River Otter Management in Pennsylvania

(2013-2022)

prepared by

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This plan was prepared and will be implemented at no cost to Pennsylvania taxpayers. The Pennsylvania Game Commission is an independently-funded agency, relying on license sales, State Game Land timber, mineral, oil/gas revenues, and federal excise taxes on sporting arms and ammunition. The Game Commission does not receive any state general fund money collected through taxes. For over 100 years, sportsmen and women have funded game, non-game, and endangered species programs involving birds and mammals in Pennsylvania. Hunters and trappers continue to financially support all of Pennsylvania's wildlife programs including river otter management.

EXECUTIVE SUMMARY

While information on the historic distribution of North American river otters in Pennsylvania is limited, otters were likely found in every major watershed in the state during the late 1800s. The combined effects of habitat destruction, water pollution, and unregulated harvest caused the extirpation of river otters from most of Pennsylvania by the early to mid-1900s. Restoration efforts began in 1982, leading to successful population recovery. Pennsylvania otter populations have been protected and have increased for more than 30 years after otter restoration was initiated. Like otter restoration, otter management will ensure that populations remain healthy and self-sustaining for the benefit all Pennsylvanians.

The purpose of this plan is to provide an overview of the current state of knowledge pertaining to river otter biology, habitat, history, resource value, and population management and provide direction for future management. It represents our guide to managing otter populations in Pennsylvania for the next 10 years. It also serves as an information and education resource for anyone seeking answers to questions concerning river otter life history and past, present, and future otter management in the Commonwealth.

Objectives defined in the plan identify the necessary steps to achieve each of the four goals. Strategies consisting of actions and research needs were developed to attain each objective. Improved population and reproductive monitoring, harvest management, habitat assessment, population management, trapping regulations, damage management, outreach, and public engagement are among the most important needs identified.

In keeping with our agency mission, river otters must be managed for the benefit of other wildlife species, their habitats, and all Pennsylvanians for generations to come. Our otter management mission is to maintain stable otter populations in balance with their habitat for the benefit of other wildlife species and humans through proper monitoring, population management, and damage control. The goals of Pennsylvania's river otter management are to (1) maintain sustained otter populations within suitable habitat, (2) minimize otter damage complaints, (3) increase public awareness and knowledge of the benefits of otters and their habitat, and (4) develop guidelines to assess river otter harvest feasibility and implement a harvest management program.

Pennsylvania's otter management plan provides the necessary direction to achieve enhanced populations, habitat, and monitoring, increased public awareness and knowledge of otters, and sustained resource opportunities for both consumptive and non-consumptive users of this valuable furbearer. Only through careful planning and sound science will we maintain a healthy balance between otters and human interests, and manage sustained river otter populations for future generations.

MISSION, GOALS, OBJECTIVES, AND STRATEGIES

Mission: Maintain river otter populations in balance with their habitat through proper population monitoring and harvest management.

GOAL 1. Maintain sustained river otter populations within suitable habitat.

Objective 1.1. Annually monitor statewide river otter status, distribution, and population trends.

Strategies

1.1.1. Determine population status and distribution using annual furbearer survey results or other method.

1.1.2. Monitor population trends based on relative abundance estimates from annual furbearer surveys or other method.

Objective 1.2. Develop a statewide river otter population monitoring program to estimate population levels.

Strategies

1.2.1. Establish a direct-census method of determining population levels such as mark-recapture to achieve a high level of accuracy.

1.2.2 Determine population estimates for each WMU.

1.2.3. Establish a census protocol to monitor future population changes.

Objective 1.3. Develop a model to monitor population changes within each WMU or other larger unit.

Strategies

1.3.1. Estimate age- or age class-specific litter size and female reproductive potential.

1.3.2. Estimate age- or age class-specific mortality from incidental mortality or future harvest.

1.3.3. Estimate age- or age class-specific survival.

Objective 1.4. Develop a geographic information system river otter habitat suitability model for Pennsylvania.

Strategies

1.4.1. Identify and map suitable waterways for river otter occupancy.

1.4.2. Map unoccupied, but potential river otter habitat.

Objective 1.5. Manage river otter populations on public and private land for maximum wildlife benefit.

Strategies

1.5.1. Integrate river otter habitat needs into the public lands planning process.

1.5.2. Provide information and assistance to private landowners to improve river otter habitat on their lands.

GOAL 2. Minimize river otter damage complaints.

Objective 2.1. Evaluate the frequency and extent of river otter damage complaints annually.

Strategy

2.1.1. Annually survey agency staff to obtain the number of otter damage complaints received and information on type of damage.

Objective 2.2. Assess the need for public outreach and engagement regarding otter damage.

Strategy

2.2.1. Conduct a survey to determine the public's knowledge of otters and options for damage control as well as the public's desired otter population level.

2.2.2. Provide technical assistance to the public to prevent or reduce otter damage.

GOAL 3. Increase public awareness and knowledge of river otters.

Objective 3.1 Increase public awareness of river otter life history, population origins, and conservation significance in Pennsylvania.

Strategies

3.1.1 Develop a PowerPoint presentation describing river otter life history, conservation significance, and management in Pennsylvania.

3.1.2 Develop a brochure or electronic document describing the role of harvest management in maintaining a balance between otter numbers and prey resources and make it accessible through the PGC website and social media.

Objective 3.2. Develop river otter viewing opportunities and guidelines to locate otter sign.

Strategy

3.2.1. Provide guidelines to the public on how to increase chances of seeing an otter and locating otter sign.

GOAL 4. Develop guidelines to assess river otter harvest feasibility and implement a harvest management program.

Objective 4.1. Assess impacts of various harvest strategies on otter populations.

Strategies

4.1.1. Assess harvest feasibility for each WMU based on population level and habitat suitability.

4.1.2. Model affects of various harvest levels on WMU-based population objectives.

Objective 4.2. Develop river otter harvest management recommendations to achieve WMU population objectives.

Strategy

4.2.1. Establish an annual regulated trapping season for otters in WMUs with adequate population levels.

4.2.2. Reinforce or provide guidelines on how to avoid an otter capture to trappers in WMUs closed to otter trapping.

4.2.3. Develop an otter management decision matrix based on population and habitat status information to help guide regulatory action or response.

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SECTION 1: BIOLOGY

Taxonomy

Two species of river otters are recognized in the world. The Nearctic river otter (*Lontra canadensis*) is a member of the Order Carnivora, Family Mustelidae, and Genus *Lontra*. The similar-looking Neotropical river otter (*L. longicaudis*) is found in portions of Europe and Asia.

River otter taxonomy has been problematic throughout much of its early history. Newly-described taxa were based on differences in gender, age, molt stage, and pelt condition and led to confusion among scientists' species and subspecies descriptions (Melquist et al. 2003). Based on phylogenetic data analysis, Van Zyll de Jong (1987) separated Old World (Eurasian) from New World (Nearctic) otters and concluded that Nearctic otters originated in Eurasia and spread southward from the Bering Land Bridge across North America and the Panamanian Land Bridge. He also recognized Neotropical river otters as a distinct species.

Hall and Kelson (1959) recognized 19 subspecies of river otters in North America. Many other variations in subspecies divisions have been proposed. Common names for river otters in North America include northern river otter, Canadian otter, land otter, and fish otter (Toweill and Tabor 1982). In the literature, the scientific name for the North American river otter was *Lutra canadensis* prior to 1998. In 1998, Koepfli and Wayne (1998) found that genetic separation between new and old world otters was significant enough to be considered separate genera. Scientists gradually adopted this change over the next 10 years. *Lontra canadensis* is accepted as proper nomenclature for this species. Both scientific names refer to the same species, sometimes creating confusion in the literature.

Distribution

Prior to European settlement, river otters ranged throughout most of the North American continent. Otters were found in all major waterways until at least 1800. Human development and habitat changes were undoubtedly responsible for extirpation from some portions of their range. Over harvest in some areas may have resulted in local extirpation. In 1977, 71% of the otter's historical range was occupied (Deems and Pursley 1978). By 1998, 90% of the otter distribution during European settlement was filled (Fig. 1; Melquist et al. 2003).

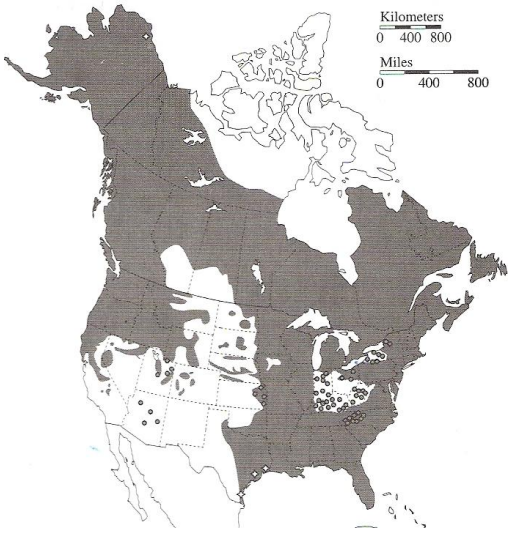

Fig. 1. North American distribution of river otters in 1998 depicted by shaded area (Melquist et al. 2003).

Today, river otters are associated with waterways and wetlands throughout North America. The primary barriers to dispersal are arid regions of southwestern North America. Mountain ranges and salt water areas can limit dispersal, but do not represent insurmountable barriers to movement

(Magoun and Valkenburg 1977). The future of wetlands and riparian areas is critical to the future status and distribution of otters in North America.

Physical description

The river otter is adapted for both land and water. Its long, cylindrical body is shaped like a torpedo reaching its greatest diameter at the thoracic region (Tarasoff et al. 1972). The head is small, blunt, and flattened with a short, wide nose. Small ears provide acute hearing, are set well back, and are closed off by anterior and posterior ridges during submersion (Pocock 1921). The eyes are small and set high on the head on a similar plane with the ears, enabling otters to swim low in the water. Otters are nearsighted, an adaptation for underwater vision. Their vision is not acute, but they can detect movement at considerable distances (Toweill and Tabor 1982). Tactile senses in river otters are highly developed. An otter's highly-sensitive whiskers behind and below the nose aid it in locating and capturing prey in murky, turbid waters and during dark nights (Melquist and Hornocker 1983). The neck is thick and rarely smaller in diameter than the head (Toweill and Tabor 1982). Like many other mustelids (members of the weasel family), otters have well-developed anal musk glands (Vaughan 1978). When frightened, these scent glands release a pungent odor.

An otter's legs are short, stocky, and powerful. The feet have five toes with inter-digital webbing and well-developed, non-retractable claws. Hind feet have heel pads with four small, rough protuberances for greater traction on slippery surfaces (Melquist and Dronkert 1987). An otter's tail accounts for about 40% of its body length (Melquist and Hornocker 1983) and is relatively long, thick, pointed, and fully-furred.

Male river otters are approximately 17% larger than females of equal age. Length and weight vary considerably among otter subspecies with a decrease in body size from north to south (Toweill and Tabor 1982), but not from west to east (Van Zyll de Jong 1972). Adults weigh 11-33 lbs (5-15 kg) with total lengths ranging from 35-54 in (89-137 cm) (Hall 1981). The average weight of males is about 25 lbs (11.3 kg), while females average 19 lbs (8.6 kg) (Deems and Pursley 1983). After 3-4 years of age, Stephenson (1977) found that maximum length is achieved and adult females showed decreased weight after 4 years.

River otter teeth are adapted for grasping, shearing, grinding, and crushing. The dental formula is incisors 3/3, canines 1/1, premolars 4/3, and molars 1/2, for a total of 36 teeth (Jones and Manning 1992). Dentition is less massive than that of the sea otter (*Enhydra lutris*). Dental anomalies, including extra premolars, have been reported (Dearden 1954), but do not appear to affect survival.

An otter pelt consists of short, dense, soft underfur protected by longer, stiff, glossy guard hairs. Air trapped within the thick underfur acts as insulation when underwater. The color of the dorsal side ranges from rich, dark chocolate brown to pale chestnut. Ventrally, the color is light brown to a silver gray. There is no significant pelage color variation between sexes, among ages, and throughout seasons of the year. Fur length, density, and to some extent color are related to climate. The more northern otters have the longest and thickest pelage (Van Zyll de Jong 1972).

Southern and western otters tend to be lighter in color than those from the north and east (Toweill and Tabor 1982).

Like other aquatic furbearers, river otters undergo only one molt each year during the summer (Ling 1970, 1984). Soon after becoming prime, the tips of guard hairs tend to curl or become "singed," decreasing the value of the river otter pelt (Obbard 1987). Otter pelts are valued because of their durability in garments. They are the standard against which other furs are rated for durability (river otters = 100% durability) (Kaplan 1974).

Reproduction and development

River otter reproductive biology and development of the young is complicated, yet intriguing. Male and female genitalia are typical of most mammals. Gender is evident even among developing embryos (Polechla 1987). Males have a penis with an ossified baculum (*os penis*). The penis is somewhat unique in vascularization and musculature among mustelids (Long 1969). An adult male otter normally possesses a well-developed baculum. The baculum increases in length until the male reaches about 3 years of age and increases in weight until about age 6 (Stephenson 1977). Testes fluctuate in size seasonally depending on level of development and sperm production. Females may develop an *os clitoridis* as they mature. This structure is cartilaginous in females less than 2 years of age, but may become ossified thereafter (Lauhachinda 1978). The uterine horns of the female become more vascularized with age. Otters have 4 mammae.

Both male and female otters do not reach sexual maturity until 2 years of age (Liers 1951, Hamilton and Eadie 1964, Tabor and Wight 1977, Lauhachinda 1978). The breeding season is typically spread over a 3-month period during late winter to early spring. The estrus period of the female lasts 42-46 days with peak receptive periods occurring every 6 days (Liers 1951). Receptive female otters may advertise their condition by marking at scent stations. Copulation normally occurs in the water, but may also occur on land, lasting up to 25 minutes (McDaniel 1963). Otter may copulate several times a day and on consecutive days (Park 1971). Melquist and Hornocker (1983) observed a radio-marked female copulating 3-4 weeks after she had given birth. The time between reproductive cycles (birth to birth) is variable. Some researchers reported annual reproduction in Oregon (Tabor and Wight 1977), Idaho (Melquist and Hornocker 1983), and Arkansas (Polechla 1987). Biannual reproduction was observed in Alabama and Georgia (Lauhachinda 1978) and Maryland (Mowbray et al. 1979). Reproduction occurred in both 1- and 2-year cycles in Arkansas (Polechla 1987) and Wisconsin (Liers 1951).

River otters undergo the process of delayed implantation as part of their reproductive cycle. Following conception, embryo development proceeds to the blastocyst stage. However, the blastocyst stops development, does not implant into the uterine wall, and floats freely in the uterus for an extended period. Photoperiod is the apparent trigger for hormonal control of the implantation process (Melquist et al. 2003). Polechla (1987) found that implantation occurred throughout river otter range when a photoperiod of approximately 10.5 hrs light: 13.5 hrs dark was reached. Delayed implantation may have an evolutionary advantage. The timing of implantation may coincide with upcoming energy-demanding reproductive events and periods of abundant food availability (Polechla 1987).

