henderson et al. 2002). To restore the marten population, in 1989 and 1990 the Canadian Wildlife Service in cooperation with

Manitoba trappers live-trapped 59 martens from the Duck Mountains and Porcupine Hills of southwestern Manitoba and quick-released them into the TMPP. Sex ratio of translocated animals was about equal and juveniles comprised about 80% of the population. The population was protected for five years following the reintroduction, after which a recreational harvest in the Canadian Turtle Mountains District was initiated during the 1995-96 trapping season using a registered trapline system (G. Armstrong, Manitoba Trappers Association, personal communication; D. Berezanski, Provincial Furbearer Manager for Manitoba Conservation, Canadian Wildlife Service, personal communication).

In 2004, the North Dakota Game and Fish Department (Department) received the first recent verified report of a marten in North Dakota, in the Pembina Gorge region of the northeastern part of the state (North Dakota Game and Fish Department, unpublished data). Additionally, in the mid-2000s, the Department received unverified reports that martens were being incidentally trapped in the Turtle Mountains of North Dakota. Assuming reports were true, it was not known if these were isolated instances or if a population had developed in the region. The objective of our study was to determine if martens from Manitoba had expanded into the Turtle Mountains of North Dakota. If martens were detected, out next objective was to determine the distribution of the population.

Study Area

The Turtle Mountains is a 1,680 km^2 (649 mi^2) plateau located in northcentral North Dakota and southwestern Manitoba (Figure 1; North Dakota Game and Fish Department 2006). The region is roughly bisected by the Manitoba – North Dakota international boundary (Henderson et al. 2002); about 1,058 km^2 (408 mi^2; 63%) of the Turtle Mountains is in North

Dakota and 622 km^2 (240 mi^2; 37%) is in Canada (North Dakota Game and Fish Department 2006). The plateau rises 180 to 240 meters above, and receives a greater amount of precipitation [about 25.4 cm (10 in.) more] than the surrounding plains, enabling the area to support a heavily wooded landscape. Climate of the Turtle Mountains is continental. Mean annual precipitation is 40.6 – 55.9 cm (16.0 – 22.0 in). Mean minimum and maximum January temperatures are -23.3°C and -12.2°C (-10.0°F and 10.0°F), respectively; mean minimum and maximum July temperatures are 11.7°C and 26.7°C (53.0°F and 80.0°F), respectively (Bryce et al. 1998).

The Turtle Mountains is characterized as having a rolling topography of thick, mature, upland deciduous forest interspersed with hundreds of small lakes and wetlands (Henderson et al. 2002). The dominant tree species is aspen (*Populus tremuloides*), but other species include bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), paper birch (*Betula papyrifera*), boxelder (*Acer negundo*), sumac (*Rhus glabra*), Saskatoon serviceberry (*Amelanchier alnifolia*), snowberry (*Symphoricarpos albus*), and balsam poplar (*Populus balsamifera*) (Stewart 1975; Bluemle 2002; Hagen et al. 2005). Understory woody vegetation includes beaked hazelnut (*Corylus cornuta*), willows (*Salicaceae spp.*), red raspberry (*Rubus idaeus*), prickly rose (*Rosa woodsii*), pin cherry (*Prunus pennyslvanica*), and highbush cranberry (*Viburnum edule*) (Bluemle 2002; Stewart 1975). Conifer trees also are present in the Turtle Mountains, but are limited and a primarily a result of past introductions. For example, between 1912 and 1959, the Canadian Department of Mines and Natural Resources planted 325,000 white spruce, 8,000 Scots pine (*Pinus sylvestris*) and 1,000 ‘other conifer species’ trees on Provincial lands. White spruce (*Picea glauca*) trees were planted in plantation blocks intermittently from 1912 to 1943, and again in the 1960s and 1970s. Additionally, in North Dakota, in the early 1960s and again in the late 1980s and early 1990s, the Turtle Mountain Tribal Forestry Office planted a wide variety of conifers in plantations on the 105.3 km^2 (40.6 mi^2) Turtle Mountain Chippewa Indian Reservation of southeastern Turtle Mountains; in 1997, plantations from previous years were disked and replanted with 18,000 spruce and pine seedlings (Henderson et al. 2002).

The majority of the Turtle Mountains of North Dakota is privately owned. Major land uses on private land include grazing and subdivision for home sites. State and federally owned lands include Lake Metigoshe State Park (6.2 km^2), Turtle Mountain State Forest Service lands [31.2 km^2; including Turtle Mountain Recreational Forest (23.1 km^2) and Twisted Oaks Recreation Area (4.54 km^2), Wakopa Wildlife Management Area (27.5 km^2), and four easement National Wildlife Refuges (NWR; Rabb Lake, Willow Lake, Lords Lake, and School Section Lake NWRs)]. The International Peace Gardens, a 9.46 km^2 park is located in the center of the Turtle Mountains, on the North Dakota-Manitoba border.

Methods

During the summer of 2007 (19 June – 30 July 2007) we conducted a track-plate-box/camera-station survey for martens in the Turtle Mountains of North Dakota (Bagherian 2008). Survey sites were chosen based on a stratified random sampling design using a Geographic Information System (ESRI ArcGIS 9.3.1; Environmental Systems Research Institute, Redlands, California). The Turtle Mountains region of North Dakota (excluding the Turtle Mountain Indian Reservation land) was divided into 12 100-km^2 units, and each 100-km^2 unit was further subdivided into 100 1-km^2 cells (Figure 3). Based on a National Land Cover database (U.S. Geological Survey Land Cover Institute, EROS Data Center, Sioux Falls, South Dakota), we determined the percentage of forest cover for each 1-km^2 cell. Cells with ≥50%

forest cover (*n* = 515 cells) were considered potential marten habitat (Hargis and McCullough 1984, Thompson 1994) and deemed suitable for sampling. Within each 100-km^2 unit, we randomly sampled about eight of the candidate cells. From this sample of candidate cells, 1-km^2 cells were randomly selected to survey for martens; within each random 1-km^2 cell, typically three random sites were chosen for placement of detection devices. This sampling method allowed us to concentrate detection efforts in areas with proportionally more forest cover and survey a relatively large area over a short time-period, thereby increasing chances of detecting this rare carnivore. Within a given survey site, we chose specific areas to survey that were a minimum of 0.4 km from vehicle access roads and 0.16 km from human trails. If a candidate cell was inaccessible (e.g., permission not granted to access a cell that was comprised of private property), we surveyed the next randomly selected 1-km^2 cell in the respective 100-km^2 unit.

We followed procedures for detecting forest carnivores similar to those established by Barrett (1983), Jones and Raphael (1993), Zielinski and Kucera (1995), and Gomper et al. (2006). Each of the three sites per 1-km^2 cell contained a track-plate-box (Figure 4), a remotely-triggered camera (Figure 5; Reconyx, RECONYX, Inc., Holmen, Wisconsin; Cuddeback Digital, Non Typical, Inc., Green Bay, Wisconsin), or both devices (Figure 5). Beaver meat (85 – 170 g per site; NDGF and USDA Wildlife Services, Bismarck, North Dakota) was used as bait and beaver castor (NDGF, Bismarck, North Dakota) and skunk essence (Minnesota Trapline Products, Pennock, Minnesota; Dusty Hough's Fur Shed, Barnesville, Minnesota) as general attractants.

We conducted two 10-14-day survey cycles (20 unique cells per cycle), with each cycle consisting of the placement of detection devices at 70 and 77 unique locations (cycle-1 and cycle-2, respectively) separated by at least 0.2 km. Survey cycles lasted 10 – 14 days; devices were set up at sites during days 1 – 5 of the cycle, checked and re-baited (if needed) on days 6 – 9, and collected on days 10 – 14. We recorded dates and GPS locations of detection devices visited by martens. We calculated the proportion of detections for each detection devices for each survey cycle (overall, and by detection device). To document activity patterns, marten detections from photographs were grouped by time of day into six, four – hour time periods (0001 – 0400 hours; 0401 – 0800 hours; 0801 – 1200 hours; 1201 – 1600 hours; 1601 – 2000 hours; and 2001 – 0000 hours) and percent frequency of detection by time-period was calculated.

Results

We surveyed a total of 147 sites in 41 candidate cells over two, 10 – 14-day cycles (Figures 6 and 7). Martens were detected in 19 cells (46.3%) at 31 (21.1%) unique sites (Figures 7 – 9). Detections were widely distributed in the survey area, occurring in 9 of the 12 100-km^2 units. However, 13 of the 19 cells with detections occurred east of U.S. Highway 281 (Figure 7). The number of detections between the two cycle periods were similar, suggesting no temporal changes in visitation rates from early to late summer. For example, we detected martens on track-plate-boxes at 6 of 31 (19.4%) sites with track-plate-boxes in the first cycle, and 5 of 34 (14.7%) in the second cycle. For camera stations, martens were detected at 9 of 39 (23.1%) sites in the first cycle, and 11 of 43 (25.6%) in the second cycle. At camera stations where martens were detected (n = 20), the first detection occurred from 1 to 9 days, with an average first detection of 3.95 ± 2.76 days. Thirteen (50%) of 26 sites with confirmed marten presence had multiple marten detections. Martens were active during all time periods (Figure 10). However, frequency of detection was greatest for the 0801 – 1200 hour (26.5%) and 2001 – 0000 hour (23.5%) time periods.

Discussion

Our population survey documented marten presence in the Turtle Mountains of North Dakota and also revealed the animals were distributed over a relatively large geographic area. Thus, this study confirmed that martens have expanded their range into the North Dakota through natural recolonization and are no longer extirpated from the state. The most logical source is the translocated marten population of the Turtle Mountain Provincial Park of Canada. Interestingly, the decidiuous upland forest of the Turtle Mountains is not considered typical marten habitat; throughout the western United States, martens are known to inhabit late-successional, mesic, coniferous forests (Buskirk and Powell 1994). Nevertheless, the translocated population appears to be persisting in the region. Whether or not the Turtle Mountains population sustains similar densities to those occurring in more traditional marten habitat is unknown. In Canada, total marten harvest is reported every year but the current status of the population in the Turtle Mountains District of Manitoba has not formally been evaluated (Manitoba Conservation Wildlife Ecosystem Protection Branch 2009).

The techniques we used to survey for martens in the Turtle Mountains were effective at detecting the presence of martens as the species readily approached track-plate-boxes and camera stations. The cameras enabled the collection of additional information (exact dates and visitation times) at survey sites that allowed us to document activity patterns of martens. We determined that the animals were active during all periods of the day but that most marten activity occurred during crepuscular and morning hours. Regardless, both techniques enabled the collection of presence/absence data, which was sufficient for verifying range expansion of the species. However, with few exceptions (See Figure 9), data collected track-plate-boxes and camera stations did not enable discrimination of sex and/or age classes of animals visiting stations. To evaluate the current status of the marten population in the Turtle Mountains of North Dakota, additional ecological (e.g., home range, habitat use) and demographic (e.g., age and sex ratios, reproduction and cause-specific mortality) information from a sample radio-collared study animals is needed. After an initial population estimate has been determined, for long-term monitoring, our survey could be repeated periodically at a sample of survey sites to document population trends. We found that nine days was a sufficient time-period to leave detection devices at sites as martens were not detected after that day. Future surveys in the region could cover the same area in less time by removing devices at sites earlier in the survey cycle.

