Article

Summer movements and activity patterns of river otters in Northeastern Ohio, USA

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Abstract

It is important to understand river otter (*Lontra canadensis*) movement and activity patterns for successful management and reintroduction plans. As part of a river otter study conducted in the Killbuck Watershed, the largest wetland complex in Ohio, USA outside of the Lake Erie marshes, 11 river otters were radio-tagged and monitored for movements and activity patterns. Twenty-seven 24-hour monitoring surveys were conducted during summer months (June–July) of 2002 and 2003. The mean movement distance of female river otters ($\bar{x}$ = 1.8 km, SE = 0.23) was less (P = 0.0012) than the mean movement distance of male river otters ($\bar{x}$ = 5.2 km, SE = 0.73). River otters were more active than inactive from 2201–0400 hrs (71% active), followed by 0401-1000 hrs (68% active), and 1601-2200 hrs (45% active); they were more inactive than active from 1001-1600 hrs (14% active). These results show that river otters can move long distances and it is important to manage not only wetland systems but riparian corridors that aid in dispersal of river otters to other wetland complexes and watersheds.

Keywords activity patterns; Killbuck Watershed; *Lontra canadensis*; movements; river otter; wetlands.

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1 Introduction

River otters are important furbearers and indicators of riparian health in North America (Melquist and Hornocker, 1983; Bowyer et al., 2003). Historically, river otters survived throughout northern Alaska, from eastern Newfoundland to the Aleutian Islands, and south to Florida and Texas, and were absent only in the treeless arctic and the arid southwestern states (Chapman and Feldhamer, 1982; Melquist and Hornocker, 1983; Melquist and Dronkert, 1987; Stone and Sheean-Stone, 1992). A combination of factors such as human infringement, habitat destruction, and unregulated trapping during the early 1900s reduced river otters from much of their historic range (Melquist and Hornocker, 1983; Melquist and Dronkert, 1987). Due to the high prices of fur in the 1970s, trapping pressure increased, causing harvest rates to escalate (Morrison et al., 1981). The increased harvest rates of river otters and other furbearers contributed to an increase in furbearer management and science based decisions (Chapman and Pursley, 1980).

River otters are one of the most aquatic members of the Family Mustelidae (Melquist and Dronkert, 1987), and are capable of traveling long distances in short time periods (McDonald, 1989). River otters are highly mobile animals that can swim at speeds of up to 11 km/hour, and cover as much as 400 m underwater before coming up for air (Whitaker and Hamilton, 1998). River otter movements vary from one area to another and are primarily dictated by drainage patterns (Melquist and Hornocker, 1983; Melquist and Dronkert, 1987; Bluett and Hubert, 1995), but are also influenced by foraging, exploring, patrolling home ranges, marking boundaries, searching for mates, dispersal, and habitat quality (Erlinge, 1967; Larsen, 1983; Melquist and Hornocker, 1983; McDonald, 1989; Martin et al., 2010). Movements in high elevation areas may follow drainage systems that are long, linear, narrow, and branched. Movements in coastal areas may be narrow in width following shorelines. Movements vary more in areas with little topographic relief and abundant wetlands and marshes (Melquist and Dronkert, 1987).

Like many mammals, principal activity patterns of river otters are crepuscular (Melquist and Hornocker, 1983; Whitaker and Hamilton, 1998). Melquist and Hornocker (1983) and Mack (1985) attributed nocturnal activity during summer months to human avoidance. However, several studies have shown river otter activities at other times of the day (Larsen, 1983; Melquist and Hornocker, 1983; Foy, 1984). Human disturbance can cause shifts in activity periods as well as other external factors (Melquist and Hornocker, 1983; Bluett and Hubert, 1995).

River otters have been reintroduced to several states and Canadian provinces where they previously survived in low numbers or were extirpated. Reestablishment of a native species, the potential for harvest, aesthetics, cultural significance, habitat availability, high fur value, public relations, and preservation of a locally rare or threatened species were reasons listed for river otter reintroductions (Berg, 1982; Raesly, 2001). A feasibility study was conducted in Ohio (1986–1987), and a river otter reintroduction project was carried out to achieve the above objectives in the state from 1988 through 1993 (Dwyer, 2003). River otters (n = 123) were released in 4 separate watersheds throughout eastern Ohio (Grand River, n = 48; Killbuck Creek, n = 24; Stillwater Creek, n = 25; and Little Muskingum River, n = 26) (Dwyer, 2003).

