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Survival and Capture Efficiency of River Otters in Southern Illinois

Andrew U. Rutter
Southern Illinois University Carbondale, rutter450@gmail.com

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SURVIVAL AND CAPTURE EFFICIENCY OF RIVER OTTERS IN SOUTHERN ILLINOIS

by

Andrew U. Rutter

B.S., Emporia State University, 2013

A Thesis
Submitted in Partial Fulfillment of the Requirements for the
Master of Science

Department of Forestry
in the Graduate School
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THESIS APPROVAL

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Approved by:

Dr. Clayton K. Nielsen, Co-Chair

Dr. Eric M. Schauber, Co-Chair

Dr. Jon E. Schoonover

Graduate School
Southern Illinois University Carbondale
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AN ABSTRACT OF THE THESIS OF

ANDREW RUTTER, for the Master of Science degree in FORESTRY, presented on July 7, 2017, at Southern Illinois University Carbondale.

TITLE: SURVIVAL AND CAPTURE EFFICIENCY OF RIVER OTTERS IN SOUTHERN ILLINOIS

MAJOR PROFESSORS: Dr. Clayton K. Nielsen and Dr. Eric M. Schauber

River otter (*Lontra canadensis*) populations in Illinois have rebounded considerably after >80 years of harvest protection and a successful reintroduction program. However, few studies of river otter ecology exist in the Midwestern U.S. where river otter numbers have increased in recent decades. Capturing study animals safely and efficiently is a critical part of wildlife research, and difficulties associated with live capture of river otters have contributed to the dearth of research on the species. Furthermore, estimating survival rates and identifying causes of mortality are important in effectively managing river otters. To address these knowledge gaps, my objectives were determine survival rates and mortality causes for river otters in southern Illinois, and to measure injury rates of river otters captured using Comstock traps. During 2014-16, I captured 42 river otters 49 times at Crab Orchard National Wildlife Refuge (CONWR) in southern Illinois. Eight river otters (3 M, 5 F) were captured in foot-hold traps during 788 trap nights (1 capture/88 trap nights), and the remaining 34 (19 M, 15 F) were captured in Comstock traps during 2,540 trap nights (1 capture/64 trap nights). I detected no significant differences in efficiency or escape rate between the 2 trap types, but Comstock traps did have higher rates for both unavailability and non-target captures. Eleven of the 20 river otters inspected for injuries received some type of injury as a result of capture in a Comstock trap (55%). The most common injury was claw loss (45%), followed by tooth fracture (25%), and lacerations (10%). The ease of setting the Comstock traps and of releasing non-target captures made them a more appealing option than foot-hold traps; however, river otters have a propensity for doing permanent damage to their teeth when live captured in Comstock traps. My study provides information on the functionality and safety of a novel live capture method for river otters.

Thirty-four (16 F, 18 M) river otters were successfully radio-marked and monitored for survival for a total of 8,235 radio-days ($\overline{x}$ days/river otter = 242.2 ± 20.6 [SE throughout]). Two river otters (2 M) died during the period of radio-telemetry monitoring: 1 was trapped during nuisance wildlife control activities at an adjacent fish hatchery, and the other died of unknown causes. Annual survival rates were 1.0 ± 0.00 (lower confidence bound = 0.83) and 0.85 ± 0.09 for females and males, respectively, and similar between sexes (χ^2_1 = 1.7, P = 0.19). Pooled-sex breeding season survival was 0.96 ± 0.04. Trapping was the primary source of mortality over the course of my study. After radio-telemetry ended, 2 river otters were harvested by recreational trappers, at 114 (1 M) and 120 (1 F) weeks post-capture, and 1 male was killed by a vehicle collision at 52 weeks post-capture. Primary mortality sources for river otters in southern Illinois are similar to those reported elsewhere (i.e., trapping and vehicle collisions). Although I found no significant difference in survival rates between sexes, the majority of otters that died during my study were male (4 M, 1 F). As river otters occupying CONWR are protected from harvest, males may be more likely to leave the confines of CONWR, thereby putting themselves at greater risk to recreational trapping mortality. My study provides useful demographic information for Illinois' recently-recovered river otter population.

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PREFACE

In addition to being an aesthetically and economically valued wildlife resource, North American river otters (*Lontra canadensis*) can have an important influence on aquatic food webs and nutrient cycling in riparian ecosystems. Functioning as apex predators, otters can provide top-down control in riparian ecosystems (Gittleman and Gompper 2005), with important effects on the biodiversity (Estes et al. 2011), nutrient and energy transfer, and disease transmission within a system. Gittleman and Gompper (2005) hypothesized that river otters may substantially impact food webs by consuming large crayfish in Missouri streams. As crayfish are known to strongly influence lower trophic levels (Whitledge and Rabeni 1997), river otter consumption of large crayfish may lead to an increase in the abundance of benthic invertebrates that large crayfish eat and, consequently, a decrease in primary production (Gittleman and Gompper 2005). Ben-David et al. (1998) found that river otters transfer nitrogen from aquatic systems to surrounding terrestrial systems through scent-marking behaviors, which can reduce nutrient loss to downstream systems. Due to their high trophic position, river otters are particularly susceptible to environmental contaminants and can serve as important indicators of pollutants in aquatic systems (Halbrook et al. 1996, Carpenter et al. 2014).

River otters were extirpated throughout much of their range in North America by the early 1900’s due to loss of habitat, overharvest, and water pollution (Nilsson 1980, Toweill and Tabor 1982, Melquist and Dronkert 1987). River otter fur is considered one of the most durable and attractive American furs. Consequently, river otter furs demand high prices, making them a target for fur trappers and contributing to overharvest in the late 19th and early 20th centuries (Schwartz and Schwartz 2001). In response, river otter recovery programs were enacted in 21 states spanning 1976-1998. Populations in 18 of these states were considered to be either stable or growing as of 2001 (Raesly 2001).

In Illinois, the decline of river otter populations became evident in the mid-1800's (Thomas 1861, Hoffmeister and Mohr 1957) and river otter harvest was prohibited in 1929 (Mohr 1943). River otters were added to the list of threatened species in Illinois in 1977, and reclassified as a state endangered species in 1989 (Bluett et al. 1995). In 1994, the Illinois Department of Natural Resources (IDNR) implemented a recovery plan for the species and began to supplement the waning population (Bluett et al. 1995). Between 1994 and 1997, 346 wild river otters were translocated from Louisiana to areas deemed suitable throughout Illinois (Bluett et al. 2004). River otters were removed from the state endangered list and categorized as a nongame species in 2004, when the population was estimated at around 10,000 with individuals occurring in every county of the state (Bluett et al. 2004). By 2012, the population had reached levels considered by the IDNR to be suitable for limited harvest; as a result, a trapping season was enacted with a season limit of 5 otters per trapper. Illinois trappers have since harvested 980-2,002 otters annually during the last 4 trapping seasons (B. Bluett, Illinois Department of Natural Resources, pers. comm.).