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Figure 1. The Turtle Mountains, a 1,680-km^2, heavily-wooded plateau located in northcentral North Dakota and southwestern Manitoba.

Figure 2. The Turtle Mountain Provincial Park (TMPP) of Manitoba Canada. Established in 1961, TMPP is located in the Turtle Mountains, just north of the North Dakota – Manitoba border, and covers a forested area of about 186 km^2. Fifty-nine American martens were reintroduced into the TMPP between 1989 and 1990 by the Canadian Wildlife Service.

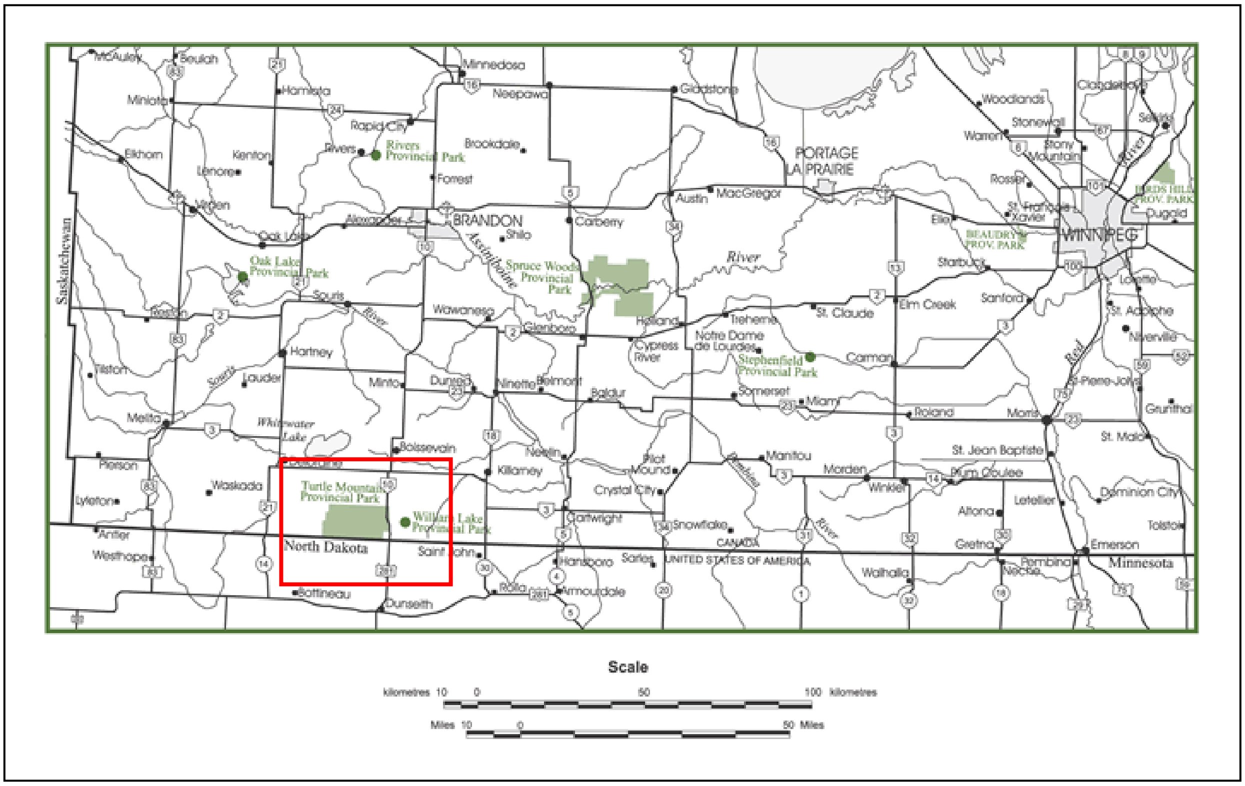


Figure 3. Survey sites were chosen based on a stratified random sampling design. The Turtle Mountains region of North Dakota was divided into 12, 100-km^2 units, and each 100-km^2 unit was further subdivided into 100, 1-km^2 cells. The percentage of forest cover for each 1-km^2 cell was determined and cells with ≥ 50% forest cover were considered potential marten habitat, suitable for sampling.

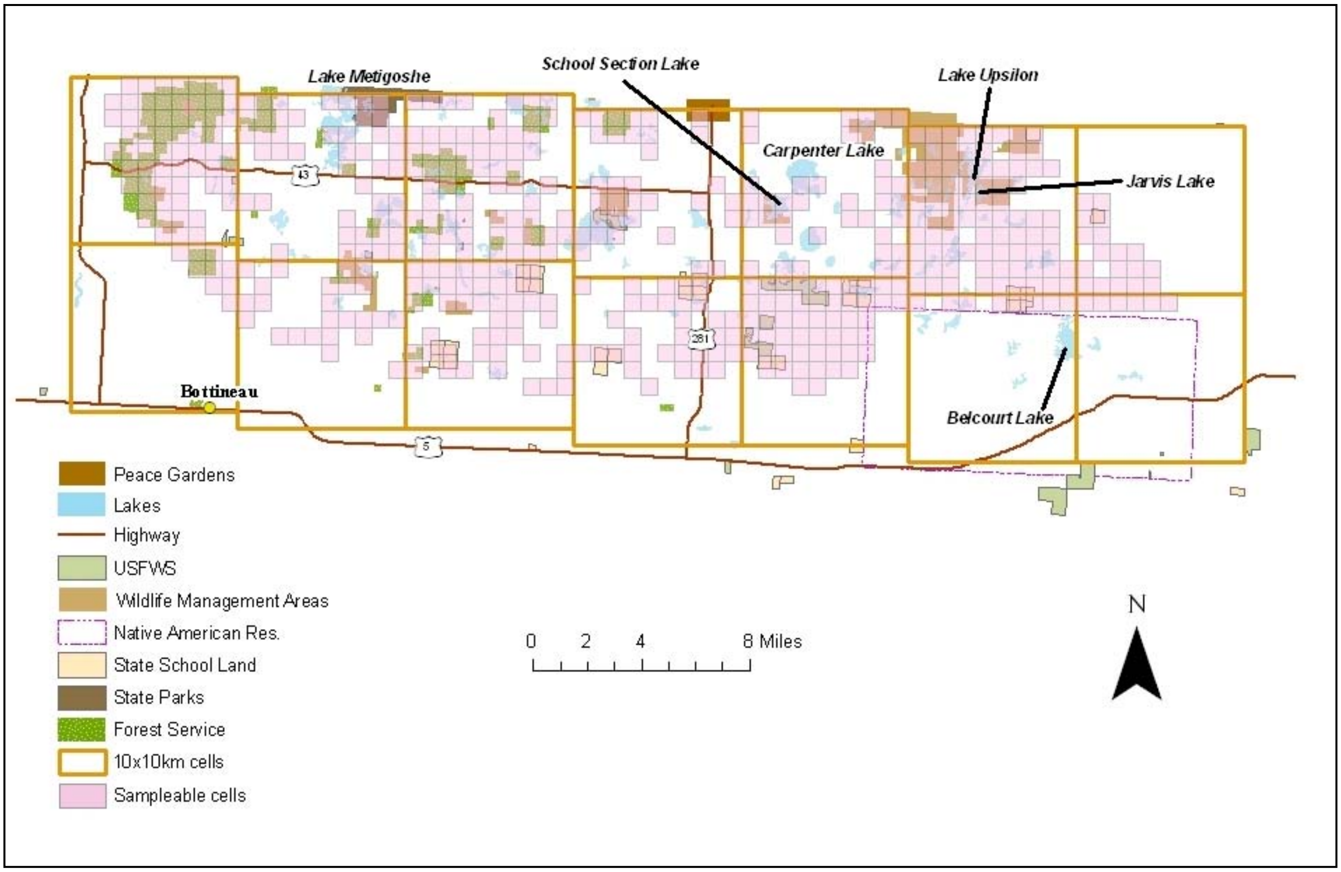


Figure 4. Track-plate-box used to survey for American martens in the Turtle Mountains of North Dakota

Figure 5. A) Camera stations used to survey for American martens in the Turtle Mountains of North Dakota. Bait was placed approximately 1 – 1.5 m from the camera and elevated approximately 0.3 m above ground with sticks or placed on large snags (0.5 – 1 m above ground) when present. B) Track-plate-box with camera. Cameras were placed at varying distances from the track-plate-boxes but low and close enough to take photos of animals entering the boxes.

Figure 6. Survey sites (n = 147) where track-plate-boxes and remote camera stations were placed in the Turtle Mountains of North Dakota to detect American martens during Summer 2007.

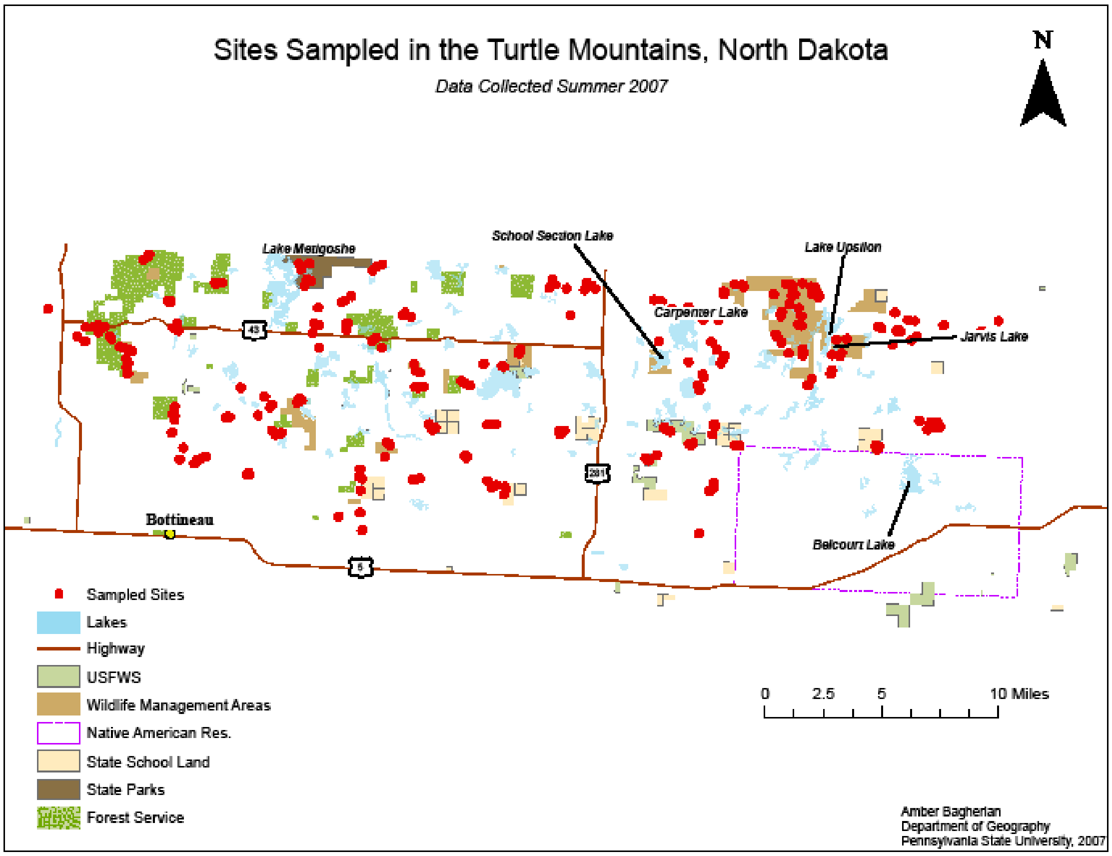


Figure 7. Forty-one, 1-km^2 cells in the Turtle Mountains of North Dakota that were surveyed for American martens during Summer, 2007.