The objective of this study was to examine movement and activity patterns of river otters during June to July, 2002 and 2003 in the Killbuck Watershed, Ohio based on 24-hour monitoring periods (Foy, 1984). Locations obtained during these periods are important in understanding movement patterns, the proximity or types of habitats used, and movement corridors.

2 Materials and Methods

Our project was conducted throughout the Killbuck Watershed in northeastern Ohio, USA. Killbuck Creek runs through 3 counties (Wayne, Holmes, and Coshocton), within a watershed that includes 157,730 ha and a channel length of 132 km. The upper end of the Killbuck Creek had a gentle slope of 39.1 cm/km for the upper 3 km of the creek. In the southern end the topography was rougher and steeper along the tributaries that drain into the Killbuck (Beck et al., 1992). Forested riparian corridors exist along portions of the Killbuck; however, other areas were dredged frequently causing this aquatic river system to be highly prone to flooding, especially during periods of early spring due to snowmelt and rain events. Approximately 56% of this area consisted of palustrine emergent, palustrine scrub-shrub, and palustrine forested wetlands that were flooded during some portion of the year. The area is in the Mahoning-Canfield-Rittman-Chili soils region, part of the Eastern Ohio Till Plain, where glacial deposits ranged from coarse-textured to fine-textured, although coarser-textured and well drained soils occurred more frequently in the southern portion of this region (Ohio

Department of Natural Resources, 1990). The Ohio Division of Wildlife (Ohio Division of Wildlife, 1999) acquired 2,234 ha of the Killbuck Watershed (Killbuck Wildlife Management Area (WMA)) in 1969, which was Ohio's largest remaining wetland complex outside of the Lake Erie region.

Climate is typically hot and humid in the summer and moderately cold throughout the winter, with an average first fall freeze date (0° C) occurring 6 October (National Oceanic and Atmospheric Administration, 1982). Average annual precipitation is 91.4 cm for this area, with a monthly average of 7.6 cm (National Oceanic and Atmospheric Administration, 1982). February is typically the driest month (4.8 cm) and July (10.7 cm) the wettest (National Oceanic and Atmospheric Administration, 1982). The Killbuck can be influenced heavily by precipitation, with minimum daily flow rates ranging from 1.7 m^3/s to 94.3 m^3/s and a mean flow rate of 22.1 m^3/s (United States Geological Survey, 2002).

We trapped river otters in the Killbuck Watershed, primarily on the Killbuck WMA, using Victor No. 1.5 padded coilsprings (Woodstream Corporation, Lititz, PA, USA) and No. 11 double longspring offset foothold traps (Sleepy Creek Manufacturing, Berkeley Springs, WV, USA) (Helon et al., 2004). Coilspring traps were modified by the addition of 2 coil springs and reinforced base plates. All traps also were equipped with 90-cm chains attached to the bottom center of base plates, and chains were modified by adding 5 swivels to allow trapped river otters to roll and avoid serious injury (Blundell et al., 1999). Traps were anchored using wooden stakes, and the area surrounding each trap site was cleared of debris that could entangle captured river otters (Serfass et al., 1996; Bowyer et al., 2003). Traps were placed at river otter pull outs, crossovers between adjacent stream and wetland units and latrine sites (Helon et al., 2004). Traps located at the crest of tall stream banks had the terminal end of the chain fastened to a long section (2–3 m) of 11 gauge wire using a one-way slide swivel. One end of the wire was anchored at the trap site and the other end was anchored in an open area to allow the trapped otter to move to the open area and remain there to prevent possible injury from lunging off the bank toward the water. During 2001 and 2002 trapping was initiated in late summer to early autumn when the majority of young river otters are able to survive autonomously (Serfass et al., 1996), and continued through December. Trapping was terminated when overnight temperatures dropped below -5° C (Helon et al., 2004).