Although much of the river otters' recovery in Illinois can be attributed to the direct supplementation of the population, river otters also probably benefitted from >80 years of harvest protection and habitat improvements resulting from the Clean Water Act of 1972 (Barrett 2008), as well as colonization from adjacent states. Natural resources agencies from Indiana, Kentucky, Missouri, and Iowa have implemented their own reintroductions efforts, with a cumulative 1,358 river otters reintroduced between 1982 and 1999 (Raesly 2001). Wisconsin has had an almost continuous river otter harvest season since 1927, with a population that was estimated at 10,800 individuals in 2015 (Rolley et al. 2015). Anderson (1995) asserted that populations of river otters within both the northwestern and southern portions of Illinois were likely being supplemented by immigrants from adjacent states (Anderson 1995).

Despite the river otter's recent recovery and the implementation of harvest in Illinois, few recent studies have investigated river otter ecology within the state (Green et al. 2015, Holland and van der Merwe 2016, Nielsen 2016). My study provides vital information on river otter survival within Illinois as well as information on a novel live-capture technique for a species that has traditionally been difficult to live capture safely and efficiently (Melquist and Hornocker 1983, Duffy et al. 1994, Serfass et al. 1996

CHAPTER 1

SURVIVAL AND CAUSE-SPECIFIC MORTALITY OF RIVER OTTERS IN SOUTHERN ILLINOIS

INTRODUCTION

Understanding survival rates and causes of mortality is important in managing harvested species (Hodgman et al. 1994, Koen et al. 2007, Barding and Lacki 2014). Survival estimates for river otters have been made using data from radio-telemetry and harvest. Hamilton (1998) estimated juvenile survival at 0.75 and adult survival at 0.81 for river otters in Missouri; subsequently, both Hamilton (1998) and Woolf and Nielsen (2001) used those estimates to model population growth of river otter populations in Illinois and Missouri, respectively. Tabor and Wight (1977) estimated annual survival for female river otters in a harvested population in Oregon as 0.73. Ben-David et al. (2001) reported a 20-mo survival estimate of 0.8 (annual estimate 0.87) for both sexes of an unharvested population in coastal Alaska. Similarly, Gorman et al. (2008) estimated annual survival for an established unharvested population in Minnesota to be 0.8 (0.68 F, 0.95 M). Barding and Lacki (2014) modeled population growth for river otters in Kentucky using adult survival estimates in the literature from 4 different states where reintroductions had occurred (Tennessee: 0.91, West Virginia: 0.57, Kentucky: 0.73, and Missouri: 0.81) (Griess 1987, Tango et al. 1991, Cramer 1995, and Hamilton 1998). Several studies have examined post-release survival of newly-reintroduced river otters in other states and documented similar survival estimates (Pennsylvania: 0.83, Indiana: 0.71, New York: 0.89) (Serfass et al. 1986, Johnson and Berkley 1999, Spinola et al. 2008).

Anthropogenic events such as vehicle collisions and trapping are typically major causes of river otter mortality, as otters have few natural predators (Melquist et al. 2003, Gorman et al.

2008). Melquist and Hornocker (1983) documented that 6 of 9 river otter deaths during their study in Idaho were the result of anthropogenic factors (e.g., shooting, trapping, road kill, and domestic dog attacks). Chanin and Jefferies (1978) reported dead European otters (*Lutra lutra*) in the U.K. being found repeatedly at the same location on roads over several years. In an analysis of 113 European otter carcasses retrieved from Scotland, Kruuk and Conroy (1991) confirmed ≥48 violent deaths that they attributed to road kill.

Both incidental and intentional harvest account for a considerable portion of otter mortalities. Tabor (1974) found that about 16% of river otters harvested in Oregon were caught in traps intended for beaver (*Castor canadensis*). Knudson (1956) reported considerable numbers of incidental river otter captures by fur harvesters in Wisconsin. Indeed, incidental captures during beaver trapping activities occur frequently despite that guidelines for trapping river otters often contain sections outlining techniques to reduce incidental river otter harvests while beaver trapping (Hamilton et al. 1998).

Mortality rates due to non-anthropogenic causes for river otters vary widely and are difficult to quantify. Melquist and Hornocker (1983) concluded that river otters are considerably more vulnerable to predators when crossing overland between water bodies. Grinnell et al. (1937) reported predation by coyotes (*Canis latrans*) on young river otters during overland crossovers in California. Melquist and Hornocker (1983) also found 1 female river otter that was killed by severe head trauma that resulted from unstable rocks at a resting site. Kruuk and Conroy (1991) attributed 29 of the 113 European otter mortalities they examined to “non-violent sources” including poisoning, hepatic neoplasm, pneumonia, and 10 deaths from unknown causes (Kruuk and Conroy 1991). Several researchers have also implicated starvation as an important mortality factor following translocations (Griess 1987, Miller 1992, and Day et al. 2013).

Research on survival and cause-specific mortality of established river otter populations is limited in general, and non-existent in Illinois. Current management plans within the state rely on population models with survival estimates obtained from Missouri populations and age-at-death data obtained from necropsies (Hamilton 1998, Woolf and Nielsen 2001, Nielsen 2016). Illinois-specific survival estimates based on radio-telemetry data will bolster current information on the species, provide data for population modeling, and highlight potential limiting factors for the species. My study also offers insight into the survival and cause-specific mortality of a well-known sentinel species (Halbrook et al. 1996, Carpenter et al. 2014) in a study area with a history of profound environmental degradation (Frisk 2007). My objectives were to estimate the seasonal and annual survival rates and categorize mortality sources for river otters in southern Illinois.

STUDY AREA

I estimated survival rates and documented mortality sources for river otters on and around Crab Orchard National Wildlife Refuge (hereafter, CONWR) in southern Illinois (Figure 1.1). Southern Illinois is a temperate region typified by cold winters, wet springs, and hot, humid summers, with an elevation of 96 - 240 m. Mean monthly temperatures range between 12.6˚ C in July to -0.5˚ C in January. Annual precipitation in the area averages 120 cm, 29 cm of which occurs as snowfall (National Oceanic and Atmospheric Administration 2000). CONWR lies within the Big Muddy River drainage basin, which forms a semi-elliptical basin that drains an area of 6,182 km^2, and is one of the principal tributaries of the Mississippi River (Lewis 1955, Ogata 1975). CONWR covers 17,761 ha in Williamson, Jackson, and Union Counties, and is managed by the U.S Fish and Wildlife Service. Land cover (%) on CONWR consists of forests

(56%), open water (20%), herbaceous (10%), croplands (10%), shrublands (2%), and developed land (2%) (Frisk 2007). CONWR is managed primarily for migratory waterfowl, native fishes, and a number of threatened and endangered species of plants and animals. As the U.S. Fish and Wildlife Service does not permit recreational trapping on CONWR, river otters that remained within the confines of CONWR were protected from harvest.

The area surrounding CONWR is composed of a matrix of exurban development along highway 13 encompassing the towns of Carbondale, Cambria, Carterville, Energy, Herrin, and Marion. Land use intensities in these areas range from agricultural fields and exurban residential areas, to shopping centers, and a major university campus. The city of Carbondale (591 persons /km^2) is 4.6 km west of CONWR, Marion (455 persons/km^2) is 3.5 km to the northeast of the refuge, and the cities of Carterville (413 persons/km^2) and Herrin (528 persons/km^2) and the village of Energy (378 persons/km^2) are just north of CONWR (U.S. Census Bureau 2010*a*, 2010*b*, 2010*c*).