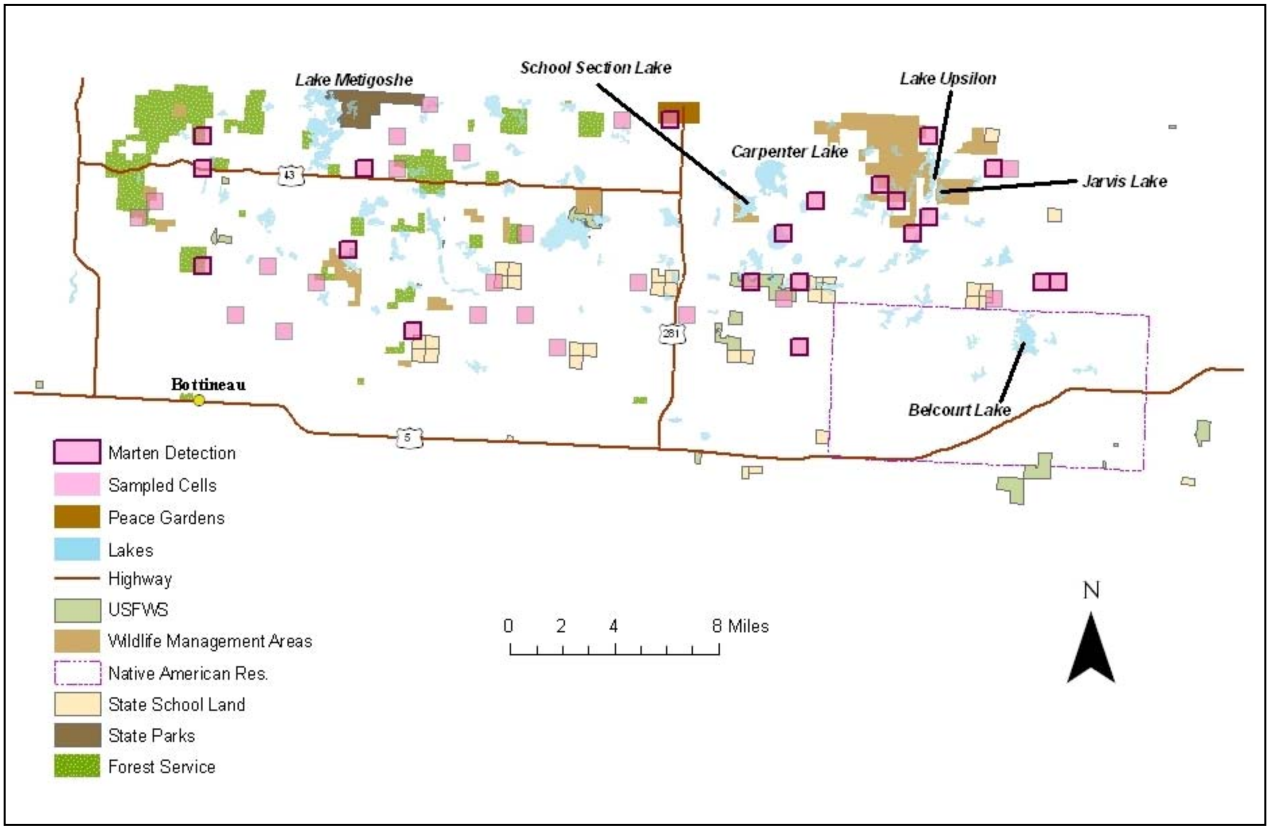


Figure 8. Locations (n = 31) where American martens were detected by track-plate-boxes or remote camera stations in the Turtle Mountains of North Dakota, Summer 2007.

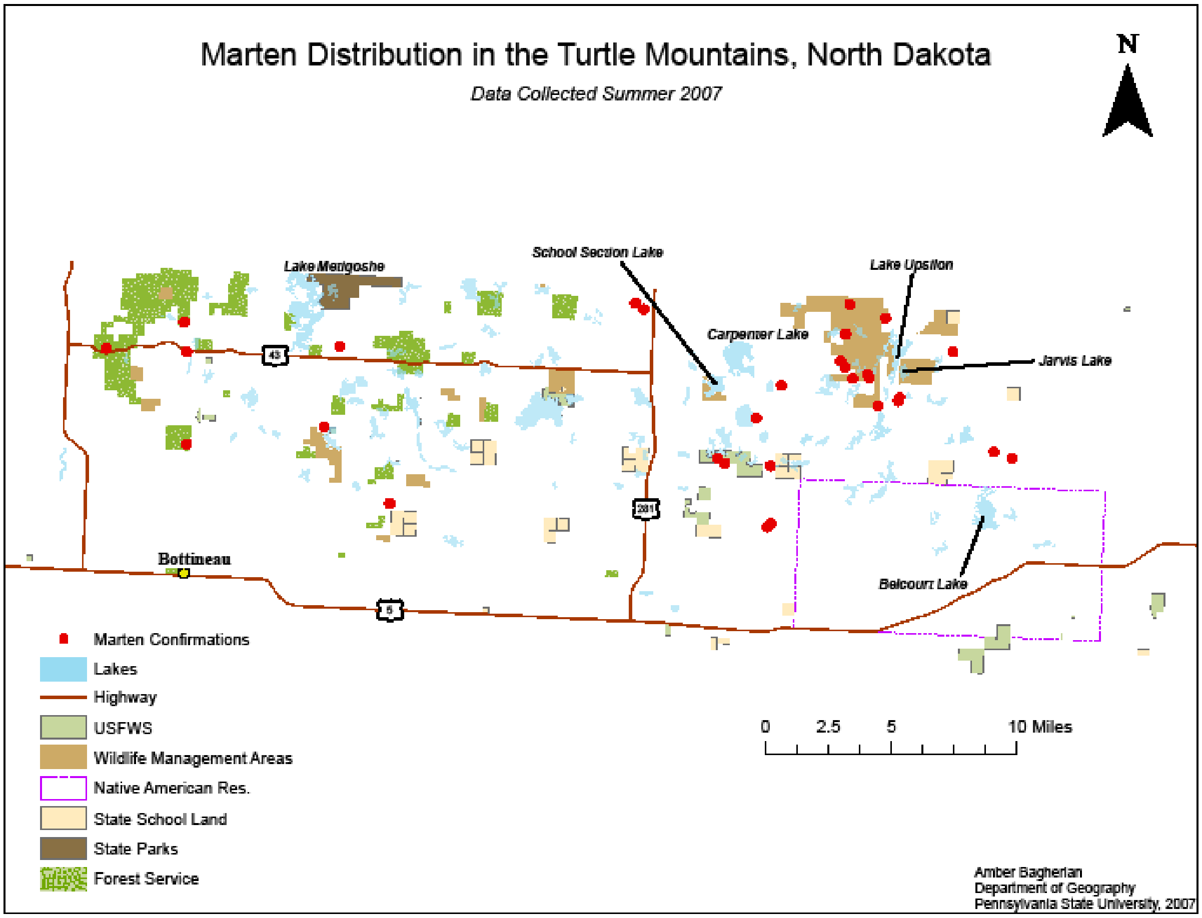
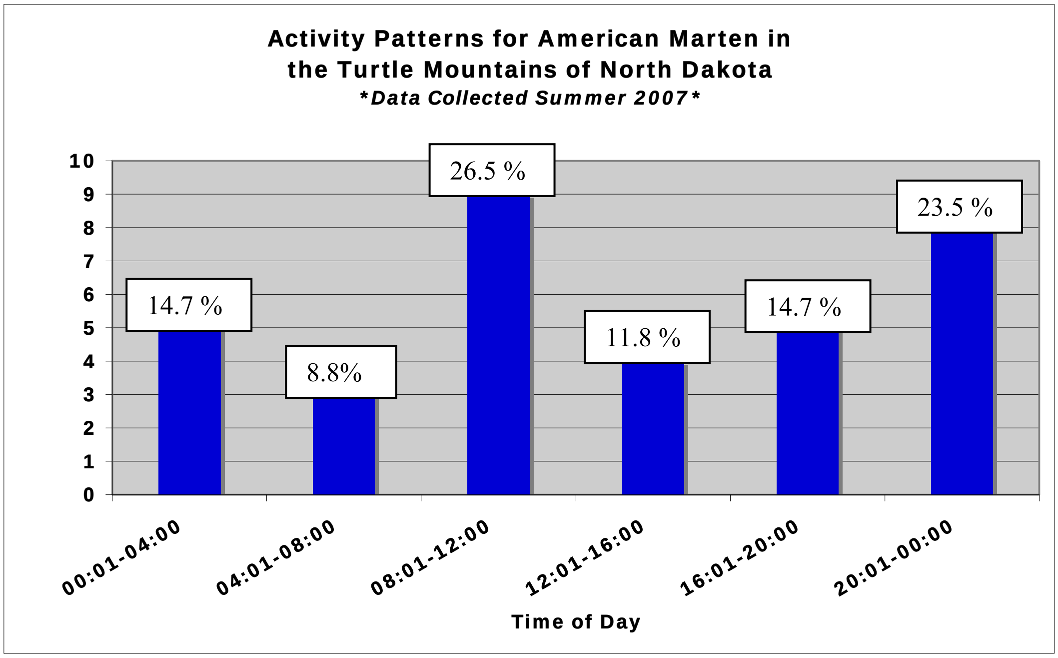


Figure 9. Remotely-triggered photograph of a juvenile American marten detected at a baited track-plate-box in the Turtle Mountains of North Dakota, Summer 2007.

Figure 10. Frequency of detections by time period (0001 – 0400 hours; 0401 – 0800 hours; 0801 – 1200 hours; 1201 – 1600 hours; 1601 – 2000 hours; and 2001 – 0000 hours) for American martens detected by remote cameras in the Turtle Mountains of North Dakota. Data were collected from 19 June to 30 July, 2007.



CHAPTER 7

Efficacy of Track-plate-boxes and Remote Cameras to Detect Fishers (*Martes pennanti*) in North Dakota

Abstract

We compared the efficacy of track-plate-boxes and remote cameras to detect fishers in eastern North Dakota ultimately to aid in enhancing effectiveness and efficiency of future surveys for species monitoring. Presence/absence data collected for fishers in 2008 and 2009 were analyzed at 41 sites in eastern North Dakota where both devices were placed and where fishers were detected by at least one device. Based on a nine-day sampling period, about 90% of the fisher detections for both years occurred by day seven, and for the 2009 survey, the gain in detections leveled off at about 11 days. While both devices enabled the collection of presence/absence data and had minimal operating requirements, initial cost of remote cameras was greater than that of track-plate-boxes. However, remote cameras detected a greater percentage of fishers (90%) and had a lower percentage of false absences (10%) than track-plate-boxes (73% and 27%, respectively). The results of this study can aid wildlife managers in the development of a fisher monitoring program in North Dakota. Both devices enabled the documentation of the species' occurrence, provided information on the current distribution of fishers in the state, and facilitated the collection of binomial data to conduct other statistical analyses (e.g., documentation of habitat use). However, the cameras provided additional behavioral information (e.g., activity patterns, documentation of family groups) at survey sites as well as a more robust dataset needed to develop an occupancy model, which yields a more accurate analysis of population status than that of presence-absence sampling.

