ASSESSING THE NATURAL HISTORY AND HABITAT USE OF THE FISHER IN EASTERN NORTH DAKOTA

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ABSTRACT

Fishers were extirpated from North Dakota by the early 1900s as a result of over-harvesting and habitat loss. However, within the past decade there has been an increase in the number of verified reports in northeastern North Dakota. Determining habitat associations is important to evaluate how fishers use different habitats within their range to identifying areas of conservation priority. Fishers have been documented to be associated with large contiguous forested tracts that have extensive canopy cover. However, the forest in North Dakota is highly fragmented and presents a unique opportunity to assess how fisher preferences in less than optimal habitat. The purpose of my study was to evaluate natural history information, assess if occupancy and visitation patterns at detection sites vary depending on size and isolation of forested patches and compare the efficacy of track-plates and remote cameras at detecting the species. I created habitat covariates defining patch-size and isolation. I then used the software PRESENCE (MacKenzie et al. 2002) to determine if the covariates I created to define patch-size and isolation had an impact on fisher occupancy (ψ) at a site. I assessed model-fit using a Pearson chi-square test with a parametric boot-strap of 1,000 simulations (MacKenzie and Bailey 2004). Also, I ran a Poisson regression using the site covariates that defined a sites category of patch-size and isolation to assess the impact that site patch-size and isolation had on Latency to Detection (LTD). Fishers were detected more frequently in the diurnal hours in 2008 and more often in the crepuscular hours in 2009. Fishers had similar rates of occupancy regardless of patch-size or isolation, demonstrating their adaptability to occupy non-preferred habitat. I compared track-plates and remote cameras in their number of false absences, percentage of sites with a detection, percentage of check periods (time from set-up to re-bait and re-bait to pull) with a detection, unit effort (number of unique detections by number of DDs), and number of functioning days to total detection days. Of 127 sites, track-plates had false absences at 11 of 41 (27%) visits to a site, and cameras only failed to detect a fisher visiting a site (based on detections at the track-plate) on 4 of 41 (10%) occasions. Fishers were detected at 30 (24%) sites by track-plates and 37 (28%) sites by cameras. Cameras outperformed track-plates in every category except for initial cost. Cameras had less false absences, more detections, provided a more thorough detection history, and captured natural history information that the track-plates could not. Advances in camera technology have increased their reliability and performance enabling them to outperform track-plates when sampling for fisher presence. Cameras now provide more detection information and require less surveyor effort than track-plates.

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CHAPTER 1

INTRODUCTION

Description

The fisher (*Martes pennanti*; Erxleben 1777) is a mesocarnivore of the family Mustelidae and subfamily Mustilinae (Powell 1981*a*). Fishers have a dark brown to black pelage, which is lighter around the face and shoulders. Fishers' coats exhibit seasonal variation and tend to be darkest in late autumn (Powell 1985). Fishers primarily are terrestrial; however, because of their long bodies and tails, short legs, plantigrade feet, flexible hind wrists, and retractable, unsheathed claws, they are able to maneuver adeptly in trees (Strickland et al. 1982, Forsyth 1985, Douglas and Strickland 1987, Powell 1993). The fisher is the largest member of the genus *Martes* (Powell 1981*a*). Fishers display pronounced sexual dimorphism, with males weighing 3.5 to 5.5 kg and measuring 90 to 120 cm in length and females weighing 2.0 to 2.5 kg and measuring 75 to 95 cm in length (Wood 1977, Hamilton and Whitaker 1979, Moors 1980, Powell 1981*a*, Forsyth 1985).

Male fishers can mate within the first breeding season (about 1 year after their birth: March-April), but they do not achieve maximal reproductive success until their second winter, when they reach adult size and their bacula are fully developed (Wright and Coulter 1967, Leonard 1986, Powell 1993, Mead 1994, Frost et al. 1997). Most females will mate successfully within their first breeding season (Savage and Savage 1981, Leonard 1986). Fishers display delayed implantation; fertilized eggs do not implant in the uterus for 10 or 11 months after copulation (Eadie and Hamilton Jr. 1958, Wright and Coulter 1967, Ewer 1973, Mead 1989, Powell 1993, Frost et al. 1997).

Implantation typically occurs between January and February, and by mid to late March, females give birth to 2-3 altricial kits (Eadie and Hamilton Jr. 1958, Caras 1967, Wright and Coulter 1967, Strickland et al. 1982, Leonard 1986, Douglas and Strickland 1987, Mead 1989, Powell 1993).

The kits remain dependent on their mother for the first 5 months, after which they begin to hunt for themselves (Arthur et al. 1993). Juveniles typically disperse and established their own home ranges by the end of their first year (Paragi 1990, Arthur et al. 1993). However, dispersal age can range from 9-16 months (Arthur et al. 1993). Fishers are estimated to live for approximately 10 years in the wild, but additional documentation is needed to assess their lifespan (Forsyth 1985, Arthur et al. 1992, Powell 1993).

Distribution and Status

Fishers are paleoendemic to North America; their historical distribution covered most of forested Canada and the northern United States, and extended into the Appalachian, Rocky, and Coastal Pacific mountain ranges (Hagmeier 1956, Powell 1981*b*, 1993, Douglas and Strickland 1987, Serfass et al. 1994, Williams et al. 1998). In the Appalachian Mountain Range, fishers occurred southward into Georgia. Their remains also have been recorded from Alabama and Arkansas; however, these remains may have resulted from the Native American trade (Parmalee 1959, Barkalow 1961, Graham and Graham 1990, Powell 1993). The central northern forests of Michigan, Minnesota, eastern North Dakota, Wisconsin, and possibly Illinois also historically maintained fisher populations (Bailey 1926, Parmalee 1957, Graham and Graham 1990, Powell 1993, Gilibisco 1994). The species' original Rocky Mountain range included parts of Colorado, Idaho, Montana, Utah, and Wyoming (Powell and Zielinski 1994, IDGF 1995, Smith 1999, Vinkey et al. 2006). In the Coastal Pacific Region, fishers inhabited regions as far south as the Sierra Nevada Mountain Range (Powell and Zielinski 1994).

Fishers are curious by nature and thus easily trapped. During the early 1900s, with pelt prices at a premium and minimal regulations, fishers were heavily harvested by trappers. The synergistic effects of over-harvesting, predator control (Douglas and Strickland 1987), and habitat alterations such as logging and burning, led to the decimation of fisher populations in many areas of the United States. By the 1930s, the species' range in the country had been reduced to California, Maine, Minnesota, New Hampshire, New York, Oregon, and Washington (Hamilton 1943, Coulter 1966, Brander and Books 1973, Kelly 1977, Hamilton and Whitaker 1979, Pack and Cromer 1981, Douglas and Strickland 1987, 1994, Powell 1993, Powell and Zielinski 1994, Serfass et al. 1994).

Since the 1930s strict protective legislation, decreases in fur prices, restoration of habitat, and reintroduction and translocation projects have enabled fisher populations to re-colonize many of the areas from which they were extirpated (Irvine et al. 1964, Wallace and Henry 1964, Weckworth and Wright 1968, Pack and Cromer 1981, Strickland 1994, Aubry and Lewis 2003, Lewis and Hayes 2004).

In North Dakota, fishers historically occurred throughout the eastern portion of the state, but were harvested to extirpation in the early 1900s (Bailey 1926). Within the past decade, there has been an increase in the number of verified carcasses in North Dakota (Gibilisco 2004, North Dakota Game and Fish Department, Bismarck North Dakota, unpublished data). It has been suggested that the natural re-colonization of fishers in North Dakota was a result of dispersing populations from Minnesota (Sovada and Seabloom 2005, Erb 2007, Triska 2010).

Activity Patterns

Research has demonstrated fishers' activity patterns to be highly dynamic and varying with season and geographic location (Coulter 1966, Kelly 1977, Powel 1981*b*, 1993, Arthur and Krohn 1991). Fishers have been classified as nocturnal (de Vos 1952, Coulter 1966, Strickland et. al. 1982, Webster et al. 1985), crepuscular (Kelly 1977), or exhibiting variations of both activity cycles (Webster et al. 1985, Arthur and Krohn 1991, Powell 1993, Weir and Corbould 2007).

Fishers tend to be active for periods of 2-5 hours, followed by periods of inactivity that typically last 10 hours or more (Powell 1993). During the breeding season (March-April), this pattern changes for males, as they begin to spend much of their time actively searching for potential mates (Coulter 1966, Kelly 1977, Leonard 1986, Arthur and Krohn 1991). Seasonality is also thought to alter the activity patterns of females. Arthur and Krohn (1991) postulated that mothers with kits need to be more active in order to provide for their young. Conversely, Weir and Corbould (2007) proposed that a female with kits would need to spend much of her time in the den nursing.

Fishers are at or near the top of the food web in most ecosystems. Therefore, predator avoidance plays a minimal role in the activity patterns of adults. However, evasion of predators may influence the activity patterns of juvenile fishers until they reach a mature size (Kelly 1977, Hamilton and Whitaker 1979, Powell 1981, 1993, Strickland et al. 1982). Rare incidences of predation by coyotes (*Canis latrans*), domestic dogs (*Canis familiaris*), and large birds of prey have occurred (Webster et al.

1985). Human trapping, and automobiles also pose a threat to both juvenile and adult animals in most regions (Hamilton and Whitaker 1979, Douglas and Strickland 1987, Krohn et al. 1994).

Early studies suggested that fisher activity is influenced by thermoregulation during the winter months (Brown and Lasiewski 1972, Buskirk and Harlow 1989). However, a recent investigation by Weir and Corbould (2007) revealed that fishers were active during hours when their prey was most mobile, regardless of the temperature. Likewise, research on the activity patterns of other predators, including American martens (*Martes americana*), barn owls (*Tyto alba*), mink (*Neovision vision*), and red foxes (*Vulpes vulpes*), showed prey availability to be a major influence on activity patterns; each of the species displayed synchronicity in their periods of activity with those of their prey (Albes 1969, Gerell 1969, Zielinski et al. 1983, Brown et al. 1988, Drew and Bissonette 1997, Stangl Jr. 2005). Fisher activity patterns likely are influenced by a dynamic multitude of factors, including prey abundance, geography, weather conditions, seasonality, and reproductive behaviors (Coulter 1966, Kelly 1977, Strickland et al. 1982, Raine 1987, Powell 1993, Weir and Corbould 2007).

Diet and Foraging Behavior

Fishers are considered opportunistic carnivores that consume any prey item they can overpower (Arthur et al. 1989, Powell 1993). Fishers are solitary hunters and typically take prey that is smaller than their own size, including mice (Muridae), shrews (Soricidae), squirrels (Sciuridae), rabbits and hares (Leporidae), porcupines (*Erethizon dorsatum*), ruffed grouse (*Bonsana umbellus*), and rarely, smaller members of the mustelid family (Hamilton and Whitaker 1979, Forsyth 1985, Powell 1993). Fishers also will feed on carrion and occasionally wild fruit (Coulter 1966, Kelly 1977, Wood 1977, Forsyth 1985, Arthur et al. 1989).

The typical foraging strategy of the fisher is characterized as a "zigzag" pattern (Ewer 1973, Powell 1993). Generally, a fisher will travel in a straight line until it reaches an area of perceived high prey density (Powell 1981*b*). The animal then will move in a repeating zigzag pattern through the area (Powell 1981*b*) until it ambushes startled prey. Powell (1981*b*) stated that when hunting porcupines, fishers demonstrate a different foraging strategy, traveling along straight routes between porcupine dens using a combination of olfactory cues and memory.

Home Ranges, Dispersal, and Communication

For the majority of the year, fishers maintain a solitary lifestyle. During the breeding season males expand their home ranges and seek out potential mates (Wright and Coulter 1967, Leonard 1986, Arthur et al. 1989, Powell 1993). Fisher home range boundaries often are established through intrasexual territoriality, with 2 females occupying separate home ranges within the broader range of a single male (Powell 1979, Leonard 1986). Based on data from 6 studies, Powell (1993) estimated the mean home range sizes for male and female fishers to be 38 km^2 and 15 km^2 respectively. A study conducted in Maine showed a mean dispersal distance of 16.4 km for males and 11.0 km for females (Arthur et al. 1993).

Fishers delineate territory boundaries by scent marking with scent glands and urine (Leonard 1986, Douglas and Strickland 1987, Powell 1993). Scent glands are located on the face, chin, anus, and within circular patches of hair on the interdigital pads of the hind feet (Douglas and Strickland 1987, Powell 1993). During the breeding season, the scent glands on the hind feet increase in size and may provide a more potent form of olfactory communication to aid in attracting mates or defining territories (Frost et al. 1997).

Survey Techniques

Wildlife researchers and managers have developed a variety of non-invasive sampling techniques for monitoring rare species and gathering information from unstable populations (Herzog et al. 2003). Techniques include snow surveys, scat-detection dog surveys, scent-stations, track-plate stations, hair snares, and camera stations (Seton 1937, Mayer 1956, Wood 1959, Lord et al. 1970, Halfpenny et al. 1995, Zielinski and Kucera 1995, Gompper et al. 2006). Scent stations are created by spreading some medium conducive to revealing tracks (shifted soil or $CaCO_3$) around an attractant (lure/bait; Wood 1959, Lindzey et al. 1977, Conner et al. 1983, Gompper et al. 2006). When an animal investigates the attractant, an impression of its print is formed in the medium. Many recent studies have opted to replace scent stations, which are popular in earlier literature, with closed track-plates when surveying for fishers. Track-plate stations reveal higher quality prints, can be performed in rocky areas, and are less constrained by weather conditions (Taylor and Raphael 1988, Nottingham Jr. et al. 1989, Raphael 1994, Zielinski and Stauffer 1996, Hamm et al. 2003). Closed track-plates consist of a piece of aluminum were the first half of the plate is sooted (typically with an acetylene torch) and the second part is covered with contact paper. The contact paper is placed with the adhesive side facing up, and an attractant (lure/bait) is placed at the end of it. The aluminum plate then is placed on a piece of plywood, and the entire device is covered with a piece of bendable plastic. Typically, track-plates are placed on the ground with the baited end against a tree. When an animal walks over the sooted section of the plate to investigate the bait/lure, its paw removes some of the soot and leaves behind a track impression. As the individual continues into the device, its sooted paw makes contact with the adhesive paper and leaves a well-defined track impression. Open track-plates differ from closed plates in that they are circular and lack a cover. The attractant is placed at the center of the device, forcing an animal to cross the soot and leave behind a print (Barret 1983). Both types of track-plates are effective at detecting animals, but closed track-plates typically are chosen over open track-plates in fisher surveys because they perform better in poor weather conditions. Recent advances in technology have also enabled remote cameras to be an effective tool for sampling for fisher presence (Kucera et al. 1995, Gomperr et al. 2006). The camera is mounted on a tree and aimed at the attractant. When an animal approaches the attractant, motion or heat sensors, or a line or plate triggers the shutter and an image is captured.

Applying the Information Derived from Surveying Techniques

Presence-absence sampling confirms if a species is detected in a given sampling unit. The presence of a species can be assumed through the positive identification of a track, scat, photograph, or hair sample; however, a lack of such evidence does not necessarily indicate the absence of a species from the sampled area. There are two reason why a species may be defined as absent from an area; when it truly is not present in the area and when it is present in the area, but the sampling technique fails to detect the species "false absence" (Dunham and Rieman 1999). Occupancy modeling takes presence-absence sampling a step further by adjusting for false absences by deriving a probability estimate for an area being occupied as opposed to just a present-absent assessment (Mackenzie et al. 2002). Occupancy allows wildlife managers to derive information on the spatial and temporal distribution of animal populations from survey tools that could previously only provide presence-absence information (MacKenzie et al. 2002, Mackenzie 2005).