METHODS

Live Capture and Radio-telemetry

River otters were captured during 2 capture seasons: October 2014 - January 2015 and October 2015 - February 2016. Researchers typically live trap river otters during these months, as young river otters are weaned and capable of surviving independently (Hamilton and Eadie 1964). I set traps opportunistically at latrine locations and along travel routes where river otter sign could be located on CONWR and the surrounding private lands. Between 10 and 40 traps were checked daily between 0500 and 1000 hrs. Trapping was discontinued when nightly temperatures were ≤ -12˚C.

Victor® No. 1.75 SoftCatch™ double coil spring traps (Woodstream Corp., Lititz, Pennsylvania) and Comstock Custom Cage Traps® (Comstock Custom Cage $_{\text{LLC}}$, Gansevoort, New York) (hereafter, Comstock traps) were set in blind configurations (i.e., without bait), as this technique has proved to be more successful than baited traps (Melquist and Hornocker 1979, Serfass et al. 1996, Blundell et al. 1999). I equipped foot-hold traps with short chains (20-25 cm), additional swivels, and shock springs to minimize trap-related injuries (Belfiore 2008). All foot-hold traps were boiled in a solution of logwood trap dye and then boiled in trap wax (F&T Fur Harvesters Co., Alpena, Michigan), and cloth gloves and a rubber kneeling pad were used when handling and setting the traps to reduce human scent. No additional preparations were used for Comstock traps before setting them in the field.

I visually estimated the body mass of each captured river otter so that an adequate intramuscular injection of Telazol® (9 mg/kg body mass) could be delivered (Blundell et al. 1999) using a Pneu-Dart® CO_2 pistol (Pneu-Dart Inc. Williamsport, Pennsylvania). Anesthetized river otters were surgically implanted with intra-abdominal radio-transmitters (model M1245B or M1230, Advanced Telemetry Systems, Inc., Isanti, Minnesota) following procedures outlined by Hernandez-Divers et al. (2001). Transmitters were equipped with mortality sensors that activated if stationary for >8 h. I determined the sex and weight of each captured river otter and examined its general body condition. I estimated the age class of each river otter based on tooth wear and discoloration, following a scale developed by Belfiore (2008). Captured river otters were tagged with individually numbered No. 1 Monel self-piercing ear tags (National Band and Tag Company, Newport, Kentucky) and passive integrated transponders (PIT) (Biomark®, Boise, Idaho) were inserted under the skin between the scapulae. Each river otter was injected with 0.5 cc of meloxicam (Boehringer Ingelheim, Inc., Ingelheim, Germany) to minimize pain, and 1.0 cc of long-acting antibiotic (Penject Procaine, Henry Schein, Inc., Melville, New York) to minimize the likelihood of infections resulting from the surgical incision or capture-related injuries. River otters were allowed to recover from surgery within a protective recovery box at the capture site. Capture and handling protocol was approved by the Southern Illinois University Animal Care and Use Committee (Protocol #14-040).

I monitored each river otter 2 d/wk using homing and triangulation via ground and aerial radio-telemetry methods (White and Garrot 1990). Locations were triangulated by collecting ≥3 bearings from known locations (Gorman et al. 2006, Zielinski et al. 2004) within 20 min. Ground telemetry was conducted using a telemetry receiver (R-1000, Communication Specialists, Inc. Orange, California), a hand-held 3-element Yagi antenna, and a compass. I conducted aerial telemetry from a fixed-wing aircraft equipped with 2 wing-mounted H-antennas to locate animals for subsequent ground telemetry and to listen for mortality signals. River otters were monitored for survival from capture through the end of transmitter life, death, or loss of radio contact.

The program Location of a Signal (Ecological Software Solutions 4.0, Urnäsch, Switzerland) was used to estimate river otter locations and error polygons obtained via triangulations. Only locations with error polygons $\leq 10{,}000 m^2$ (1 ha) were kept for analysis.

When a mortality signal was heard, homing was used to find the carcass as soon as logistically possible. I conducted field investigations and necropsies to categorize the cause of death as: 1) anthropogenic (e.g., fur-trapping, nuisance trapping, vehicle collision), 2) natural (e.g., disease, starvation), or 3) unknown.

Survival

River otters that survived 2 weeks after their initial capture were entered into survival analysis. I censored river otters from analysis when transmitters were lost or failed, and pooled data over study years by sex. I used Program R version 3.4.0 and the package 'survival' (The R Foundation for Statistical Computing, 2017) to estimate annual and breeding-gestation season survival rates using a Kaplan-Meier survival curve with staggered entry based on date of initial capture and right-censored any individuals with unknown fates (Hosmer et al. 2008). I was unable to assess survival separately for any other season due to premature transmitter failure. Premature transmitter failure resulted in a lack of monitoring data necessary to partition additional seasons out of our annual survival estimate. Annual survival was estimated for 52 weeks; the 13-week breeding-gestation season was 1 March-31 May (Hamilton and Eadie 1964, Melquist and Hornocker 1983, Gorman et al. 2006) Log-rank tests were used to test for differences ($\alpha = 0.05$) in annual and seasonal survival rates between sexes (Pollock et al. 1989). Because the R package provided standard error values of zero in cases when observed survival was 1.0, I calculated the lower bound of the 95% adjusted Wald confidence interval when such cases occurred (Agresti and Coull 1998).

RESULTS

During 12 October 2014-3 October 2016, 34 (16 F, 18 M) river otters were successfully instrumented and monitored for survival for a total of 8,235 radio-days ($\overline{x}$ days/river otter = 242.2 ± 20.6 [SE throughout]) (Figure 1.2). Two male river otters died during the radio-telemetry monitoring period: 1 was trapped during nuisance wildlife control activities at an adjacent fish hatchery, and the other died of unknown causes. The cause of the unknown death could not be determined due to advanced decomposition. Three river otters died after the monitoring period: 2 were harvested by recreational trappers, at 114 (1 M) and 120 (1 F) weeks post-capture. One male was also killed by a vehicle collision at 52 weeks post-capture. Annual survival was similarly high for both sexes ($\chi^2_1 = 1.7$, $P = 0.19$; Figure 1.3, Table 1.1) and survival estimates with sexes pooled were similarly high during the breeding season (0.96 ± 0.04) as over the entire year (0.92 ± 0.05; Table 1.1).

DISCUSSION

River otter survival rates vary across their range, but are generally higher in unexploited populations (Ben-David et al. 2001, Gorman et al. 2008) than exploited populations (Tabor and Wight 1977). The pooled annual survival estimate for river otters in southern Illinois was similar to estimates documented for unexploited populations in Minnesota and Alaska (Ben-David et al. 2001, Gorman et al. 2008); which was expected given most study animals (61%) were protected from harvest by residing on CONWR.