Because of delayed implantation, reported gestation periods vary considerably among researchers. The exact duration of the inactive (unimplanted) and the active (implanted) stage of pregnancy is unknown. Gestation periods ranging from 288-380 days have been reported (Liers 1951, Hamilton and Eadie 1964). River otters as well as other aquatic and semi-aquatic mammals have the longest period of delay, averaging 274 days (Ferguson et al. 1996). Growth of the embryo proceeds rapidly after implantation is complete (Huggett and Widdas 1951). The active period of pregnancy is believed to last 60-63 days (Lancia and Hair 1983).

Prior to the birthing period, females normally retreat to a pond, lake, or small tributary stream with adequate food, shelter, and isolation from disturbances. Natural shelters or burrows of other animals are often used as natal dens. Natural as well as artificial rock cavities are also used. The natal den is rarely used by the female and her offspring during other seasons (Melquist and Hornocker 1983). Female otters generally do not use the same den each year.

Litter sizes of 1-6 have been reported. However, litters of 2-3 are most common (Melquist and Dronkert 1987). Ovulation rates range from 2.4 to 3.0 eggs per female (Toweill and Tabor 1982). Lauhachinda (1978) reported a slight increase in corpora lutea production (2.4 to 3.3) from age 3-6, and then a decline to an average of 3.0 per female for otters aged 7-15. Birth of litters may occur from November through May. Peak parturition occurs during March and April across otter range (Hamilton and Eadie 1964, Tabor and Wight 1977). Wide variation in the timing of parturition is normal and may occur even within a local population.

Weighing about 4-6 ounces (120-160 g) at birth, newborn pups are black, blind, toothless, and helpless (Melquist and Dronkert 1987). Lengths of newborns range from 8-11 inches (20-28 cm). Otter milk has a high content of fat and protein, but is low in carbohydrates (Toweill and Tabor 1982). Pups grow rapidly on this diet and emerge from natal dens in 2 months. By 3 months, the young are weaned and can travel well enough to leave the natal area with the female (Melquist and Hornocker 1983). Adult males do not participate in rearing the young.

Mortality

Human activities cause the majority of river otter mortality. Habitat destruction and modification are by far the most serious sources of mortality among otters. More direct mortality factors include road accidents, accidental trapping, and trapping incidental to beaver harvest. Less common mortality sources are predation, parasites, diseases, and disorders related to water toxicity.

River otters are a relatively long-lived species. They have been known to live 14 years in the wild (Lauhachinda 1978, Brown and Parsons 1983). A 10-15 year life is the estimated longevity in the wild (Melquist and Dronkert 1987).

Habitat destruction, without exception, was the primary cause of the decline in otter numbers that led to the extirpation from nine states and one Canadian province (Deems and Pursley 1978). Habitat degradation and loss is represented in many forms. Lauhachinda (1978) attributed the disappearance of otters from parts of West Virginia, Tennessee, and Kentucky to groundwater

acidity due to mining operations. Other forms of otter habitat destruction include development of waterways for economic or recreational benefit, destruction of riparian habitat for additional farmland or building sites, and declines in water quality resulting in conditions such as increased siltation or additions of pesticide residues or other toxins associated with intensive farming practices (Melquist et al. 2003).

Because of the susceptibility of otters to pollution, this furbearer has been recognized as an indicator species for environmental health of aquatic ecosystems (Melquist and Dronkert 1987). Industrial pollutants, heavy metals, and chlorinated hydrocarbons undergo biomagnifications as they move up the food chain (Halbrook et al. 1981). Accumulation of chemical compounds is a serious threat to all upper trophic life forms, especially otters. Several recent studies have monitored levels of pollutants such as mercury (Haines et al. 2010, Spencer et al. 2011) and polychlorinated biphenyls (PCBs)(Grove and Henry 2008, Lemarchand et al. 2010) in otter tissue. Some otter population declines have been directly linked to toxins such as PCBs (Henny et al. 1981). Additive or synergistic effects of many pollutants are largely unknown.

Otters have few natural enemies. They are essentially safe from predators in the water, but are vulnerable on land. Bobcats (*Felis rufus*), dogs, coyotes (*Canis latrans*), foxes, and alligators (*Alligator mississippiensis*) have been identified as predators (Young 1958, Vallentine et al. 1972). Other predators such as mountain lions (*Felis concolor*), wolves (*Canis lupus*), black bears (*Ursus americanus*), and large raptors likely kill otters on occasion (Rosen 1975, Toweill and Tabor 1982). Most predation is directed toward young animals or adults traveling on land. No natural predator has had a serious impact on otter populations (Toweill and Tabor 1982).

River otters are susceptible to a variety of viral, bacterial, fungal, and protozoan diseases (Melquist et al. 2003). Canine distemper (Davidson 2006) and rabies (Serfass 1995) are among the more common viral diseases reported. In general, little is known about diseases in free-ranging otters.

A wide variety of ecto- and endoparasites are known to infect otters. Kimber and Kollias (2000) summarized parasite reports for river otters. They found 11 species of ectoparasites (7 species of tick, one sucking louse, one flea, and two species of beetle) and 36 species of helminth endoparasites. Infection of the nematode *Dracunculus lutrae* has been reported by trappers (Davidson 2006). The large white roundworms are coiled in the subcutaneous tissues and occasionally found by trappers while skinning otters.

Trapper harvest of otters for their fur can have a direct impact on otter populations if taking is unregulated. No state or Canadian province allowed unregulated harvest of river otters in recent history.

Food habits and foraging behavior

River otters are primarily non-selective fish eaters and are regarded as specialists at catching fish. Though their diet varies seasonally and regionally, the bulk of a river otter's diet is composed of fish. For the most part, crustaceans (primarily crawfish), reptiles, amphibians, birds, insects, and mammals are of lesser importance.

Otters normally take a wide variety of food items. However, certain patterns of fish vulnerability are evident. Predation on fish is directly proportional to their availability and inversely proportional to their swimming ability (Ryder 1955, Toweill 1974, Stenson et al.1984, Serfass et al. 1990). Toweill and Tabor (1982) offered three general concepts associated with otter prey selection: (1) otters do not select a particular species of fish when hunting, (2) slow-swimming species of fish are more vulnerable than fast-swimming species, and (3) injured or weakened fish are more vulnerable to otter predation than healthy, vigorous fish. Otters tend to select larger, less maneuverable fish. Larger fish are less able to find effective cover than smaller fish.

Catchability is a key factor in prey selection. Feeding patterns of otters essentially target abundant, slow-moving fish species that are selected more often than their abundance in the watershed would indicate (Toweill and Tabor 1982). Examples include suckers (*Catostomus* sp.), carp (*Cyprinus* sp.), chubs (*Semotilus* sp.), daces (*Rhinichthys* sp.), shiners (*Notropis* sp.), and catfishes and bullheads (*Ictalurus* sp.). Fish species found in large schools such as sunfishes (*Lepomis* sp.), darters (*Etheostoma* sp.), and perch (*Perca* sp.) are also important prey. Bottom-dwelling fish, mudminnows (*Umbra limi*) and sculpins (*Cottus* sp.) for example, are particularly susceptible to otter predation because of their habit of remaining immobile until a predator is close. Fast-moving species like trout (*Salmo* sp.) and pike (*Esox* sp.) are taken by otters in lesser quantities. Most researchers have reported these otter feeding patterns (Lagler and Ostenson 1942, Wilson 1954, Greer 1955, Ryder 1955, Sheldon and Toll 1964, Knudsen and Hale 1968, Toweill 1974, Lauhachinda 1978, Serfass et al. 1990).

Other prey items including several species of crayfish are important in an otter's diet. Several researchers found that crawfish were the dominant food item during warmer months, while fish were the primary food item during colder months (Roberts et al. 2008, DeKar et al. 2010, Stearns and Serfass 2011). Based on prey availability, DeKar et al. (2010) found that otter consumption represented a large fraction of prey production, indicating potentially strong effects of otters on the trophic dynamics of stream ecosystems in Ontario, Canada. Reptiles and amphibians, primarily frogs and snakes, are consumed (Toweill and Tabor 1982, Melquist and Hornocker 1983). Turtles are somewhat rare food items, but are taken on occasion (Toweill and Tabor 1982, Ligon and Reasor 2007).

Avian prey is important to otters in some locations. Waterfowl and rails (*Rallus* sp.) are preyed upon with some regularity (Knudsen and Hale 1968, Lauhachinda 1978) and may represent an unknown proportion of hunter-crippled birds or carrion. However, there have been observations of otters actively hunting and killing healthy birds (Cahn 1937, Meyerriecks 1963). Otters have been known to prey on chicks in coastal nest colonies with serious impacts (Verbeek and Morgan 1978, Speich and Pitman 1984).

A variety of mammals have been reported in the otter diet, but occurrence is uniformly low. Field (1970) presented evidence of otters actively hunting and capturing small mammals in the snow up to the size of a snowshoe hare. Otter predation on other furbearers is extremely uncommon (Toweill and Tabor 1982). Muskrats have been reported as food items, but contribute little to the otter diet (Wilson 1954, Melquist and Hornocker 1983). Otter predation on beavers has been reported (Green 1932). However, scat analysis and recent studies show that beavers are

not eaten by otters (Larsen 1983, Melquist and Hornocker 1983). Simultaneous use of a beaver lodge by both beavers and otters has been documented (Melquist and Hornocker 1983).

Small proportions of freshwater mussels, periwinkles, clams, and snails occur in the otter's diet, but are apparently not important (Toweill and Tabor 1982). Likewise, a wide variety of insects have been recorded in food habit studies. However, the occurrence of insects in scats or digestive tracts may be part of fish gut remains, since insects are a staple in fish diets (Toweill and Tabor 1982). Plant parts such as blueberries (*Vaccinium* sp.) and rose hips (*Rosa* sp.) have been reported (Toweill and Tabor 1982).

River otters have high metabolic rates as compared to other land mammals (Iversen 1972) and have efficient digestive systems. Liers (1951) found that otters previously fed bland foods passed exoskeletal remains of crawfish in about 1 hour after feeding.

Otters typically forage by diving and catching fish or digging in pond or stream substrate. Melquist et al. (2003) described otter foraging behavior in a variety of aquatic habitats. In shallow streams, fish are forced to seek shelter along the shoreline to avoid potential predation. Undercut banks, along submerged logs, overhanging vegetation, and other obstructions provide escape cover for fish. In exposed areas, fish quickly retreat to shelter when an otter is present and often get captured. In larger streams, otters forage in areas where fish tend to congregate such as in deep pools, logjams, and slow-moving stream sections. Otters in lakes forage along the shoreline or among boat docks. In shallow lakes and ponds, otters feed along the shoreline and capture fish by direct pursuit.

During foraging behavior observation, Melquist and Hornocker (1983) reported no evidence of cooperative hunting among otters. Beckel (1990) observed group foraging, but saw no coordinated hunting strategy. Serfass (1995) observed a group of four otters, believed to be an otter family, herd fish in a stream into the center of a pool and successfully catch two fish. He believed that this foraging behavior was a result of juvenile otters transitioning from their dependence on the female for acquiring food.

Hunting success rates of otters is poorly documented. Varley (1998) conducted a study in Yellowstone National Park and observed two female otter successfully catching fish during 37-40% of their dives in a lake. One of the otters was successful during 62% of her dives in an inlet.

Social organization, spatial distribution, and behavior

The basic river otter social group is the family unit consisting of an adult female and her juvenile offspring. Adult females spend a considerable amount of time teaching vital survival skills to pups. Social relations beyond the family group are generally uncommon. Unrelated otters typically show mutual avoidance (Melquist and Hornocker 1983). Adult males are not associated with the family group and are normally solitary.

Where food is abundant, river otters may form social groups as part of cooperative foraging in coastal areas (Blundell et al. 2002). The family unit may include one or more helpers, who may be members of a previous litter or an unrelated individual (Rock et al. 1994). Shannon (1998)

defined another social group called a clan. Composed primarily of males, clans consisting of 9-30 otters have been reported as part of cooperative foraging in marine environments (Woolington 1984, Shannon 1989, 1991, Reid et al. 1994, Rock et al. 1994, Testa et al. 1994). Females are thought to avoid joining foraging groups because of the time-consuming task of raising young (Blundell et al. 2002).

River otters are intelligent, quick, highly active, and inquisitive. Their reputation for play behavior is unmatched. In captivity, they often engage in repetitive actions such as sliding, wrestling, and retrieving or juggling inanimate objects from underwater. Play behavior is poorly documented for wild otters. Only 6% of field observations of free-ranging otters in Idaho showed play behavior and was usually associated with immature individuals, primarily juveniles (Melquist and Hornocker 1983). Playfulness may primarily be displacement behavioral in response to captive conditions (Melquist et al. 2003). Sliding over snow and ice as a means of efficient travel is common among otters. However, mud and snow slides created by repetitive use during play are rare (Mowbray et al. 1979, Melquist and Hornocker 1983).

Otters regularly communicate using their sense of smell. Olfactory communication through scent marking with feces, urine, and anal gland secretions play a significant role in intergroup communication. Scent markings apparently do not function as territorial boundaries, but are a means of advertising the presence of individuals or groups, minimizing intraspecific contact (Hornocker et al. 1983). Scent posts are maintained throughout an otter's range. Scent posts are 1-2 m^2 areas of digging and scratching without evidence of food remains, scats, or beds (Mowbray et al. 1979). Otter latrines are specific sites for defecation purposes used on a regular basis (Greer 1955). However, single scats may be deposited near scent posts, rolling areas, or structures such as logs extending into the water (Melquist and Hornocker 1979).

Otter latrine sites at or near the shoreline are somewhat prominently displayed and often consist of new and old scats that are tubular or patty-like in shape. Fresh scats are often surrounded with a jelly-like, intestinal substance. Recent scats reek of strong fish odor. Old scats often disintegrate into piles of fish scales or crawfish remains. Large rocks or waterway banks bordering deep water are common latrine locations. Otters will often roll in vegetation, then urinate and defecate on it as part of territorial marking. The same latrine sites may be used year after year.

River otters are generally nocturnal or crepuscular. Early morning activity is very common among otters throughout their range. The peak of feeding activity occurs from dawn to mid-morning (Toweill and Tabor 1982). Diurnal activity is not uncommon. Individual differences among otters and disturbance sources such as human activity may cause variations in activity patterns (Melquist and Hornocker 1983). Unlike most predators, otters do not have to synchronize foraging with prey activity. They have access to aquatic prey throughout the day and night. Melquist and Hornocker (1983) recorded greatest daily movements of family groups of otters in Idaho during the spring following snow melt and least movement during the winter when many small tributaries and ponds were covered with ice and snow.

Daily movements of single otters and family groups tend to be < 6.2 mi (10 km), but vary by season. Dispersing otters are highly mobile with recorded 1-day distances of up to 26 mi (42 km)(Melquist and Hornocker 1983).