Introduction

Wildlife researchers and managers have developed a variety of non-invasive sampling techniques for monitoring rare species and gathering information on unstable populations (Herzog et al. 2003). In the recent past, surveys using track-plate-boxes and/or remote cameras have been used to document presence of carnivores (Halfpenny et al. 1995, Zielinski and Kucera 1995, Fecske et al. 2002, Gompper et al. 2006). Track-plate-boxes are comprised of an aluminum plate (0.25 m x 0.55 m x 1.5 mm thick), a plywood baseboard (0.3 m x 0.6 m x 12.7 mm thick), and a flat, flexible plastic rectangle (0.6 m x 1 m and 6.5 mm thick; Figure 1). The plastic rectangle is inserted into two grooves cut in the elongate sides of the wooden base, creating a dome that provides a protective cover for the metal plate. A layer of carbon soot is created on about half of one side of the metal plate component using an acetylene torch. White household shelf- liner paper (adhesive side up) is placed on the clean part of the plate, leaving a small amount of space for bait and the plate is placed inside the domed structure. Assembled and baited/lured boxes are placed against a tree with the bait end adjacent to the tree (Figure 1). Small logs and branches are used to fill any openings between the plate and tree to ensure animals enter the carbon-sooted end. Visiting animals deposit carbon-sooted tracks on the adhesive paper leaving evidence of their presence (Figure 2). Track-plate-boxes yield high-quality track prints on a medium that can be stored as a permanent record. Unlike conventional scent stations, track-plate-boxes can be set up in rocky areas and are less constrained by weather conditions (Taylor and Raphael 1988, Nottingham et al. 1989, Raphael 1994, Zielinski and Stauffer 1996, Hamm et al. 2003).

In addition to track-plate-boxes, recent advances in technology have made cameras efficient tools for detecting wildlife (Kucera et al. 1995, Gompper et al. 2006). Remotely-triggered cameras [e.g., Reconyx (Reconyx, LLP, Holmen, Wisconsin); Cuddeback (Cuddeback Digital, Park Falls, Wisconsin)] typically are mounted to trees and aimed at an attractant (bait or lure) that is placed on a log or a stick about 0.3 m above ground, 1.0 – 1.5 m in front of the camera. Grasses, shrubs, and small trees around cameras are cleared to ensure unobstructed photos of animals entering the sites. When an animal approaches the attractant, motion or heat sensors, or a line or plate triggers the shutter and an image is captured. For each visit, date and time are recorded on photographs, which may be black-and-white images or in color.

Comparing track-plate-boxes and remote cameras for their ability to detect target species is important in order to determine which devices are most appropriate for various applications (Foresman and Pearson 1998, Moruzzi et al. 2002, York et al. 2001, Zielinski et al. 2006). Track-plates and remote cameras have received mixed reviews for their detection capabilities (Bull et al. 1992, Foresman and Pearson 1998, Mowat and Paetkau 2002, Gompper et al. 2006). The objective of our study was to compare the efficacy of track-plate-boxes and remote cameras at detecting fishers in eastern North Dakota, ultimately to aid in enhancing effectiveness and efficiency of future surveys for monitoring the species. Our research was the first study to compare the latest technological advances of both devices at the same sampling sites. This was carried out through the analysis of presence-absence data obtained from a population survey conducted in for fishers in 2008 and 2009. Presence-absence sampling is a cost effective tool for assessing the spatial and temporal distribution of animal populations (Zielinski and Stauffer 1996).

Study Area

This research was part of a larger project to document the current distribution of fishers in North Dakota (see Chapter 1). The survey sites used for this part of the study occurred within forested patches where fishers were detected along the Goose, Pembina, Tongue, Turtle and Red Rivers in northeastern North Dakota (Figure 3). Historically, the region was characterized by tallgrass prairie and riparian forest contained within the floodplain (Renard et al. 1986). However, during the late 1800s, pioneers settling in North Dakota converted the tallgrass prairie and riparian areas to monoculture fields (Renard et al. 1986). Today, the forested areas are limited, occurring primarily along the rivers and in shelterbelts at the edges of agricultural fields (Bailey 1926, Renard et al. 1986, Sovada and Seabloom 2005). Dominant overstory vegetation of forest patches consisted of American elm (*Ulmus Americana*), aspen (*Populus tremuloides*), balsam popular (*Populus basamifera*), boxelder (*Acer negundo*), bur oak (*Quercus macrocarpa*), eastern cottonwood (*Populus deltoids*), green ash (*Fraxinus pennsylvannica*), paper birch (*Betula paperifera*), and members of the family Salixaceae (Bailey 1926, Sovada and Seabloom 2005). The understory varied throughout the study area, but consisted predominately of chokecherry (*Prunus virginiana*), gooseberry (*Ribes missouriense),* hawthorne (*Crateagus spp.*), raspberries (*Rubus spp.),* and serviceberry (*Amelanchier arborea*).

Methods

Presence/absence data collected for fishers in 2008 and 2009 (See Chapter 1) were analyzed at 41 sites in eastern North Dakota (along the Turtle, Red, Pembina, and Tongue Rivers) where two detection devices (track-plate-box and remote camera; Figure 4) were placed over a nine and 13-day period in 2008 and 2009, respectively, and where fishers were detected by at least one device. To determine amount of time necessary to leave detection devices at survey sites, while minimizing the number of false absences (when fishers actually were present, but not detected) we documented Latency to Detection (LTD; number of sampling days that pass until a fisher was detected) for the two survey periods. Additionally, we compared association of detections for with time-of-day (crepuscular, diurnal and nocturnal hours) using Chi-Square tests (Conover 1999), to aid in identifying time-periods when placement of devices at sites might cause the least amount of disturbance to potentially visiting animals. Detection devices were compared based on their relative detection ratios (total number of detections/ total number of sites) and number of false absences; a false absence occurred when one device received a detection but the other did not at the same site.

Results

In 2008, we received 90% of fisher detections by day seven of the nine-day sampling period (Figure 5), and in 2009, 90% of fisher detections were received by day ten of the 13-day sampling period (Figure 6). Additionally, based on a horizontal slope, the gain in detections in 2009 leveled off at about 11 days. When the two sampling periods were compared (based on an equal sampling period of nine days), about 90% of the fisher detections for both years occurred by day seven (Figure 7). Both devices enabled the collection of presence-absence data and had minimal operating requirements (Table 1). Remote cameras detected a greater percentage of fishers and had a lower percentage of false absences than track-plate-boxes (Table 2). Remote cameras were more expensive to purchase than track-plate-boxes, but cameras enabled the collection of behavioral information at survey sites. For example, fishers were detected at camera stations during crepuscular and early morning hours in 2008 ($\chi2 = 8.13$; $n = 72$; $P =$

0.01), but in 2009, were detected during all time periods ($\chi2 = 0.37$; $n = 172$; $P = 0.83$; Figure 8). Additionally, during the two-year period, juveniles (1 or 2) were documented at survey sites on seven occasions (6/27/08, 7/14/08, 6/29/09, 7/16/09, 7/20/09, 7/23/09, and 8/6/09). Based on dates detected and behavior exhibited by juveniles in other studies (Eadie and Hamilton 1958, Coulter 1966, Wright and Coulter 1967, Mead 1989, Powell 1993) time-period of parturition for fishers in eastern North Dakota was estimated to occur mid-to-late March.

Discussion

The results from this study can aid wildlife managers in the development of a fisher monitoring program in North Dakota. Presence-absence surveys using both devices enabled the documentation of the species' occurrence, provided information on the current distribution of fishers in the state, as well as additional information that can be gleaned from the data. For example, presence-absence sampling provided binomial information that could be analyzed statistically (i.e, assessing habitat at sites where fishers were detected versus where they were not detected). Track-plate-boxes performed sufficiently for this type of sampling and were less expensive than remote cameras. However, track-plate-boxes did not perform as well as the cameras at detecting fishers when the species was present. Additionally, while not formally evaluated, we found that track-plate-boxes required a greater amount of maintenance during survey cycles as the aluminum plates often had to be re-sooted and fitted with new shelf-liner paper due to visits by non-target animals and rainy weather, whereas the cameras required little maintenance. Nevertheless, our results indicated that track-plate-boxes were useful devices for detecting fisher presence.

When cursory information is needed on a population and/or under conditions where budgets may be constrained, track-plate-boxes may be appropriate devices to conduct fisher population surveys. However, for a variety of reasons, remote cameras may more desirable, especially in situations in which initial costs to acquire sufficient numbers of cameras for sampling is not an issue. First, the cameras detected more fishers when they were present than the track-plate-boxes, as the camera stations did not require animals to enter an enclosure to leave evidence of their presence and they also detected approaching animals over a broader area. Getting the greatest number of detections during field surveys is important, not only for establishing occurrence of rare species, but also to build sample sizes to increase statistical power (probability of detecting a change given that a change actually has occurred; i.e., documenting population declines/increases based on reduced/increased visitation by animals to detection devices). For less effort in the field, the cameras also provided more information, including the exact dates that fishers visited sites, numbers of animals at sites, visitation times, and duration at sites. We used the information to evaluate activity patterns of the species, document family groups, and estimate parturition dates of fishers in the region. Documenting breeding activity was important for our initial survey of fisher presence in North Dakota (See Chapter 1) as the animals formerly were extirpated from the state (Bailey 1926). However, the behavioral information collected at survey sites also could be used by wildlife managers to increase efficiency of future surveys for population monitoring. For example, we assessed survey-cycle duration for fishers and determined that detection devices placed for 11 days should be sufficient for detecting fishers if they are present at survey sites. However, if time were a factor for managers, then devices left out in the field for at least seven days would detect most fisher presence in a given drainage. Additionally, based on activity patterns, time-of-day devices were set in the field probably mattered little as far as disturbing and/or scaring animals from approaching survey sites where they were detected as over the two-year period, animals were documented at sites during all time periods. However, more information is needed on activity patterns of fishers in North Dakota, because our findings between the two years differed, and in 2009, probably were influenced by a major flood event that occurred that spring in the Red River Valley. In general, activity patterns of fishers have been characterized as being highly dynamic and influenced by a multitude factors, including prey abundance, geography, weather conditions, seasonal, and reproductive behaviors (Coulter 1966, Kelly 1977, Strickland et al. 1982, Raine 1987, Arthur and Krohn 199, Powell 1993, Weir and Corbould 2007). Finally, cameras provided a more robust dataset that could be used to develop an occupancy model, which yields a more accurate analysis of population status than presence-absence sampling. In presence-absence sampling, a lack of detection does not necessarily indicate the absence of a species from the survey area. Occupancy modeling adjusts for false absences and derives a probability estimate for the survey area (Mackenzie et al. 2002). In addition to building a strong predictive model of fisher presence recent developments in occupancy modeling also have resulted in the derivation of population parameters (MacKenzie et al. 2002, Mackenzie 2005) which are necessary for modeling populations. Thus, remote cameras yield the greatest amount of data for a less amount of effort in the field and may be appropriate to use when more specific information is needed on the population.