Trapping was the primary source of mortality over the course of my study. In addition to the one male river otter that was killed by nuisance wildlife control activities during the monitoring period, 2 more were harvested by recreational trappers, and one was killed by a vehicle collision. Because these river otters were harvested after their transmitters failed, their deaths were not incorporated into my survival estimates. Regardless, primary mortality sources for river otters in southern Illinois were similar to those reported elsewhere (i.e., trapping and vehicle collisions) (Melquist et al. 2003, Gorman et al. 2008, Spinola et al. 2008).

Annual survival is often lower for males among exploited river otter populations and trappers tend to trap more males than females (Lauhachinda 1978, Polecha 1987, Chilelli et al.1996). This bias has been attributed to male river otters being more vulnerable to harvest due to increased movement associated with larger home ranges and more extensive travel during the breeding season (Melquist and Hornocker 1983, Melquist and Dronkert 1987, and Blundell et al. 2001). Although I found no significant difference in survival rates between sexes, the majority of deaths that occurred during my study were male (4 M, 1 F). Gorman et al. (2008) suggested that males in their study area might have benefitted from having larger home ranges than females, by spending less time in areas where traps were set for other species (e.g., beaver). During my study, I believe male river otters may have put themselves at greater risk to recreational trapping mortality by leaving the protected confines of CONWR more frequently than females.

Despite a relatively high road density within southern Illinois (1.4 km/km^2), I confirmed only one vehicle collision mortality during the post-monitoring period (1 M) that occurred on a highway that bisects CONWR. Road mortality is a particularly well-documented mortality source for carnivores, and can become especially common where highways bisect high-quality wildlife habitat (Gibeau and Heuer 1996, Clevenger1998). Road crossings appear as a common location of otter mortality throughout the literature (Melquist et al. 2003, Gorman et al. 2008, Spinola et al. 2008). Vehicle collisions were the leading identified source of mortality for newly released river otters in both Indiana and New York (Johnson and Berkley 1999, Spinola et al. 2008), and other studies in the U.K. have identified vehicle collisions as a major source of mortality for otters (Chanin and Jefferies 1978, Kruuk and Conroy 1991). Taking this all into consideration, a road mortality on a road that bisects CONWR was not particularly surprising. Vehicle collisions like this highlight the importance of wildlife crossing opportunities where high-speed highways transverse wildlife habitat.

I documented only 1 death (1 M) during the breeding-gestation period over the course of my study, and a pooled-sex breeding season survival of 0.96 ± 0.04. Previous research on season-specific survival estimates has focused on trapping vs. non-trapping seasons (Gorman et al. 2008), and to my knowledge no other study has examined river otter breeding season survival specifically. As male river otters tend to travel more extensively during the breeding season, I would expect them to have a lower probability of survival during that period by potentially making themselves more vulnerable to capture by trappers (Melquist and Hornocker 1983, Melquist and Dronkert 1987). However, the source of the one male mortality we had could not be determined, and occurred within the confines on CONWR where trapping is not permitted.

MANAGEMENT IMPLICATIONS

My study provides information useful for river otter management in lightly-harvested populations in the Midwest. Survival estimates were higher than those used by Nielsen (2016) to model the growth of river otter populations in Illinois (Nielsen 2016: 0.73, 0.81vs. This study: 0.92), and those used by Woolf and Nielsen (2001) (0.81). Nielsen (2016) used age-at-death for river otters collected as road kills and incidental harvests to establish his estimates. Ideally, survival rates based on radio-telemetry should provide a less biased representation of survival as they incorporate all mortality sources that are present. However, most river otters that remained within the confines of CONWR were protected from harvest, and thus may not accurately depict what harvest pressure actually exists in southern Illinois. Future studies would benefit by monitoring river otter survival in areas where more recreational harvest pressure takes place. Additionally, Nielsen's (2016) relatively conservative state-space modeling approach indicated that Illinois' river otter populations will continue to grow or remain stable with harvest rates ≤ 20%, and concluded that Illinois' river otter population is thriving and could withstand a regulated harvest. Although my survival estimates are likely a biased representation of the actual harvest pressure that exists for Illinois river otters, they are higher than those used in previous population models within the state, and thus add credence to the conservatism of those models in terms of survival.

In addition to providing useful demographic information specific to Illinois' river otter population, my results can provide information for managers in other states or other countries. This information can provide a useful benchmark to gauge their own survival estimates as well as future population modeling and population viability analysis efforts (Barding and Lacki 2014).

CHAPTER 2

CAPTURE EFFICIENCY OF RIVER OTTERS IN SOUTHERN ILLINOIS

INTRODUCTION

Capturing study animals safely and efficiently is a critical part of furbearer research and management programs (Schemnitz 1994). Researchers that live trap mammals must assume the responsibility of using methods that treat both target and non-target species humanely (Sikes and Gannon 2011). Optimizing furbearer capture techniques to maximize capture efficiency while reducing capture-related injury rates has directed much of the research on humane traps (Kreeger et al. 1990, Earle et al. 2003, Kolbe et al. 2003).

Earle et al. (2003) found that trap-related injury rates for bobcats (*Lynx rufus*) could be reduced without sacrificing trap performance when they compared a newly developed padded jaw foot-hold trap an unpadded jaw analog. Similarly, Kreeger et al. (1990) assessed the physiological responses of live-captured red foxes (*Vulpes vulpes*) using padded and unpadded jaw foot-hold traps and found lower levels of capture-related trauma associated with padded jaw traps. Kolbe et al. (2003) compared their novel box trap design to accepted capture methods for lynx (*Lynx lynx*) and found that it provided improvements in terms of both capture-related injuries and efficiency. Continual appraisal of new and traditional capture techniques ensures researchers and managers are utilizing the most safe and efficient means of live capture.

River otters have traditionally been captured for research purposes using either foot-hold traps set in blind configurations at latrines (Melquist and Hornocker 1983, Shirley et al. 1983, Serfass et al. 1996) or cage-type traps such as box traps and Hancock cage traps (Northcott and Slade 1976, Shirley et al. 1983, Penak and Code 1987). However, river otters have been shown to avoid Hancock traps after their initial capture (Duffy et al. 1994), and river otters captured using Hancock traps have sometimes sustained substantial tooth damage (Blundell et al. 1999). Other studies have recommended foot-hold traps as a safe and efficient means to capture river otters (Melquist and Hornocker 1983, Serfass et al. 1996, Blundell et al. 1999). However, using foot-hold traps for river otters requires additional time in the field searching for suitable locations, and a deep-seated knowledge of how to set them effectively (Serfass et al. 1996, Blundell et al. 1999, Belfiore 2008).

I compare the functionality of a newly designed box trap known as a Comstock Custom Cage Trap (Comstock Custom Cage LLC, Gansevoort, New York) (hereafter, "Comstock trap") and a recommended style of foot-hold trap (Serfass et al. 1996, Belfiore 2008) known as a Victor® No. 1.75 SoftCatch™ double coil spring (Woodstream Corp., Lititz, Pennsylvania). Comstock traps differ from other cage-type live traps in that they include a suspended wire trigger mechanism (rather than a traditional foot treadle), and spring-powered doors. These modifications allow the user to set the trap in a submerged or partially submerged setting that will potentially capture an otter or other large animal swimming through the trap. My objective was to measure injury rates of river otters captured using Comstock traps and compare the functionality of this new method to that of standard foot-hold traps. To my knowledge, no other studies have used Comstock traps to live capture otters for research purposes.