A home range consists of the area where an animal lives, reproduces, and satisfies all of its life requirements. The shape and size of river otter home ranges depend on the distribution of suitable habitat and available food as well as on weather, topography, density, reproductive status, and season of the year (Melquist et al. 2003). Within a home range, activity is concentrated at one or more sites supplying abundant food and cover (Melquist and Hornocker 1983). Age and gender classes show varied home range sizes. Males have larger home ranges than females. Lactating females have the smallest home ranges (Melquist and Hornocker 1983). Home range overlap is very common, but mutual avoidance is typically practiced. River otters do not defend territories, but exhibit very flexible spacing strategies (Hornocker et al. 1983).

Home range sizes and densities throughout North America have been estimated using multiple methods, sample sizes, and age and gender groups making comparisons difficult (Table 1). The distribution of adequate food and shelter differ among regions. Linear and two-dimensional home ranges are also difficult to compare. Strong site attachment for activity centers which often determines seasonal home range limits may be the primary reason for the existence of otter home ranges (Melquist and Hornocker 1983).

Table 1. Home range and density estimates of river otters in North America.

State or province	Home range estimate	Density estimate	Source
Alaska	19-40 km; 9-25 km^2	1 otter/ 1.9-2.1 km	Larsen (1983)
	1-23 km	1 otter/ 1.2 km	Woolington (1984)
	20-40 km	1 otter/0.2-0.8 km	Testa et al. (1994)
			Bowyer et al. (1995)
Alberta	n/a	1 otter/ 10-17 km	Reid (1984)
Colorado	29-57 km^2	n/a	Mack (1985)
Idaho	8-78 km	1 otter/ 3.9 km	Melquist and Hornocker (1983)
Missouri	4-9 km^2	1 otter/ 4.0 km^2	Erickson et al. (1984)
	11-78 km	1 otter/ 8.0 km	Erickson et al. (1984)
Texas	2-5 km^2	1 otter/ 0.7-1.1 km^2	Foy (1984)

Otter population densities vary according to habitat suitability. The most dense otter populations occur in the least disturbed, food-rich coastal marshes and estuaries.

Habitat

River otters are able to adapt to diverse aquatic habitats. Their presence is an indicator of high quality watercourses. The availability of food, shelter, and water determines the duration and intensity of habitat use. In inland habitats, otters frequent lowland marshes and swamps interconnected with meandering streams and small lakes (Melquist and Hornocker 1983). Otters

may be common in the tributaries of major unpolluted watersheds with minimal human impact, but may be scarce in highly-disturbed and polluted watercourses (Melquist and Dronkert 1987) or in mountain streams with limited food resources (Melquist et al. 2003). Water altered by acid mine drainages do not support otters, nor their prey. During otter restoration in western Pennsylvania during 1993, acid mine pollution postponed reintroduction efforts in parts of the Youghiogheny River watershed. A blow-out of a deep mine contaminated the Casselman River, a feeder of the Youghiogheny River (Kosack 1995).

Adequate food is a key habitat component that influences otter habitat use considerably. Habitat that supports otter prey species is important. Logjams, fallen or partially-submerged trees, and other shallow water structures often provide abundant food, adequate shelter, and minimal disturbance. These types of areas have been referred to as *activity centers* because of their high frequency of use (Melquist and Hornocker 1983).

Other key habitat components are temporary dens and resting sites. Sheltered sites that provide protection and seclusion are preferred. However, otters select these sites according to availability and convenience (Melquist and Hornocker 1983). Beavers create important den sites as well as foraging areas for otters. The strong relationship between beaver habitat and use by otters has been well documented (Choromanski and Fritzell 1982, Melquist and Hornocker 1983, Reid 1984, Reid et al. 1994, Swimley et al. 1999). In Idaho, Melquist and Hornocker (1983) found that 15 radio-marked otters used active and abandoned beaver bank dens more (32%) for den and resting sites than any other site category. Beaver stick lodges accounted for 6% of selected den or resting sites. Logjams (18%) and riparian vegetation (11%) were also frequently used. They also found that dispersing otters often rested in dense riparian vegetation and snow or ice cavities. They surmised that these individuals were probably unfamiliar with the location of more suitable resting sites or because no more suitable site was available.

Two key habitat needs, availability of prey and shelter, are largely satisfied by beaver ponds. LeBlanc et al. (2007) found otter activity at beaver ponds positively associated with beaver presence, pond size, and vegetation cover in New Brunswick, Canada. They found that the dynamics of beaver pond succession (pond creation, expansion, and abandonment) created a mosaic of ponds that ultimately influenced the river otter's own pattern of habitat use and distribution.

Riparian vegetation along streams, rivers, lakes, and other wetland areas is a key component of otter habitat. Cavities along tree roots, dense shrubs, and tall grass provide escape cover and temporary resting sites. The habitat conditions created by adequate riparian vegetation and structure increase the likelihood that an area will be used (Melquist and Dronkert 1987). Otters tend to avoid watercourses with gradually-sloping shorelines of sand and gravel, such as water storage reservoirs (Melquist and Hornocker 1983, Reid et al. 1994). Bare shorelines lack escape cover and den and resting sites for otters. Structural diversity of shorelines tends to increase escape cover for prey species and makes them more available to otters (Allen 1987).

SECTION 2: HISTORIC AND CURRENT STATUS IN PENNSYLVANIA

Historic status

River otter bones were commonly found in prehistoric Native American village sites throughout Pennsylvania (Doutt et al. 1977). Otters historically occurred in every major watershed statewide. During 1894, Rhoads (1903) reported viable otter populations in the heavy-populated counties of Chester, Delaware, Philadelphia, and Bucks as well as unpolluted glacial lakes and tidewater streams. Unlike beavers, wolves, and panthers, he believed otters escaped extirpation because of their nocturnal activity patterns and extreme wariness.

The combined effects of habitat destruction, water pollution, and unregulated harvest caused the extirpation of river otters from most of Pennsylvania by the early to mid-1900s. Noxious stream conditions were produced by drainage from tanneries, mines, oil wells, chemical works, factories, and foundries beginning in the 1800s (Rhoads 1903). Deteriorating water quality quickly eliminated fish and other aquatic life from Pennsylvania's waterways. The last recorded otter in the Allegheny River was in 1899; the last in Pymatuning Swamp was in 1908 (Doutt et al. 1977). In 1952, the Pennsylvania Game Commission (PGC) closed otter trapping season.

River otters were never completely extirpated from Pennsylvania. The Pocono region always supported otters, especially the counties of Wayne, Pike, and Monroe (Doutt et al. 1977; Eveland 1978).

Population recovery

Nationwide, 21 states implemented river otter reintroduction projects during 1976-1998, releasing 4,018 river otters (Raesly 2001). Based on various forms of direct and circumstantial evidence, Raesly (2001) found that most reintroductions were considered successful in restoring extirpated otter populations.

During 1982-2004, the Pennsylvania River Otter Reintroduction Project, headed by Dr. Thomas Serfass, established stable, self-sustaining river otter populations in Pennsylvania. The program reintroduced 153 river otters successfully to eight water systems in central and western Pennsylvania (Fig. 2). The effort was comprised of five developmental and implemental stages: 1) site selection, 2) identification and selection of appropriate sources and numbers of animals, 3) veterinary care, captive management, and translocation, 4) public relations and education, and 5) post-translocation monitoring and evaluation (Serfass et al. 1993, Hubbard and Serfass 2004). A successful, ecologically-based, and publicly-supported reintroduction project resulted from the carefully planned effort.

States conducting reintroduction projects obtained otters from a variety of sources. Raesly (2001) surveyed state agency biologists and found that most (64%) states released at least some otters originating from coastal Louisiana as part of their reintroduction programs. In Pennsylvania, released otters originated from Louisiana, Maryland, Michigan, New Hampshire, New Jersey, New York, and the native Pennsylvania population (Serfass et al. 1993).

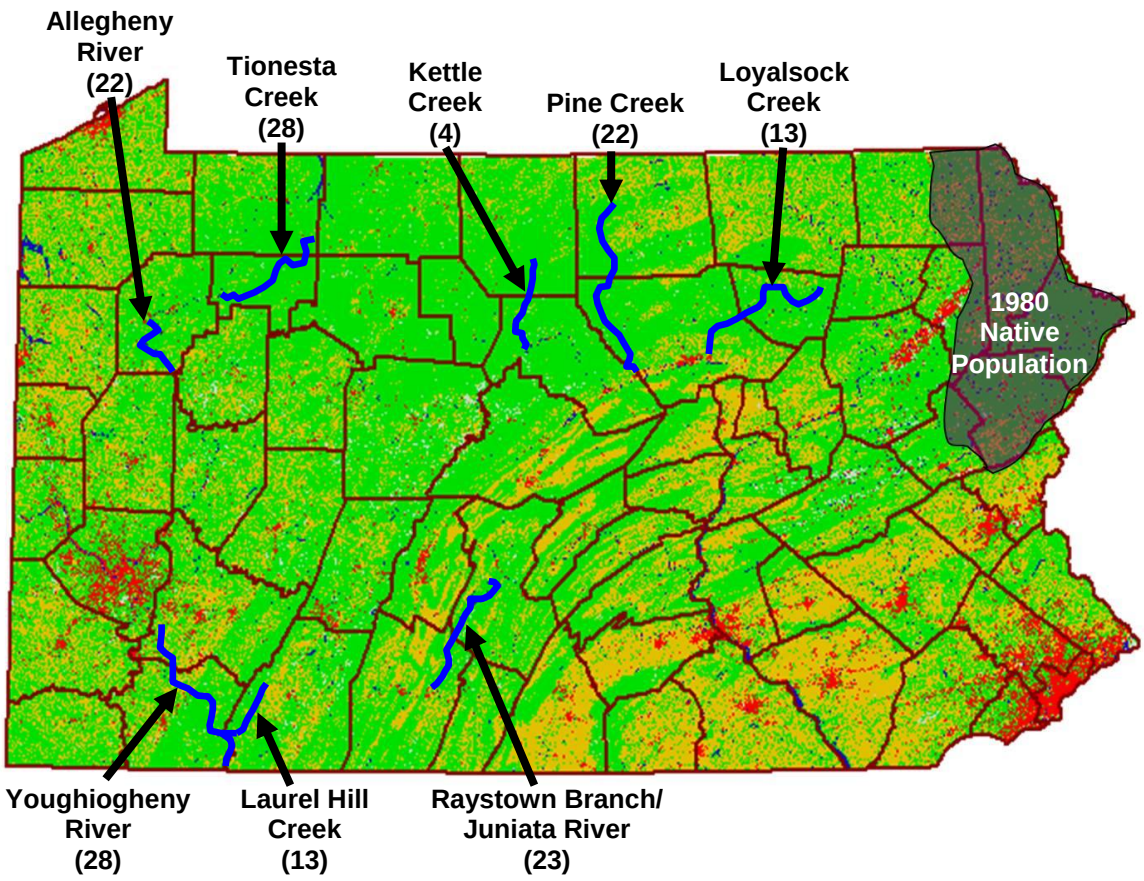

Fig. 2. Pennsylvania river otter reintroduction sites and number of otters released (in parentheses) during 1982-2004.

Pennsylvania's otter population has been protected and growing for over 30 years after otter restoration was initiated. Restoration efforts, range expansion of native population, and influx from Ohio, New York, and Maryland restoration efforts lead to successful population recovery.

Population monitoring

We currently use a combination of population indices such as accidental capture frequency and local status and distribution field surveys to monitor otter populations. Since no harvest season for otters exists in Pennsylvania, mortality information is collected from records of accidental captures, highway accidents, and mortalities resulting from damage control and illegal take. Based on records of 211 otter carcasses collected during 1996-2009, most reported mortality was a result of accidental captures (69%) and highway accidents (24%)(Fig. 3). A very small proportion (2%) of otter mortality was attributed to damage control measures and illegal take.

As river otter populations expanded throughout the Commonwealth, reports of accidental otter captures have steadily increased. Otters are typically captured in foothold or body-gripping traps set for raccoons or beavers. Some are released at the capture site by trappers or local wildlife

conservation officers. Otter mortalities usually associated with body-gripping sets occur occasionally during beaver trapping and are not always avoidable.

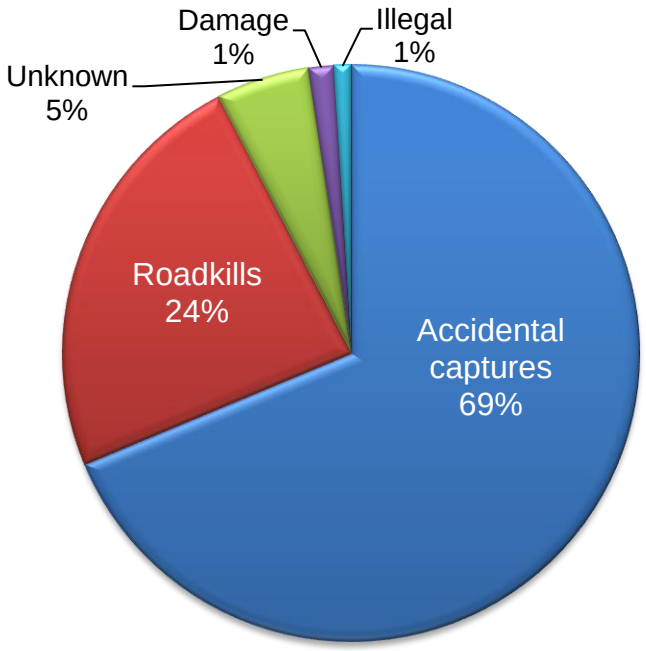

Fig. 3. Causes of river otter mortality during 1996-2009 in Pennsylvania (n=211).

Reports of accidental otter captures provide annual trends in relative density and distribution. Two independent survey mechanisms, the annual Furtaker Survey (Appendix 1) and the annual Wildlife Conservation Officer furbearer questionnaire (Appendix 2), are currently used to monitor accidental otter captures. These techniques are not designed to provide complete counts of these captures, but rather to monitor temporal trends in otter abundance and distribution.

The annual Furtaker Survey is a mail questionnaire sent to approximately 20% of licensed furtakers to assess harvest levels for various furbearers. Furtakers are asked to report the number and WMU locations of otters captured incidentally in traps set for other furbearers. There has been a general increase in the numbers of otters captured during the past 5 years (Table 2). If the number of otters captured per trapper is extrapolated to include all furtakers, the estimated number of captured otters averages 138 each year during the 2007-2011 furtaker seasons.

WMU 3C, located in the northeast corner of PA within sustained otter range, has the greatest number of incidental captures, averaging 37 each year (Fig. 4). Trappers in the northwestern WMUs, 1B and 2F, consistently catch an estimated average of 16 and 14 incidental otter each year, respectively. In central Pennsylvania, trappers sporadically catch incidental otters from WMUs 4D and 4E. The estimated mean incidental catch is 11 otters annually from these units. Lesser and more sporadic incidental otter captures occur in the remaining WMUs.