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Table 1. Comparison of cost and performance for two devices (track-plate-boxes and remote cameras) used to detect fishers in eastern North Dakota.

	Track-plate-box	Remote cameras
Initial cost	$20.00	$200.00 – $600.00
Operating requirements	Contact paper; acetylene torch	Batteries
Ability to collect presence/absence data	Yes	Yes
Ability to collect behavioral information	Poor	Good
Ability to perform in inclement weather	Fair	Good

Table 2. Comparison of total number of fisher detections and false absences for two devices (track-plate-boxes and remote cameras) used to detect fishers at 41 sites in eastern North Dakota where fishers were detected by at least one device. A false absence occurred when one device received a detection, but the other did not at the same site. Percentages are in parentheses.

	Track-plate-box	Remote cameras
Total Detections	30 (73)	37 (90)
False Absences	11 (27)	4 (10)

Figure 1. A) Track-plate-box configuration consisting of an aluminum plate, a plywood baseboard, and a flat, flexible plastic rectangle. B) A layer of carbon soot is applied to about half of one side of the aluminum plate using an acetylene torch. White household shelf liner paper (adhesive side up) is placed on the clean part of the plate, and a small amount of space is left for bait. The plate is placed inside the domed structure. C) The assembled, baited track-plate-boxes are placed against a tree with the bait end adjacent to the tree. Snags and other coarse woody debris fill any openings between the plate and tree to ensure that animals enter the carbon-sooted end.

Figure 2. Track impressions on adhesive paper left by a fisher visiting a track-plate-box station during a survey for the population in eastern North Dakota (2008, 2009).

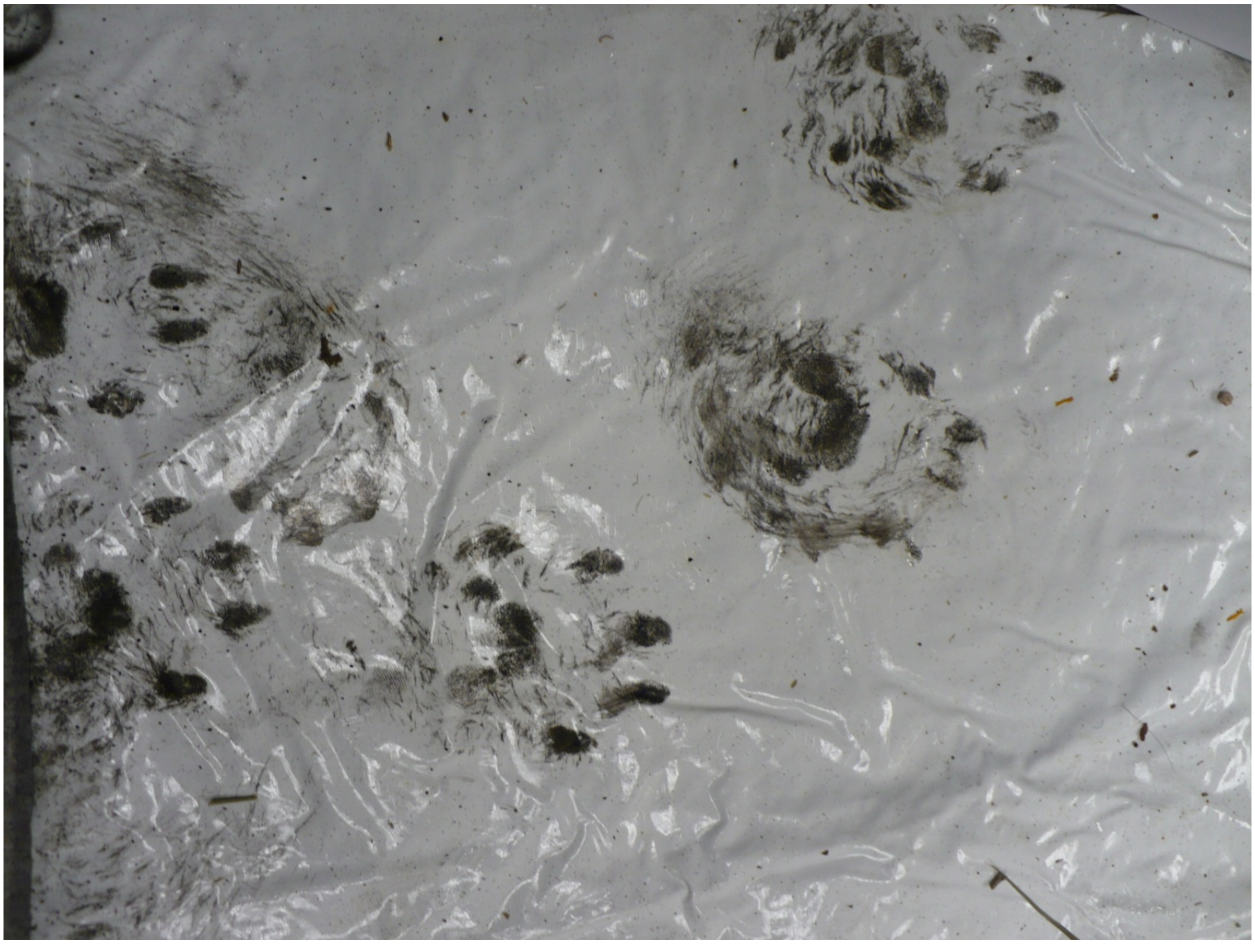


Figure 3. Survey sites used to assess detection devices (track-plate-boxes and remote cameras) occurred along the Pembina, Tongue, Turtle, Red, and Goose Rivers in northeastern North Dakota (2008 and 2009) where fishers were detected.

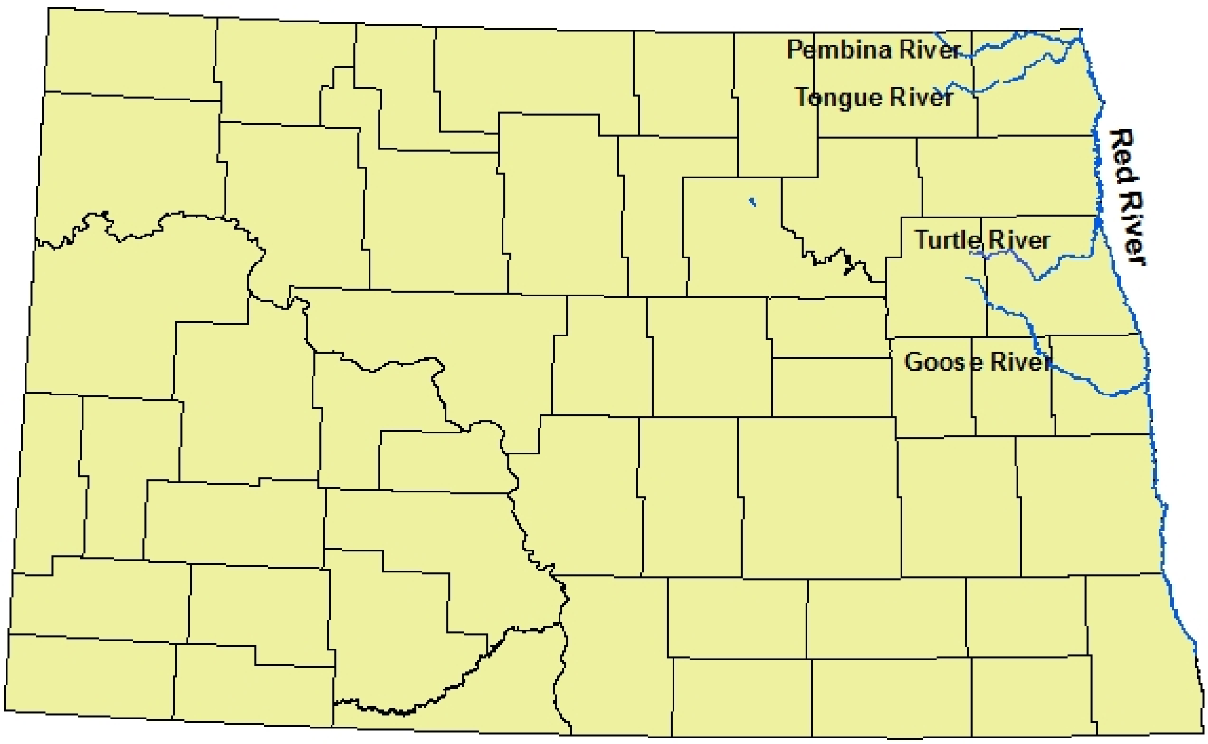


Figure 4. Track-plate-box and remote camera placed at survey sites in eastern North Dakota (2008, 2009) to detect fishers.

Figure 5. Latency to Detection (the number of sampling days that pass until an animal is detected) for 2008 fisher population survey conducted in eastern North Dakota. The sampling period was nine days per survey site (n = 38) and about 90% of fisher detections occurred by day seven.