We guided trapped river otters into transport boxes removed the trap using a notched board which subsequently was replaced with a solid board, weighed them, and subtracted the weight of the empty box from the total weight to obtain the weight of each otter. We restricted radio-marking to river otters that were ≥ 3.6 kg. Trapped otters were transported to a veterinary facility where they were anesthetized with ketamine hydrochloride by a veterinarian at a rate of 22 mg/kg (Melquist and Hornocker, 1979; McDonald, 1989; Testa et al., 1994). The veterinarian then implanted a 30 × 100 mm, 90 g intraperitoneal transmitter (Advanced Telemetry Systems (ATS) M1200, Isanti, MN, USA) as outlined by Kollias (1999). Transmitters were equipped with a motion-sensitive mortality switch that activated after 8 hours of non-activity. We also injected river otters with vitamin B and vaccines (Diptheria, Hepatitis, Leptosporosis, Parainfluenza, and Parvo Virus). An examination for overall physical condition and injuries that might have occurred from use of the foothold traps was performed. An American Veterinary Identification Devices ((AVID), Norco, CA, USA) passive integrated transponder (PIT) tag was inserted under the skin at the base of the tail of each captured river otter to provide permanent identification (Bowyer et al., 2003). Approximately 35 minutes was required for processing from the time anesthesia was administered until the last shots were given. Following surgery, we held river otters in captivity for < 5 hours in a transport cage to ensure that they were fully mobile, before being released (Testa et al., 1994) at their respective capture sites (Rock et al., 1994). Released river otters showed no adverse effects from the procedure and were energetic. The West Virginia University Animal Care and Use Committee approved the protocols used in this study (01-0714).

We monitored river otters on the ground using an omni-directional “whip” antenna mounted to the roof of a vehicle and an ATS R2000 receiver. Once a signal was detected, we more accurately located the river otter using a 3-element Yagi antennae. We obtained locations on the ground during June to July 2002 and 2003. We randomly assigned days and order of tracking and tracked each river otter once a month. During each 24-hour monitoring period 2–4 river otters were tracked. We obtained locations every 3 hours for a 24-hour period (Table 1). Monitoring periods were conducted regardless of weather conditions, unless lightning was present, in which case the monitoring period was ended for safety reasons. We determined river otter locations by triangulation from a minimum of 2 points. River otters were located every 3 hours to minimize the possibility of autocorrelation among telemetry locations (White and Garrot, 1990). We obtained telemetry readings as close to the animal as possible and temporal intervals were minimized (< 5 min) between azimuths (White and Garrot, 1990; Owen, 2003). Average azimuth error was determined by the difference between azimuths taken on transmitters hidden in the wetland and the true azimuths from the telemetry station to the location of the transmitter. We calculated the average error polygon as the average size of the polygon created by the error arcs of 2 azimuths taken on a transmitter from 2 stations (Hurst and Lacki, 1999). At the time of locating river otters we determined if the river otter was active or at rest (denned) by the signal fluctuations. If the signal was fluctuating, we assumed the river otter was moving or active, and was recorded as being at rest if little or no fluctuation occurred.

Table 1 Dates of 24-hour tracking periods for river otters in the Killbuck Watershed, Ohio during 2002 and 2003.

Otter	Sex	Year	First Survey	Second Survey
064	F	2002	6 Jun 2002[a]	24–25 Jul 2002
222	F	2002	19–20 Jun 2002	30–31 Jul 2002
245	M	2002	*[b]	9–10 Jul 2002
284	M	2002	*[b]	9–10 Jul 2002
325	M	2002	19–20 Jun 2002	30–30 Jul 2002
405	M	2002	13 Jun 2002 [a]	24–25 Jul 2002
064	F	2003	27–28 Jun 2003	10–11 Jul 2003
185	F	2003	12–13 Jun 2003	10–11 Jul 2003
222	F	2003	12–13 Jun 2003	6–7 Jul 2003
325	M	2003	27–28 Jun 2003	18–19 Jul 2003
405	M	2003	1–2 Jun 2003	*[b]
634	F	2003	12–13 Jun 2003	6–7 Jul 2003
652	M	2003	1–2 Jun 2003	18–19 Jul 2003
673	M	2003	12–13 Jun 2003	18–19 Jul 2003
753	M	2003	27–28 Jun 2003	18–19 Jul 2003

a = Survey ended early due to lightning.