Table 2. Estimated number of river otters captured during the past 5 trapping seasons based on mail surveys sent to approximately 20% of licensed furtakers.

Season	Survey respondents	Furtakers	Otter captures reported by survey respondents	Estimated total otter captures
2007-08	2,994	28,033	7	66
2008-09	2,622	29,717	12	136
2009-10	3,186	31,110	14	137
2010-11	4,421	35,267	24	191
2011-12	3,609	36,187	16	160

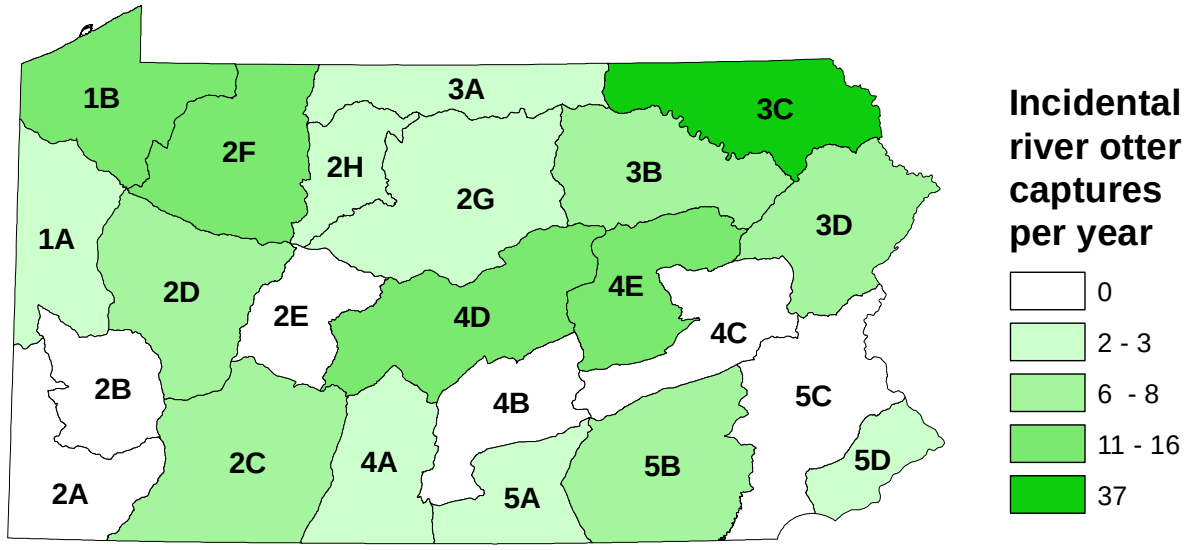

Fig. 4. Spatial distribution of the average number of river otter incidental captures per year during 2007-2012 among WMUs, estimated from Furtaker mail survey results.

Furbearer questionnaires are mailed annually to all Wildlife Conservation Officers (WCOs) to collect a variety of furbearer information. Accidental captures of otters during the previous calendar year were reported by WCOs via this survey. This second measure of otter accidental captures shows an increasing linear trend during 1995-2011 (Fig. 5). There was little or no change in beaver trapping effort during the same period. Numbers of accidental otter captures, primarily by beaver trappers, have increased with greater than 25 captures reported annually since 1996 (Fig. 5).

Starting in 2001, we attempted to minimize incidental captures of river otters by publishing capture avoidance guidelines in our Hunting and Trapping Digest. Body-gripping trap trigger configurations, snare loop sizes, and trap site locations to avoid otter captures were key topics covered in this attempt to change beaver trapline habits. This educational effort likely reduced incidental otter captures. We believe that the increasing trend in incidental otter captures depicted in Figure 5 relates more to otter range expansion and increasing population density than

to any other factor. We expect the trend in incidental otter captures to stabilize or slightly increase as the use of otter capture avoidance techniques are used more widely.

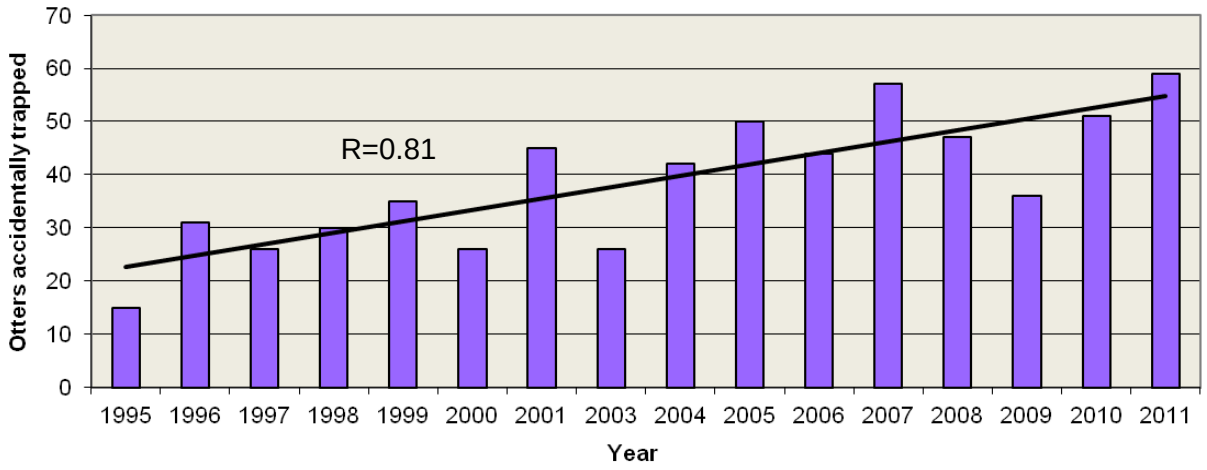

Fig. 5. Statewide river otter accidental captures recorded by Wildlife Conservation Officers in annual furbearer questionnaires. Incidental capture information was not collected during 2002.

Current status and distribution

As part of WCO furbearer surveys, we annually ask WCOs to report the status of otter populations within their local districts. In 1995, otters were absent in 51% of WCO districts. In 2011, otters were absent in only 10% of WCO districts. The maps in Figure 6 depict the change in otter distribution and population status during 1995 and 2010 within 137 Pennsylvania WCO districts. The solid blue areas represent occupied river otter range in Figure 6. In 1995, otters ranged over 49% of WCO districts. In 2010, otters occurred within 87% of WCO districts.

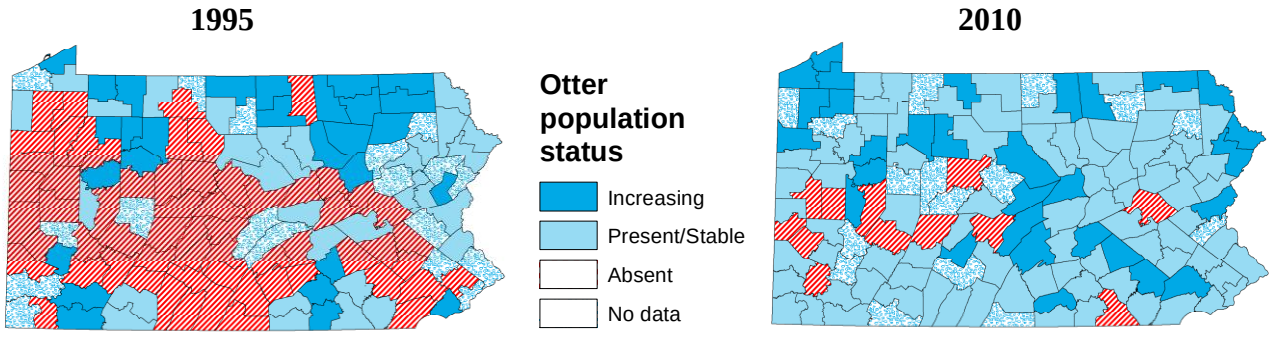

Fig. 6. Pennsylvania river otter distribution and population status in 1995 and 2010 based on surveys of Wildlife Conservation Officers. Subdivisions represent Wildlife Conservation Officer district boundaries.

During 2010, field officers reported that otter populations were well established throughout Pennsylvania except for scattered WCO districts primarily in the southern half of Pennsylvania.

All data suggest that otter populations are currently increasing in density and expanding geographically throughout Pennsylvania. Otter populations occupy all major river systems. The Delaware, Susquehanna, Allegheny, and Youghiogheny Rivers support sustained otter populations and act as travel corridors from which new populations disperse and expand geographically. The Potomac and Lake Erie watersheds maintain less dense populations, but continue to increase in otter numbers annually.

SECTION 3: RESOURCE AND ECONOMIC VALUES

Resource value

River otters have been an economically important furbearer species since the Europeans first arrived in North America. Over 11,000 otter pelts were shipped from Canada to London by the Hudson Bay Company in 1873 (Rhoads 1903). Fur values at the turn of the twentieth century ran as high as $10-12 per pelt (Rhoads 1903). During the fur boom in the 1920s, otter pelts sold for an average of $31 (Deems and Pursley 1983). Market values decreased during subsequent decades, and generally followed inflation rates thereafter. Annual harvest reached about 50,000 pelts during the late 1970s (Deems and Pursley 1978). Higher harvest totals appeared to correlate with higher pelt prices.

The value of regulated river otter trapping as an outdoor activity and tradition is difficult to quantify. For most trappers, there is no single motive driving their participation. Recreation, challenge, outdoor experience, and similarly-phrased reasons are identified as primary motivators (Bailey 1981, Boddicker 1981, Marshall 1981, Samuel and Bammel 1981). Income from trapping is less important to trappers, but fur values profoundly affect trapper numbers, trapping effort, and harvest for most furbearer species (Erickson and Sampson 1978, Erickson 1981).

Over the years, otter pelts have been and continue to be widely used in the garment industry. Use of otter pelts varies from natural long hair to sheared and dyed garments (Ethier 2003). When plucked, otter pelts are never sheared (Schipper 1987). Fashions are unpredictable, but drive the world demand for pelts. World markets for otter pelts frequently fluctuate and correspondingly change the price paid for pelts at local markets. Proper pelt handling and preparation as well as pelt primeness, size, and characteristics determine prices paid.

Due to new technologies in the dressing process and new world markets, otter pelts tend to bring a higher dollar value now than in the recent past. Northeastern states and Canadian provinces reported otter pelt prices averaging $60.68 over the past 5 years and $67.82 over the past 10 years (Northeast Furbearer Resources Technical Committee, pers. commun., 2012). River otter pelts sold for an average of $86.34 at the January 2013 Fur Harvesters Auction in North Bay, Ontario. Prices are expected to hold at current levels or increase.

Because otter have specialized requirements and are large in size, raising them in captivity on a fur farm was never a profitable venture (Toweill and Tabor 1982). Some individuals in parts of Europe and Asia maintain otters as pets, but this practice never became popular in North America.

Damage management

River otters may cause severe depredation problems in and around fish hatcheries. Serfass et al. (1990) found that 10 of 21 fish hatcheries surveyed in Pennsylvania experienced losses due to otter depredation. Small farm ponds and other confined watercourses supporting high densities of fish are most susceptible to predation problems. In isolated cases, economic loss can be

significant (Serfass et al. 1990). Concentrated otter food sources will always run a high risk of repeat visitation from otters that have experienced easy-to-catch prey.

Since 2010, we annually monitor river otter damage complaints from WCO records. On the furbearer questionnaire (Appendix 2), officers were asked to report nuisance complaints received from the public. During 2009, officers documented 7 complaints, 10 complaints in 2010, and 19 complaints in 2011. We expect nuisance complaints to continue to increase as otter densities increase and range expansion occurs.

Although otters are often blamed for depredation on game fish populations, the bulk of the otter's diet is non-game fish. Fish most easy to catch typically fall prey to otters. In some instances, trout, especially stocked trout, are abundant and easy to catch. Like any predator, otters will seek prey items requiring the least amount of energy expenditure.

Otters have been accused of preying on beavers (Green 1932) and muskrats (Wilson 1954). However, studies of otter predation on other furbearers have found this behavior to be extremely unusual (Toweill and Tabor 1982).

SECTION 4: POPULATION MANAGEMENT

Management approaches

River otter management programs throughout North America have taken one or both of two general approaches or management phases: conservation and population regulation (Melquist and Dronkert 1987). First, conservation of river otters may involve an attempt to increase the numbers of a small or declining population. Second, population regulation involves an effort to achieve a sustained yield (harvest). As part of population regulation, damage control may be necessary to stabilize or reduce the density of an otter population that is too dense or has an unacceptable rate of increase. In general, the need to decrease otter populations is rare, except for isolated depredation problems.

Successful river otter restoration efforts require proper planning, execution, and post-release monitoring. Ninety percent of historical North American otter range was occupied by 1998, primarily as a result of successful restoration efforts (Melquist et al. 2003). In Pennsylvania, otter translocations were successful and contributed greatly to establishing self-sustaining and growing otter populations. Population monitoring is an ongoing effort that will continue indefinitely. Since the conservation phase of otter management in Pennsylvania has concluded, we are now ready to enter the population regulation phase of management.

Population and harvest management

The U.S. Fish and Wildlife Service recently offered general advice for the export of river otter from the United States in a 19 September 2012 memorandum from the chief of the Division of Scientific Authority to the chief of the Division of Management Authority (Appendix 3). The recommendation was that the export of otters taken in states with open harvest seasons for river otter will not be detrimental to the survival of the species. This advice also applies to states opening otter harvest seasons for the first time.

River otters are included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) due to the similarity of this species to other endangered otter species included in the CITES Appendices. The U.S. Fish and Wildlife Service regulates and monitors the export of otter pelts from the U.S. State agencies generally use a combination of monitoring methods best-suited for their conditions to gain information on otter population status within their jurisdiction.

Of the 49 states that otters inhabit, 37 manage a regulated otter harvest season (Fig. 7). Twelve states currently have closed otter seasons with three states listing otters as state threatened. Pennsylvania, Rhode Island, and Indiana are the only eastern states with a closed harvest season for river otters. Where regulated harvest is permitted, regulations consist of restrictions on harvest season length, harvest methods, and bag limits. Harvest quotas are used in some states as well as mandatory reporting requirements.