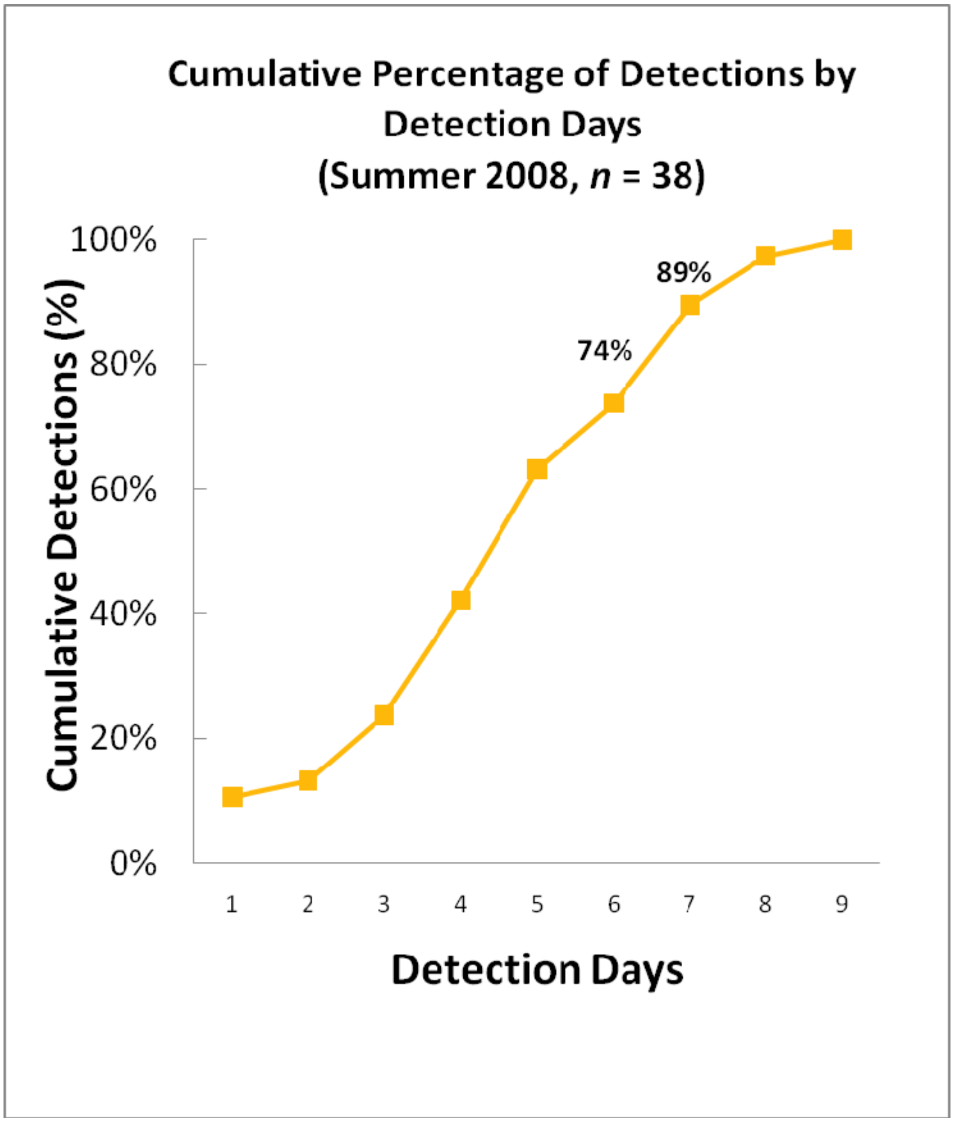


Figure 6. Latency to Detection (the number of sampling days that pass until an animal is detected) for 2009 fisher population survey conducted in eastern North Dakota. The sampling period was 13 days per survey site and about 90% of fisher detections occurred by day 10; based on a horizontal slope, the gain in detections leveled off at about 11 days.

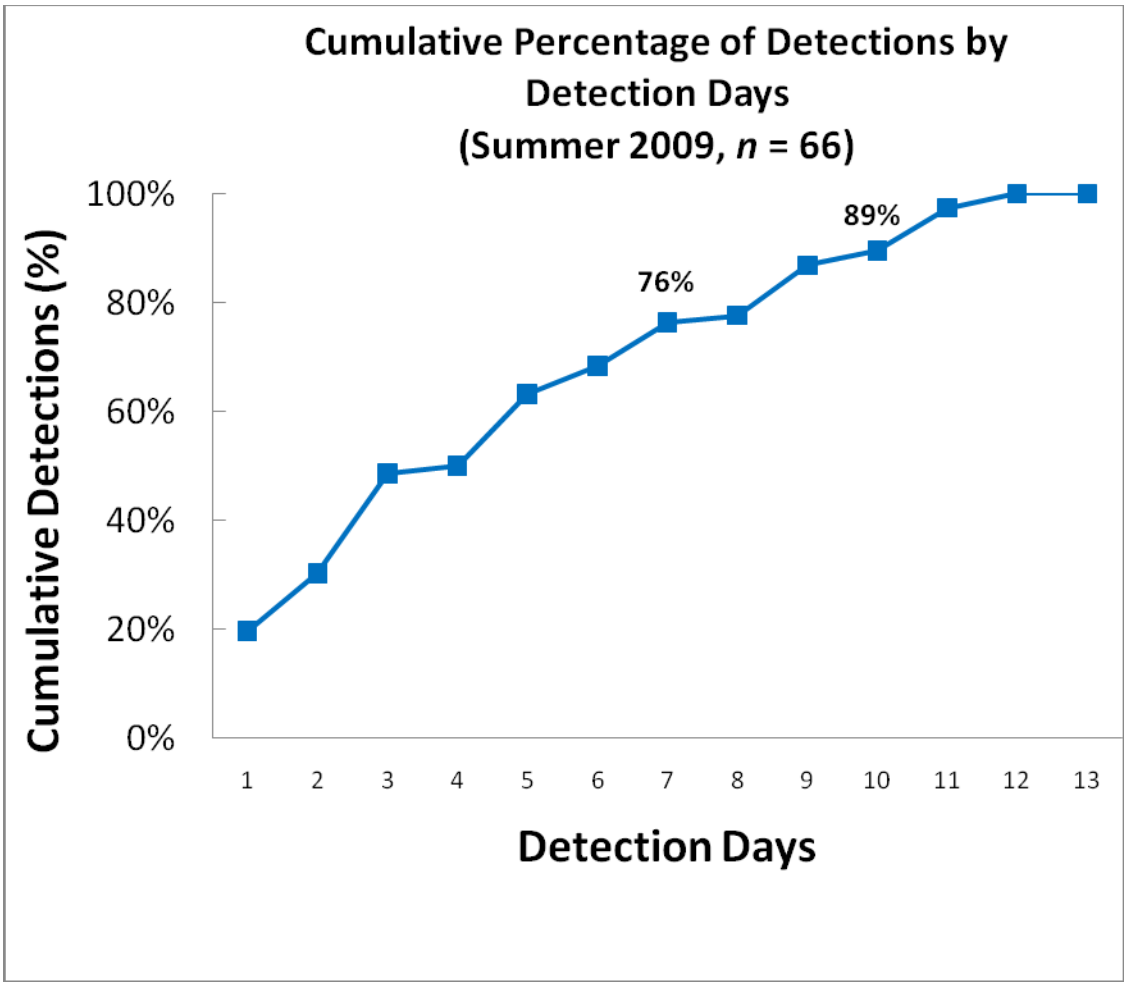


Figure 7. Comparison of Latency to Detection (the number of sampling days that pass until an animal is detected) for 2008 and 2009 fisher population surveys conducted in eastern North Dakota, when sampling periods equaled nine days for the two survey periods. About 90% of fisher detections occurred by day seven.

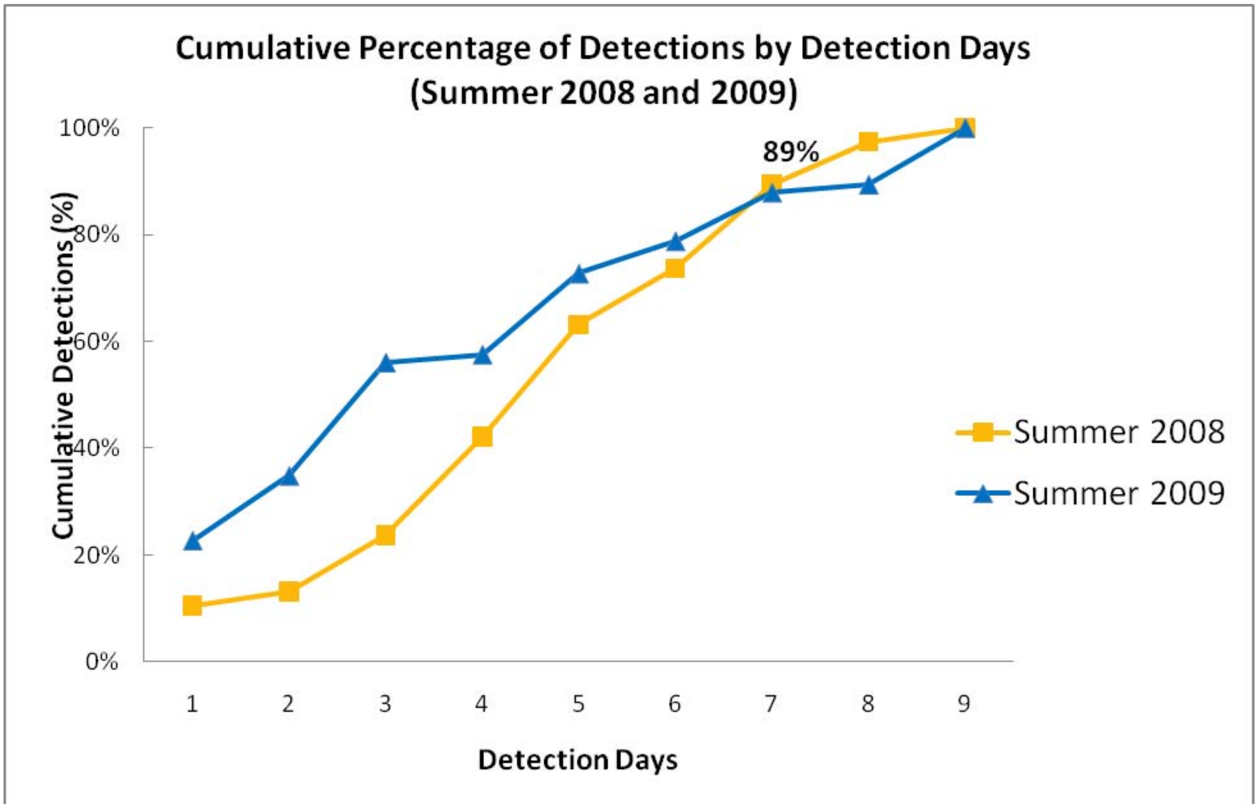
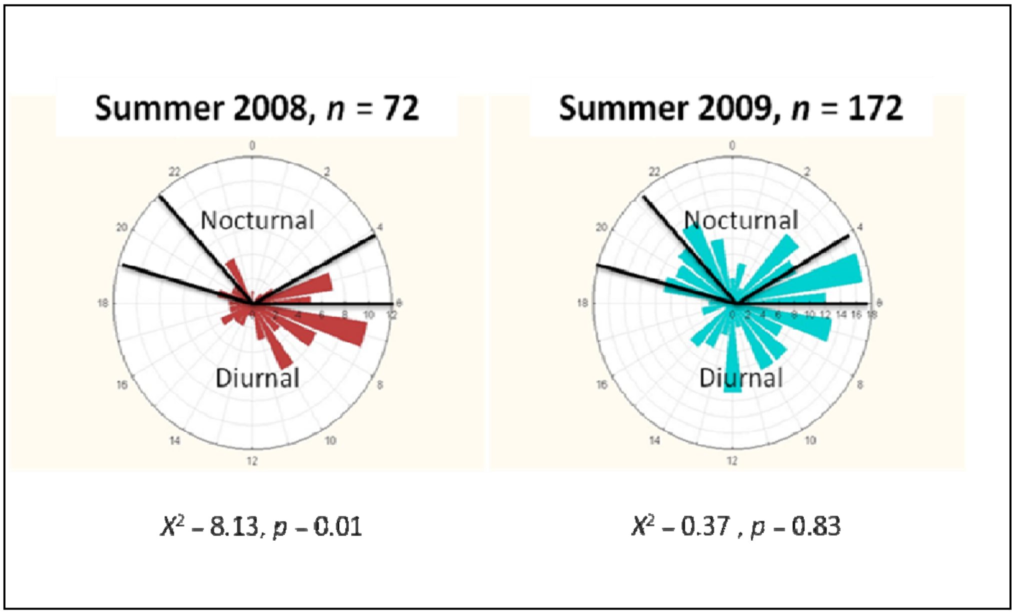


Figure 8. Comparison of the time-of-day when fishers were detected at remote camera stations. Fishers were most active during crepuscular and early morning hours in 2008, but in 2009 were active during all time periods.