STUDY AREA

See Chapter 1.

METHODS

Capture and Handling

River otters were captured at latrine locations and along travel routes during 2 capture seasons: October 2014 - January 2015 and October 2015 - February 2016. Researchers typically live trap river otters during these months, as young river otters are weaned and capable of surviving independently (Hamilton and Eadie 1964). I set traps opportunistically where river otter sign was located. Between 10 and 40 traps were checked daily between 0500 and 1000 hrs. Trapping was discontinued when nightly temperatures were ≤ -12˚C.

Victor® No. 1.75 SoftCatch™ double coil spring traps (Woodstream Corp., Lititz, Pennsylvania) were set in blind configurations (i.e., without bait), as this technique has proved to be more successful than baited traps (Melquist and Hornocker 1979, Serfass et al. 1996, Blundell et al. 1999). Foot-hold traps were set on trails leading to and from latrine locations and were equipped foot-hold traps with short chains (20-25 cm), additional swivels, and shock springs to minimize trap-related injuries. All foot-hold traps were anchored into solid substrate using Duckbill® earth anchors (Foresight Products Corp., Fort Mill, South Carolina). Solid obstructions (sticks and rocks) were removed from foot-hold trap sites to reduce the likelihood of entanglement. A fluffed section of pillow batting was placed under the pan of each foot-hold set on dry land to keep soil from obstructing the pan. Each trap was buried under the substrate flush with the surrounding surface and camouflaged with surrounding soil and vegetation (Blundell et al. 1999). In some cases, the most appropriate trap locations were on trails where river otters were entering and leaving the water. When this was the case, traps were set in shallow water to one side of the trail and were equipped with one-way cables leading to land-buried Duckbill® earth anchors. This was done to reduce the likelihood of captured river otters becoming entangled in the water (Belfiore 2008). All foot-hold traps were boiled in a solution of imitation logwood trap dye (F&T Fur Harvesters Co., Alpena, Michigan) and then boiled in trap wax (F&T Fur Harvesters Co., Alpena, Michigan). Cloth gloves and a rubber kneeling pad were used when handling and setting the traps to reduce human scent.

Comstock traps were set in narrow stretches of streams, in drainage ditches, or in culverts where pinch points could be located. Where a pinch point could not be located, woody debris and/or rocks were placed around the trap in an attempt to further constrict the thoroughfare (Figure 2.1a). I also set Comstock traps at overland travel routes between water bodies where river otter sign was identified (Figure 2.1b). Traps were camouflaged with grasses and other vegetation. Comstock traps were never set with more than 1/3 of the trap submerged, and any traps that were partially submerged were visited before other traps each day, to minimize the time captured river otters spent in the water. Partially submerged Comstock traps were pinned open with metal stakes whenever rain was forecast, to ensure no animals were captured when water levels rose. Each Comstock trap was equipped with a 1-5 m cable that was anchored to a nearby object to protect against trap loss during flooding events. No additional efforts were taken to control human scent on Comstock traps before setting them in the field.

I visually estimated the weight of each captured river otter upon capture so that an adequate intramuscular injection of Telazol® (9 mg/kg body weight) could be delivered using a Pneu-Dart® CO_2 pistol (Pneu-Dart Inc. Williamsport, Pennsylvania). The age class of each captured river otter was estimated based on tooth wear and discoloration using a scale developed by Belfiore (2008) as well as its body size. River otters were then transported to a nearby U.S. Fish and Wildlife Service facility providing heat, electricity, and shelter to conduct injury assessments. River otters were allowed to recover within a protective recovery box at the capture site. All capture and handling protocols were approved by the Southern Illinois University Animal Care and Use Committee (Protocol #14-040).

Injury Assessment

Anesthetized river otters were inspected thoroughly for old and recent injuries to teeth and appendages, following protocol established by Blundell et al. (1999). Old dental injuries could be identified by discoloration at the broken area, smooth rounded edges at the fracture site, or a lack of recent gum damage when incisors were missing (Blundell et al. 1999); these were not included in analysis. Recent injuries to the appendages were identified by edema or fresh lacerations, luxations, and fractures (Blundell et al. 1999). Recent injuries were scored based on a standardized scale of trauma developed by the International Organization for the Standardization of Traps (Olsen et al. 1986, Jotham and Phillips 1994) (Table 2.1).

Capture Efficiency

I compared effectiveness of foot-hold and Comstock trap types on the basis of capture efficiency (captures/trap nights), escape rate (escapes/[escapes+captures]), and unavailability rate (traps unavailable/trap nights). These correspond with 3 of the 4 criteria outlined by Blundell et al. (1999), albeit measured differently. Although Blundell et al. (1999) categorized trap utility as number of latrines with traps/total number of latrines, many of my traps were located along travel routes thought to be used by river otters where latrines were not necessarily present. Thus, I did not duplicate this comparison. I redefined “malfunction rate” as “unavailability rate” which included any situation where a trap was rendered unable to capture a passing river otter due to environmental conditions, flaws in trap functionality (e.g., set off by water flow, set off by floating debris, door caught open on floating debris, frozen open), or the capture of a non-target species. I also compared adjusted capture efficiency between the 2 trap types to exclude unavailable trap nights (captures/[trap nights-traps unavailable]). This comparison adjusted for higher levels of unavailable trap nights resulting from abiotic factors that differed between trap types and differential non-target capture rates between trap types.

Data Analysis

Measures of capture efficiency were compared between foot-hold and Comstock traps using a Chi-square test of independence ($\alpha = 0.05$) (Fleiss 1981). I used a mixed model logistic regression to further compare the efficiency (captures/trap nights) of foot-hold traps and Comstock traps (fixed effect of trap type) for river otter capture using Program R version 3.4.0 and the package 'lme4' (Bates et al. 2015, R Foundation for Statistical Computing 2017). The mixed model framework allowed me to incorporate random intercept values among trap locations ($n = 188$) to account for nonindependence of trap night results (success or failure) from the same trap location due to differential river otter capture success between locations. I pooled effort and river otter capture data from both the 2014-15 and 2015-16 capture seasons into 1 sampling period for this analysis.