*b = River otters could not be located at that time period.

To determine peak activity periods of river otters, we divided the diel period into 4 6-hour periods (0401–1000, 1001–1600, 1601–2200, 2201–0400 hours) (McDonald, 1989). Once a river otter was located, signal intensity was monitored for about 5 minutes to determine fluctuation in signal strength, which we assumed was due to movement and recorded the river otter active, we recorded no signal fluctuation as being non-active (at rest or denned) (Melquist and Hornocker, 1983; McDonald, 1989). The proportion of active and non-active locations during the 24-hour surveys was summed to get a percentage of activity patterns for each of the 4 time periods.

We estimated Universal Transverse Mercator (UTM) locations by entering coordinates of azimuth locations into program LOCATE II (Nams, 1990). We entered UTM coordinates into Animal Movement Analysis Extension (Hooge and Eichenlaub, 2000) in ArcView® (Hooge and Eichenlaub, 2000; Merrill and Mech, 2003), and determined distance traveled between locations during the 3-hr intervals. We compared distance moved (dependent variable) to determine differences between sexes and years (independent variable) ($P < 0.05$) using analysis of variance (ANOVA). We used G-tests to determine if the proportion of locations where river otters were active or non-active were different among time periods ($P < 0.05$). Following a significant G-test, we used G-tests to compare each pair of means. We tested assumptions of normality using the univariate procedure in SAS, and Bartlett's test to test homogeneity of variance assumptions. We used square root and natural log transformations on dependent variables (movements) to meet the normality assumptions (Dowdy and Wearden, 1991).

3 Results

River otters were captured from October to December 2001 (n = 7) and September to December 2002 (n = 7). During summer months (June–July) of 2002 and 2003 11 river otters were monitored for 27 24-hr activity periods. We monitored 6 river otters for 10 24-hour periods during 2002, 2 river otters for 1 period, and 4 river otters for 2 periods. In 2003 we tracked 9 river otters for 17 24-hour periods, 1 river otter for 1 period and 8 river otters for 2 periods (Table 1). One hundred ninety locations, divided into the 4 time periods (0401–1000, 1001–1600, 1601–2200, 2201–0400 hours) were used to determine if river otters were active or at rest. Activity varied among the 4 time periods ($n = 190$, $G_3 = 44.06$, $P < 0.001$). River otters were least active between 1001 and 1600 hours and most active between 2201 and 1000 (Table 2). There was a greater proportion of activity during the evening through the early morning hours (Fig. 1). The second peak of activity occurred early in the morning during the hours of 0400 through 0700.

Table 2 Proportion of locations during which river otters were active or non-active during summer months (June–July) in the Killbuck Watershed, Ohio during 2002 and 2003.

		Location Type[a]			
		Active		Non-active	
Time periods (hrs)	Total locations	No.	%[b]	No.	%
0401–1000	50	34	68% a	16	32%
1001–1600	49	7	14% c	42	86%
1601–2200	42	19	45% b	23	55%
2201–0400	49	35	71% a	14	29%

[a] = Active locations were determined by monitoring signal fluctuation for approximately 5 minutes.
[b] = Proportions with the same letter are not different ($P > 0.01$) using paired G-tests.

We found no interaction between sexes and years ($F_{1,26} = 0.37$, $P = 0.55$) in mean distance moved. Mean distance moved differed ($F_{1,26} = 13.71$, $P = 0.0012$) between females ($\bar{x} = 1.8$ km; SE = 0.23; range = 0.7–3.5) and males ($\bar{x} = 5.2$ km; SE = 0.73; range = 0.7–9.9) during 2002 and 2003, with males moving greater distances than females. River otters moved an average of 3.2 km (n = 9; SE = 1.07; range = 0.7–9.2) during 2002 and 3.9 km (n = 18; SE = 0.60; range = 0.8–9.9) during 2003 ($F_{1,26} = 1.49$, $P = 0.23$) during each 24-hr period.