CHAPTER 8

Establishing the Origin of River Otters in North Dakota using Microsatellite Analysis

Abstract

In the recent past, river otters naturally recolonized a portion of their former range in North Dakota, in the northeast and eastcentral part of the state. Potential source populations include otters from Minnesota, South Dakota, and Canada. The objective of this study was to establish the origin of the North Dakota otter population. We conducted a genetic analysis on tissue samples collected from 85 otters, from North Dakota (n = 21), Minnesota (n = 15), South Dakota (n = 21), and Manitoba (n = 28). DNA was isolated from samples and genotyping was performed using PCR amplification on 11 polymorphic microsatellite loci. Data were incorporated into programs FSTAT, GENEPOP, and STRUCTRE for analysis. Analyses were completed for the North Dakota, South Dakota, and Minnesota samples. Calculated F_{ST} values indicated little genetic differentiation between the North Dakota and Minnesota otter populations (F_{ST} = 0.016), and moderate genetic differentiation between the North Dakota and South Dakota populations (F_{ST} = 0.087). Based on proportions of alleles assigned to the three populations, the genetic composition of the North Dakota and Minnesota populations were similar to each other, but differed from that of South Dakota. Individuals separated into two population clusters; North Dakota and Minnesota otters formed one cluster and individuals from South Dakota formed a second cluster. Initial findings indicated that the Minnesota otter population acted as a source population for otters in North Dakota. We also documented limited gene flow among the three states. However, for the North Dakota population, observed heterozygosities at 10 (91%) loci were less than expected heterozygosities, and resulting F_{IS} values at five (45%) loci suggested

some level of inbreeding ($F_{IS} > 0.25$). To maintain the genetic health of North Dakota's otter population long-term, immigration should be encouraged among populations in Minnesota, South Dakota, and Canada.

Introduction

In the recent past, river otters have naturally recolonized a portion of their former range in North Dakota. The current distribution of the otter occurs the northeast and eastcentral part of the state, although there also is limited otter presence in southeastern North Dakota (Chapter 1). The most likely source of North Dakota otters is otter population in Minnesota. Otters currently are harvested throughout northern and central Minnesota, including the seven counties (Kittson, Marshall, Polk, Norman, Clay, Wilkin, and Traverse Counties) that border the Red River of western Minnesota and eastern North Dakota (Figure 1). Based on Minnesota trapping records (1996-97 – 2007-08 seasons), the greatest numbers of animals were taken from Polk ($n = 581$) and Marshall ($n = 199$) Counties, bordering the Red River of eastcentral and northeastern North Dakota (Figures 1 and 2; Erb 2008); the fewest numbers of otters were taken from Wilkin ($n = 2$) and Traverse ($n = 1$) Counties, which border southeastern North Dakota. Another potential source is South Dakota. Although otters are listed as a state-threatened species in South Dakota, in 1998-99, the Flandreau Santee Sioux reintroduced 34 otters from Louisiana on tribal lands along the Big Sioux River in eastcentral South Dakota (Boyle 2006). Success of the reintroduction effort was not formally evaluated, but numerous sightings in the release area indicated population persistence (Kiesow 2003), and in recent years, there has been an increase in the number of verified reports of otters in northeastern South Dakota (South Dakota Department of Game, Fish and Parks, unpublished data). Finally, it is possible that otters recolonized North Dakota from Canada. In Manitoba, the current range of the otter is closely related to the distribution of forested habitat (Stenson 1986) and the population supports an annual recreational trapping season throughout most of the province. However, Trapping Area Zone 1, which includes the Red River Basin in Canada, is closed to otter trapping (Manitoba Wildlife and Ecosystem Protection Branch 2009-10 Trapping Guide, Winnipeg, Manitoba), presumably due to lower densities in this Zone. Therefore, although possible, it is less likely that otters in North Dakota came from Manitoba. The objective of this study was to establish the origin of the North Dakota otter population. We accomplished this through a genetic analysis of tissue samples collected from otters in North Dakota, South Dakota, Minnesota, and Canada.

Methods

We obtained muscle tissue samples from 21 otters that had been killed incidentally (e.g., accidental trappings, road-kills, etc.) in eastern North Dakota (2004 – 2008) from the North Dakota Game and Fish Department (NDGF). We also received samples (n =21) from incidentally-killed otters (2003 – 2008) in South Dakota from the South Dakota Department of Game, Fish and Parks. Fifteen of the South Dakota samples were from Moody County (where the river otter reintroductions occurred), one sample came from Minnehaha County in southeastern South Dakota, and the remaining five samples came from counties in northeastern South Dakota, in Roberts (n = 1), Grant (n = 3), and Codington (n = 1) Counties. In addition, we obtained muscle tissue samples (n = 15) from harvested otters (mid-2000s) in western Minnesota from the Minnesota Department of Natural Resources. Finally, hair samples from 28 harvested otters (2006-07 season) were provided to us by the Wildlife and Ecosystem Protection Branch of Manitoba Conservation. The Canada samples were collected in southeastern Manitoba in Open

Trapping Area Zone 4 (Manitoba Wildlife and Ecosystem Protection Branch 2009-10 Trapping Guide, Winnipeg, Manitoba). All samples were stored in plastic twist-shut bags or tubes and frozen before being shipped to Frostburg State University (FSU), Frostburg, Maryland. Hair samples were clipped from dried pelts, shipped in individual sealed envelopes. All samples were stored at -80 degrees Celsius upon arrival at FSU.

DNA was isolated from muscle tissue samples using the Qiagen DNeasy Blood and Tissue kit (Qiagen Inc.,Valencia, California) following published protocol for isolation from soft tissue (Qiagen 2006). DNA from hair samples was isolated using the Bio Rad Insta Gene Matrix, a chelex-based protocol (Bio Rad Inc., Hercules, California). Isolated DNA was stored in micro centrifuge tubes at 4° C prior to analyses. Forward primers (Integrated DNA Technologies Inc., Coralville, Iowa) were fluorescently tagged with either HEX or 6FAM and the reaction procedure was adapted from Beheler et al. (2004, 2005). We analyzed 11 microsatellite loci determined to be polymorphic in otters [RIO01, RIO02, RIO04, RIO05, RIO06, RIO08, RIO10 (Beheler et al 2004) and RIO13, RIO17, RIO18, and RIO19 (Beheler et al 2005)]. Genotyping for each sample was performed at all microsatellite loci using Polymerase chain reaction (PCR) amplification based on protocols outlined by Beheler et al. (2004 and 2005). Amplified DNA were visualized using capillary electrophoresis on an ABI 310 Genetic Analyzer. Allele sizes were determined using GeneScan (Applied Biosystems) and Genotyper (Applied Biosystems). Genetic data were analyzed using three software programs: FSTAT (Goudet 1995), GENEPOP (Raymond 1995), and STRUCTURE (Pritchard 2000).

Programs GENEPOP and FSTAT were used to 1) assess linkage disequilibrium (non-random association of alleles at two or more loci), 2) calculate the frequency of alleles at each locus and across all loci, 3) calculate observed and expected heterzygosities for individual loci

[Expected heterozygosity (H_E) is the proportion of the total number of individuals expected to be heterozygotes at each locus (ranging 0.0 to 1.0). Observed heterozygosity (H_O) is the observed proportion of heterozygotes, averaged over loci] and 4) determine F-statistics (F_{ST}, F_{IS}) for all of the populations [F_{ST} values measure the genetic variation between populations and range from 0.0 to 1.0. Values 0.0 to 0.05 indicate negligible genetic differentiation within the population, 0.06 to 0.15, moderate genetic differentiation, 0.16 – 0.24, great genetic differentiation and values >0.25 indicate very great genetic differentiation within the population. F_{IS} is known as the "inbreeding coefficient" and values range between -1.0 to 1.0. Negative values indicate heterozygote excess (outbreeding) and positive values indicate heterozygote deficiency (inbreeding); values >0.25 are considered high, equivalent to parent-offspring or sibling-sibling mating].

Program STRUCTURE was used to create graphical outputs of the data, to visualize similarities and differences between individuals and define populations. In a bar graph output, the genotypes of loci for all individuals in respective populations are grouped into related genotypes based on unique colors. Then, the individuals' genotypes are reconstructed based on proportions of alleles assigned to particular groups (colors) and plotted for each individual in respective populations. The result is an estimate of membership fraction to respective populations. In a triangle output, unique colors are assigned to individuals from respective populations. Allele frequencies at each locus are used to calculate a pairwise distance matrix to assign each individual to a population based on their overall genotype. Genetically similar individuals are grouped closer together forming population clusters in one area of the triangle, whereas genetically distinct individuals occur farther away, forming clusters in different areas of the triangle.

Preliminary Results

Initial genetic analyses using genotypes at 11 polymorphic microsatellite loci were completed for muscle tissue samples from North Dakota, Minnesota, and South Dakota, and four of 28 hair samples from Manitoba. However, two of the Manitoba hair samples contained PCR inhibitors, therefore, genotypes could not be determined for these individuals. Output from statistical programs indicated no evidence of linkage disequilibrium ($P < 0.05$) verifying that alleles at particular loci were independent. We also visually determined that all loci were sufficiently polymorphic (>2 unique alleles per loci) and thus diagnostic for differentiation among populations. Calculated F_{ST} values indicated little genetic differentiation between the North Dakota and Minnesota otter populations ($F_{ST} = 0.016$; Table 1), but moderate genetic differentiation between the North Dakota and South Dakota populations ($F_{ST} = 0.087$). Moderate genetic differentiation also occurred between the Minnesota and South Dakota populations ($F_{ST} = 0.097$).

Based on proportions of alleles assigned to particular populations, the bar graph output from Program STRUCTRE indicated individuals from the North Dakota and Minnesota otter populations had a similar genetic composition that differed from that of the South Dakota population (Figure 3). The triangle plot revealed two population clusters (Figure 4); individuals from South Dakota formed one population cluster and individuals from North Dakota and Minnesota formed a second population cluster. Sample size for Canada otters was too low to draw conclusions, although the two individual otters analyzed were positioned closer to individuals from North Dakota and Minnesota, than those from South Dakota. For the North Dakota population, observed heterozygosities (H_O) at 10 (91%) loci were less than expected heterozygosities (H_E), and resulting F_{IS} values at five (45%) loci suggested some level of inbreeding ($F_{IS} > 0.25$; Table 2).

Discussion

Although results were incomplete for tissue samples from Manitoba (pending additional analyses to be finished March 2010), based on initial findings, the Minnesota otter population acted as a source population for otters in North Dakota. F_{ST} values indicated that the North Dakota and Minnesota populations were genetically similar to each other, representing one panmictic population. We speculate that otters initially entered North Dakota from Rivers of Minnesota that drain into the Red River of northeastern and east central North Dakota (Figure 1). Peak harvests in Minnesota counties that bordered this region occurred in the early to mid 2000s (Figure 2) and it was during the early 2000s that NDGF began receiving more reports of the species in the eastern part of the state (NDGF, unpublished data). Based on field surveys (2006 – 2008) and an analysis of verified reports (2005 – May 2009), otters were found to occur predominantly in rivers of northeast and eastcentral North Dakota, (Chapter 1). Thus, individual otters from Minnesota's population likely dispersed west into the Red River and beyond, expanding their range into North Dakota.