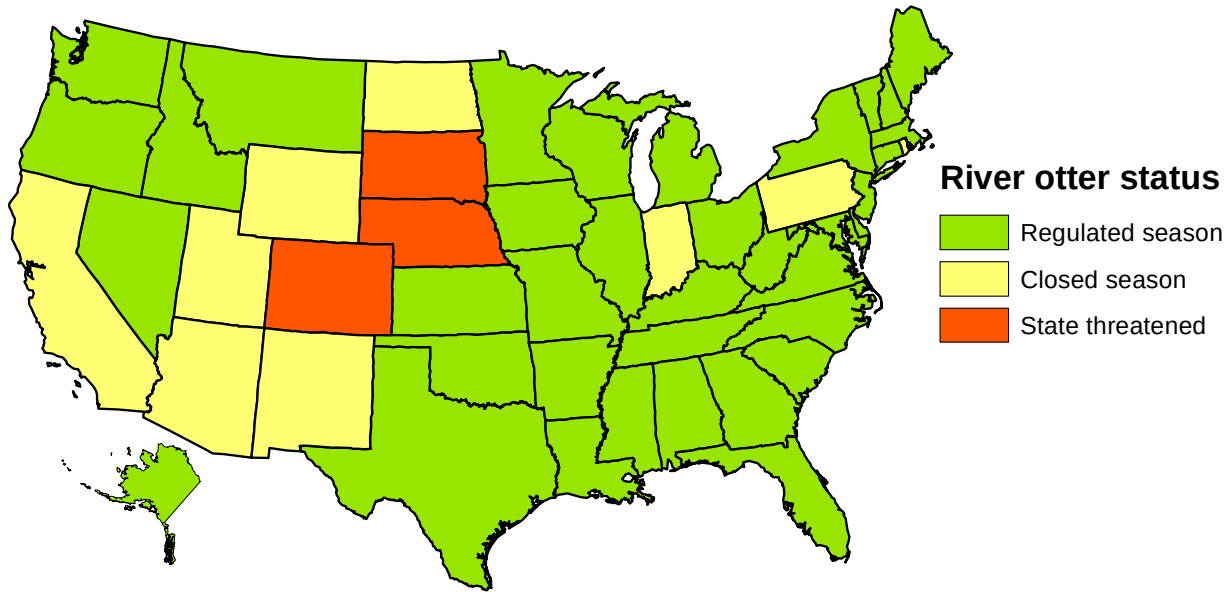

Fig. 7. River otter harvest status or state designation in 2012.

Population monitoring

Wildlife agencies developed otter monitoring programs in part to satisfy CITES reporting requirements. Before otter export tags are issued, states must first show that an otter harvest season will not be detrimental to the resident population. A variety of indices are used to monitor population trends. Census techniques including abundance questionnaires, harvest analysis, scat and track surveys, carcass analysis, and radiotelemetry and radioisotope studies are used to collect population information (Melquist et al. 2003). There is no single, widely-accepted method of monitoring the relative abundance of otter populations.

The types of data needed to adequately indicate status of a furbearer population ideally include harvest level, catch per unit effort, age-specific pregnancy rates, litter size, and survival (Dixon 1981). Because of the otter's secretive nature, use of various den sites, high mobility, and variable spacing in relation to prey density and habitat, simple and reliable methods of determining otter population status have yet to be developed.

The distribution and presence of otters in an area can be determined through field surveys by searching for tracks, scats, and other sign. Although population densities do not appear to correlate with the amount of otter sign observed (Melquist and Hornocker 1983), these indirect measures of otter occurrence are useful as trend indicators. Foy (1984) found that an increase in sign during early spring was not due to changes in density but to variations in habitat and behavior. Similarly, Stevens and Serfass (2008) found that the largest peak in latrine visitation occurred just prior to and during the breeding season (February-March) in Pennsylvania and Maryland. Using remote cameras, they recorded single otters making 59% of documented latrine visits. Most (87%) visits occurred at night and most (64%) lasted <1 min.

Sign surveys such as winter track count, bridge sign, and scent station surveys provide indices of otter occurrence. Aerial winter track surveys for otters in the snow can be a reliable method of monitoring distribution. However, poor snow conditions and inclement weather can prohibit aerial surveys and limit the usefulness of this technique as a population index. Melquist and Dronkert (1987) cautioned that otter densities may not correlate with the amount of sign observed. Where winter snow conditions are consistently favorable for conducting aerial track surveys, this method is useful.

Swimley et al. (1998) used latrine surveys to document otter occurrence and identified variables (vertical banks, rock formations, points of land, backwater sloughs, tributary streams, and beaver bank dens, lodges, or ponds) as predictors of otter latrine sites, making survey work more efficient in Pennsylvania. Sign survey guidelines have been established (Robson 1982) and used in conjunction with road bridge surveys to increase cost efficiency. Monitoring scent stations or latrine sites annually in the same area over the same period can be used as an index of distribution (Foy 1984). Scent station visitation can be influenced by seasonal changes in behavior and habituation to scent (Robson 1982, Robson and Humphrey 1985).

Sign surveys near bridge crossings have become popular among monitoring techniques. These riparian surveys are not suitable in roadless areas, but are one of the most practical and economical method of detecting otter presence. Improvement to bridge-sign survey methodologies is an on-going effort. Jeffress et al. (2011) suggested that sign surveys may be flawed when conducted only once and cover short distances. They found that mean detection probabilities varied by substrate, observer experience, and survey length. Otter sign was not concentrated near access points. When survey distance was increased from 200 m to 1,000 m, a nearly 3-fold increase in detection probability was observed. After accounting for imperfect detection, their estimates of otter site occupancy based on a 400-m survey increased >3-fold. Stevens et al. (2011) concluded that monitoring the presence of river otters based on searching for latrines at bridge or random sites was considerably less effective than by using prior selection of surveys areas based on riparian habitat features.

The accuracy of otter track survey data is largely dependent on reliability of field observers. Evans et al. (2009) found that experienced observers misidentified 37% of otter tracks. In addition, 26% of tracks from species determined to be "otter-like" were misidentified as otter tracks. They recommended that observer skill in identification of animal tracks and other indirect signs be measured to detect and reduce observer errors in wildlife monitoring.

Most researchers recommend combining sign survey indices with results from other forms of otter population monitoring. In Missouri, Roberts et al. (2011) recommended that in addition to bridge-sign surveys, managers should use at least one other measure (catch-per-unit-effort or mark-recapture) in order to monitor the long-term relative abundance of otters.

Harvest monitoring

In addition to river otter population monitoring results, states with CITES approval must annually submit harvest data and number of pelts tagged to the U.S. Fish and Wildlife Service. The CITES export tag requirement for each pelt provides a mechanism for monitoring

characteristics of the harvest and population trends (indirectly) as well as helping to prevent overharvest (Melquist et al. 2003).

Melquist et al. (2003) noted that harvest data have some limitations. Harvest information alone is generally a poor short-term indicator of abundance, distribution, and status. Annual changes in the harvest may reflect changes in abundance, but are often influenced by weather conditions, pelt price, prey abundance cycles, economics, and other factors (Hamilton and Fox 1987). When harvest data are collected over long periods of time, they are more reliable in depicting general trends in abundance and distribution (Obbard et al. 1987).

State agencies have the ability to regulate the harvest to ensure that otter populations are not adversely affected by regulated trapping. Trapping season length and area-specific bag limits or quotas assist in controlling the harvest and preventing any negative impact. A harvest model used in Minnesota suggested that a 15-17% harvest (including a 10% poaching factor) of the fall population maintained stable otter numbers (Melquist et al. 2003). To address the issue of otters being trapped incidental to beaver trapping, many states hold otter and beaver seasons concurrently. A legal otter harvest increases the biological data available for use in population monitoring. Regulated harvest helps wildlife agencies deal with depredation problems at fish hatcheries and private ponds. Conover (2011) surmised that if hunting or trapping were to end, some wildlife populations would increase, animals would become more habituated to humans, wildlife damage would increase, and landowner tolerance for wildlife would decrease.

Two of the most effective, direct measures of otter abundance are trapper catch-per-unit-effort (number of otters caught per trap night) and capture-mark-recapture. These removal methods of population estimation offer a direct means of estimating numbers. Since otters are difficult to observe and count, but there is a reasonable chance of capturing them, models for estimating populations sizes using capture information are prudent (Lancia et al. 2005). Indirect measures of these methods such as number of animals seen per day or number of marked animals observed are sometimes used as indices to population abundance.

Long-term harvest data in conjunction with other population indicators are important for proper monitoring (Erickson 1982). Adjustments for various external biases that influence harvest success such as pelt price changes and weather conditions are necessary (Melquist and Dronkert 1987).

Population growth

Mortality and natality information is needed for reliable interpretation of harvest data. Population models used to estimate recruitment and predict harvest must include estimates of birth and death rates (Melquist and Dronkert 1987). Basic measures of reproductive output and population age structure are necessary prerequisites to effective otter management.

Where harvest occurs and/or carcasses are available, litter size can be assessed primarily by examination of reproductive tracts. Corpora lutea counts derived from ovary analysis provide evidence of litter size throughout pregnancy. However, these counts do not reflect intrauterine losses. Examination of the uterus is useful after conception and during the delayed implantation

period, before blastocysts implant in the uterine wall. Blastocysts can be counted when flushed from the oviducts and uterus. Placental scars are not easily identified on the uterine wall, as is the case with most furbearers exhibiting delayed implantation (Payne 1982). Fetal counts offer the simplest and most accurate method of determining litter size. Accuracy is increased when these counts are made as close to parturition as possible. Because most otter trapping seasons occur prior to late-stage pregnancy, fetal examination is often not possible from harvested samples (Melquist and Dronkert 1987). After litter size has been estimated, pregnancy rate can be obtained from reproductive tract examination and an estimate of fecundity can be calculated.

Age and gender ratios are important in determining reproductive rates. Otters examined from the harvest tend to show male gender bias. Gender ratios favoring males is common among river otter studies (Melquist and Hornocker 1983). The greater number of males in harvested samples is attributed to differences in trapping vulnerability. Males travel more, have larger home ranges, and, therefore, have a high probability of capture (Melquist and Dronkert 1987).

Reproductive performance can be affected by variations in the gestation period, sex ratio, breeding age, and survivability. Population density and habitat conditions also influence reproduction. Harvest management must ensure that a reproductively viable population exists.

Aging techniques

Several physical characteristics have been used to estimate age of otters. Growth characteristics of the baculum and testes of males and development of the female reproductive tract are useful in determining sexual maturity (Hamilton and Eadie 1964, Polechla 1987). Various other methods using body size, skull characteristics, eye lens weight, and skeletal features have been used with limited accuracy (Melquist et al. 2003).

The most reliable and useful technique for determining age of otters is examination of dental characteristics and number of annuli present in tooth cementum (Toweill and Tabor 1982). Juvenile otters lack cementum annuli. However, they can be separated from adults using tooth pulp cavity closure measurements. The ratio of the pulp cavity width to the entire canine tooth width is greater than or equal one half in juveniles (Kuehn and Berg 1983). Adults are most accurately aged from cementum annuli counts. Wild-caught otters have been aged at up to 17 years old using tooth cementum analysis (G. Matson, pers. commun., 2013).

Management guidelines for Pennsylvania

We completed our attempts to increase a small or nonexistent population of river otters through recovery efforts in Pennsylvania. In a few, isolated streams, water quality issues remain, slowing otter re-occupancy. However, the majority of the historic statewide otter range has been reestablished. The river otter recovery efforts of concerned biologists and state agencies were a success. Viable otter populations have been established in areas where they were once extirpated.

Our otter management mission is to maintain stable otter populations in balance with their habitat for the benefit of other wildlife species and humans through proper monitoring, population management, and damage control. The goals of Pennsylvania's river otter

management are to (1) maintain sustained otter populations within suitable habitat, (2) minimize otter damage complaints, (3) increase public awareness and knowledge of the benefits of otters and their habitat, and (4) provide opportunities to use and experience otters.

In order to maintain river otter populations on a sustained basis in suitable habitat, we must continue our current population monitoring activities [Objective 1.1] and annually determine otter status, distribution, and population trend. Our annual WCO Furbearer Questionnaire is our instrument to monitor annual status and distribution [Strategy 1.1.1] as well as estimate relative abundance [Strategy 1.1.2] on a local level. This survey should continue to be conducted annually in order to gather trend information.

River otter populations are difficult to monitor and information on densities is lacking throughout their range. Continued monitoring of Pennsylvania's otter population is critical to ensure long-term sustainable use of this furbearer. A highly regulated otter harvest is feasible in Pennsylvania. However, in the absence of a regulated harvest, a combination of population indices should be used to monitor otter populations in Pennsylvania. Estimating otter population numbers is difficult due to this furbearer's elusive nature and capture difficulty. However, new monitoring techniques such as using fecal DNA to conduct a mark-recapture analysis for estimating otter abundance have recently been developed (Mowry et al. 2011). Population density estimates would be superior to trends in population indices. Other DNA-based population estimates of river otters are available such as sampling otter hair.

We would like a more robust population monitoring method that would estimate population levels or densities [Objective 1.2]. Mowry et al. (2011) estimated otter population density using fecal DNA to identify individual otters using mark-recapture analysis. They calculated an otter population density of 0.24 otters/km for their Missouri study area. Faculty and students from the Pennsylvania Cooperative Fish & Wildlife Research Unit at Penn State University are currently investigating this fecal DNA technique and developing a statewide monitoring program to estimate otter population levels in Pennsylvania. Once this direct-census method is established [Strategy 1.2.1], we will expand this monitoring effort to include all WMUs. We will be able to estimate population densities on a WMU-basis [Strategy 1.2.2]. We will use this census protocol to monitor future population changes [Strategy 1.2.3].

Using a combination of population indices and population estimates, WMU-based management recommendations can be developed. WMU-based population goals and harvest feasibility should be established as otter populations continue to expand. Harvest strategies can be implemented and assessed in specific WMUs based on monitoring results.

The change in the abundance of a population in response to a management action can be detected in basic measures of population parameters. Population change is often viewed as a result of mortality, reproduction, immigration, and emigration. The development of a population model requires estimates of these demographic parameters. We need to monitor otter population changes within each WMU by developing a population model using the best demographic measures available [Objective 1.3].

Sustained reproduction is critical for population stability. Measures of reproductive performance and litter size including counts of corpora lutea, blastocysts, placental scars, and fetuses are useful in estimating fecundity. Natality and recruitment are key reproductive parameters in monitoring populations. Most northeastern states and eastern Canadian provinces routinely collect this type of information as part of annual monitoring (Appendix 4). Those jurisdictions that examine otter carcasses from harvested, incidentally taken, or road-killed otters monitor age, sex, and reproductive status.

Crimmins et al. (2011) evaluated the success of restoration efforts in Missouri by examining age-specific reproductive capacity. They collected 387 harvested female otter carcasses during 1996-1999 and found mean annual corpora lutea counts of 2.48. They concluded that the southern Missouri river otter population had one of the greatest potential reproductive capacities recorded for that species.

We need to determine the basic reproductive parameters (litter size, age at first reproduction, reproductive rate) of river otter populations within each WMU [Strategy 1.3.1]. In absence of a regulated harvest, fecundity information on otters will be difficult to determine. We have little data on litter size and age at first reproduction and whether these parameters differ among WMUs.

We should also continue to monitor mortality by collecting otter carcasses that have resulted from lethal captures incidental to beaver trapping, highway accidents, damage control activities, and other sources [Strategy 1.3.2]. By determining age, we can obtain basic information on survival also [Strategy 1.3.3].

Information on otter habitat suitability is lacking or outdated. The Pennsylvania GAP Analysis Project (Myers et al. 2000) outlined potential habitat for river otters in 2000 (Fig. 8). Water quality has improved over the past 13 years and an updated suitability map for river otters is needed [Objective 1.4].