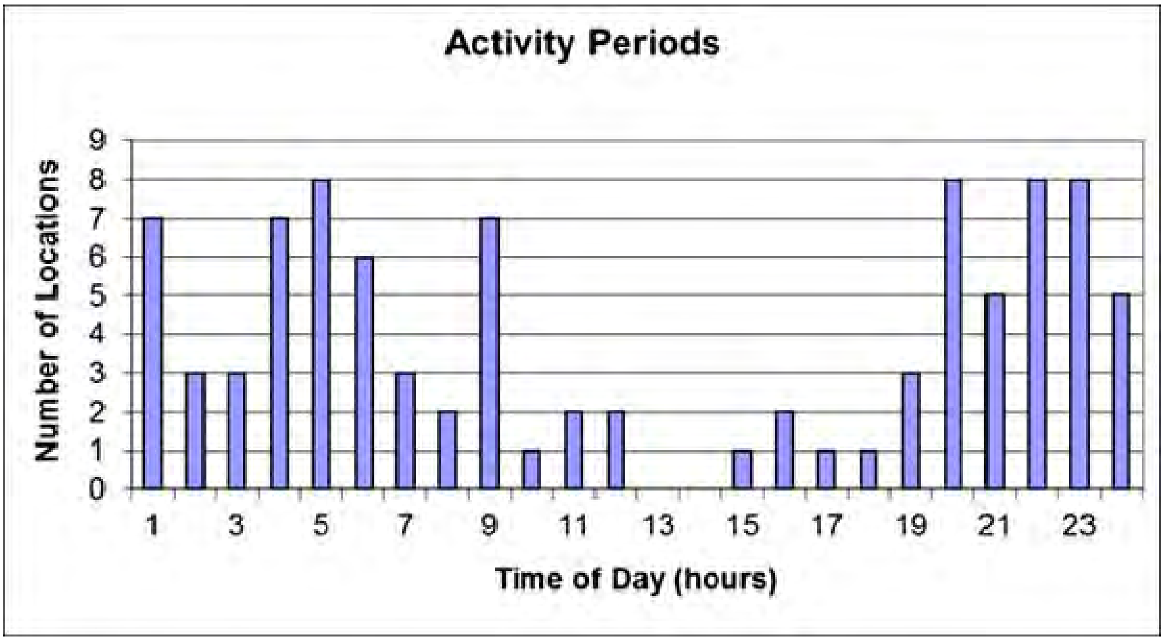

Fig. 1 Number of locations (by hour) during which river otters were known to be active during (June–July) in the Killbuck Watershed, Ohio, USA during 2002 and 2003.

4 Discussion

Most river otter activity occurred during the early morning hours and evening hours with river otters staying active throughout much of the night, which corresponds with other studies (Larsen, 1983; Melquist and Hornocker, 1983; Foy, 1984; Woolington, 1984; Mack, 1985; McDonald, 1989). However, we recorded some activity during the middle of the day, as observed in several other studies (Larsen, 1983; Melquist and Hornocker, 1983; Foy, 1984; Woolington, 1984).

Table 3 Movement of river otter studies conducted across the USA.

Investigator(s)	Study Location	Sex	Mean Movement (km)
Larsen (1983)	coastal Alaska	male	5.8
Melquist and Hornocker (1983)	Idaho	male	5.1
		female	2.1
Foy (1984)	Texas	male	1.4
		female	0.9
Griess (1984)	Tennessee	male	7.6
		female	7.2
Our study	Ohio	male	5.2
		female	1.8