Objectives

I used information collected from a fisher population survey conducted by Triska (2010) in eastern North Dakota using cameras and track-plates to gain insight into some of the behavior patterns of fishers at detection sites. I evaluated detections to determine the number of repeat detections at sites, the hours fishers are active at detection sites, and the duration of visits at detection sites.

Also, I determine if there was an association between occupancy rates and forest patch size and isolation for the areas surveyed (Mackenzie et al. 2002). In evaluating occupancy by forest patch size and patch isolation, I gained insight into which size areas are most efficient to sample for fisher presence. I used camera detections and habitat information to determine if occupancy rates varied among different levels of patch size and isolation and if latency to detection differed among different levels of patch size and isolation. I hypothesized that larger patches would have higher levels of occupancy when compared to smaller patches. Also, I hypothesized that more contiguous patches would have higher rates of occupancy than patches that had higher degrees of isolation. I hypothesized that smaller patches would have lower latency to detections than larger patches and that more contiguous patches would have lower latency to detections than those patches that were more isolated.

Advances in technology have allowed wildlife managers to use new tools to detect and monitor wildlife (Herzog 2003). Comparing track-plates and cameras is important in order to determine which are most appropriate for various applications (Foresman and Pearson 1998, York et al. 2001, Moruzzi et al. 2002, 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). I used the information gained from comparing the track-plates and cameras at the same site to compare number of false absences, the percentage of detections received by the devices, number of check periods with a detection for the devices, per unit effort (detections/ number of active detection days), and number of functioning days to total detection days. I hypothesized that track-plates and remote cameras would have equal fisher detection rates.

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Chapter 2

Assessing the Natural History and Habitat Use by Visitation Patterns of the Fisher in Eastern North Dakota

Abstract

Fishers were extirpated from North Dakota by the early 1900s as a result of over-harvesting and habitat loss. However, within the past decade there has been an increase in the number of verified reports in northeastern North Dakota. Determining habitat associations is important to evaluate how fishers use different habitats within their range to identifying areas of conservation priority. Fishers have been documented to be associated with large contiguous forested tracts that have extensive canopy cover. North Dakota presents a unique opportunity to assess the natural history of fishers in a fragmented landscape and habitat associated with detection sites. The purpose of my study was to gain natural history information and to assess if occupancy and visitation patterns at detection sites vary depending on size and isolation of forested patches. Fishers were detected more frequently in the diurnal hours in 2008 and more often in the crepuscular hours in 2009. Fishers had similar rates of occupancy regardless of patch-size or isolation, demonstrating their adaptability to occupy non-preferred habitat. Also, fishers were detected sooner in smaller when compared to larger patches and sooner in more isolated patches when compared to more contiguous patches. Fishers were not restricted in activity times possibly because they are exploiting a variety of prey species and were not restricted by predation and competition. Fishers in this portion of their range demonstrated their adaptability by occupying areas regardless of patch-size or isolation. Wildlife managers in this region will be able to detect fishers more quickly by

sampling smaller patches. With the potential to reduce the sampling period to 7 days for smaller patches in comparison to 14 days for larger patches.

Introduction

Fishers historically occurred throughout the eastern portion of North Dakota, but were harvested to extirpation in the early 1900s (Bailey 1926, Gibilisco 2004). Recently, fishers have been re-colonizing eastern North Dakota, likely the result of an expanding population in Minnesota (Sovada and Seabloom 2005, Erb 2007, Triska 2010, North Dakota Game and Fish Department, Bismarck North Dakota, unpublished data). Determining habitat associations of fishers is important to evaluate how the species uses different habitats within their range to identifying areas of conservation priority (Allen 1983, Jones and Garton 1994, Bull et al. 2001, Weir and Harestad 2003, Zielinski et al. 2004). Fishers have been described as a habitat specialist, preferring contiguous tracts of forest with canopy closure, dense undergrowth, coarse woody debris, conifers, and some connectivity to old growth forest (de Vos 1952, Coulter 1966, Kelly 1977, Powell 1982, Allen 1983, Arthur et al. 1994, Jones and Garton 1994, Weir and Harestad 2003, Zielinski et al. 2004). Fishers are known to avoid areas with minimal canopy cover (Coulter 1966, Kelly 1977, Powell 1977, Arthur et al. 1989, Jones and Garton 1994), but have been reported to have successfully recolonized second growth mid-succession forests in the upper Midwest (Powell 1993). North Dakota presents a unique opportunity to assess how fishers are distributed in what would appear to be less than optimal habitat (narrow patches of riparian forest and surrounded primarily by agricultural enterprises; Bailey 1926, Renard et al. 1986, Kort 1988, Sovada and Seabloom 2005). I assessed if visitation patterns and occupancy rates at detection sites varied depending on size and isolation of forested patches. Identifying possible relationships that exist between visitation patterns and habitats will help establish efficient sampling protocols for long-term monitoring (Foresman and Pearson 1998, Hilty and Merenlender 2000).

Study Area

My study sites were located within the riparian forests along the Forest River, Goose River, Park River, Pembina River, Tongue River, Turtle River, Red River of the North (hereafter Red River) and the Pembina Hills in northeastern North Dakota (Figure 1). Historically, northeastern North Dakota was dominated by tallgrass prairie, with forested areas occurring mostly along water systems (Renard et al. 1986). During the late 1800s, pioneers settling in North Dakota began the conversion of the tallgrass prairie to what today primarily are agricultural fields (Renard et al. 1986). The forested region of the Pembina Hills, riparian forests persist in many areas and forested shelterbelts have been established in historically non-forested portions of the landscape to control erosion (Bailey 1926, Renard et al. 1986, Kort 1988, Albert 1995, Hagen et a;. 2005, Sovada and Seabloom 2005).

The forested areas throughout eastern North Dakota are similar in habitat composition, with the dominate overstory vegetation consisting of American elm (*Ulmus americana*), aspen (*Populus tremuloides*), balsam popular (*Populus basamifera*), box elder (*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.), juneberry (*Amelanchier alnifolia*), raspberry (*Rubus* spp.), and serviceberry (*Amelanchier arborea*). When compared in size to the agricultural fields, these forested areas were minimal, but provided essential habitat to a multitude of organisms (Bailey 1926, Johnson and Beck 1988, Hagen et al. 2005).

Methods and Materials

My study was a part of a larger population study that delineated the distribution of fishers in North Dakota through the use of track-plates and remote cameras (Triska 2010). The "survey sites" were survey during June, July, and August in 2008 and 2009. In the Summer of 2008, a survey site was comprised of an enclosed track-plate and a remote camera, whereas in Summer 2009 I only used remote cameras. I attempted to only analyzed survey sites at ≥1-km intervals along each survey area to help ensure independence. During Summer 2008 I monitored 184 survey sites among 5 sampling periods (cycles)(Figure 2). Of the 184 survey sites 132 had both devices, 48 were track-plate only and 4 were camera only. During a cycle I monitored 20-30 survey sites for a period 7-9 days. In Summer 2009 I monitored 160 survey sites among 4 cycles for this year a cycle consisted of 40-55 survey sites monitored for a period 13 days (Figure 2).

Track-plates consisted of a plywood base (1.91 cm x 30.48 cm x 76.2 cm), 2 flexible black plastic sheets (0.32 cm x 40.64 cm x 71.12 cm), and an aluminum plate (0.16 cm x 20.32 cm x 76.2 cm; Zielinski and Kucera 1995, Peters 2002). The plastic sheets were inserted into grooves cut lengthwise along the sides of the plywood to provide a weather protective cover. Where the 2 pieces of plastic sheets met I covered the gap with a piece of black duct tape to further weatherize the track-plate. Track-plates were positioned with 1 end against a tree so that animals could enter only from the front and the aluminum plates then were laid on the plywood track-plates with the sooted end at the entrance. Sticks were placed around the back to further prevent animals from entering the back (Peters 2002).

During both summers I used 3 models of Cuddeback® (Non Typical Inc., Green Bay, Wisconsin, USA) remote camera models the Excite®, Expert®, and the infrared Noflash® and in Summer 2009 I included the use of the DLC Covert II® remote camera (DLC Trading Co. llc, Lewisburg, Kentucky, USA). When both devices were at a site the remote camera monitored the track-plate, whereas at camera only sites the camera monitored bait on the ground. Cameras were mounted on a tree opposite the opening of the track-plate or bait at a distance of (1-2 m) and at a height of (0.5-1.5 m) to monitor individuals that entered the track-plate or examined the bait. A piece of American beaver (*Castor canadensis*) meat (approximately 85 g) and a smear of castor mixed with glycerol (approximately 2 g) were placed at the rear of the track-plate when present or directly on the ground. I hung a perforated film canister from a surrounding branch at a height of (approximately 2 m) that contained a cotton swab soaked in striped skunk (*Mephitis mephitis*) essence. In Summer 2008 I checked sites at 3-5 days within a survey cycle to record detections and perform site maintenance (e.g., re-bait and replace batteries in cameras). During Summer 2009 I checked sites on day 7. Therefore during each cycle there were 2 check periods (set-up to re-bait and re-bait to removal). Detections either occurred in the form of a print on the contact paper attached to track-plates (or the sooted part of the track-plates) or a picture from remote cameras. Print detections were considered unique if they were captured pre- or post-re-bait, therefore the maximum number of unique detections that could occur at a track-plate was 2 per cycle.

Picture detections were considered unique if ≥30 min elapsed between fisher photos. The first 24 hr survey period after set-up of a device was considered the first Detection Day (DD). Subsequent DDs were calculated with the next DD beginning after the previous DD completed 24 hrs of functioning properly. I omitted DDs for periods where a detection device was a malfunctioning or was otherwise inoperable. For track-plates I eliminated all the DDs that accumulated between the failure date and the set-up or re-bait date and for remote cameras I eliminated all DDs that occurred after the last successful picture was taken.

Visitation patterns

I measured the intensity of detections at survey sites by tallying the number of unique detections at a site. Also, I evaluated intensity by tallying the number of detection days that received ≥1 detection. I used Civil Twilight information provided by the Astronomical Applications Department for U.S. Naval Observatory (Astronomical Administration Department U. S. Naval Observatory, Washington D. C., USA, www.noaa.gov) to delineate the time of day into the 3 categories of crepuscular, diurnal, and nocturnal. Crepuscular was defined as 30 min before and 30 min after dawn and dusk, the crepuscular hours were adjusted to coincide with the change in sunrise and sunset as defined by the Astronomical Applications Department for U.S. Naval Observatory. Diurnal was defined as the time period between the end of the dawn crepuscular hour and the beginning of the dusk crepuscular hour. Nocturnal was defined as the time between the end of the dusk crepuscular hour and the beginning of the dawn crepuscular hour. I used a chi-square goodness-of-fit test to determine if the percentage of detections for the time periods of crepuscular, diurnal, and nocturnal occurred in the same percentage that would be expected for those time periods if fishers had no preference for time periods. I used Kruskal-Wallis test to determine if the length of duration differed depending on the time of day between survey years. Data was analyzed using Minitab® (Minitab Inc., State College, Pennsylvania) and SAS® (SAS Institute Inc., Cary, North Dakota, USA).

Habitat assessments

I assessed if visitation patterns differed among survey sites by patch-size and degree of isolation. To create the covariates I used ArcMap 9.3 to establish a 1-km buffer on both sides of the survey rivers. I then aggregated all forested patches within 250 m of and measured the forest patch-sizes in hectares. Forest patches were delineated into 3 hectare size categories small (0-50 ha), medium (50-250 ha), and large (250^{+} ha). I created 3 covariates with continuous measurements to assess isolation, distance in meters to the nearest (small patch; 0-50 ha), nearest (medium patch; 50-250 ha), and nearest (large patch; 250^{+} ha)(Table 1). Also, I created 3 categorical covariates that were derived from the continuous covariates to evaluate forest patch-size and degree of isolation (Table 1). When analyzing occupancy rates by patch-size and isolation I only used data from the Forest River, Park River, Pembina Hills, Pembina River, Red River (north of confluence with the Turtle River), Tongue River, and Turtle River for Summer 2009. I used the software PRESENCE (MacKenzie et al. 2002) to determine if the covariates I created to define patch-size and isolation had an impact on fisher occupancy (ψ) at a site. I assessed model-fit using a Pearson chi-square test with a parametric boot-strap of 1,000 simulations (MacKenzie and Bailey 2004). PRESENCE ranked the models using Akaikie Information Criterion (AIC), with the lowest model having the strongest predictive power of occupancy. I determined the Latency to Detection (LTD) at a site to be the number of DDs that accumulated until the first detection. I calculated the LTD mean for each survey area and year. I used a LTD cumulative density graph to evaluate the necessary number of DDs required to detect a fisher when the site is occupied by a fisher. I ran a Poisson regression using the site covariates that defined a sites category of patch-size and isolation to assess the impact that site patch-size and isolation had on LTD for 2009.

Results

In 2008 I surveyed with both track-plates and remote cameras for 1,496 DDs, track-plates functioned properly for 1,488 DDs whereas remote cameras were functional for 1,467 DDs (Figure 3). During 2009 I only surveyed with remote cameras. In 2009 the remote cameras were set-up for a total of 2,304 DDs and functioned properly for 2,215 of the DDs (Figure 3). During both summers detections occurred throughout the study area, but were concentrated in the northeastern portion of the state (Figure 4). During 2008 camera detections by functional camera days ranged from (0%) on the Goose River (*n* = 7), Park River (*n* = 40), and Sheyenne River (*n* = 34) to (20%) on the Red River (South; *n* = 184)(Figure 5). In 2009 camera detections by functional camera days ranged from Sheyenne River (<1%, *n* = 382) to Red River (North; 24%, *n* = 339)(Figure 6). The average distance separating adjacent survey sites was 4,011 m (SD ± 3,394 m; range 213-20,577 m). During 2008 fishers were detected at 54 sites (29%) and in 2009 at 78 sites (45%)(Figure 7). For 2008 the number of sites with a detection by sites surveyed ranged from (0%) on the Goose River (*n* = 1), Park River (*n* = 5), and Sheyenne River (*n* = 5) to (20%) on the Red River (South; *n* = 26)(Figure 8). In 2009 the detections by number of sites surveyed was lowest on the Sheyenne River (3%, *n* = 27) and highest on the Pembina River (90%, *n* = 10)(Figure 9). In 2009, 81% of the detection sites had >1 fisher detection (Figure 10). The most detections at a site were 15. Of the sites that detected a fisher, 56% received > 1 detection on subsequent DDs (Figure 11).

Of the 69 detections that occurred in 2008, 56 (81.1%) were diurnal, 7 (10.1%) were nocturnal, and 6 (8.7%) were crepuscular (Figure 12). Among the 182 detections from 2009, 108 (58.3%) were diurnal, 44 (24.2%) were nocturnal, and 30 (16.5%) were crepuscular (Figure 13). Detections by time category differed between 2008 and 2009 (Figure 14). In 2008 detections occurred more frequently during the diurnal period than expected (χ^2_2 = 11.35, p = 0.003, n = 69), whereas in 2009 the detections occurred more frequently during the crepuscular period than expected (χ^2_2 =7.27, p = 0.026, n = 182). In 2008 I had 69 separate fisher detections, 47 of the detections occurred for duration that lasted ≤1 min and 22 that were >1 min, with a average of 2.77 (± 0.6 SE)(Figure 15). In 2009 I had 182 separate fisher detections, 121 of the detections occurring at a duration of ≤1 min and 61 that were >1 min, with an average of 2.39 min (± 0.3 SE)(Figure 16). Length of visit did not differ between time of day.