RESULTS

I live-captured 42 river otters (21 M, 21 F) 49 times from October 2014 to February 2016; 14 non-target species were also captured (Table 2.2). Eight river otters (3 M, 5 F) were captured in foot-hold traps during 788 trap nights, and the remaining 34 (19 M, 15 F) were captured in Comstock traps during 2,540 trap nights. Seven recapture events occurred during my study (5 M, 2 F); 4 of which were initially captured in Comstock traps and that were recaptured using that method. Two other river otters were initially captured in foot-hold traps and then recaptured in Comstock traps (2 F), and 1 male was initially captured in a Comstock trap and recaptured in a foot-hold trap. Two of these recaptures occurred in Comstock traps set in the same location as their initial capture. One male was captured 3 times in Comstock traps set at 2 separate locations. On one occasion, 2 river otters were captured in the same Comstock trap. Five river otters (2 M, 3 F) died as a result of capture complications (Table 2.4), and 3 died (2 M, 1 F) upon drug application. I detected no significant differences in capture efficiency between the 2 trap types (mixed model logistic regression: $z = -0.85$, $P = 0.39$; Comstock traps = 64 trap nights/river otter capture, foot-hold traps = 88 trap nights/river otter capture). Comparisons of escape rate using Chi-square test of independence were also non-significant (Table 2.3). Comstock traps did have higher rates for both unavailability and non-target captures than did foot-hold traps (Table 2.3).

I assessed 20 of the 34 river otters captured in Comstock traps for injuries that resulted from capture (Table 2.4). Eleven (55%) of the 20 river otters inspected for injuries received some type of injury as a result of capture in a Comstock trap. Claw loss was the most common injury among river otters (45%), followed by tooth fracture (25%), and lacerations (10%).

DISCUSSION

When reporting efficiency as trap nights/river otter capture, my results are comparable to those in the literature, but are not the most efficient reported. Published capture efficiencies range from as few as 21 trap nights per river otter capture (Blundell et al. 1999), to as many as 419 trap nights per river otter capture (Melquist and Hornocker 1983). Although foot-hold and Comstock traps did not differ significantly in terms of efficiency or escape rate, Comstock traps had higher rates of both unavailability and non-target captures. My adjusted capture efficiency comparison likely accounted for differences in efficiency that occurred due to unavailability of in-stream Comstock traps (e.g., set off by water flow, set off by floating debris, door caught open on floating debris, frozen open, non-target captures), yet no differences existed between the trap types when those adjustments were made. Foot-hold traps were undeniably easier to transport and carry due to their small size and weight.

In contrast to results reported by previous studies using Hancock traps, I documented several recaptures in Comstock traps during my study. Both Duffy et al. (1994) and Blundell et al. (1999) reported that river otters became trap-shy after their initial captures in Hancock traps. Eventually, I observed signs that river otters avoided Comstock traps that had been set at the same location for a long period of time. Tracks and slides could be seen going around several Comstock traps set on overland crossovers after a fresh snowfall. While I was able to confirm river otter escapes from foot-hold traps by the presence of tracks at the trap site, Comstock traps set at in-stream pinch points may have been triggered by any number of abiotic factors and been documented as a “possible escape” as no apparent sign was present. This likely resulted in a higher measure of escape rate for Comstock traps than actually occurred.

River otters I assessed for injuries did sustain tooth damage as a result of capture in Comstock traps, although it was lower than rates reported in other studies (25% of 20 river otters). Thus, it is possible that Comstock traps may result in a lower proportion of river otters to sustain dentition injuries as a result of live capture. Previous studies have reported damage to the dentition of captured river otters as a major concern, as dentition damage is permanent and can represent a serious impediment to foraging (Biknevicius and Van Valkenburgh 1996). Serfass et al. (1996) reported 37.9% of 29 river otters had dentition injuries as a result of capture in padded-jaw foot-hold traps. Blundell et al. (1999) found no differences in the overall trauma caused by foot-hold and Hancock traps to river otters, although they did find Hancock traps were prone to cause more serious injuries to dentition (>45% of 10 river otters). As a result, they recommended foot-hold traps as the safer method for river otter live capture (Blundell et al. 1999).

Some captured river otters received lacerations from what I assumed were the exposed Comstock trap trigger mechanisms (10% of 20 river otters). In one instance, this exposed trigger mechanism resulted in what was categorized as a major cutaneous laceration and an eye laceration, although I believe simple modifications of the trigger mechanism could ameliorate this problem. For example, replacing the current trigger mechanism with a W-shaped or M-shaped trigger mechanism that would not provide the opportunity for captured river otters to puncture or cut themselves while captured may fix the problem. Another option might be to add a magnetic strip to the inner wall of Comstock traps to keep the trigger mechanism immobilized and out of the way of captured river otters.

The 2 juvenile river otters died when captured in in-stream Comstock traps due to hypothermia. Because thermal conductance is inversely related to body size in mammals (Scholander et al. 1950), juvenile river otters likely had a harder time thermo-regulating than larger-bodied river otters when captured in in-stream Comstock traps. Despite my best efforts to pin traps open before rain events and check in-stream traps preferentially, I was unable to get to 2 river otters before they drowned. Conversion of hydrologic regimes for agricultural purposes can increase the magnitude and intensity of flooding events (Poff et al. 1997, Walser and Bart 2006). Many of the streams within the Big Muddy River drainage were channelized supposedly to control flooding and increase arable land. As a result, water levels in streams and ditches in my study area are markedly unpredictable (Lopinot 1972). This made getting to in-stream Comstock traps in response to rising water levels more difficult and contributed to the 2 mortalities.

River otters seem more likely to injure their dentition when enclosed in any cage-type trap than when captured by foot-hold traps. However, river otters within a cage are arguably easier to handle when attempting to relocate or administer anesthesia. Additionally, non-target captures (e.g., beaver) in Comstock traps, although captured more frequently, were considerably easier to release from a Comstock trap than a foot-hold trap and injuries to non-target animals captured in Comstock traps were nearly nonexistent. Injuries to non-target species should be considered when choosing a suitable live capture method.

Finding appropriate set locations for Comstock traps also seemed to be considerably easier than finding foot-hold set locations. Setting foot-hold traps effectively requires a deep-seated knowledge of the traps themselves and where to set them. Comstock traps by comparison require far less of a learning curve to set effectively. In most cases, setting foot-hold traps for river otters also requires finding an active latrine site (Serfass et al. 1996, Blundell et al. 1999, Belfiore 2008). Depending on the study area, finding active river otter latrines can require a lot of additional time spent afield searching for suitable latrine sites to set. Comstock traps do not necessarily need to be set where a latrine is present and, consequently may require far less time afield.

Although standard foot-hold traps remain a relatively safe and effective method to live capture river otters for those who have the skill to use them, I believe Comstock traps provide an alternative that is comparable in both capture efficiency and escape rate. The many other positive attributes of Comstock traps may make them a more appealing option for researchers and managers attempting to live capture and transport river otters.

MANAGEMENT IMPLICATIONS

Based on my findings, I recommend researchers and managers attempting to live capture river otters limit Comstock trap use to land sets and areas where water levels are not prone to flash flooding. Discontinuing the use of partially submerged Comstock traps during colder weather will likely make this a safer method. Comstock traps may be more appropriate for river otter live capture where non-target species are particularly abundant or where finding active latrines proves difficult. Foot-hold traps may prove to be a better method in settings where latrines are easier to find and non-target species are not as abundant. In any case, I believe a synergistic approach using both foot-hold and Comstock traps may provide researchers and managers with the flexibility to adapt to various field conditions and maximize their sample size.