As with most mammals, male river otters will typically have larger home ranges, move greater distances, and be more active than females (Melquist and Hornocker, 1983; Foy, 1984; Griess, 1984; McDonald, 1989). It is important to understand river otter movement patterns for successful management and reintroduction plans. Den sites and prey sources were abundant in this study area, and mating activity was over at the time of the monitoring periods in this study which can alter movement patterns. Movement patterns were likely based on river otters hunting prey for short periods of time and returning to a den site for periods of rest. Movements also could be due to exploring new territory which is important for restoration purposes, as well as capitalizing on available food resources within home ranges. We found differences in movement distances between females and males over the 2 years (2002 and 2003), similar to other studies indicating that male river otters moved greater distances than females (Melquist and Hornocker, 1983; Foy, 1984; Griess, 1984; McDonald, 1989) (Table 3). Larsen (1983) found mean male river otter movement in coastal southeastern Alaska to be 5.8 km compared to 5.2 km in the present study. Melquist and Hornocker (1983) also reported a mean movement of 5.1 km for a 24-hour period for male river otters in west central Idaho. Female river otters in Kelp Bay, Alaska were reported to have moved distances between 0–2.9 km (Foy, 1984), and Melquist and Hornocker (1983) also observed females moved shorter distances than males. Most of the females that we were tracking were observed with pups, which likely influenced the localized movements. Female river otters were located at den sites in areas where prey species were abundant allowing them to forage close to dens. Much of their movement patterns consisted of short hunting and foraging expeditions close to the den, and returning for periods of rest. However, we did have one female river otter that moved > 40 km into another watershed. Due to the distance that she moved we were unable to track her and include her in our results. Overall males moved greater distances than females that remained within the study area.

Distances moved do not necessarily equate to river otters covering large areas. Much of the movements observed were back and forth throughout wetland systems as river otters hunted and foraged for food, as well as potentially patrolling and scent marking their territories (Erlinge, 1968; Larsen, 1983). Melquist and Hornocker (1983) mentioned the possibility that some of the long-distance movements can be associated with exploring unfamiliar areas. During 2002 2 male river otters (284, 325) moved distances of 9.2 and 8.4 km respectively, and 2 male river otters (673, 405) moved distances of 8.1 and 9.9 km, respectively in 2003. These consisted of long distance movements to wetlands where they typically were not found throughout most of the study. These excursions can be similar to what Melquist and Hornocker (1983) observed during their study and may be caused by river otters exploring new territories when they exhibited maximum long distance movements ranging from 7–42 km.

The high quality habitat on the Killbuck WMA (i.e., 56% palustrine scrub shrub, emergent, and forested wetlands) and the timing of the study (June–July) suggests that river otter movements were primarily influenced by foraging or exploring. Activity patterns can shift due to human disturbances or other factors such as prey availability, weather, and water conditions. Unlike many other predators, river otter diets allow them to obtain food at any time throughout a 24-hour period (Melquist and Dronkert, 1987).

Throughout this study, there was little human traffic or disturbance on the study area. We conducted 24-hour surveys during June–July with average climate being hot and humid with day temperatures reaching 28˚–32˚ C (Ohio Department of Natural Resources, 1990). Greatest movements occurred during the highest activity periods (0401–1000, and 2201–0400). The majority of the time, river otters were active throughout the morning, evening, and night, and remained denned up during the middle of the day. This may be due to the heat; river otters would use this time to den or rest, considering that they can hunt for food resources during cooler times of the day. Due to the heat in the middle of the day, we hypothesize that prey species (i.e., fish, crustaceans, reptiles, amphibians, birds, and insects) are less active, thereby making prey harder for river otters to locate. The combination of little movement and a plethora of cover (i.e., vegetation, woody debris) may prevent river otters from successfully capturing prey species. However, prey species are more abundant during this time of year (Weller, 1981), allowing river otters to move less frequently and shorter distances while foraging to meet their daily intake requirements. Moreover, water levels within the study area usually drop and smaller water bodies start drying up during summer months and concentrate prey species, which also can have an effect on river otter movements (Melquist and Hornocker, 1983; McDonald, 1989). Receding high water levels also landlock and concentrate prey species, allowing greater foraging success for river otters. Moreover, the topography of the Killbuck Watershed allows river otters to move great distances relatively easily. The Killbuck Creek runs through the center of the wildlife management area and adjacent to the creek are several managed and unmanaged marshes, and tributaries that offer an abundant food supply and cover for resting and denning.

We believe that most of the movements observed for females were short distances used for feeding, foraging and hunting. They also may have included bouts of activity to teach pups how to swim, forage, and hunt. Male movements may also have been associated with feeding, along with locating other river otter latrines to determine if other males were in the area as well as marking their territories throughout their home range.