All the models passed the assessment of model fit (Mackenzie and Bailey 2004). The ΔAIC values for the covariate models did not differ from the null model (Donovan and Hines 2007) (Table 2). There were a maximum of 9 DDs per device for Summer 2008 and 13 DD for Summer 2009. The mean LTD in was around 5 DD for both summers (Table 3). During 2008 90% of the detections occurred by the seventh DD (Figure 17). In 2009 90% of the detections occurred by the tenth DD (Figure 18). I scaled the total possible DDs for 2009 back to 9 DDs, in order to compared them to 2008. When scaled to 9 DDs, results for 2009 displayed similar results with 90% of the detections occurring by the seventh DD (Figure 19). In 2009 the LTDs differed between patch-sizes ($\chi^2_2 = 7.51$, $p = 0.006$, $n = 55$). Poisson regression with the categorical covariates the LTDs differed among categories. Small patches (0-50 ha) received detections sooner than medium patches (50-250 ha), and medium patches received detections sooner than large patches (500^+ ha)(Figure 20). Patches with a greater degree of isolation generally received detections sooner than patches that were less isolated for all distance to nearest small patch ($\chi^2_2 = 4.24$, $p = 0.0395$, $n = 55$)(Figure 21), medium patch ($\chi^2_2 = 23.31$, $p = <0.0001$, $n = 55$,)(Figure 22), and large patch ($\chi^2_2 = 23.31$, $p = <0.0001$, $n = 55$)(Figure 23).

Discussion

Survey sites that had a detection generally received subsequent detections. The detected individuals may be exhibiting a trap response (Hamm et al. 2003) or these areas may have higher levels of occupancy. In past studies fishers have displayed highly dynamic activity patterns ranging from nocturnal (de Vos 1952, Coulter 1966, Strickland et al. 1982, Webster et al. 1985, Smith 2010), crepuscular (Kelly 1977), or variations of both activity cycles (Webster et al. 1985, Arthur and Krohn 1991, Powell 1993, Weir and Corbould 2007). Consistent with previous literature, my detection times differed (Powell 1993); fishers were detected more frequently in the diurnal hours in 2008 and more often in the crepuscular hours in 2009. Fishers are possibly exploiting a variety of prey species in North Dakota and are not restricted in activity times by predation and competition and therefore are active throughout all periods of the day with dynamic peaks occurring throughout years demonstrating the fishers' adaptability. Fishers have demonstrated their ability to be euryphagic consuming any prey item they can overpower (Arthur et al. 1989, Powell 1993). Research on the activity patterns of other predators, including American martens (*Martes americana*), barn owls (*Tyto alba*), mink (*Neovision vision*), and red foxes (*Vulpes vulpes*), showed prey availability to be a major influence on activity patterns; each of the species displayed synchronicity in their periods of activity with those of their prey (Albes 1969, Gerell 1969, Zielinski et al. 1983, Brown et al. 1988, Drew and Bissonette 1997, Stangl Jr. 2005). Prey items for the fisher in this region were likely effected by the large flood event that inundated the riparian forest in the winter of 2010 (Triska 2010). Therefore, fishers may have altered their hours of activity in order to have higher success at hunting the prey or may have switch to an alternative prey as a result of the large flood.

Fishers may not have ever been heavily predated on by other carnivore species; however even without heavy predation, carnivores have been recognized to have substantial impacts on the activity patterns of their prey species (Ripple et al. 2010). Since the European settlement of North Dakota in the late 1800s many large carnivore species such as the grizzly bear (*Ursus arctos*), wolverine (*Gulo gulo*), and wolf (*Canis lupus*) have been extirpated from eastern North Dakota and species such as the American black bear (*Ursus americanus*) and bobcat (*Lynx rufus*), and mountain lions (*Felis concolor*), are rare (Bailey 1926). Past studies documented the occasional predation of fishers by coyotes (*Canis latrans*), domestic dog (*Canis familiaris*), and large birds of prey (Webster et al. 1985). However, more recent evidence has indicated that bobcats, raptors, coyotes, domestic dogs, mountain lions, and wolves may contribute more to fisher mortality than previously recognized (G. Wengert, University of California, Davis, personal communication). Currently large carnivores only persist as remnant populations in North Dakota (Bailey 1926), thus fishers may have little competition for resources and predator avoidance likely plays a minimal role in the activity patterns of fishers. Kelly (1977) and Paragi et al. (1994) found fishers to be more active during summer within the diurnal period when compared to other seasons and activity patterns to differ between age and sex. In my study I could not differentiate between age and sex of the individuals. Therefore a stronger pattern may exist that I could not recognize by examining the detections from pictures alone. Fishers' behaviors are likely influenced by many dynamic factors such as predation, prey abundance, weather conditions, seasonality, reproductive behaviors, and stochastic weather events (Coulter 1966, Kelly 1977, Strickland et al. 1982, Raine 1987, Powell 1993, Weir and Corbould 2007). Fishers are possibly exploiting a variety of prey species in North Dakota and are not restricted in activity times by predation and competition and therefore are active throughout all periods of the day, with peak activity times being plastic and pendant on specific conditions.

The lengths of visits typically were ≤1 minute and did not differ by time of day. Fishers generally consumed the bait when present or inspected the area where the bait was placed and then immediately exited the view of the camera. Occasionally fisher pictures were captured of individuals marking the site with urine, digging near the bait, inspecting devices, and one instance of two juvenile fishers wrestling (35 min). The length of visits appear consistent with literature, which suggest that fishers when awake are often on the move only stopping if there is a large amount of carrion or if they successfully kill a large prey item (Ewer 1973, Powell 1993).

Fishers demonstrated similar levels of occupancy in patches regardless of size or isolation. The techniques I used did not provide enough evidence to assess potential relationships between the different demographic groups within population and their habitat preferences. It is possible that juveniles are occupying the lower quality habitat and although they may have low fitness, they were still detected and contribute to higher levels of occupancy within the habitat (Garshelis 2000). Regardless of age or sex, fishers in this portion of their range have demonstrated their ability to adapt and use less than preferred habitat (de Vos 1952, Coulter 1966, Kelly 1977, Powell 1982, Allen 1983, Arthur et al. 1994, Weir and Harestad 2003, Jones and Garton 1994, Zielinski et al. 2004). I chose to only use information from 2009 to assess detection by patch-size and isolation, because in 2009 I maintained equal sampling effort at all sites. Also, I only chose rivers that had high enough detection rates to assume fishers were present within the area.

Analyzing the LTDs allowed me to determine the length of survey time required to detect a fisher at occupied sites in eastern North Dakota. The slope of the cumulative percentage line of LTD for 2008 did not reach a horizontal asymptote and indicated that new detections were acquired until the last day of the sampling period. Therefore, in 2009 I extended the survey period an extra 5 DDs to a total of 13 DDs. When I plotted the cumulative density graph of LTDs for 2009, the cumulative density line began to reach a horizontal asymptote by the end of the 13 DDs sampling period (Figure 6). Although some literature indicates that camera surveys should be extended to a 22-day sampling period (Fowler and Golightly 1994), I found that advances in remote cameras and the high probability of detection in this area made it possible to detect fishers within 13 DDs. When I compared LTDs between summers by scaling the DDs for 2009 to match 2008 LTD was found to be consistent throughout both summers (Figure 7). Detections generally occurred sooner in smaller patches than larger patches. If fishers are equally present among patches of all sizes they are more likely to encounter devices in a smaller patch than a larger patch. Fishers' being detected throughout both small and large patches possibly a result of fishers spending more time searching though the smaller patches, because they are lower quality habitat and not necessarily an indication of habitat quality. Detections also occurred sooner for patches that were more isolated (Figure 10, Figure 11, and Figure 12). Fishers may be spending more time in isolated patches than in patches with less isolation. Patches with connectivity may allow fishers to move more freely on to the next patch when foraging as opposed to keeping them temporarily confined.

Management Implications

Although fishers have demonstrated their ability to survive in this fragmented landscape, large forested areas likely still remain essential to this population (de Vos 1952, Coulter 1966, Kelly 1977, Powell 1982, Allen 1983, Arthur et al. 1994, Jones and Garton 1994, Weir and Harestad 2003, Zielinski et al. 2004). However, much of the agricultural industry in North Dakota is moving towards large contiguous monoculture fields that better suit large machinery (Benton et al. 2003). The Conservation Restoration Program (CRP) and similar incentives will remain important to fishers and other wildlife that are located within these forest regions. The differences in LTDs were statistically significant for different patch-sizes and have significant implications for wildlife managers developing a survey design that is restricted in resources. Wildlife managers in North Dakota can more efficiently cover a larger survey area by surveying smaller patches for a shorter survey duration. The LTD results from my study suggest that a survey length of 7 DDs is sufficient to detect fishers in the smaller patches. This is substantial compared to the > 13 DDs that are needed to thoroughly survey large patches. Fishers are currently protected in North Dakota, however there is interest in initiating a trapping season by the NDGF. The smaller patches in the northern survey areas had low LTD average of 4.7 (± 7.3 S.E.) and high detections (52%, n = 35). The low LTDs coupled with the high detection may indicate this population's susceptibility to over harvest if a trapping season is initiated without population estimates.

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Figure 1. Location of study are in northeastern North Dakota.

North Dakota

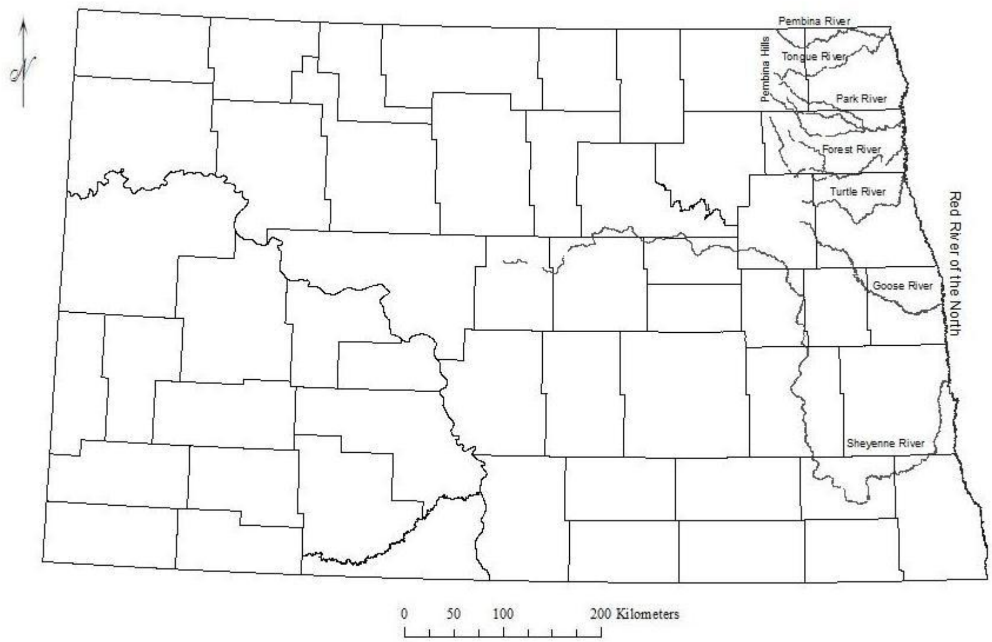


Figure 2. Sites surveyed in eastern North Dakota throughout 2008 and 2009.

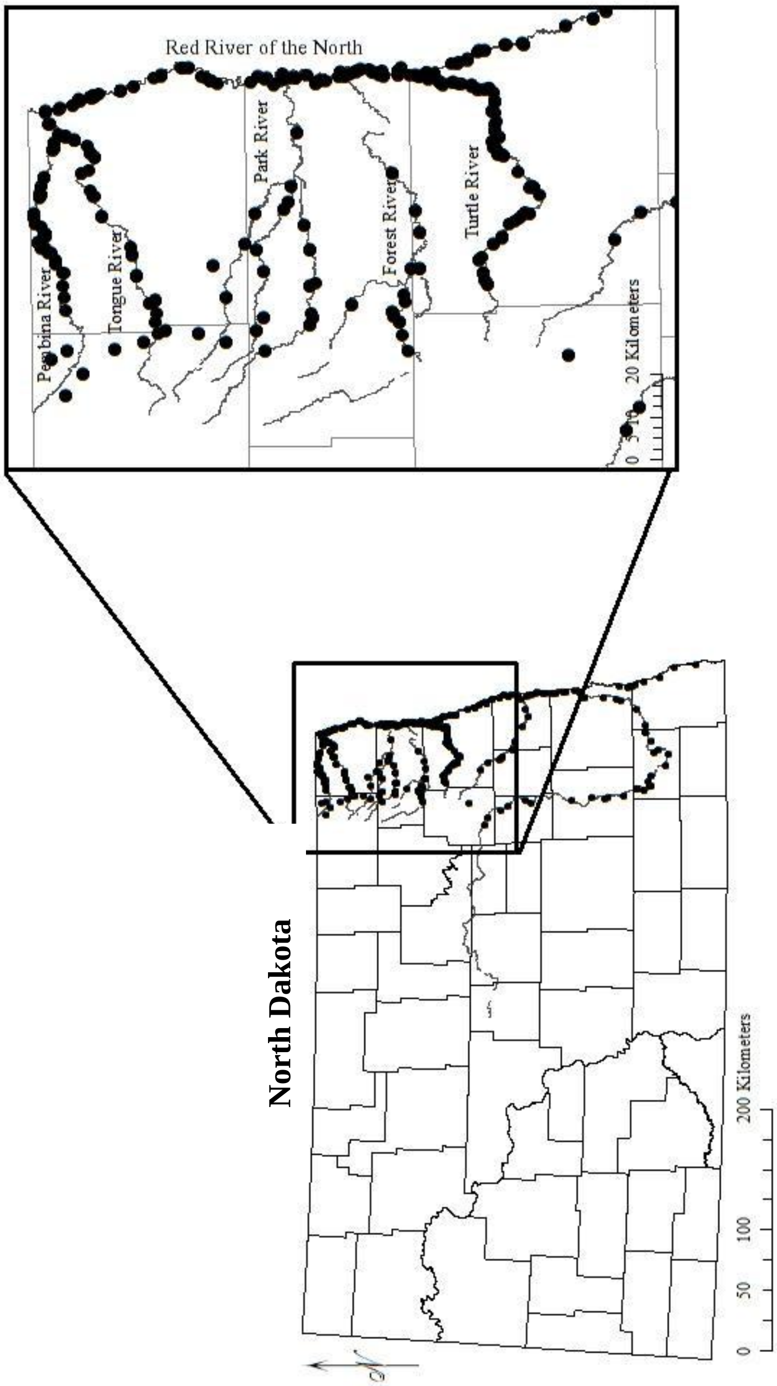

Red River of the North
Pembina River
Tongue River
Park River
Forest River
Turtle River
20 Kilometers
North Dakota
200 Kilometers
0
50
100

Table 1. Describes the covariates that were used to assess patch-size and isolation of patches

	Habitat Covariates	Description
Continuous Covariates	Hectares	Area (ha) of surveyed patch
	Isolation Small	Distance (m) to nearest small patch
	Isolation Medium	Distance (m) to nearest medium patch
	Isolation Large	Distance (m) to nearest large patch
Categorical Covariates	Patch-size	Small (0 - 50 ha), Medium (50 - 250 ha), Large (250^{+})
	Isolation Small	Near (0 - 200 m), Medium (200 - 400 m), and Far (>400 m)
	Isolation Medium	Near (0 - 500 m), Medium (500 - 1,000 m), and Far (>1,000 m)
	Isolation Large	Near (0 - 400 m), Medium (400 - 5,000 m), and Far (>5,000 m)

Figure 3. Number of functional DDs compared to the number of non-functional DDs for Summer 2008 and Summer 2009.