TABLES

Table 1.1. Annual and seasonal survival rates (*S*) for river otters in southern Illinois, USA, October 2014 to October 2016.

Group	Radio-days	Mortalities	*S*	*SE*
Males	4,590	4[b]	0.85	0.09
Females	3,759	1[b]	1.0	0.83[c]
Breeding[a]	2,829	1	0.96	0.04
Annual	8,235	5	0.92	0.05

[a] 1 March – 31 May

[b] Two males and 1 female died during the post-monitoring period and thus were not included in survival estimates

[c] Lower bound of the 95% adjusted Wald confidence interval

Table 2.1. Trauma scale used to assess the intensity of injuries sustained by river otters during live capture in southern Illinois, USA, October 2014 to February 2016.

Pathological Observations	Score (points)
Claw loss	2
Edematous swelling or hemorrhage	5-15
Minor cutaneous laceration	5
Minor subcutaneous soft tissue maceration or erosion	10
Major cutaneous laceration, except of foot pads or tongue	10
Minor periosteal abrasion	10
Severance of minor tendon or ligament	25
Amputation of 1 digit	25
Fracture of permanent tooth exposing pulp cavity	30
Major subcutaneous soft tissue maceration or erosion	30
Major laceration on foot pads or tongue	30
Severe joint hemorrhage	30
Joint luxation below carpus or tarsus	30
Major periosteal abrasion	30
Simple rib fracture	30
Eye lacerations	30
Minor skeletal-muscle degeneration	30
Simple fracture distal to the carpus or tarsus	50
Compression fracture	50
Comminuted rib fracture	50
Amputation of 2 digits	50
Major skeletal-muscle degeneration	55
Limb ischemia	55
Amputation of three or more digits	100
Any fracture of joint luxation on limb proximal to the carpus or tarsus	100
Any amputation above digits	100
Spinal cord injury	100
Severe internal organ damage (internal bleeding)	100
Compound or comminuted fracture at or below carpus or tarsus	100
Severance of major tendon or ligament	100
Compound rib fracture	100
Ocular injury resulting in blindness	100
Myocardial degeneration	100
Death	100

Table 2.2. Species captured during river otter live capture efforts in southern Illinois, USA, October 2014 to February 2016.

	Foot-hold	Comstock	
Species Captured	2014-2015	2014-2015	2015-2016
River otter (*Lontra canadensis*)	8	18	16
Beaver (*Castor canadensis*)	7	52	43
Raccoon (*Procyon lotor*)	32	29	142
Muskrat (*Ondatra zibethicus*)	-	13	9
Opossum (*Didelphis virginiana*)	-	1	17
Bobcat (*Lynx rufus*)	1	-	5
Coyote (*Canis latrans*)	6	-	-
Mink (*Neovison vison*)	-	-	2
Striped skunk (*Mephitis mephitis*),	-	-	7
Eastern cottontail (*Sylvilagus floridanus*)	-	-	2
Wood duck (*Aix sponsa*)	-	2	5
Pied-billed grebe (*Podilymbus podiceps*)	-	1	-
Red-eared slider (*Trachemys elegans*)	-	17	68
Largemouth bass (*Micropterus salmoides*)	-	1	-
Bluegill (*Lepomis macrochirus*)	-	1	-

Table 2.3. Functionality comparisons of Comstock and foot-hold traps used to live-capture river otters in southern Illinois, USA, October 2014 to February 2016.

Trap Function	Type of Trap							
	Comstock			Foot-hold			Results	
	Numerator	Denominator[b]	Rate	Numerator	Denominator[b]	Rate	X^2	*P*-value[a]
Efficiency (captures/trap nights)	40	2540	0.016	9	788	0.011	0.48	0.48
Adjusted efficiency (captures/[trap nights-traps unavailable for capture])	40	2006	0.020	9	667	0.013	0.79	0.37
Escape Rate (escapes/[escapes+captures])	63	103	0.612	21	30	0.70	0.06	0.80
Unavailability Rate (traps unavailable for capture/trap nights)	534	2540	0.210	121	788	0.154	8.12	0.004*
Non-target Capture Rate (non-target captures/trap nights)	406	2540	0.160	42	788	0.053	46.27	<0.0001*

a. *P*-values from chi-square distribution with 1 d.f.
b. Sample sizes are denominators in rate calculations

Table 2.4. Cumulative injury assessment results for river otters captured in Comstock traps based on scale of trauma developed by the International Organization for the Standardization of Traps captured in southern Illinois, USA, October 2014 to February 2016.

ID	Cumulative Trauma Score	Injuries Sustained	Cause of Death
M-07	100	-	Hypothermia
M-19[a]	2	Claw loss	-
M-29	0	None	-
M-30	2	Claw loss	-
M-31	32	Claw loss, Tooth Fracture	-
M-34	2	Claw loss	-
M-37	100	Major cutaneous laceration,eye laceration	Capture-related Injuries
M-38	0	None	-
M-39	32	Claw loss, Tooth Fracture	-
M-40	0	None	-
M-41	30	Tooth Fracture	-
F-02[a]	0	None	-
F-24	100	-	Drowned
F-27	7	Claw loss, Minor cutaneous laceration	-
F-28	0	None	-
F-32	100	Claw loss, Tooth Fracture	Drowned
F-33	100	-	Hypothermia
F-35	0	None	-
F-36	2	Claw loss	-
F-42	32	Claw loss, Tooth Fracture	-

a. Two river otters (1 M, 1 F) were inspected for injuries after their respective recaptures. One was initially captured in a foot-hold, and the other was initially captured in a Comstock.