We should obtain water quality information from the PA Department of Environmental Protection and fisheries information from the PA Fish and Boat Commission to define suitable waterways for river otters [Strategy 1.4.1]. We should also map potential, but unoccupied otter habitat [Strategy 1.4.2] to help identify any waterways where range expansion is possible. Since water quality issues are under the jurisdiction of other agencies, we should cooperate with their ongoing efforts to improve stream conditions in watersheds potentially suited to otters.

River otters occur on public and private lands throughout Pennsylvania. We should manage otter populations on public and private lands [Objective 1.5] by including their habitat needs in habitat management efforts. Otter habitat needs should be incorporated in the state game lands planning process as well as in planning processes conducted by the PA Department of Conservation of Natural Resources, PA Fish and Boat Commission, Allegheny National Forest, National Park Service, and other agencies managing public lands [Strategy 1.5.1]. We should provide private landowners with information and technical assistance to improve otter habitat on their lands [Strategy 1.5.2].

Although few damage complaints are currently recorded each year, we should monitor and attempt to minimize otter damage complaints [Objective 2.1]. Annual monitoring of otter complaints via the WCO Furbearer Questionnaire should continue. We should expand upon this survey by requesting more detailed information concerning each otter damage complaint from WCOs [Strategy 2.1.1].

We should evaluate the need for public education with regard to river otter damage complaints [Objective 2.2]. We should conduct a survey to determine the public's knowledge of river otters, their behavior, options for damage control, and desired population levels [Strategy 2.2.1]. We should also provide technical assistance to the public to prevent or reduce otter damage problems.

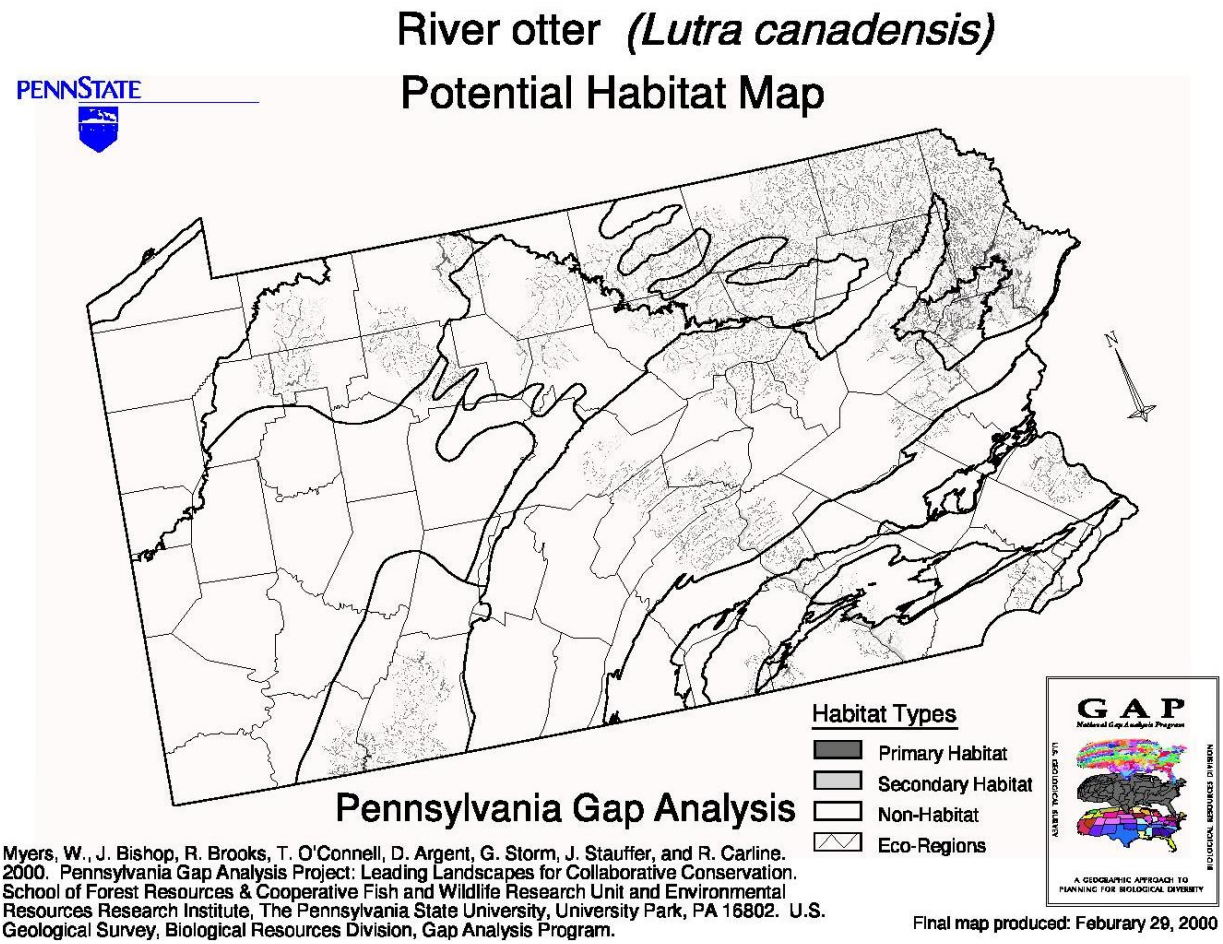

Fig. 8. Potential river otter habitat in 2000 determined from Pennsylvania GAP Analysis (Myers et al. 2000).

In an effort to make the public more knowledgeable and more aware of otter life history, conservation significance, and management in PA [Objective 3.1], we should develop an up-to-date PowerPoint presentation [Strategy 3.1.1]. To describe the role of harvest management in

maintaining a balance between otter numbers and prey resources, we should develop an informational brochure for public distribution [Strategy 3.1.2].

Where appropriate, we should develop river otter viewing opportunities and guidelines to locate otter sign [Objective 3.2]. Because of their secretive behavior and nocturnal habits, river otter sightings are considered rare events. Latrine sites, pathways, slides, tracks, and other sign observed along a watercourse provide key evidence of otter presence in an area. We should provide the public with guidelines on how they might increase their chances of seeing an otter or locating otter sign [Strategy 3.2.1].

We should provide both consumptive and non-consumptive use river otter opportunities for the public. We need to assess the impacts of various harvest strategies on otter populations and develop guidelines to assess the feasibility of a river otter harvest [Objective 4.1]. The harvest feasibility in each WMU should be assessed using population status and abundance information and habitat suitability data [Strategy 4.1.1]. We should also model the affects of different harvest levels on population objectives established within each WMU.

We need to implement a harvest management program that will establish recommendations to achieve WMU population objectives [Objective 4.2]. If populations in specific WMUs can withstand a limited, highly-regulated harvest, we should establish a taking season for otters in those areas [Strategy 4.2.1]. Population levels within harvest areas must be able to sustain a limited harvest on an annual basis. We can model our harvest strategies using information and experiences from regulated take programs administered in eastern states.

In an effort to continue to educate and reinforce trapping practices recommended to avoid otter captures in areas closed to otter trapping [Strategy 4.2.2], we should develop outreach materials targeted specifically at beaver trappers. The following guidelines should be incorporated into our outreach materials: Beaver trappers must be alert and recognize otter sign in order to minimize any chance of accidental otter capture. Since otters have such a wide distribution in Pennsylvania, trappers should use otter avoidance techniques wherever they set beaver traps. Trappers should use baited sets for beavers and avoid making “blind” sets in main channels, bank dens, crossover locations, or near dams. If 330 body-gripping traps are used, triggers should be shortened and positioned off of center. Trappers should attempt to catch beavers in an area quickly and move to a new area. They should not leave beaver traps set in an area after 3-5 days without trapping success, hoping to catch the few remaining beavers. Modifying beaver trapping techniques to avoid otter capture is an important step in otter conservation.

A highly-regulated otter harvest is feasible in Pennsylvania. As part of preparations needed to implement a harvest season, we should develop an otter management decision matrix to help guide regulatory action or response (Table 2) [Strategy 4.2.3]. We need to develop WMU-based management recommendations using a combination of population monitoring information and habitat suitability. Some measure of water quality and/or prey abundance would represent habitat capacity. Otter population trend and/or density information would represent biological capacity.

Plan implementation

The goals, objectives, and strategies of this management plan provide guidance and direction as we seek to fulfill our mission. A timetable for completion of objectives and supporting strategies is depicted in Appendix 5. Agency personnel from many organizational divisions will be required to help implement strategies and complete objectives. Their involvement in assisting to complete these tasks is also summarized in Appendix 5.

Table 2 . Possible river otter management decision matrix depicting regulatory action or response based on population density within suitable habitat and habitat.

	Conditions within a Wildlife Management Unit	**Habitat capacity** Water quality/prey abundance in WMU: Suitable stream quality in ≥ 90% of watercourses	Suitable stream quality in < 90%, but ≥75% of watercourses	Suitable stream quality in < 75% of watercourses
Biological capacity Population trend or density in WMU	Stable or increasing populations	REGULATED HARVEST *- Standard Season* *- Bag Limit = 1* *- Mandatory Reporting* *- Carcass Collection*	RESTRICTED HARVEST *- Quota-based Season* *- Bag Limit = 1* *- Mandatory Reporting* *- Carcass Collection*	NO HARVEST
	Population poorly established	NO HARVEST	NO HARVEST	NO HARVEST
	Population not established	NO HARVEST	NO HARVEST	NO HARVEST

LITERATURE CITED

Allen, A.W. 1987. The relationship between habitat and furbearers. Pages 164-179 *in* M. Novak, J. Baker, M. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association, Ontario, Canada.

Bailey, T.N. 1981. Characteristics, trapping techniques, and views of trappers on a wildlife refuge in Alaska. Pages 1904-1918 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Beckel, A.L. 1990. Foraging success rates of North American river otters, Lutra canadensis, hunting alone and hunting in pairs. Canadian Field-Naturalist 104:586-588.

Blundell, G.M., M. Ben-David, and R.T. Bowyer. 2002. Sociality in river otters: cooperative foraging or reproductive strategies? Behavioral Ecology 13:134-141.

Boddicker, M.L. 1981. Profiles of American trappers and trapping. Pages 1919-1949 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Bowyer, R.T., J.W. Testa, and J.B. Faro. 1995. Habitat selection and home ranges of river otters in a marine environment: effects of the Exxon Valdez oil spill. Journal of Mammalogy 76:1-11.

Brown, M.K., and G.R. Parsons. 1983. Otter management in northern New York: preliminary results. Transactions of the Northeast Section of the Wildlife Society 40:96.

Cahn, A.R. 1937. The mammals of the Quetico Provincial Park of Ontario. Journal of Mammal Research 18:19-30.

Choromanski, J.F., and E.K. Fritzell. 1982. Status of the river otter (Lutra canadensis) in Missouri. Transactions of the Missouri Academy of Sciences 16:43-48.

Conover, M.R. 2001. Effect of hunting and trapping on wildlife damage. Wildlife Society Bulletin 29:521-532.

Crimmins, S.M., N.M. Roberts, and D.A. Hamilton. 2011. Age-specific reproductive rates of river otters in southern Missouri. Southeastern Naturalist 10:501-508.

Davidson, W.R. 2006. Field manual of wildlife diseases in the southeastern United States. Southeastern Cooperative Wildlife Disease Study, Third edition, University of Georgia, Athens, Georgia, USA.

Dearden, L.C. 1954. Extra premolars in the river otter. Journal of Mammal Research 35:125-126.

Deems, E.F., Jr., and D. Pursley. 1978. North American furbearers, their management, research and harvest status in 1976. International Association of Fish and Wildlife Agencies, USA.

Deems, E.F., Jr., and D. Pursley. 1983. North American furbearers: a contemporary reference. First edition. International Association of Fish and Wildlife Agencies, USA.

DeKar, M.P., D.D. Magoulick, and J. Beringer. 2010. Bioenergetics assessment of fish and crayfish consumption by river otter (*Lontra canadensis*): integrating prey availability, diet, and field metabolic rate. Canadian Journal of Fisheries and Aquatic Sciences 67:1439-1448.

Dixon, K.R. 1981. Data requirements for determining the status of furbearer populations. Pages 1360-1373 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Doutt, J.K., C.A. Heppenstall, and J.E. Guilday. 1977. Mammals of Pennsylvania. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Erickson, D.W. 1981. Furbearer harvest mechanics: an examination of variables influencing fur harvests in Missouri. Pages 1469-1491 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Erickson, D.W. 1982. Estimating and using furbearer harvest information. Pages 53-65 *in* G.C. Sanderson, ed. Midwest furbearer management. Proceedings of the Symposium of the 43rd Midwest Fish and Wildlife Conference, Wichita, Kansas, USA.

Erickson, D.W., and F.W. Sampson. 1978. Impact of market dynamics on Missouri's furbearer harvest system. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 32:17-29.

Erickson, D.W., C.R. McCullough, and W.R. Porath. 1984. River otter investigations in Missouri: evaluation of experimental river otter reintroductions. Final report, Missouri Department of Conservation Federal Aid Project Number W-13-R-38, Study Number 63, Job Number 2.

Ethier, Y. 2003. Regarding otter. International Trapper 11:17-20.

Evans, J.W., C.A. Evans, J.M. Packard, G. Calkins, and M. Elbroch. 2009. Determining observer reliability in counts of river otter tracks. Journal of Wildlife Management 73:426-432.

Eveland, T. 1978. The status, distribution, and identification of suitable habitat of river otters in Pennsylvania. M.S. Thesis. East Stroudsburg University, East Stroudsburg, Pennsylvania.

Ferguson, S.H. J.A. Virgl, and S. Lariviere. 1996. Evolution of delayed implantation and associated grade shifts in life history traits of North American carnivores. Ecoscience 3:7-17.

Field, R.J. 1970. Winter habits of the river otter (*Lutra canadensis*) in Michigan. Michigan Academy of Sciences 3:39-58.

Foy, M.K. 1984. Seasonal movement, home range, and habitat use of river otter in southeast Texas. M.S. Thesis, Texas A&M University, College Station, Texas, USA.

Green, H.U. 1932. Observations on the occurrence of the otter in the Riding Mountain National Park, Manitoba, in relation to beaver life. Canadian Field-Naturalist 46:204-206.

Greer, K.R. 1955. Yearly food habits of the river otter in the Thompson Lakes region, northwestern Montana, as indicated by scat analysis. American Midland Naturalist 54:299-313.

Grove, R.A. and C.J. Henry. 2008. Environmental contaminants in male river otters from Oregon and Washington, USA, 1994–1999. Environmental Monitoring and Assessment 145:49-73.

Haines, K.J.R., R.D. Evans, M. O'Brien, and H.E. Evans. 2010. Accumulation of mercury and selenium in the brain of river otters (*Lontra canadensis*) and wild mink (*Mustela vison*) from Nova Scotia, Canada. Science of The Total Environment 408:537-542.

Halbrook, R.S., J.H. Jenkins, P.B. Bush, and N.D. Seabolt. 1981. Selected environmental contaminants in river otters (*Lutra canadensis*) of Georgia and their relationship to the possible decline of otters in North America. Pages 1752-1762 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Hall, E.R. 1981. The mammals of North America. Second edition, John Wiley, New York, New York, USA.