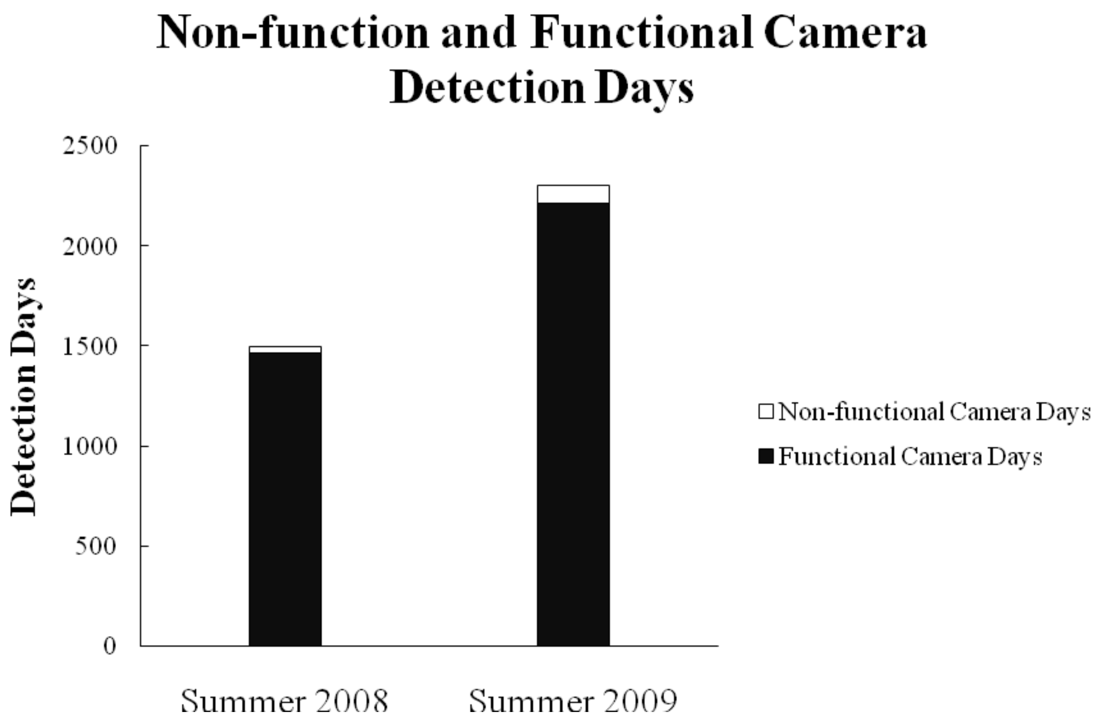

Non-function and Functional Camera Detection Days
Detection Days
2500
2000
1500
1000
500
0
Summer 2008
Summer 2009
Non-functional Camera Days
Functional Camera Days

Figure 4. Sites that detected a fisher in northeastern North Dakota throughout the summers of 2008 and 2009.

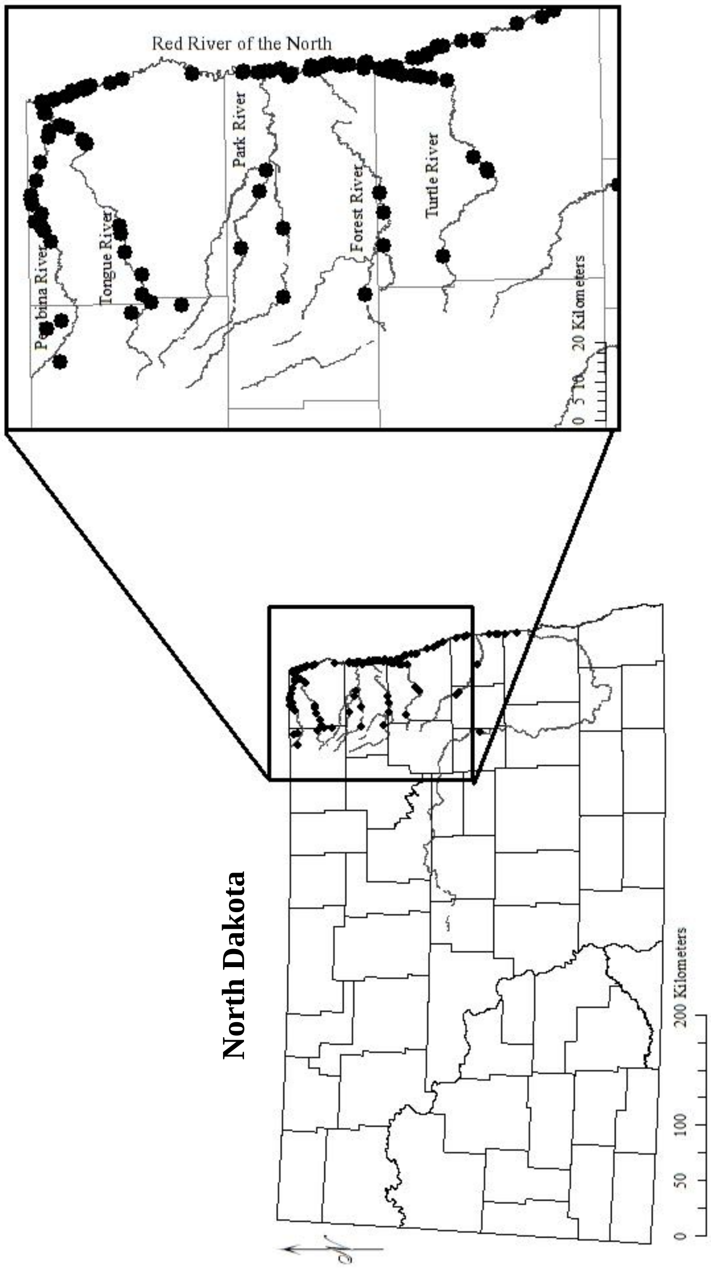

Red River of the North
Pembina River
Tongue River
Park River
Forest River
Turtle River
0 5 10 20 Kilometers
North Dakota
0 50 100 200 Kilometers

Figure 5. The percentage of functional DDs that received detections by the total number of functional DDs surveyed for all the rivers surveyed in Summer 2008. Forest River (*n* = 48), Goose River (*n* = 7), Park River (*n* = 40), Pembina River (*n* = 204), Red River (North) (*n* = 403), Red River (South) (*n* = 184), Sheyenne River (*n* = 34), Tongue River (*n* = 178), and Turtle River (*n* = 365).

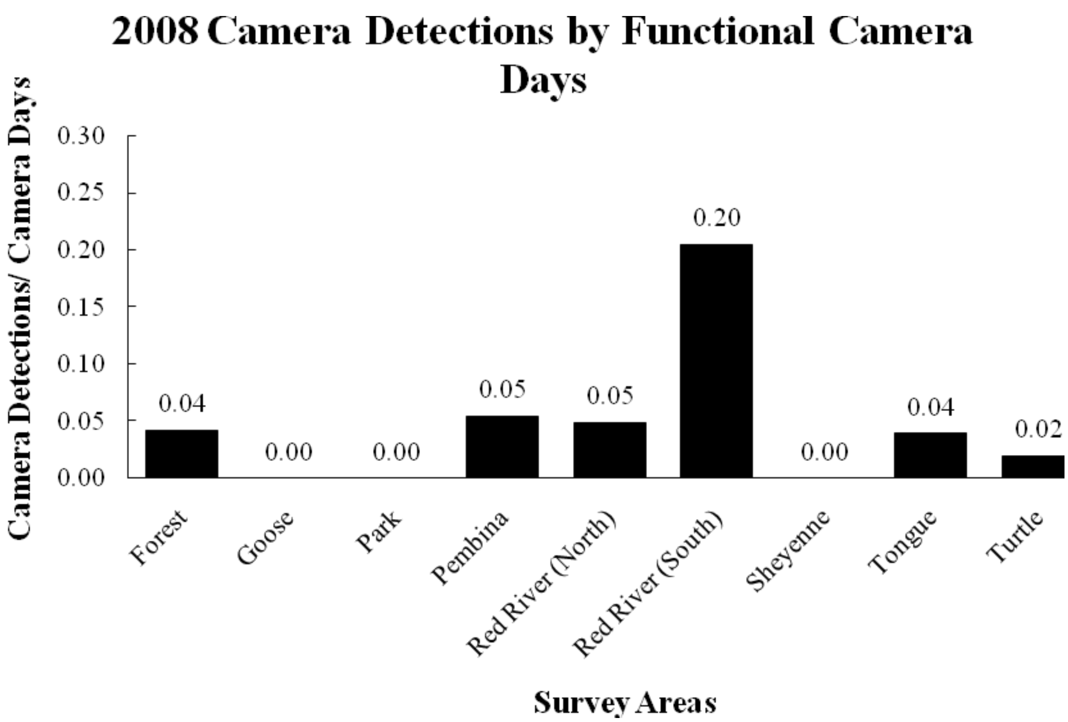

2008 Camera Detections by Functional Camera Days
Camera Detections/ Camera Days
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.04
0.00
0.00
0.05
0.05
0.20
0.00
0.04
0.02
Forest
Goose
Park
Pembina
Red River (North)
Red River (South)
Sheyenne
Tongue
Turtle
Survey Areas

Figure 6. The percentage of functional DDs that received a detection by the total number of functional DDs surveyed for all the rivers surveyed in Summer 2009. Forest River (n = 113), Goose River (n = 172), Park River (n = 251), Pembina River (n = 125), Pembina Hills (n = 108),Red River (North) (n = 339), Red River (South) (n = 342), Sheyenne River (n = 382), Tongue River (n = 120), and Turtle River (n = 257).

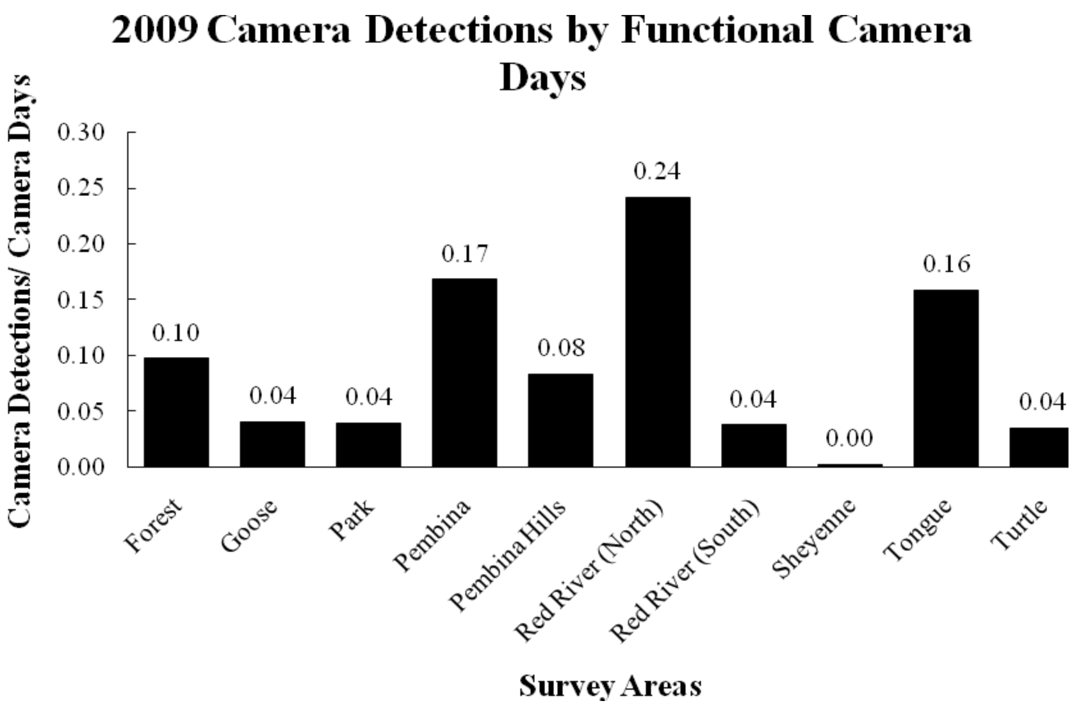

2009 Camera Detections by Functional Camera Days
Camera Detections/ Camera Days
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.10
0.04
0.04
0.17
0.08
0.24
0.04
0.00
0.16
0.04
Forest
Goose
Park
Pembina
Pembina Hills
Red River (North)
Red River (South)
Sheyenne
Tongue
Turtle
Survey Areas

Figure 7. Percentage of sites that received fisher detections for all the rivers surveyed in Summer 2008. Forest River (n = 6), Goose River (n = 1), Park River (n = 5), Pembina River (n = 22), Red River (North) (n = 71), Red River (South) (n = 26), Sheyenne River (n = 5), Tongue River (n = 22), and Turtle River (n = 42).

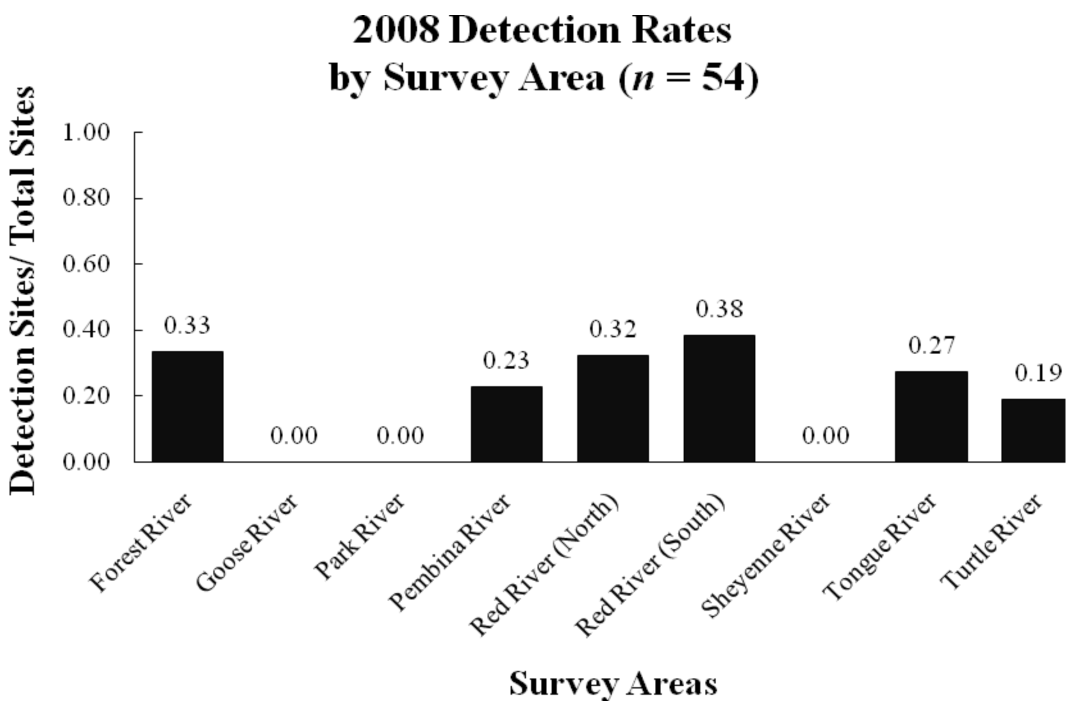

2008 Detection Rates
by Survey Area (n = 54)
Detection Sites/ Total Sites
1.00
0.80
0.60
0.40
0.20
0.00
0.33
0.00
0.00
0.23
0.32
0.38
0.00
0.27
0.19
Forest River
Goose River
Park River
Pembina River
Red River (North)
Red River (South)
Sheyenne River
Tongue River
Turtle River
Survey Areas

Figure 8. Percentage of sites that received fisher detections for all the areas surveyed in Summer 2009. Forest River (n = 9), Goose River (n = 14), Park River (n = 19), Pembina River (n = 10), Pembina Hills (n = 8), Red River (North) (n = 26), Red River (South) (n = 27), Sheyenne River (n = 29), Tongue River (n = 9), and Turtle River (n = 20).