Otters occurred with limited frequency in southeastern North Dakota (Chapter 1), and also were found in northeastern South Dakota (South Dakota Department of Game, Fish and Parks, unpublished data), but, our genetic analysis indicated otters in North Dakota did not originate from the South Dakota population. In fact, South Dakota otters were genetically distinct from the North Dakota/Minnesota population. This is intuitive because the state's population originated from animals that came from Louisiana, and most likely, otters in northeastern South Dakota originated from the reintroduced South Dakota population. However, two (9%) of the individuals in South Dakota were genetically similar to otters from the North Dakota/Minnesota population, indicating some gene flow among states. Nevertheless, F_{IS} values at five (45%) of 11 loci examined suggested a degree of inbreeding in the North Dakota otter population.

Reduced heterozygosity in the North Dakota population could have been due to the founder effect, which is the loss of genetic variation that occurs when a new population is established by a very small number of individuals from a larger population. It is also possible that continued harvest pressure in counties of western Minnesota (documented by reduced take in most of these counties in the late 2000s; Figure 2) could exacerbate effects of inbreeding in the North Dakota population by limiting immigrants. Persistent inbreeding within a population can result in reduced offspring survival, lowered fecundity and ultimately decreased population fitness (Leiberg et al. 2005). Therefore, immigration among populations in Minnesota, South Dakota, and Canada should be encouraged to maintain the genetic health of North Dakota's population long-term.

Literature cited

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Table 1. Matrix of F_{ST} values comparing river otter populations in North Dakota, South Dakota, and Minnesota. Values 0.0 to 0.05 indicate negligible genetic differentiation within the population, 0.06 to 0.15, moderate genetic differentiation, 0.16 – 0.24, great genetic differentiation and values >0.25 indicate very great genetic differentiation within the population.

	F_{ST} values for otter populations		
	North Dakota	South Dakota	Minnesota
North Dakota	---	0.087	0.016
South Dakota	0.087	---	0.097
Minnesota	0.016	0.097	---

Table 2. Observed (H_O) and expected (H_E) heterozygosity, and F_{IS} values for 11 polymorphic loci of river otters from North Dakota (n = 21), South Dakota (n = 21), Minnesota (n = 15), and Canada (n = 2). Parameters were calculated using Programs GENEPOP and FSTAT. H_E = the proportion of loci expected to be heterozygous in a population (ranging from 0 to 1.0). F_{IS} = inbreeding coefficient; high F_{IS} values (>0.25) imply considerable inbreeding.

Locus	Alleles Per Locus	H_O	H_E	F_{IS}
RI001	9	0.352	0.681	0.428
RI002	9	0.802	0.815	0.057
RI004	9	0.394	0.590	0.227
RI005	19	0.388	0.903	0.411
RI006	8	0.575	0.737	0.202
RI008	6	0.696	0.771	-0.119
RI010	10	0.468	0.854	0.631
RI013	13	0.704	0.920	0.280
RI017	4	0.382	0.566	0.393
RI018	12	0.659	0.872	0.125
RI019	6	0.506	0.728	0.188

Figure 1. Major rivers and waterbodies of eastern North Dakota and northwestern Minnesota. River otters currently are harvested for recreation in Minnesota including the seven counties (Kittson, Marshall, Polk, Norman, Clay, Wilkin and Traverse Counties) that border the Red River of eastern North Dakota. Numbers in parentheses indicate total numbers of otters harvested for that county over eleven trapping seasons (1996-97 – 2007-08; Erb 2008).

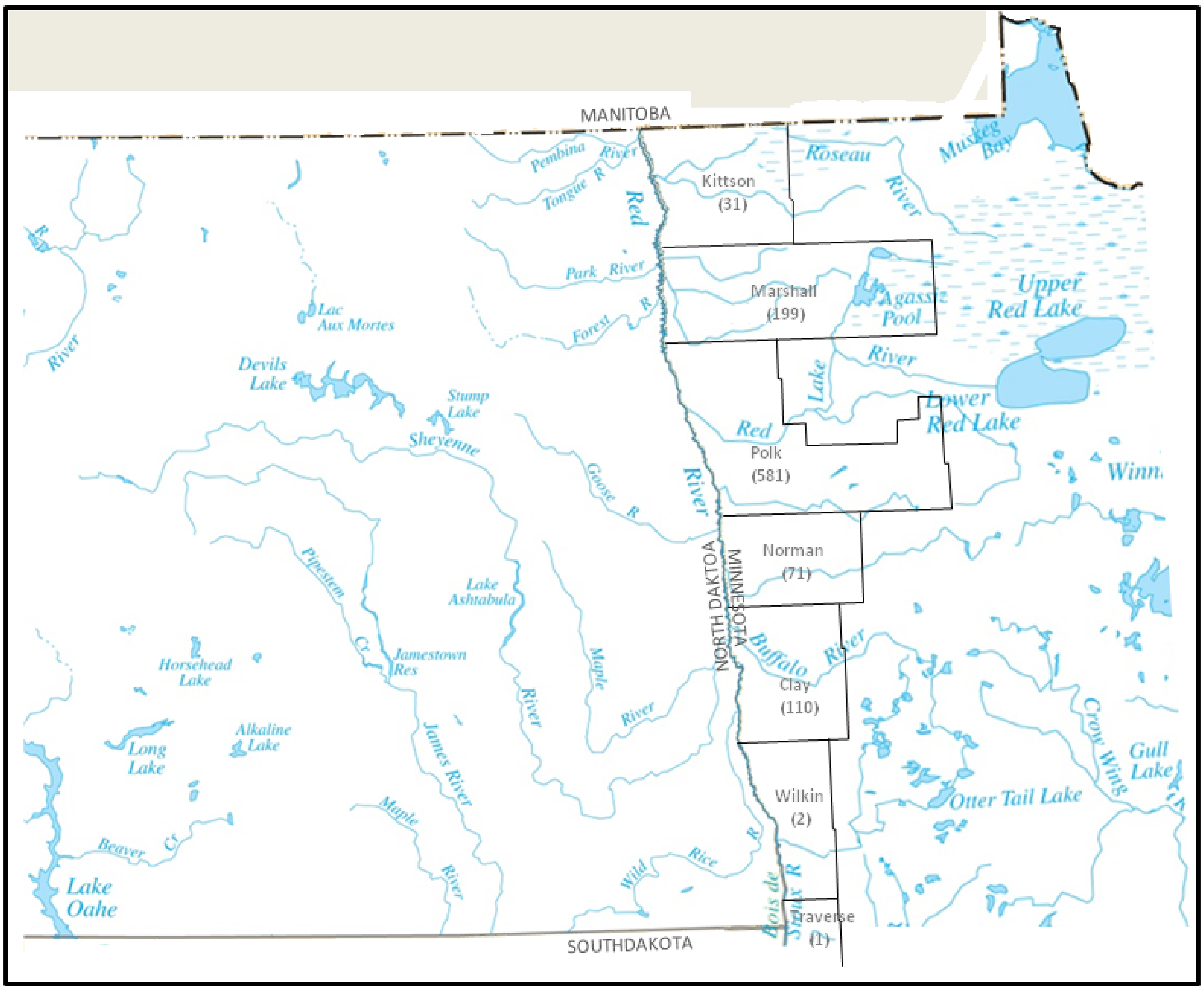

Figure 2. Numbers of river otters harvested (1996-97 – 2007-08) in counties of western Minnesota (Kittson, Marshall, Polk, Norman, Clay, Wilkin and Traverse Counties) that border the Red River of eastern North Dakota (Data taken from Erb 2008).

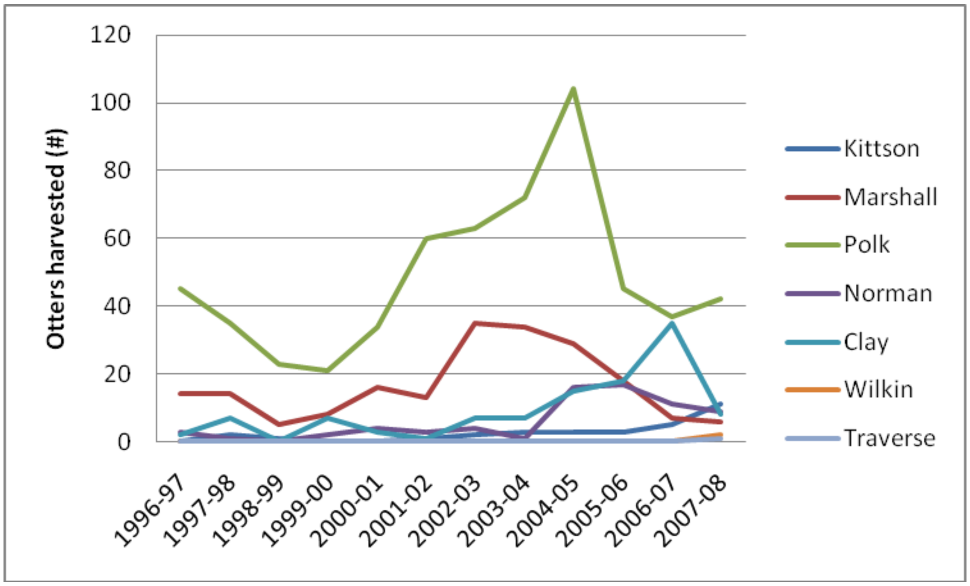

Figure 3. Bar graph output from Program STRUCTURE. Three otter populations (South Dakota, North Dakota, Minnesota) are contained within black lines. Individuals are represented by bars. Program STRUCTURE analyzes the genotypes of loci for all individuals in respective populations and groups related genotypes based on unique colors. Then, the proportions of alleles assigned to particular groups (colors) are plotted for each individual. Individuals from the North Dakota and Minnesota otter populations had a similar genetic composition that differed from that of the South Dakota population.

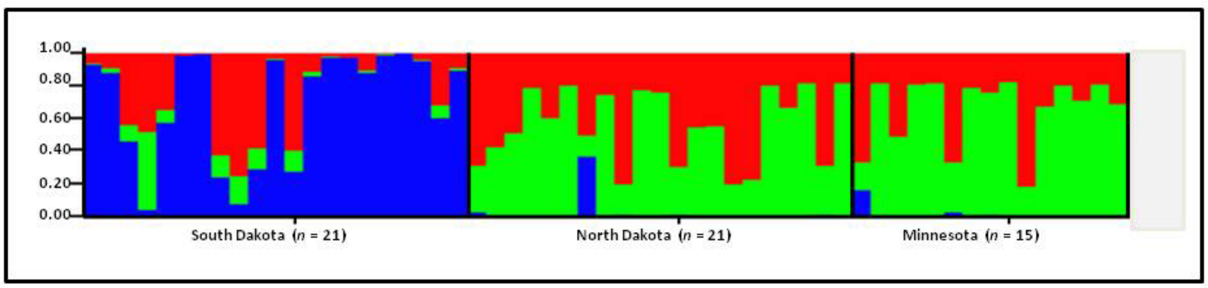

Figure 4. Triangle plot output from Program STRUCTURE. Individual otters (n = 59) are represented by colored dots. Genetically similar individuals are closely grouped into clusters, and genetically distinct individuals occur in different areas of the triangle. Individuals from South Dakota formed one population cluster and individuals from North Dakota and Minnesota formed a second population cluster.