FIGURES

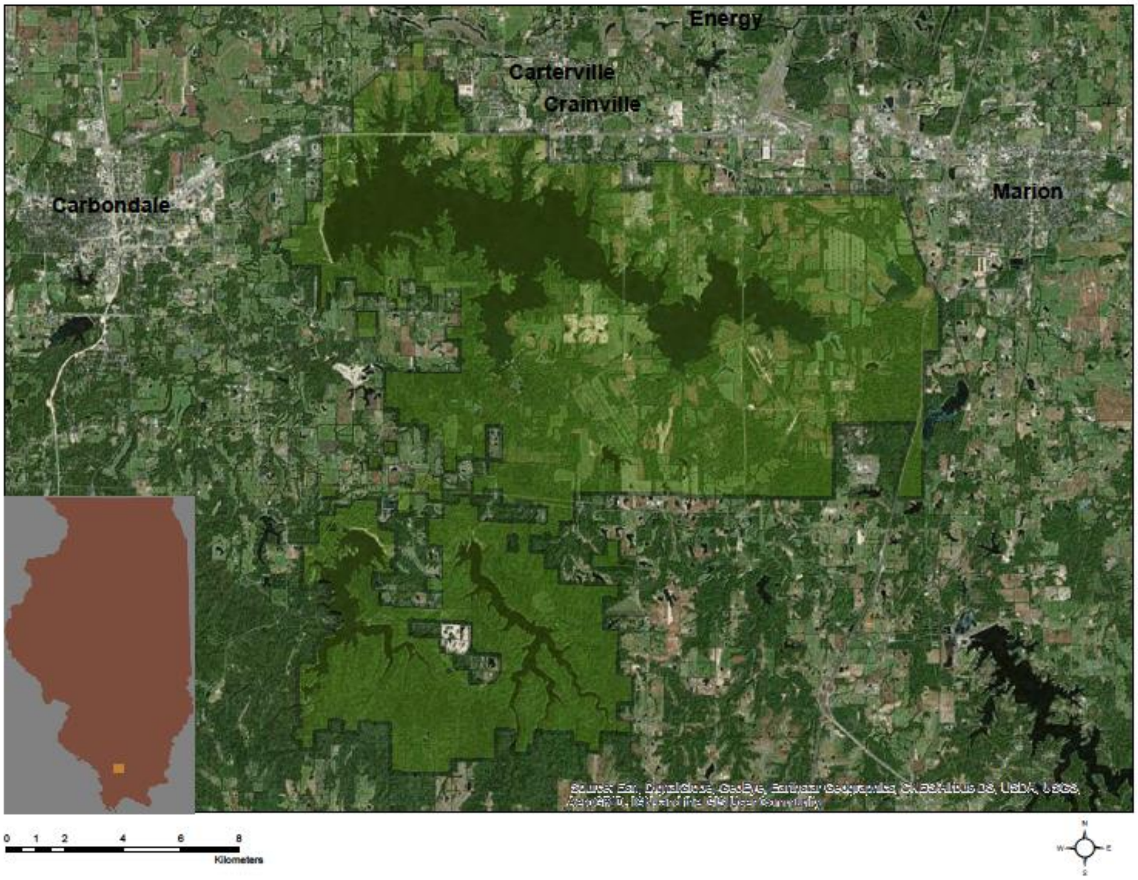

Figure 1.1. Study area where river otters were monitored for survival in southern Illinois, USA, October 2014 to October 2016.

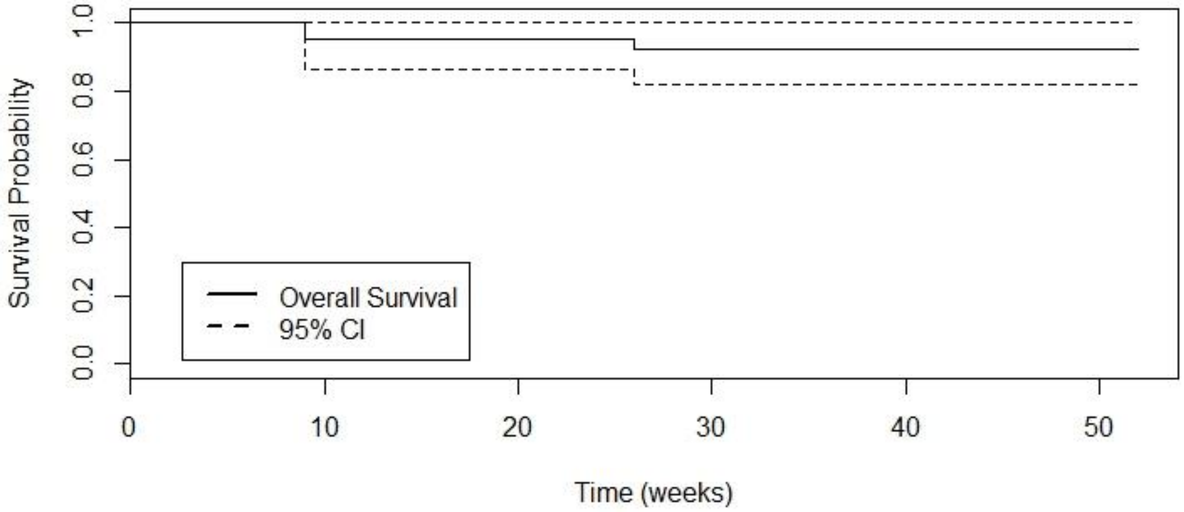

Figure 1.2 Kaplan-Meier annual survivorship for river otters in southern Illinois, USA, October 2014 to October 2016 (*n* = 34).

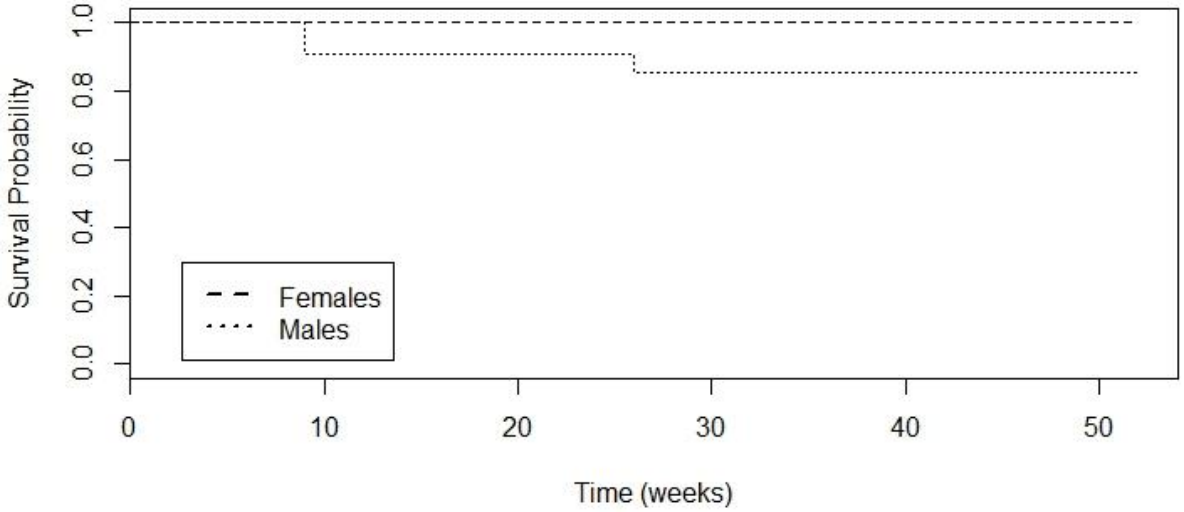

Figure 1.3 Kaplan-Meier sex-specific annual survivorship for river otters in southern Illinois, USA, October 2014 to October 2016 (*n* = 34).

Figure 2.1. Representative examples of Comstock trap locations used to capture river otters in southern Illinois, USA, October 2014 to February 2016. a.) shows an in-stream pinch point utilizing woody debris to block the thoroughfare, b) shows an overland crossover pinch point utilizing woody debris to block the thoroughfare.

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VITA

Graduate School
Southern Illinois University

Andrew U. Rutter

rutter450@gmail.com

Emporia State University
Bachelor of Science, Biological Sciences, May 2013

Special Honors and Awards:
- 2014 Richard Daniel Memorial Scholarship (via Illinois Trappers Association)
- 2015James S. Fralish Student Travel Award in Forestry
- 2016 James S. Fralish Student Travel Award in Forestry

Thesis Title:
Survival and Capture Efficiency of River Otters in Southern Illinois

Major Professor: Clayton K. Nielsen and Eric M. Schauber