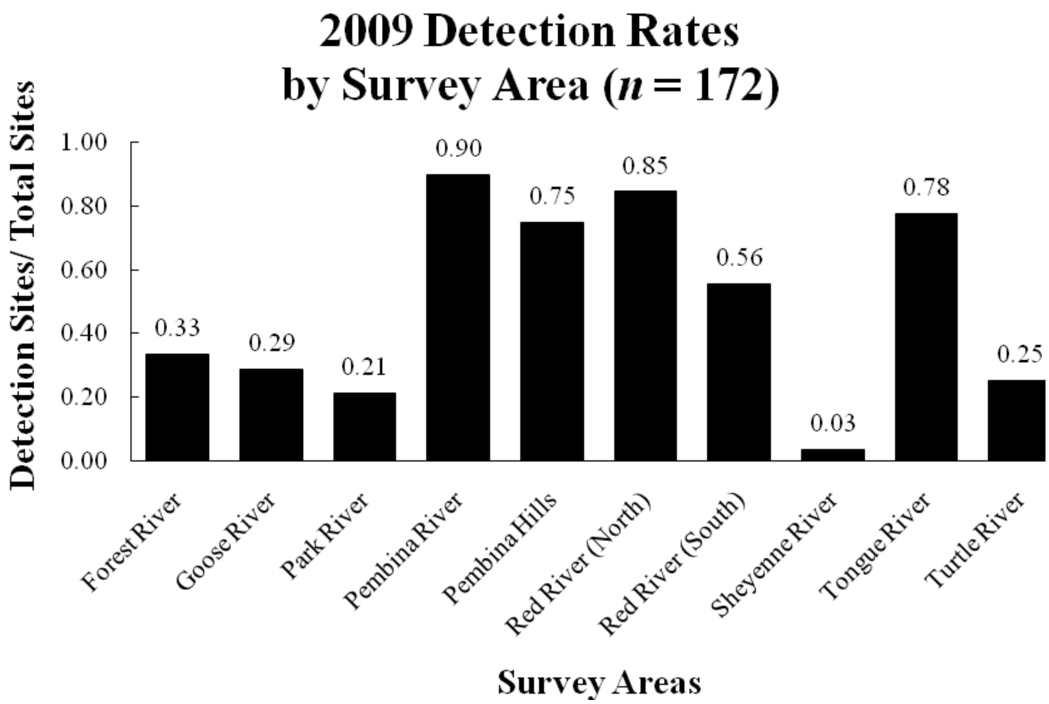

2009 Detection Rates
by Survey Area (*n* = 172)
Detection Sites/ Total Sites
1.00
0.80
0.60
0.40
0.20
0.00
0.33
0.29
0.21
0.90
0.75
0.85
0.56
0.03
0.78
0.25
Forest River
Goose River
Park River
Pembina River
Pembina Hills
Red River (North)
Red River (South)
Sheyenne River
Tongue River
Turtle River
Survey Areas

Figure 9. Number of unique detections (detections had to be separated by at least 30 minutes) at sites for Summer 2009.

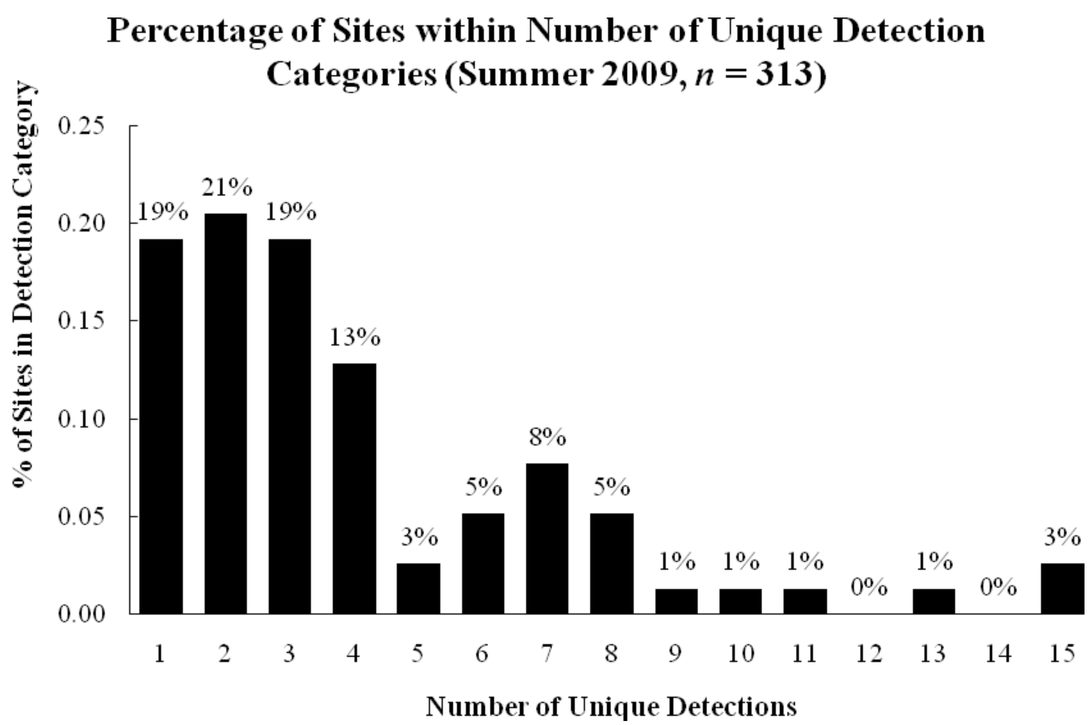

Percentage of Sites within Number of Unique Detection Categories (Summer 2009, n = 313)
% of Sites in Detection Category
0.25
0.20
0.15
0.10
0.05
0.00
19%
21%
19%
13%
3%
5%
8%
5%
1%
1%
1%
0%
1%
0%
3%
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Number of Unique Detections

Figure 10. Number of detection days with at least 1 detection (detections had to be separated by at least 24 hours) at sites for Summer 2009.

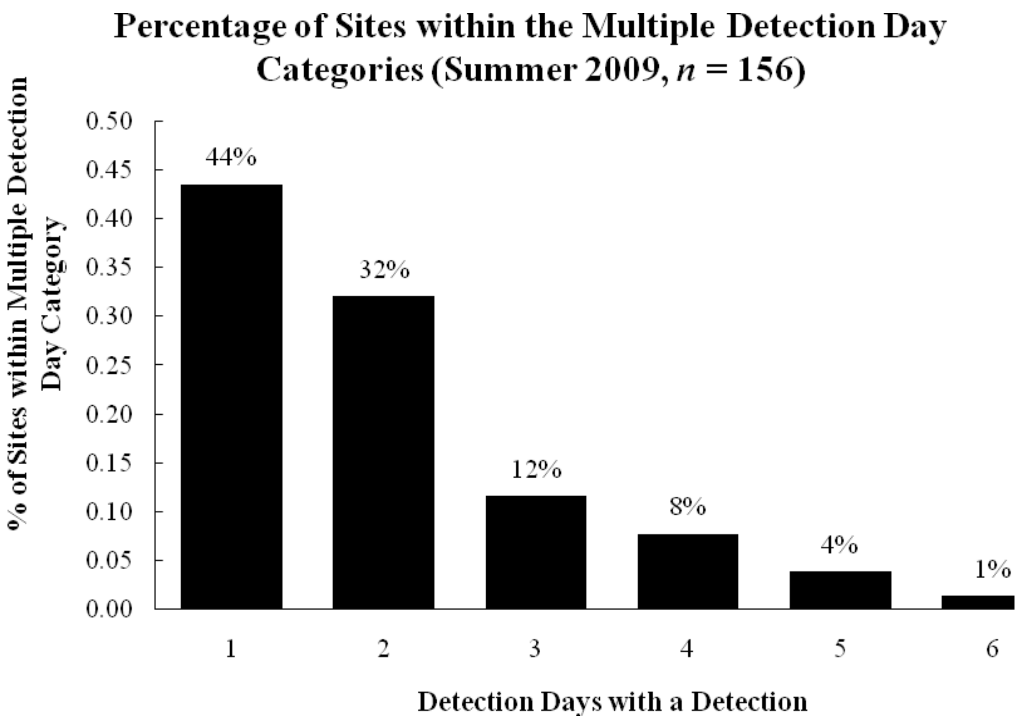

Percentage of Sites within the Multiple Detection Day Categories (Summer 2009, n = 156)
% of Sites within Multiple Detection Day Category
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
44%
32%
12%
8%
4%
1%
1
2
3
4
5
6
Detection Days with a Detection

Figure 11. Detection Counts by Time of Day for Summer 2008, (χ_2^2 = 11.35, p = 0.003, n = 69).

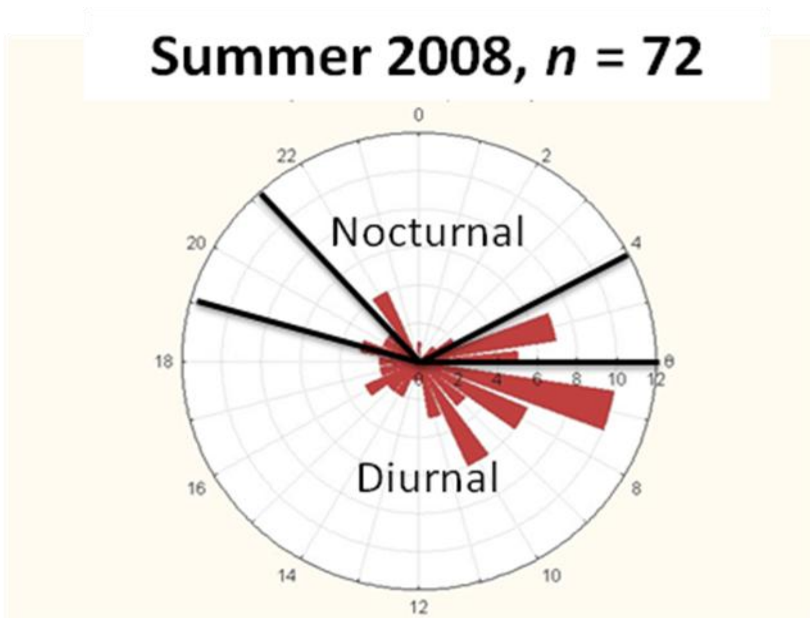

Summer 2008, n = 72
Nocturnal
Diurnal
0
2
4
6
8
10
12
14
16
18
20
22
0 2 4 6 8 10 12

Figure 12. Detection Counts by Time of Day for Summer 2009, (χ_2^2 =7.27, p = 0.026, n = 182).

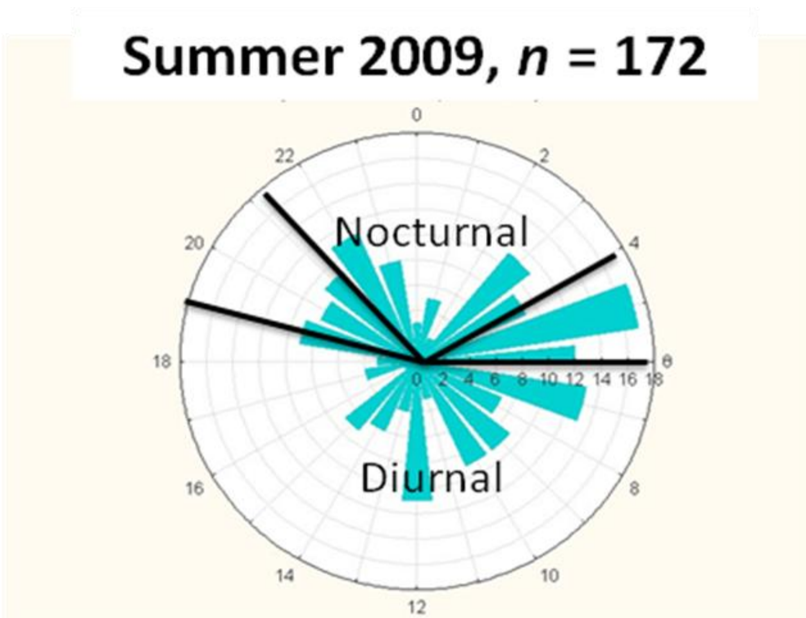

Summer 2009, n = 172
0
2
4
6
8
10
12
14
16
18
20
22
Nocturnal
Diurnal
0 2 4 6 8 10 12 14 16 18

Figure 13. Explains the proportion of detections expected in time categories compared to the proportion that were detected in Summer 2008 and Summer 2009. Summer 2008 crepuscular (n = 6), diurnal (n = 56), nocturnal (n = 7). Summer 2009 crepuscular (n = 30), diurnal (n = 108), nocturnal (n = 44).

Percentage of Day within the Time Catergories

Percentage of Detections that Occurred within the Time Categories (Summer 2008, n = 69)

Percentage of Detections that Occurred within the Time Categories (Summer 2009, n = 182)

Figure 14. Duration of visits in minute categories for all detections in Summer 2008.