Knowledge of river otter activity patterns and movements is important to aid in management practices to reduce impacts on corridors important for river otter dispersal and emigration. The Killbuck Watershed is comprised of a variety of wetland habitats necessary for river otters to successfully survive and reproduce. Results from this study suggest that quality habitat exists in the Killbuck Watershed allowing river otters to remain in this area without having to move great distances in search of prey or denning and resting sites. Continuation of management efforts to maintain wetland diversity is important for river otters in this area. The Killbuck Watershed offers a wide variety of wetland ecosystems with waterway corridors allowing river otters to move freely to a variety of wetlands as well as dispersal and emigration or immigration purposes. The majority of these aquatic corridors are forested with steep banks, and fluctuating water levels. Managing these wetland systems offers a variety of habitats that provide a diversity of prey species used by river otters. Waterways also should be managed by preventing dredging so that log piles and backwater areas can be created, and to keep a wooded buffer along the banks. These recommendations are important for creating denning, resting, and foraging areas, and dispersal corridors for river otters. These marsh habitats, with a diverse vegetative structure, provide areas for river otters to forage and den or rest, and adjacent aquatic corridors offer access to other wetland habitats within the watershed. River otter management at the Killbuck WMA should continue to focus on wetland management (i.e., drawdowns) to create marsh habitats that provide a diversity of plant species. Logjams and woody debris should not be removed from aquatic corridors to allow a diversity of habitat structure and areas for prey species to congregate.

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References

Beck T, Boone KM, Brown LC. 1992. Wayne County Water Resources. Ohio State University Extension Fact Sheet, AEX-480.85, Columbus, OH, USA

Berg WE. 1982. Reintroduction of fisher, pine marten, and river otter. In: Midwest Furbearer Management (Sanderson GC, ed). 159-174, North Central and Central Plains Sections of the Wildlife Society, Wichita, KS, USA

Bluett R, Hubert G Jr. 1995. Background. In: Illinois River Otter Recovery Plan (Bluett R, ed). 1-22, Illinois Department of Natural Resources, Springfield, IL, USA

Blundell GM, Kern JW, Bowyer RT, et al. 1999. Capturing river otters: a comparison of Hancock and leg-hold traps. Wildlife Society Bulletin, 27: 184-192

Bowyer RT, Blundell GM, Ben-David M, et al. 2003. Effects of the Exxon Valdez oil spill on river otters: injury and recovery of a sentinel species. Wildlife Monographs, 153: 1-53

Chapman JA, Pursley D. 1980. Worldwide Furbearer Conference Proceedings. Frostburg, MD, USA

Chapman JA, Feldhamer GA. 1982. Wild mammals of North America. The Johns Hopkins University Press, Baltimore, MD, USA

Dowdy S, Wearden S. 1991. Statistics for Research. John Wiley and Sons, New York, NY, USA

Dwyer CP. 2003. Population assessment and distribution of river otters following their reintroduction into Ohio. Ohio Division of Wildlife 2003 Wildlife Research Report. Columbus, OH, USA

Erlinge S. 1967. Home range of the otter *Lutra lutra* in southern Sweden. Oikos, 18: 186-209

Erlinge S. 1968. Territoriality of the otter *Lutra lutra* L. Oikos, 19: 81-98

Foy MK. 1984. Seasonal movements, home range, and habitat use of river otter in southeastern Texas. Thesis. Texas A&M University, TX, USA

Griess JM. 1984. River otter reintroduction in Great Smokey Mountains National Park, Knoxville, TN. Thesis. University of Tennessee, Tennessee, USA

Helon DA, Anderson JT, Dwyer CP, et al. 2004. Summer home range size and habitat use by river otters in Ohio. Proceedings IXth International Otter Colloquium Volume 21A

Hooge PN, Eichenlaub B. 2000. Animal Movement Extension to ArcView Version 2.2. U.S. Geological Survey, Alaska Biological Science Center, Anchorage, AK, USA