Hall, E.R., and K.R. Kelson. 1959. The mammals of North America. Ronald Press, New York, USA.

Hamilton, D.A., and L.B. Fox. 1987. Wild furbearer management in the midwestern United States. Pages 1100-1116 *in* M. Novak, J. Baker, M. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association, Ontario, Canada.

Hamilton, W.J., Jr., and W.R. Eadie 1964. Reproduction in the otter, *Lutra canadensis*. Journal of Mammal Research 45:242-252.

Henny, C.J., L.J. Blus, S.V. Gregory, and C.J. Stafford.1981. PCBs and organochlorine pesticides in wild mink and river otters from Oregon. Pages 1763-1780 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Hornocker, M.G., J.P. Messick, and W.E. Melquist. 1983. Social strategies in three species of Mustelidae. Acta Zoologica Fennica 174:185-188.

Hubbard, B. and Serfass, T. 2004. Assessing the distribution of reintroduced populations of river otters in Pennsylvania (USA); development of a landscape-level approach. International Union for the Conservation of Nature and Natural Resources Otter Specialist Group Bulletin 21(2): 60-65.

Huggett, A. St. G., and W.F. Widdas. 1951. The relationship between mammalian foetal weight and conception age. Journal of Physiology 114:306-317.

Iversen, J.A. 1972. Basal energy metabolism of mustelids. Journal of Comparative Physiology 81:341-344.

Jeffress, M.R., C.P. Paukert, B.K. Sandercock, and P.S. Gipson. 2011. Factors affecting detectability of river otters during sign surveys. Journal of Wildlife Management 75:144-150.

Jones, J.K., Jr., and R.W. Manning. 1992. Illustrated key to skulls of genera of North American land mammals. Texas Tech Univ. Press, Lubbock, Texas, USA.

Kaplan, D.G. 1974. World of furs. Fairchild Publications, New York, New York, USA

Kimber, K.R. and G.V. Kollias. 2000. Infectious and parasitic diseases and contaminant related problems of North American river otters (*Lontra canadensis*): a review. Journal of Zoo and Wildlife Medicine 31:452-472.

Knudsen, K.F., and J.B. Hale 1968. Food habits of otters in the Great Lakes region. Journal of Wildlife Management 32:89-93.

Koepfli, K.-P., and R.K. Wayne. 1998. Phylogenetic relationships of otters (Carnivora: Mustelidae) based on Mitochondrial *b* sequences. Journal of Zoology. 246:401-416.

Kosack, J. 1995. The Pennsylvania Game Commission 1895-1995, 100 years of wildlife conservation. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Lagler, K.F., and B.T. Ostenson. 1942. Early spring food of the otter in Michigan. Journal of Wildlife Management 6:244-254.

Lancia, R.A. and J.D. Hair. 1983. Population status of bobcat (*Felis rufus*) and river otter (*Lutra canadensis*) in North Carolina. North Carolina State University, Project E-1, Raleigh, North Carolina, USA.

Lancia, R.A., W.L. Kendall, K.H. Pollock, and J.D. Nichols. 2005. Estimating the number of animals in wildlife populations. Pages 106-153 *in* C.E. Braun, ed. Techniques for wildlife investigations and management. The Wildlife Society, Bethesda, Maryland, USA.

Larsen, D.N. 1983. Habitats, movements, and foods of river otters in coastal southeastern Alaska. M.S. Thesis, University of Alaska, Fairbanks, Alaska, USA.

Lauhachinda, V. 1978. Life history of the river otter in Alabama with emphasis on food habits. Ph.D. Dissertation, Auburn University, Auburn, Alabama, USA.

LeBlanc, F.A., D. Gallant, L. Vasseur, and L. Léger. 2007. Unequal summer use of beaver ponds by river otters: influence of beaver activity, pond size, and vegetation cover. Canadian Journal of Zoology 85:774–782.

Lemarchand, C., R Rosoux, and P. Berny. 2010. Organochlorine pesticides, PCBs, heavy metals and anticoagulant rodenticides in tissues of Eurasian otters (*Lutra lutra*) from upper Loire River catchment (France). Chemosphere 80:1120-1124.

Liers, E.E. 1951. Notes on the river otter (*Lutra canadensis*). Journal of Mammal Research 32:1-9.

Ligon, D.B., and J. Reasor. 2007. Predation on alligator snapping turtles (*Macrochelys temminckii*) by northern river otters (*Lontra canadensis*). The Southwestern Naturalist 52:608-610.

Ling, J.K. 1970. Pelage and molting in wild mammals with special reference to aquatic forms. Quarterly Review of Biology 45:16-54.

Ling, J.K. 1984. Epidermal cycles and moulting in marine mammals. Acta Zoologica Fennica 171:23-26.

Long, C.A. 1969. Gross morphology of the penis in seven species of mustelidae. Mammalia 33:145-160.

Mack, C. 1985. River otter restoration in Grand County, Colorado. M.S. Thesis, Colorado State University, Fort Collins, Colorado, USA.

Magoun, A.J. and Valkenburg, P. 1977. The river otter (*Lutra canadensis*) on the north slope of the Brooks Range, Alaska. Canadian Field-Naturalist 91:303-305.

Marshall, A.D. 1981. Characteristics of Georgia trappers. Pages 2004-2008 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

McDaniel, J.C. 1963. Otter population study. Proceedings of the Southeastern Association of Fish and Game Commissioners 17:163-168.

Melquist, W.E., and A.E. Dronkert. 1987. River otter. Pages 627-641 *in* M. Novak, J. Baker, M. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association, Ontario, Canada.

Melquist, W.E. and M.G. Hornocker. 1979. Methods and techniques for studying and censusing river otter population (Technical Report 8). Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho, USA.

Melquist, W.E. and M.G. Hornocker. 1983. Ecology of river otters in west central Idaho. Wildlife Monographs 83.

Melquist, W.E., P.J. Polechla, and D. Toweill. 2003. River otter. pages 708-734 *in* G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Second edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

Meyerriecks, A.J. 1963. Florida otter preys on common gallinule. Journal of Mammal Research 44:425-426.

Mowbray, E.E., D. Pursley, and J.A. Chapman. 1979. The status, population characteristics and harvest of the river otter in Maryland (Publications on Wildlife Ecology No. 2). Maryland Wildlife Administration.

Mowry, R.A., M.E. Gompper, J. Beringer, and L. Eggert. 2011. River otter population size estimation using noninvasive latrine surveys. Journal of Wildlife Management 75:1625-1636.

Myers, W., J. Bishop, R. Brooks, T. O'Connell, D. Argent, G. Storm, J. Stauffer, and R. Carline. 2000. Pennsylvania gap analysis project: leading landscapes for collaborative conservation. School of Forest Resources & Cooperative Fish and Wildlife Research Unit and Environmental Resources Research Institute, The Pennsylvania State University, University Park, Pennsylvania, USA.

Obbard, M.E. 1987. Fur grading and pelt identification. Pages 717-826 *in* M. Novak, J. Baker, M. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association, Ontario, Canada.

Payne, N.F. 1982. Assessing productivity of furbearers. Pages 39-50 *in* G.C. Sanderson, ed. Midwest furbearer management. Proceedings of the Symposium of the 43rd Midwest Fish and Wildlife Conference, Wichita, Kansas, USA.

Park, E. 1971. The world of the otter. J.B. Lippincott, New York, USA.

Pocock, R.I. 1921. On the external characteristic of some species of Lutrinae (otters). Proceedings Zoological Society of London 3:535-546.

Polechla, P.J. 1987. Status of the river otter (*Lutra canadensis*) population in Arkansas with special reference to reproductive biology. Ph.D. Dissertation, University of Arkansas, Fayetteville.

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

Reid, D.G. 1984. Ecological interactions of river otters and beavers in a boreal ecosystem. M.S. Thesis, University of Alberta, Calgary, Alberta, Canada.

Reid, D.G., T.E. Code, A.C.H. Reid, and S.M. Herrero. 1994. Spacing, movements, and habitat selection of the river otter in boreal Alberta. Canadian Journal of Zoology 72:1314-1324.

Rhoads, S.N. 1903. The mammals of Pennsylvania and New Jersey. Privately published, Philadelphia, Pennsylvania, USA.

Roberts, N.M., C.F. Rabeni, J.S. Stanovick, and D.A. Hamilton. 2008. River otter, *Lontra canadensis*, food habits in the Missouri. Canadian Field-Naturalist 122:303-311.

Roberts, N.M., S.M. Crimmins, D.A. Hamilton, and E. Gallagher. 2008. An evaluation of bridge-sign surveys to monitor river otter (*Lontra canadensis*) populations. American Midland Naurtalist 160:358-363.

Robson, M.S. 1982. Monitoring river otter populations: scent station vs. sign indices. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Robson, M.S., and S.R. Humphrey. 1985. Inefficacy of scent-stations for monitoring river otter populations. Wildlife Society Bulletin 13:558-561.

Rock, K.P., E.S. Rock, R.T. Bowyer, and J.B. Faro. 1994. Degree of association and use of a helper by coastal river otters, *Lutra canadensis*, in Prince William Sound, Alaska. Canadian Field-Naturalist 108:367-369.

Rosen, M. 1975. Bald eagle and river otter. Canadian Field-Naturalist 89:455.

Ryder, R.A. 1955. Fish predation by the otter n Michigan. Journal of Wildlife Management 19:497-498.

Samuel, D.E., and L.L. Bammel. 1981. Attitudes and characteristics of independent trappers and National Trappers' Association members in West Virginia. Pages 2021-2036 *in* J.A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Frostburg, Maryland, USA.

Schipper, S.S. 1987. Garment manufacturing. Pages 878-888 *in* M. Novak, J. Baker, M. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association, Ontario, Canada.

Serfass, T.L., R.L. Peper, M.T. Whary, and R.P. Brooks. 1993. River otter (Lutra canadensis) reintroduction in Pennsylvania: prerelease care and clinical evaluation. Journal of Zoo and Wildlife Medicine 24:28-40.

Serfass, T.L. 1995. Cooperative foraging by North American river otters, *Lutra canadensis*. Canadian Field-Naturalist 109:458-459.

Serfass, T.L., L.M. Rymon, and R.P. Brooks. 1990. Feeding relationships of river otters in northeastern Pennsylvania. Transactions of the Northeastern Section of the Wildlife Society 47:43-53.

Shannon, J.S. 1989. Social organization and behavior ontogeny of otters (Lutra canadensis) in coastal habitat in northern California. International Union for the Conservation of Nature and Natural Resources Otter Specialist Group Bulletin 4:8-13.

Shannon, J.S. 1991. Progress on Californian otter research. International Union for the Conservation of Nature and Natural Resources Otter Specialist Group Bulletin 6:24-31.

Shannon, J.S. 1998. Behaviour of otters in a marine coastal habitat: summary of work in progress. International Union for the Conservation of Nature and Natural Resources Otter Specialist Group Bulletin 15:114-117.

Sheldon, W.G., and W.G. Toll. 1964. Feeding habits of the river otter in a reservoir in central Massachusetts. Journal of Mammalogy 45:449-455.

Speich, S.M., and R.L. Pitman. 1984. River otter occurrence and predation on nesting marine birds in the Washington Islands wilderness. Murrelet 65:25-27.

Spencer, S.H., D. Shutler, and M.S. O'Brien. 2011. Correlates of mercury in female river otters (*Lontra canadensis*) from Nova Scotia. Environmental Toxicology and Chemistry 30:1879-1884.

Stearns, C.R., and T.L. Serfass. 2011. Food habits and fish prey size selection of a newly colonizing population of river otters (*Lontra canadensis*) in eastern North Dakota. American Midland Naturalist 165:169-184.

Stenson, G.B., G.A. Badgero, and H.D. Fisher. 1984. Food habits of the river otter *Lutra canadensis* in the marine environment of British Columbia. Ph.D. Dissertation, University of British Columbia, Vancouver, Canada.

Stephenson, A.B. 1977. Age determination and morphological variation of Ontario otters. Canadian Journal of Zoology 55:1577-1583.

Stevens, S.S., E.H. Just, R.C. Cordes, R.P. Brooks, and T.L. Serfass. 2011. The influence of habitat quality on the detection of river otter (*Lontra canadensis*) latrines near bridges. American Midland-Naturalist 166:435-445.

Stevens, S.S., and T.L. Serfass. 2008. Visitation patterns and behavior of Nearctic river otters (*Lontra canadensis)* at latrines. Northeastern Naturalist 15: 1-12.

Swimley, T.J., T.L. Serfass, R.P. Brooks, and W.M. Tzilkowski. 1998. Predicting river otter latrine sites in Pennsylvania. Wildlife Society Bulletin 26:836-845.

Swimley, T.J., R.P. Brooks, and T.L. Serfass. 1999. Otter and beaver interactions in the Delaware Water Gap National Recreation Area. Journal of the Pennsylvania Academy of Science 72:98-101.

Tabor, J.E., and H.M. Wight 1977. Population status of river otter in western Oregon. Journal of Wildlife Management 41:692-699.

Tarasoff, F.J., A. Basaillon, J. Pierard, and A.P. Whitt. 1972. Locomotory patterns and external morphology of the river otter, sea otter, and harp seal (Mammalia). Canadian Journal of Zoology 50:915-929.

Testa, J.W. D.F. Holleman, R.T. Bowyer, and J.B. Faro. 1994. Estimating populations of marine river otters in Prince William Sound, Alaska, using radio-tracer implants. Journal of Mammalogy 75:1021-1032.

Toweill, D.E. 1974. Winter food habits of river otters in western Oregon. Journal of Wildlife Management 38:107-111.

Toweill, D.E., and J.E. Tabor. 1982. River otter. pages 688-703 *in* J.A. Chapman and G.A. Feldhamer, editors. Wild mammals of North America: biology, management, and economics. First edition, Johns Hopkins University Press, Baltimore, Maryland, USA.

Vallentine, J.M., Jr., J.R. Walther, K.M. McCartney, and L.M. Ivy. 1972. Alligator diets on the Sabine National Wildlife Refuge, Louisiana. Journal of Wildlife Management 36:809-815.

Van Zyll de Jong, C.G. 1972. A systematic review of the Nearctic and Neotropical river otters (Genus *Lutra*, Mustelidae, Carnivora). Royal Ontario Museum, Life Sciences Contributions 80:1-104.

Van Zyll de Jong, C.G. 1987. A phylogenetic study of the Latrinae (Carnivora; Mustelidae) using morphological data. Canadian Journal of Zoology 65:2536-2544.

Varley, N. 1998. Yellowstone's river otters: enigmatic water weasels. Yellowstone Science 6:15-18.

Vaughan, T.A. 1978. Mammalogy. W.B. Saunders Company, Philadelphia, Pennsylvania, USA.

Verbeek, N.A.M., and J.L. Morgan. 1978. River otter predation on glaucous-winged gulls on Mandarta Island, British Columbia. Murrelet 59:92-95.