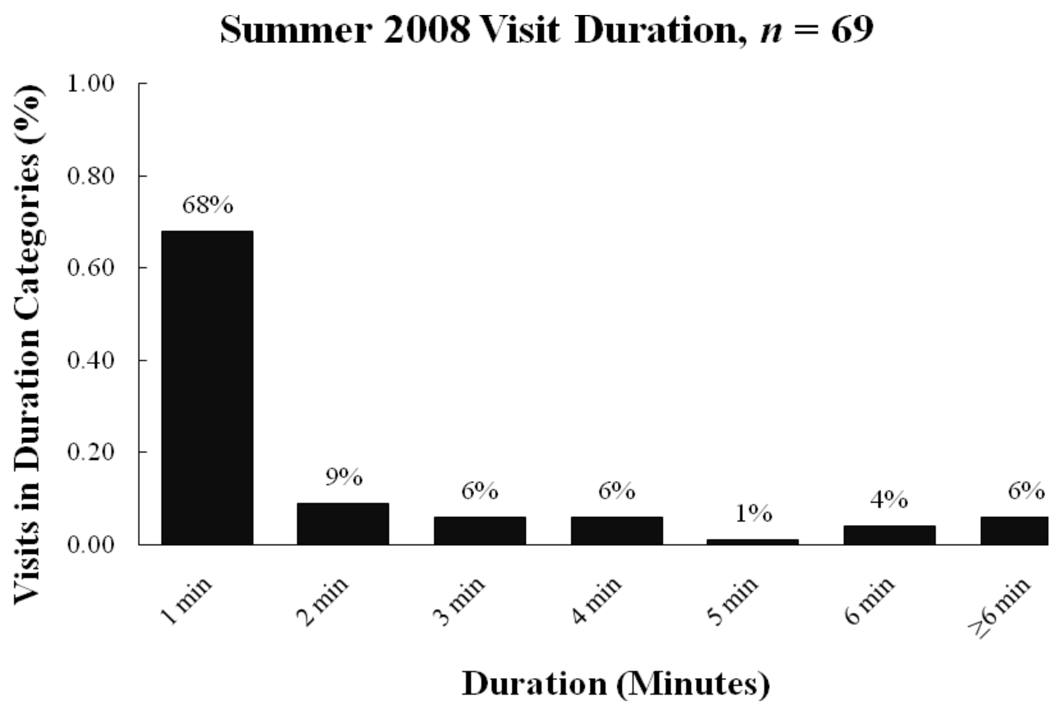

Summer 2008 Visit Duration, n = 69
Visits in Duration Categories (%)
1.00
0.80
0.60
0.40
0.20
0.00
68%
9%
6%
6%
1%
4%
6%
1 min
2 min
3 min
4 min
5 min
6 min
≥6 min
Duration (Minutes)

Figure 15. Duration of visits in minute categories for all detections in Summer 2009.

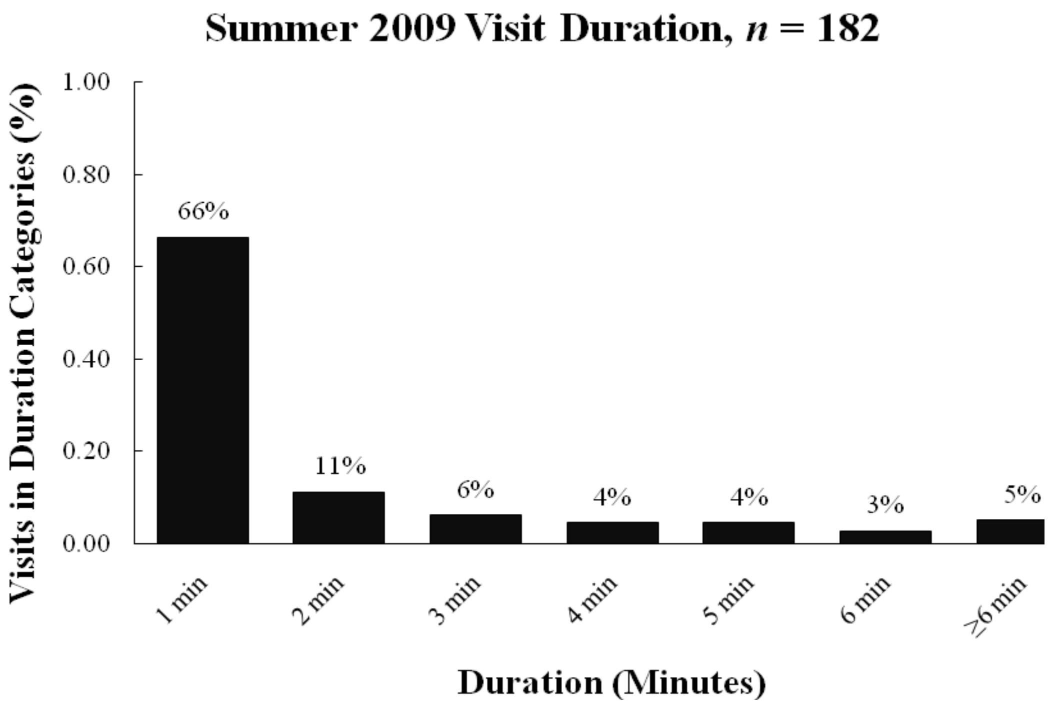

Summer 2009 Visit Duration, *n* = 182
Visits in Duration Categories (%)
1.00
0.80
0.60
0.40
0.20
0.00
66%
11%
6%
4%
4%
3%
5%
1 min
2 min
3 min
4 min
5 min
6 min
≥6 min
Duration (Minutes)

Table 2. Results for the occupancy models that were ran through PRESENCE.

Occupancy Models Developed in PRESCENCE 2.3 for the Sites Found in the Northern Section

Model	AIC	? AIC	AIC weight	Model Likelihood	# of Parameters	-2 Log Likelehood
psi(isosmallcat),p(.)	725.46	0.00	0.37	1.00	2.00	721.46
psi(isolargecat),p(.)	726.49	1.03	0.22	0.60	2.00	722.49
1 group, Constant P	727.95	2.49	0.11	0.29	2.00	723.95
psi(hacat),p(.)	728.89	3.43	0.07	0.18	2.00	724.89
psi(isomedcat),p(.)	728.97	3.51	0.06	0.17	2.00	724.97
psi(isolarge),p(.)	729.02	3.56	0.06	0.17	2.00	725.02
psi(isosmall),p(.)	729.39	3.93	0.05	0.14	2.00	725.39
psi(isomed),p(.)	729.88	4.42	0.04	0.11	2.00	725.88
psi(hectacres),p(.)	730.55	5.09	0.03	0.08	2.00	726.55

Table 3. Mean Latency to Detection (LTD) in days for fishers in the areas surveyed in Summer 2008 and Summer 2009.

Survey Year	**Surveyed Area**	***n***	**Mean (LTD)**	**SE Mean**	**Minimum**	**Maximum**
2008	Forest River	2	5.5	0.5	5	6
	Goose River	*	*	*	*	*
	Park River	*	*	*	*	*
	Pembina River	4	4.75	0.85	3	7
	Red River (North)	16	4.13	0.53	1	7
	Red River (South)	7	5.29	0.81	3	8
	Sheyenne River	*	*	*	*	*
	Tongue River	5	5.2	0.8	2	6
	Turtle River	5	6	0.9	3	8
2009	Forest River	3	5.67	2.33	2	10
	Goose River	4	7.5	1.5	5	11
	Park River	4	4.25	1.8	1	9
	Pembina River	9	4.67	1.11	1	11
	Pembina Hills	5	5.4	1.81	1	11
	Red River (North)	22	4.32	0.71	1	11
	Red River (South)	15	3.87	0.8	1	12
	Sheyenne River	1	6	*	6	6
	Tongue River	7	6.57	1.19	3	11
	Turtle River	5	3	1.55	1	9

N/A = Not applicable, because there was a lack of detections or too few detections.

Figure 16. Cumulative fisher detections that occurred over the 9 detection day sampling period for Summer 2008.

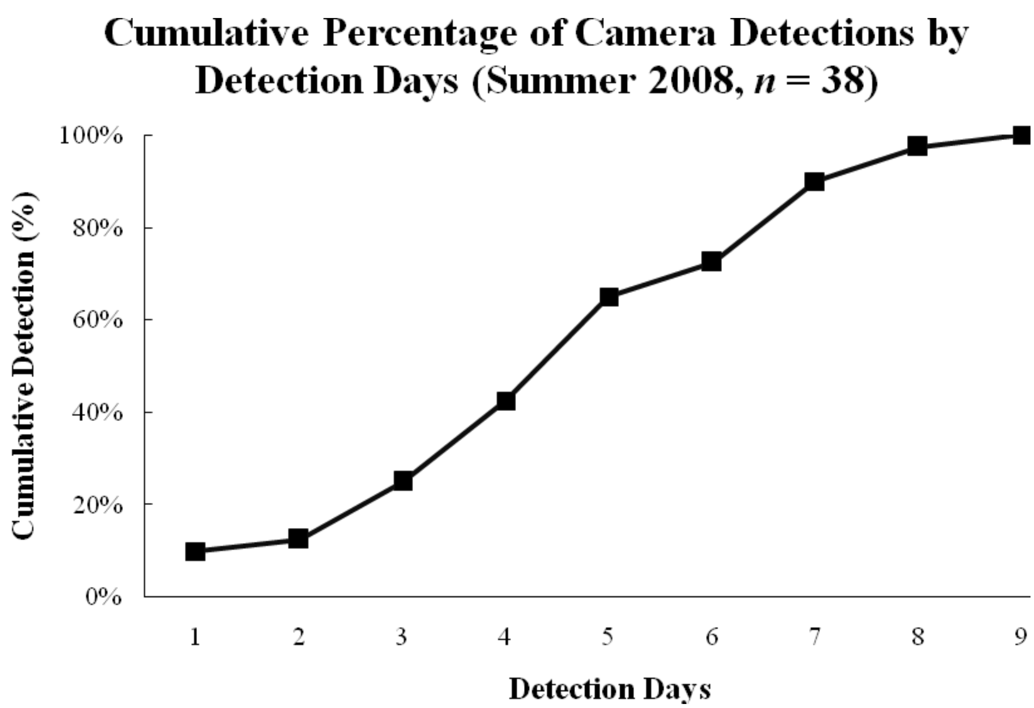
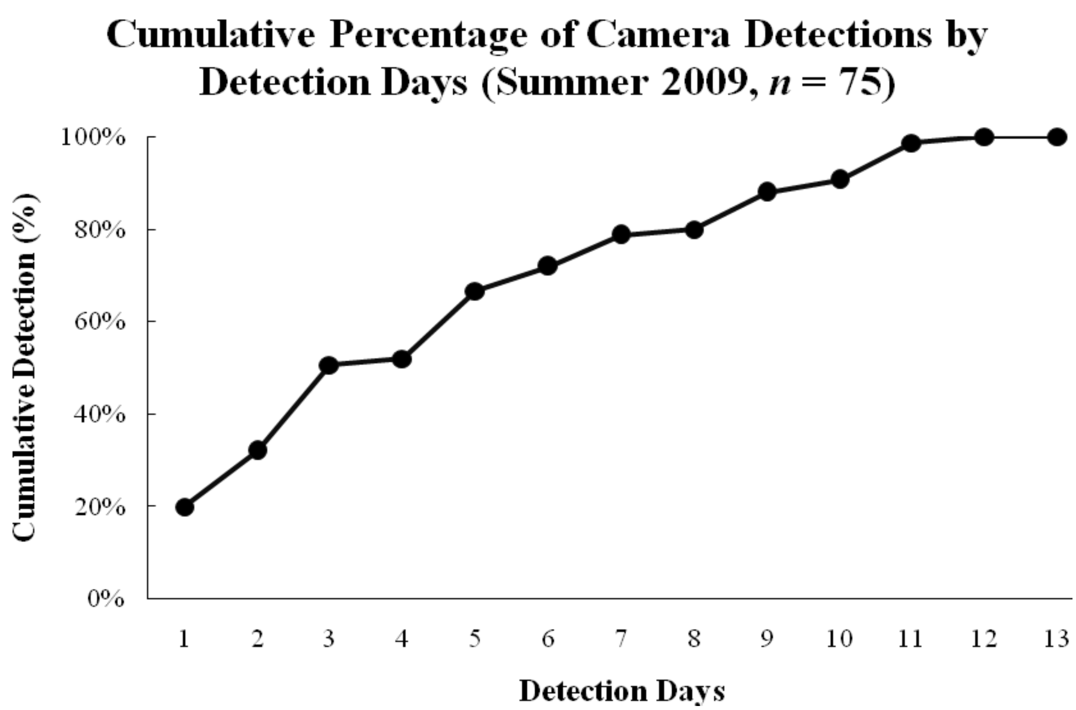
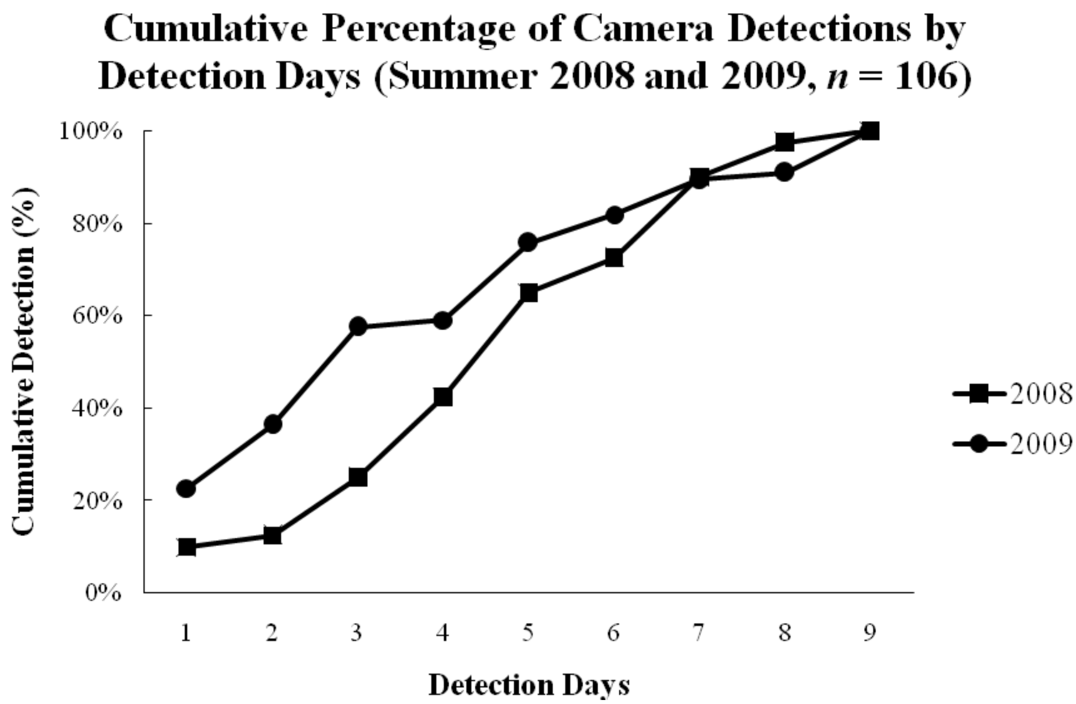

Cumulative Percentage of Camera Detections by Detection Days (Summer 2008, n = 38)
Cumulative Detection (%)
100%
80%
60%
40%
20%
0%
1
2
3
4
5
6
7
8
9
Detection Days

Figure 17. Cumulative fisher detections that occurred over the 13 detection day sampling period for Summer 2009.



Cumulative Percentage of Camera Detections by Detection Days (Summer 2009, n = 75)
100%
80%
60%
40%
20%
0%
Cumulative Detection (%)
1
2
3
4
5
6
7
8
9
10
11
12
13
Detection Days

Figure 18. Comparing the cumulative fisher detections that occurred throughout the first 9 DDs for Summer 2008 and Summer 2009.



Cumulative Percentage of Camera Detections by Detection Days (Summer 2008 and 2009, *n* = 106)
Cumulative Detection (%)
100%
80%
60%
40%
20%
0%
1
2
3
4
5
6
7
8
9
Detection Days
2008
2009

Figure 19. Compares how LTD differs among the patch categories. The categories were defined as small (0-50 ha, n = 26), medium (50-250 ha, n = 18), and large (250^{+} ha, n = 31) patch-size categories.