Hurst TE, Lacki MJ. 1999. Roost selection, population size, and habitat use by a colony of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*). American Midland Naturalist, 142: 363-371

Kollias GV. 1999. Health assessment, medical management, and prerelease conditioning of translocated North American river otters. In: Therapy III-zoo and Wild Animal Medicine (Fowler ME, Miller E, eds). 443-448, Philadelphia, PA, USA

Larsen DN. 1983. Habitats, movements and foods of river otters in coastal southeastern Alaska. Thesis. University of Alaska, Fairbanks, AK, USA

Mack CM. 1985. River otter restoration in Grand County, Colorado. Thesis. Colorado State University, Fort Collins, CO, USA

Martin DJ, McMillian BR, Erb JD, et al. 2010. Diel activity patterns of river otters (*Lontra canadensis*) in southeastern Minnesota. Journal of Mammalogy, 91: 1213-1224

McDonald KP. 1989. Survival, home range, movements, habitat use, and feeding habits of reintroduced river otters in Ohio. Thesis. Ohio State University, Columbus, OH, USA

Melquist WE, Hornocker MG. 1979. Methods and techniques for studying and censusing river otter populations, Moscow. In: Forest, Wildlife, and Range Experiment, Station, Technical Report 8. University of Idaho, USA

Melquist WE, Hornocker MG. 1983. Ecology of river otters in west central Idaho. Wildlife Monographs, 83: 1-60

Melquist WE, Dronkert AE. 1987 River otter. In: Wild Furbearer Management and Conservation in North America (Novak M, Baker JA, Obbard ME, eds). 625-641, North Bay, Ontario, Canada

Merrill SB, Mech LD. 2003. The usefulness of GPS telemetry to study wolf circadian and social activity. Wildlife Society Bulletin, 31: 947-960

Morrison DW, Edmunds RM, Linscombe G, et al. 1981. Evaluation of specific scent station variables in northcentral Louisiana. In: Annual Conference of the Southeast Association of Fish and Wildlife Agencies. 281-291, USA

Nams VO. 1990. Locate II program. Pacer Publishing, Travo, Nova Scotia, Canada

National Oceanic and Atmospheric Administration. 1982. Monthly normals of temperature, precipitation, and heating and cooling degree days, Ohio. No. 81. Climatology of the United States, Columbus, OH, USA

Ohio Department of Natural Resources. 1990. Soil Regions of Ohio. Columbus, OH, USA

Ohio Division of Wildlife. 1999. Killbuck Marsh Wildlife Area. Publication 233(R901). Columbus, OH, USA

Owen SF. 2003. Ecology and management of raccoons within an intensively managed forest in the central Appalachians. Dissertation. West Virginia University, Morgantown, WV, USA

Raesly EJ. 2001. Progress and status of river otter reintroduction projects in the United States. Wildlife Society Bulletin, 29: 856-862

Rock KR, Rock ES, Bowyer RT, et al. 1994. Degree of association and use of a helper by coastal river otters, *Lutra canadensis*, in Prince William Sound, Alaska. The Canadian Field-Naturalist, 108: 367-369

Serfass TL, Brooks RP, Swimley TJ, et al. 1996. Considerations for capturing, handling, and translocating river otters. Wildlife Society Bulletin, 24: 25-31

Stone D, Sheean-Stone O. 1992. Otters. In: International Union for Conservation of Nature and Natural Resources. Species Survival Commission. Island Press, Covelo, CA, USA

Testa JW, Holleman DF, Bowyer RT, et al. 1994. Estimating populations of marine river otters in Prince William Sound, Alaska, using radiotracer implants. Journal of Mammalogy, 75: 1021-1032

United States Geological Survey. 2002. Hydrograph and station description for 03139000. Killbuck Creek, OH, USA

Weller MW. 1981. Freshwater Marshes Ecology and Wildlife Management. University of Minnesota Press, Minneapolis, MN, USA

Whitaker JO, Hamilton WJ. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, NY, USA

White GC, Garrot RA. 1990. Analysis of Wildlife Radio-tracking Data. Academic Press, San Diego, CA, USA

Woolington JD. 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska. Thesis. University of Alaska, Fairbanks, AK, USA