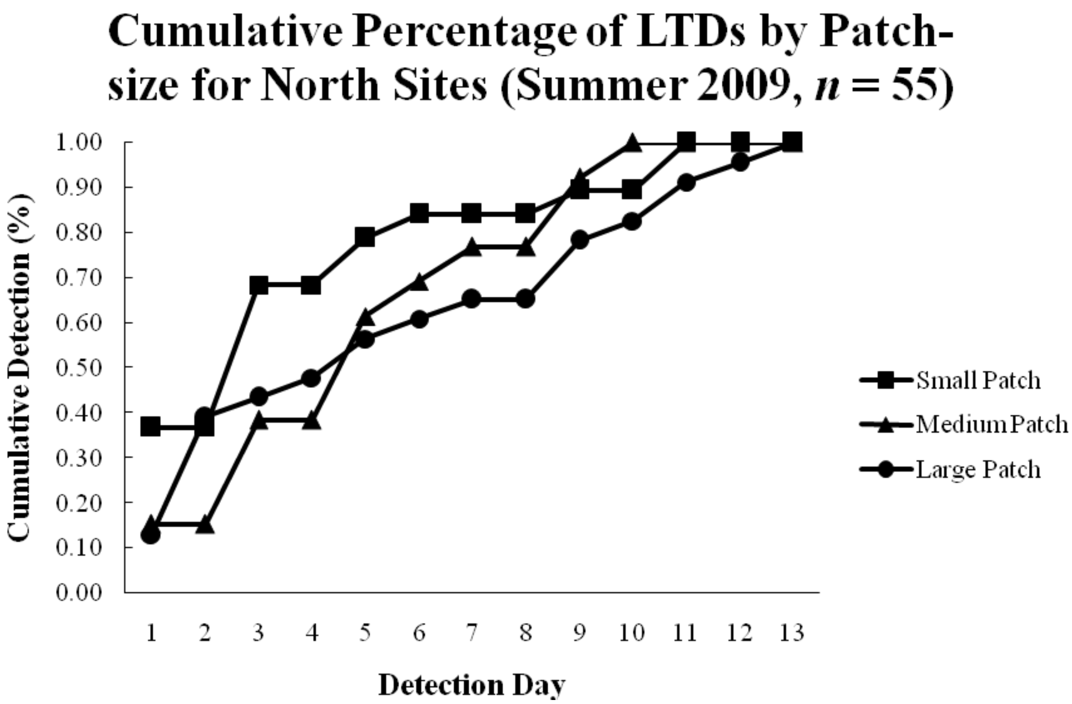

Cumulative Percentage of LTDs by Patch-size for North Sites (Summer 2009, n = 55)
Cumulative Detection (%)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
Detection Day
Small Patch
Medium Patch
Large Patch

Figure 20. Compares how LTD differs among the isolation to nearest small patch (0-50 ha) category . The three isolation distance categories for small patches were near (0-200 m), medium (200-400 m), and far (400^+ m).

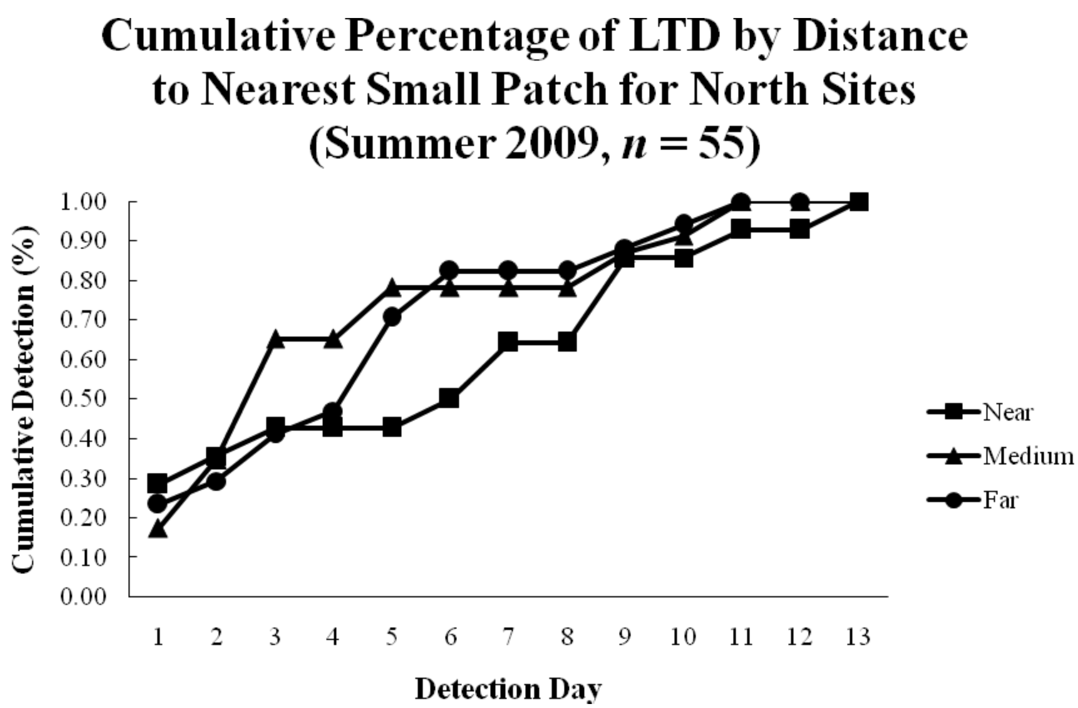

Cumulative Percentage of LTD by Distance to Nearest Small Patch for North Sites (Summer 2009, *n* = 55)
Cumulative Detection (%)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
Detection Day
Near
Medium
Far

Figure 21. Compares how LTD differs among the isolation to nearest medium patch (50-250 ha) category . The three isolation distance categories for small patches were near (0-350 m), medium (350-1,000 m), and far ($1,000^{+}$ m).

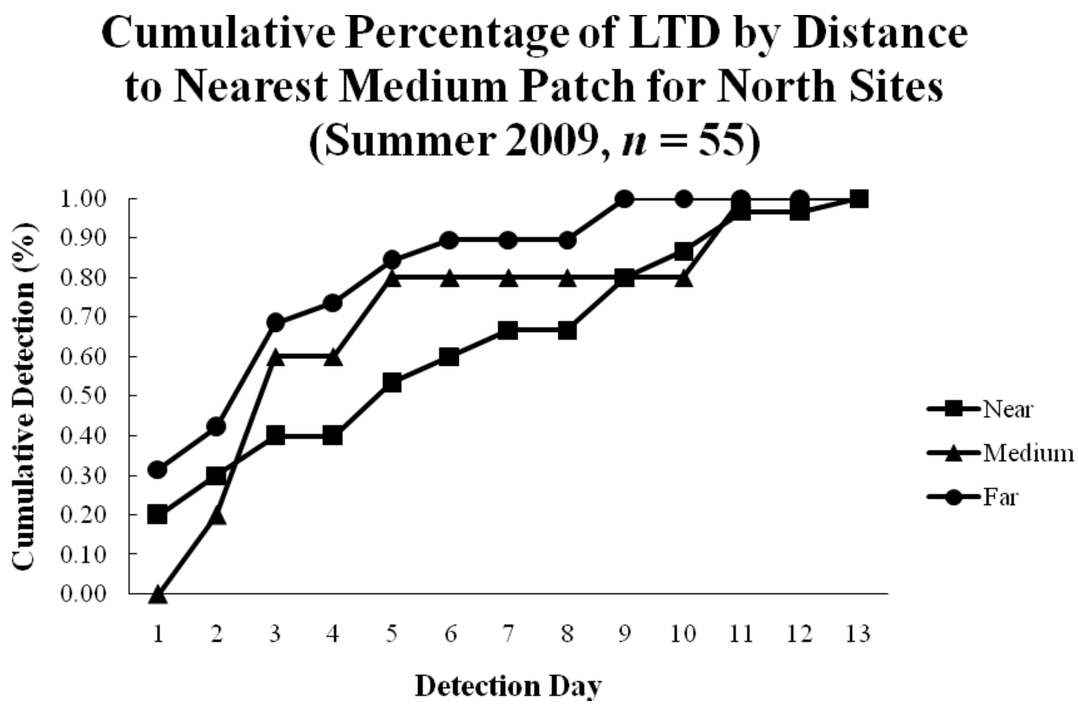
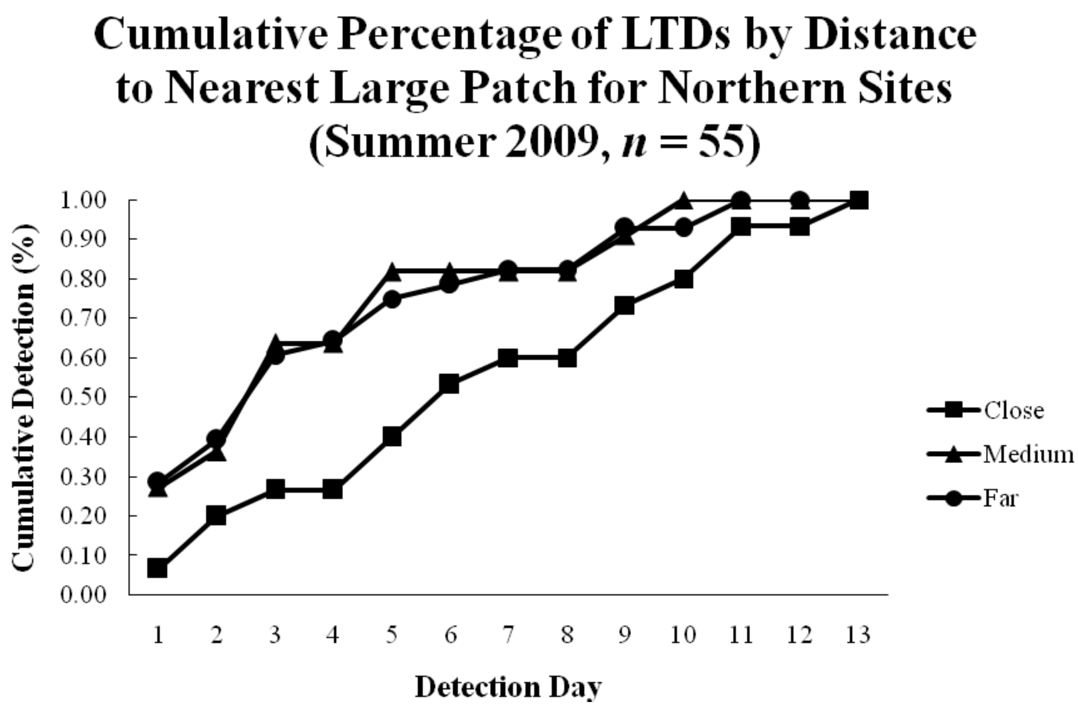

Cumulative Percentage of LTD by Distance
to Nearest Medium Patch for North Sites
(Summer 2009, n = 55)
Cumulative Detection (%)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
Detection Day
Near
Medium
Far

Figure 22. Compares how LTD differs among the isolation to nearest large patch (250^+ ha) category . The three isolation distance categories for small patches were near (0-400 m), medium (400-5,000m), and far ($5,000^+$ m).


Cumulative Percentage of LTDs by Distance to Nearest Large Patch for Northern Sites (Summer 2009, n = 55)
Cumulative Detection (%)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
Detection Day
Close
Medium
Far

CHAPTER 3

EFFICACY OF ENCLOSED TRACK-PLATES AND REMOTE CAMERAS AT DETECTING THE PRESENCE OF FISHERS IN EASTERN NORTH DAKOTA

Abstract

Carnivores often are difficult to monitor because they are elusive, maintain low population densities, and occupy large home ranges. The objective of this research was to compare the efficacy of enclosed track-plates and remote cameras at detecting the presence of fishers in eastern North Dakota. I compared track-plates and remote cameras in their number of false absences, percentage of sites with a detection, percentage of check periods (time from set-up to re-bait and re-bait to pull) with a detection, unit effort (number of unique detections by number of DDs), and number of functioning days to total detection days. Of 127 sites, track-plates had false absences at 11 of 41 (27%) visits to a site, and cameras only failed to detect a fisher visiting a site (based on detections at the track-plate) on 4 of 41 (10%) occasions. Fishers were detected at 30 (24%) sites by track-plates and 37 (28%) sites by cameras. Wildlife managers should select survey techniques based on the specific project goals for the species and geographic region under study. Cameras were more effective in detecting the presence of fishers. The advances in cameras have enabled them to provide more information on fishers with less effort in comparison to track-plates.

Introduction

Carnivores often are difficult to monitor because they are elusive, maintain low population densities, and occupy relatively large home ranges (Long et al. 2007). Documenting the range of threatened or endangered carnivores is an especially important first step in determining where best to allocate conservation efforts (Zielinski and Kucera 1995, Yoccoz et al. 2001). Wildlife researchers have developed a variety of non-invasive sampling techniques for monitoring carnivores including hair snares, remote camera stations, scat-detection dog surveys, scent-stations, snow surveys, and track-plate stations (Seton 1937, Mayer 1956, Wood 1959, Lord et al. 1970, Halfpenny et al. 1995, Zielinski and Kucera 1995, Belant 2003, Long et al. 2007).

Various studies have shown that track-plates (Mayer 1956, Lord et al. 1970, Herzog et al. 2007) and remote cameras (Browder et al. 1995, Karanth 1995, Carthew and Slater 1999, Culter and Swann 1999, York et al. 2001, Moruzzi et al. 2002, Long et al. 2006) were effective devices for presence-absence sampling, and several studies have compared the relative efficacy of track-plates and cameras in detecting the presence of a focal species (Bull et al. 1992, Zielinski and Kucera 1995, Foresman and Pearson 1998, Mowat et al. 2000). Comparisons of the 2 devices included cost, construction and assemblage time, training required, deployment effort and set-up time, ability to distinguish individuals, Probability of Detection (POD), Latency to Detection (LTD), false absences (failure to detect a species when it is present), and applicability to occupancy modeling (Foresman and Pearson 1998, Culter and Swann 1999, Hilty and Merenlender 2000, Mowat et al. 2000, Campbell 2004, Gompper et al. 2006, O'Connel et al. 2006, Herzog et al. 2007, Long et al. 2007).

Prior to the advent of digital memory cards and quick infrared triggers cameras were technically challenging, unreliable, had higher LTDs, and lower PODs compared to track-plates and generally were regarded as inferior to track-plates for presence-absence sampling (Bull et al. 1992, Fowler and Golightly 1995, Mowat et al. 2000). Therefore, earlier models of cameras only were recommended for studies that required identifying individuals or behavioral studies (Bull et al. 1992, Fowler and Golightly 1995, Mowat et al. 2000). Improvements in camera technology have made them more desirable for wildlife studies (O'Connel et al. 2006, Long et al. 2008). Advantages of using cameras instead of track-plates include less re-baiting, less technician training, ease of deployment, ease of species identification, higher PODs, and increased information on detection history and the number of individuals (Foresman and Pearson 1998, Hilty and Merenlener 2000, Gompper et al. 2006, O'Connell et al. 2006).

Assessing the efficacy of cameras and track-plates for use with different species and under various environmental conditions remains important for enhancing monitoring protocols associated with these devices (Long et al. 2008). Although studies have been conducted comparing track-plates and cameras for detecting fishers, none have compared the devices at the same sites with the camera monitoring the entrance to the track-plate (Bull et al. 1992, Fowler and Golightly 1995, Zielinski and Kucera 1996, Foresman and Pearson 1998, Mowat et al. 2000, Campbell 2004, Gompper et al. 2006, O'Connell et al. 2006). As part of a population survey to document fisher distribution in eastern North Dakota (Triska 2010), I analyzed survey sites where fishers were detected, by either a track-plate, a remote camera, or both devices. My objective for this part of the project was to compare the efficacy of enclosed track-plates (Zielinski and Kucera 1995) to cameras at detecting the presence of fishers. I particularly was interested in determining if fishers attracted to the vicinity of enclosed track-plates typically entered the device. The information gained from this project will help wildlife managers determine what technique they should use to survey for fishers.

Study Area

My study sites were located within the forested areas along the Pembina River, Tongue River, Turtle River, and Red River of the North in northeastern North Dakota (Figure 1). Historically, northeastern North Dakota was dominated by tallgrass prairie, with forested areas occurring mostly along water systems (Renard et al. 1986). During the late 1800s, pioneers settling in North Dakota converted the tallgrass prairie to agricultural fields (Renard et al. 1986), but riparian forests persist in many areas and forested shelterbelts have been established in historically non-forested portions of the landscape to control erosion (Bailey 1926, Kort 1988, Sovada and Seabloom 2005).

The riparian areas in my study area were similar in habitat composition, with the dominate trees consisting 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 structure and composition of the understory vegetation varied throughout the study area, but was predominately chokecherry (*Prunus virginiana*), gooseberry (*Ribes missouriense*), hawthorne (*Crateagus* spp.), raspberry (*Rubus* spp.), and serviceberry (*Amelanchier arborea*).

Methods and Materials

I monitored survey sites during June, July, and August 2008. Each survey site was comprised of an enclosed track-plate and a remote camera (Figure 2). Sites were generally spaced at ≥1-km intervals along each river to ensure independence. The average distance separating adjacent sites was 3,015 m (SD ± 2,615 m; range 213-15,742 m). Track-plates consisted of a plywood base (1.91 cm x 30.48 cm x 76.2 cm), 2 flexible black plastic sheets (0.32 cm x 40.64 cm x 71.12 cm), and an aluminum plate (0.16 cm x 20.32 cm x 76.2 cm; Zielinski and Kucera 1995, Peters 2002). The plastic sheets were inserted into grooves cut lengthwise along the sides of the plywood to provide a weather protective cover. Where the two pieces of plastic sheets met I covered the gap with a piece of black duct tape to further weatherize the track-plate. Track-plates were positioned with one end against a tree and sticks were placed around the back so that animals could enter only from one direction (Peters 2002). Sooted-aluminum plates then were laid on the plywood track-plates with the sooted end at the entrance. About 85 g of American beaver (*Castor canadensis*) meat and about 2 g of castor mixed with glycerol were placed at the rear of the track-plate. I used three models of Cuddeback® (Non Typical Inc., Green Bay, Wisconsin, USA) remote camera models the Excite®, Expert®, and the infrared Noflash®. Cameras were mounted on a tree opposite the opening of the track-plate at a distance of (1-2 m) and at a height of (0.5-1.5 m) to monitor individuals that entered the track-plate. I hung a perforated film canister from a surrounding branch at a height of approximately 2 m that contained a cotton swab soaked in skunk (*Mephitis mephitis*) essence.

Each survey cycle consisted of a 7-9 day sampling period. I checked sites at days 3-5 to record detections and performed site maintenance (e.g., re-baited and replaced batteries in cameras). Therefore during each cycle there were two check periods (set-up to re-bait and re-bait to removal). Detections either occurred in the form of a print on the contact paper attached to track-plates (or the sooted part of the track-plates) or a picture from cameras. Print detections were considered unique if they were captured pre- or post-re-bait, therefore the maximum number of unique detections that could occur at a track-plate was 2 per cycle. Picture detections were considered unique if ≥30 min elapsed between fisher photos. The first 24 hr survey period after set-up of a device was considered the first Detection Day (DD). Subsequent DDs were calculated with the next DD beginning after the previous DD completed 24 hrs of functioning properly. The survey period lasted at most for 9 DDs per device.

Overall, I analyzed sites among 5 sampling periods (cycles). For analyses, I omitted DDs for periods where a detection device was a malfunctioning or was otherwise inoperable. For track-plates I eliminated all the DDs that accumulated between the failure date and the set-up or re-bait date and for cameras I eliminated all DDs that occurred after the last successful picture was taken. A false absence occurred when one of the devices documented fisher presence and the other device failed to capture the detection (Mackenzie et al. 2006). I compared track-plates and cameras by false absences, percentage of sites with a detection, percentage of check periods (time from set-up to re-bait and re-bait to pull) with a detection, unit effort (number of unique detections by number of DDs), and number of functioning days to total detection days.

Results

I surveyed 127 sites for a total of 1,029 DD. Photographic evidence showed fishers approaching a track-plate but not entering to have occurred during 11 of 41 (27%) visits to a site, and cameras only failed to detect a fisher visiting a site (based on detections at the track-plate) on 4 of 41 (10%) occasions. Of 127 sites, fishers were detected at 30 (24%) sites by track-plates and 37 (28%) sites by cameras. There were 235 check periods; track-plates had fisher detections during 35 (15%) of the check periods, whereas cameras had detections within 42 (18%) of the check periods. Track-plates had 35 (2%) unique detections/ DDs, whereas cameras had 66 (6%) unique detections/ DDs. Track-plates were inoperable for 8 DDs (1%) because they were knocked over by cattle. Cameras failed to function for 29 DDs (3%) because of battery failure, full memory card, and cattle knocking them off their mounts. Track-plates functioned properly for more days than cameras, however the difference was minimal (<21 DD) and during periods where 1 of the devices was inoperable the opposing device never received a detection.

Discussion

Cameras were more effective in detecting the presence of fishers. In contrast to previous reports indicating the inefficacies of earlier cameras for conducting field research (Bull et al. 1992, Fowler and Golightly 1995, Mowat et al. 2000), the cameras I used were reliable and outperformed track-plates in detecting fishers and provided more detailed information of detection events. For example, cameras had less false absences, detected fishers at more sites and throughout more of the check periods, and had more unique detections. Also, cameras recorded a thorough detection history (e.g., number of unique detections, time of detections, duration of visits, and number of individuals). The false absences are especially important when assessing species with low detection rates (Long et al. 2007). I did not check sites every other day and had a shorter survey duration than suggested in the protocol established by Zielinski and Kucera (1995); because I was limited in resources and wanted to minimize the amount of time I spent on private land (Hilty and Merenlender 2000, Mowat et al. 2000). However, re-baiting more often throughout the cycle would likely not have lowered the false absences in track-plates, because all but 2 of the false absences occurred within 24-hrs of re-bait. I could not make meaningful conclusion about LTDs for track-plates in comparison to cameras because sites only were checked mid-way and at the end of sampling periods. Cameras, however, had more detections per check period than track-plates. Missed detections with cameras were mostly related to operator errors. For example, the cameras field of view may have been restricted from being angled towards the front of the track-plate. Also, only remote cameras captured images of family groups and recorded the time and date of detections; this information confirmed the presence of reproducing individuals within the study area and provided information on activity patterns.

Management Implications

Cameras clearly are an effective and versatile tool for detecting fishers and other wildlife (Zielinskia and Kucera 1995, Foresman and Pearson 1998, Campbell 2004, Gompper et al. 2006, O'Connell et al. 2006). Also, cameras have demonstrated their potential to gain behavioral information (Bridges et al. 2004, Stevens and Serfass 2008). Cameras outperformed track-plates in every category except for initial cost. The initial cost of the track-plate was $20 with the cameras ranging from $200-$600 depending on the model. However, continued technological advances and ongoing reduction in costs likely will further enhance the desirability of cameras for field research (Kays and Slauson 2008). Although, this study was conducted during the summer and battery failure was not an issue, the results demonstrated that cameras require less researcher-visits to survey sites. The cameras ability to perform with less researcher-visits when compared to track-plates is important for organizations trying to lower transportation cost and operate with less field technicians; this feature of the cameras can help defer their initial higher costs in comparison to track-plates. Wildlife managers should select survey techniques based on the geographic region under study and specific project goals for the species (Zielinski and Kucera 1995, Foresman and Pearson 1998, Gompper et al. 2006, Long et al. 2008). As the goals of a project expand past basic presence-absence sampling and involve gaining data for occupancy modeling, defining habitat preferences, and behavioral information cameras become the more appropriate technique (Campbell 2004, Gompper et al. 2006, O'Connell et al. 2006).

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Figure 1. Location of study area in north eastern North Dakota.

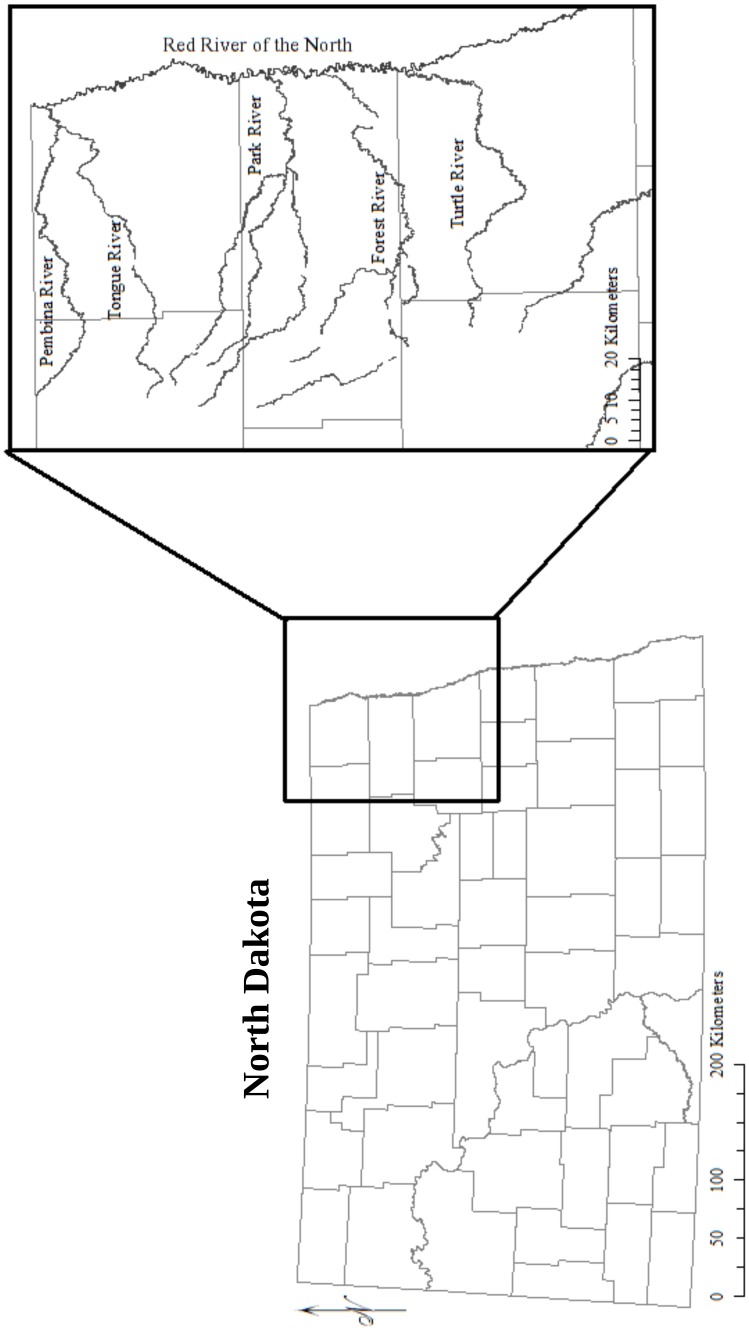
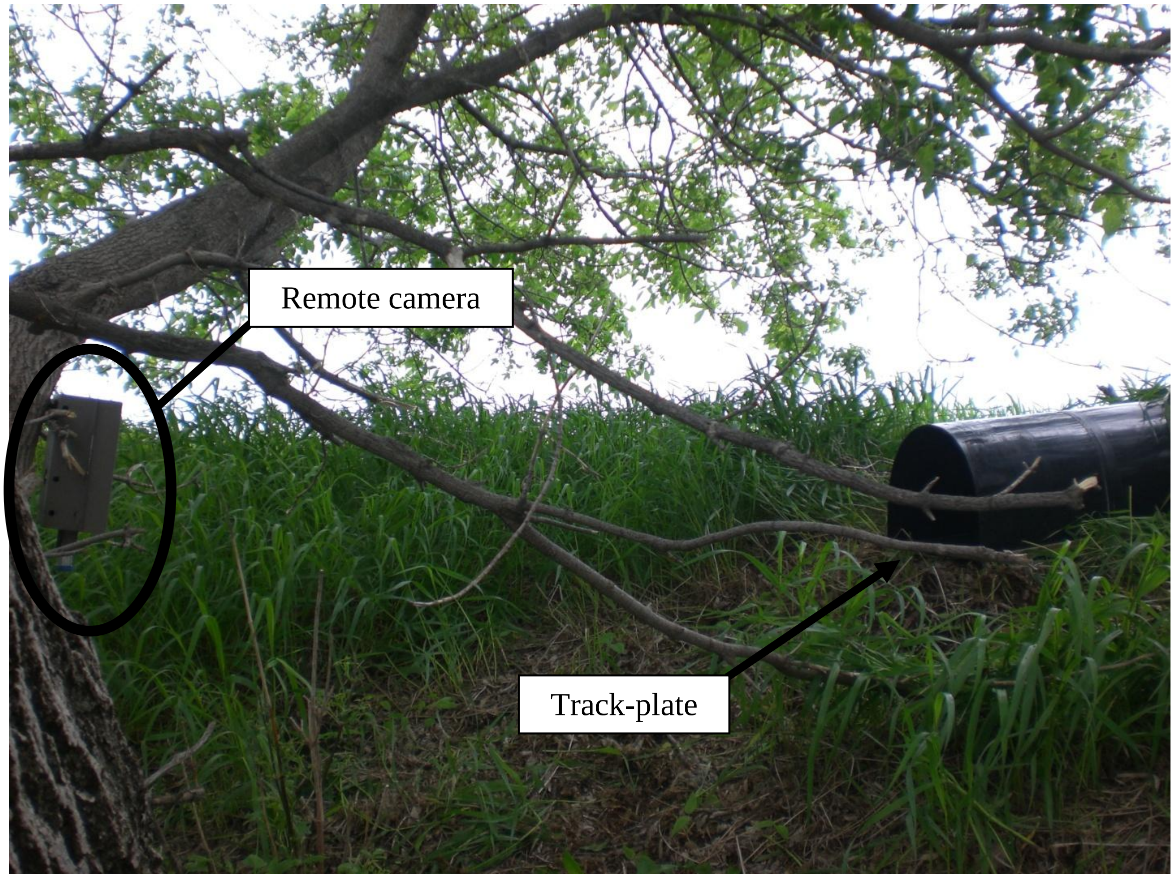

Red River of the North
Pembina River
Tongue River
Park River
Forest River
Turtle River
0 5 10 20 Kilometers
North Dakota
0 50 100 200 Kilometers
N

Figure 2. Picture of site set-up with the remote camera monitoring the entrance to the track-plate.


Remote camera
Track-plate