Wilson, K.A. 1954. The role of mink and otter as muskrat predators in northeastern North Carolina. Journal of Wildlife Management 18:199-207.

Woolington, J.D. 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska, M.S. Thesis, University of Alaska, Fairbanks, Alaska, USA.

Young, S.P. 1958. The bobcat of North America. Wildlife Management Institute, Washington, D.C., USA.

APPENDIX 1. Furtaker survey randomly distributed to approximately 20% of fur hunters and trappers annually.

2011-2012 PENNSYLVANIA FURTAKER SURVEY

PART I

1. Did you trap or hunt furbearers in 2011-2012 (Please "check" (✓) one)? ☐ **YES** → Please continue below. ☐ **NO** → Please return survey in envelope provided.

PART II

HARVEST RECORD: Please record: 1) Wildlife Management Unit (WMU) in which you trapped or hunted; 2) number of days or nights that you trapped or hunted in each WMU; 3) average number of traps that you set each night; 4) and number of animals harvested for each WMU. **Even if you did not successfully harvest a species, please record the WMU in which you trapped or hunted.**

		First WMU	# days or nights trapped or hunted	Average number of traps set per night	Harvest	Second WMU	# days or nights trapped or hunted	Average number of traps set per night	Harvest	Third WMU	# days or nights trapped or hunted	Average number of traps set per night	Harvest
RACCOON	Trapped												
	Hunted												
RED FOX	Trapped												
	Hunted												
GRAY FOX	Trapped												
	Hunted												
COYOTE	Trapped												
	Hunted												
MUSKRAT	Trapped												
OPOSSUM	Trapped												
MINK	Trapped												
SKUNK	Trapped												
BEAVER	Trapped												
WEASEL	Trapped												

1. If you trapped and released any **BOBCATS** during the 2011-2012 season, please provide the following information for each WMU where this occurred (DO NOT INCLUDE BOBCATS LEGALLY HARVESTED WITH A PERMIT):

   1st WMU _____ NUMBER _____ 2nd WMU _____ NUMBER _____ 3rd WMU _____ NUMBER _____

2. If you trapped and released any **FISHERS** during the 2011-2012 season, please provide the following information for each WMU where this occurred (DO NOT INCLUDE FISHERS LEGALLY HARVESTED WITH A PERMIT):

   1st WMU _____ NUMBER _____ 2nd WMU _____ NUMBER _____ 3rd WMU _____ NUMBER _____

3. If you trapped and released any **OTTERS** during the 2011-2012 season, please provide the following information for each WMU where this occurred:

   1st WMU _____ NUMBER _____ 2nd WMU _____ NUMBER _____ 3rd WMU _____ NUMBER _____

APPENDIX 2. Furbearer questionnaire mailed annually to Wildlife Conservation Officers.

2011-2012 Furbearer Questionnaire

All questions pertain to furbearer information within your district during May 2011 to April 2012. If you are new to this district or cannot answer these questions, please submit this form anyway (leaving unknown answers blank) or forward it to the WCO who previously occupied or covered your district. Please do not answer "many" or "several" to questions asking "How many?" Give us your best estimates. **Please note that these types of questions will be asked annually**.

Instructions: Click on the **blue underline** or table box to enter text. Click on the **check box** (☐) to select or deselect that response. Press **Tab** to advance or click on the next entry field.

District No. _____ WCO Name _____

WMU	Number of beaver complaints

Beavers

1. How many beaver complaints were serviced within each WMU in your district? →
2. How many problem beavers did you trap and transfer to a new location? _____
3. How many problem beavers did you dispatch/euthanize? _____
4. How would you describe beaver populations in your district?

Beaver populations are present each year and are ... ☐ *increasing,* ☐ *decreasing,* ☐ *stable*

or

Beaver populations are not present each year and are ... ☐ *poorly established,* ☐ *nonexistent*

River Otters

5. How many river otters were accidentally caught by trappers within your district? _____
6. How would you describe river otter populations in your district?

Otter populations are present each year and are ... ☐ *increasing,* ☐ *decreasing,* ☐ *stable*

or

Otter populations are not present each year and are ... ☐ *poorly established,* ☐ *nonexistent*

Fishers

7. How many reliable reports of fishers have you received in your district? _____
8. How many fishers were accidentally caught by trappers in your district? _____
9. How would you describe fisher populations in your district?

Fisher populations are present each year and are ... ☐ *increasing,* ☐ *decreasing,* ☐ *stable*

or

Fisher populations are not present each year and are ... ☐ *poorly established,* ☐ *nonexistent*

Bobcats

10. How would you describe bobcat populations in your district?

Bobcat populations are present each year and are ... ☐ *increasing,* ☐ *decreasing,* ☐ *stable*

or

Bobcat populations are not present each year and are ... ☐ *poorly established,* ☐ *nonexistent*

(continued on next page)

APPENDIX 2 (cont.). Furbearer questionnaire mailed annually to Wildlife Conservation Officers.

Coyotes

11. Did you receive any coyote-related complaints during this period? ☐ *Yes* ☐ *No*

If you received coyote complaints, please record the type and number of complaints and animals killed. Omit any complaints that the Bureau of Dog Law Enforcement (PA Dept of Agriculture) serviced.

Number of Coyote **Complaints**:		Number of **Animals Killed** by Coyotes:	
_____	Cattle	_____	Cows
_____	Sheep	_____	Calves
_____	Goats	_____	Sheep/Lambs
_____	Poultry/Waterfowl	_____	Goats
_____	Attacked Dogs	_____	Poultry/Waterfowl
_____	Attacked Cats	_____	Dogs
_____	Afraid of Coyotes	_____	Cats
_____	Chased/Attacked Deer	_____	Rabbits
_____	Chased/Attacked Wild Turkey	_____	Deer
_____	Other _____	_____	Other _____

Nuisance Complaints

12. If you received nuisance complaints concerning other furbearer species, how many occurred in your district?

Number of Complaints:					
_____	Bobcat	_____	River Otter	_____	Raccoon
_____	Fisher	_____	Mink	_____	Opossum
_____	Fox	_____	Muskrat	_____	Skunk
_____	Weasel			_____	Other furbearer _____

Other Mammals - Porcupines

13. How many porcupine complaints did you receive in your district during the past year? _____

14. Approximately how many dead porcupines did you see along roadways within your district? _____

15. How would you describe porcupine populations in your district?

Porcupine populations are present each year and are ... ☐ *increasing,* ☐ *decreasing,* ☐ *stable*

- **or** -

Porcupine populations are <u>not</u> present each year and are ... ☐ *poorly established,* ☐ *nonexistent*

Thank you for your cooperation and assistance!

Please return this questionnaire to your regional wildlife management supervisor and other appropriate supervisors as an e-mail attachment.

APPENDIX 3. U.S. Fish and Wildlife Service memorandum excerpt offering general advice for the export of river otter from the United States.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

SEP 19 2012

MEMORANDUM

To: Chief, Division of Management Authority

From: Chief, Division of Scientific Authority Rosemarie Gnam

Subject: General advice for the export of river otter (*Lontra canadensis)* from the United States, (2012-2013 through 2017-2018 harvest seasons)

This general advice supersedes the "Advice for the export of river otter (*Lontra canadensis)* from States and Tribes with open harvest seasons (2011-2012 through 2012-2013 harvest seasons)," dated March 6, 2012.

The North American river otter (*Lontra canadensis*) occurs throughout the United States and Canada. In the United States, the species inhabits all 49 of the States within its historic range. Currently, 36 States and 13 Tribes have each been approved for the export of river otter pelts under the CITES Export Program (CEP). Of the States that currently have a regulated trapping season for river otter, all States have been approved except Nevada, which has not requested approval. The available information suggests that the species is secure in the United States and tribal trust lands and that the States and Tribes are managing the species sustainably. Therefore, we advise that the export of river otter (*Lontra canadensis)* taken in States with open harvest seasons for river otter will not be detrimental to the survival of the species. In addition to States that currently have open harvest seasons for river otter, this advice also applies to States opening otter harvest seasons for the first time; however, it does not include States with closed seasons that wish to export pelts of otter that were killed by other means (eg., road kills or kills incidental to beaver harvest). We will consider such requests separately on a State-by-State basis.

This finding is valid through the 2017-2018 harvest season unless we receive additional information on the species' status or management suggesting this finding should be modified. We will continue to monitor the status of river otter populations in the wild and will update our finding in 2018 based on new information gathered during the 2012 to 2018 time period.

APPENDIX 4. River otter population and harvest monitoring methods used by northeastern jurisdictions in North America during 2012.

Jurisdiction	Population monitoring			Harvest determination methods
	Methods	Biological data sources	Biological data types collected	
Connecticut		Harvest carcasses	Age, sex, reprod. status, body condition	Pelt tagging
Delaware	Hunter survey Sighting reports			Mail survey
Maine				Pelt tagging
Maryland	Hunter survey			Furbuyer records
Massachusetts	Roadkills Sighting reports			Mail survey Pelt tagging
New Brunswick	Roadkills	Incidental take	Age, sex, reprod. status, other methods	Furbuyer records
New Hampshire				Furbuyer records Trapper reports
New Jersey	Roadkills Sighting reports Other methods		Age, sex, reprod. status, body condition	Pelt tagging
New York	Roadkills Sighting reports Bridge surveys		Age, sex, reprod. status, body condition	Mail survey Pelt tagging
Newfoundland		Harvest carcasses		Pelt tagging Furbuyer records Trapper reports
Nova Scotia	Hunter survey	Harvest carcasses	Age Sex Reproductive status	Furbuyer records Trapper reports
Ontario	Plot/Transect surveys			Furbuyer records Trapper reports
Pennsylvania	Incidental captures, hunter survey, roadkills	Incidental take roadkills	Age, sex, reprod. status, body condition	Mail survey
Prince Edward Island	Plot/Transect surveys	Harvest carcasses	Age Sex Reproductive status Body condition	Phone survey Other method
Quebec				Furbuyer records

Jurisdiction	Population monitoring			Harvest determination methods
	Methods	Biological data sources	Biological data types collected	
Rhode Island	Roadkills			Pelt tagging Trapper reports
Vermont	Plot/Transect surveys			Mail survey Furbuyer records
Virginia	Sighting reports			Furbuyer records
West Virginia	Other methods	Harvest carcasses	Sex	Pelt tagging Furbuyer records

APPENDIX 5. Objective and supporting strategy completion timetable and agency organizational divisions required for implementation.

Objective	Strategy	Year of completion										Responsible agency organizational division[1]
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
1.1 Annually monitor statewide river otter status, distribution, and population trends.	**1.1.1** Determine population status and distribution using annual furbearer survey results or other method.	●	●	●	●	●	●	●	●	●	●	Regions BWM
	1.1.2 Monitor population trends based on relative abundance estimates from annual furbearer surveys or other method.		●	●	●	●	●	●	●	●	●	Regions BWM
1.2 Develop a statewide river otter population monitoring program to estimate population levels.	**1.2.1** Establish a direct-census method of determining population levels such as mark-recapture to achieve a high level of accuracy.	●	●	●	●							Regions BWM
	1.2.2 Determine population estimates for each WMU.			●	●	●	●	●	●	●	●	Regions BWM
	1.2.3 Establish a census protocol to monitor future population changes.			●	●							BWM
1.3 Develop a model to monitor population changes within each WMU or other defined unit.	**1.3.1** Estimate age- or age class-specific litter size and female reproductive potential.			●	●	●	●	●	●	●	●	Regions BWM
	1.3.2 Estimate age- or age class-specific mortality from incidental mortality or future harvest.			●	●	●	●	●	●	●	●	Regions BWM
	1.3.3 Estimate age- or age class-specific survival.			●	●	●	●	●	●	●	●	BWM

[1]*Regions* – regional office and field staff; *BWM* – Bureau of Wildlife Management; *BHM* – Bureau of Wildlife Habitat Management; *BI&E* – Bureau of Information and Education; *BATS* – Bureau of Automated Technology Services.

Objective	Strategy	Year of completion										Responsible agency organizational division[1]
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
1.4 Develop a geographic information system river otter habitat suitability model for Pennsylvania.	**1.4.1** Identify and map suitable waterways for river otter occupancy.				●	●	●					Regions BWM BHM BATS
	1.4.2 Map unoccupied, but potential river otter habitat.				●	●	●					Regions BWM BHM BATS
1.5 Manage river otter populations on public and private land for maximum wildlife benefit.	**1.5.1** Integrate river otter habitat needs into the public lands planning process.			●	●	●						Regions BWM BHM BATS
	1.5.2 Provide information and assistance to private landowners to improve river otter habitat on their lands.			●	●	●						Regions BWM BHM BATS
2.1 Evaluate the frequency and extent of river otter damage complaints annually.	**2.1.1** Annually survey agency staff to obtain the number of otter damage complaints received and information on type of damage.	●	●	●	●	●	●	●	●	●	●	Regions BWM
2.2 Assess the need for public outreach and engagement regarding otter damage.	**2.2.1** Conduct a survey to determine the public's knowledge of otters and options for damage control as well as the public's desired otter population level.					●	●	●				Regions BWM BHM BATS
	2.2.2 Provide technical assistance to the public to prevent or reduce otter damage.					●	●	●				Regions BWM BHM BATS

[1]*Regions* – regional office and field staff; *BWM* – Bureau of Wildlife Management; *BHM* – Bureau of Wildlife Habitat Management; *BI&E* – Bureau of Information and Education; *BATS* – Bureau of Automated Technology Services.

Objective	Strategy	Year of completion										Responsible agency organizational division[1]
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
3.1 Increase public awareness of river otter life history, population origins, and conservation significance in Pennsylvania.	**3.1.1** Develop a PowerPoint presentation describing river otter life history, conservation significance, and management in Pennsylvania.			●	●							BWM BI&E
	3.1.2 Develop and distribute a brochure describing the role of harvest management in maintaining a balance between otter numbers and prey resources.			●	●							BWM BI&E
3.2 Develop river otter viewing opportunities and guidelines to locate otter sign.	**3.2.1** Provide guidelines to the public on how to increase chances of seeing an otter and locating otter sign.							●	●			Regions BWM BI&E
4.1 Assess impacts of various harvest strategies on otter populations.	**4.1.1** Assess harvest feasibility for each WMU based on population level and habitat suitability.			●	●	●	●	●	●	●	●	Regions BWM
	4.1.2 Model affects of various harvest levels on WMU-based population objectives.			●	●	●	●	●	●	●	●	BWM

Objective	Strategy	Year of completion										Responsible agency organizational division[1]
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
4.2 Develop river otter harvest management recommendations to achieve WMU population objectives.	**4.2.1** Establish an annual regulated trapping season for otters in WMUs with adequate population levels.			●	●	●	●	●	●	●	●	Regions BWM
	4.2.2 Reinforce or provide guidelines on how to avoid an otter capture to trappers in WMUs closed to otter trapping.			●	●							Regions BWM
	4.2.3 Develop an otter management decision matrix based on population and habitat status information to help guide regulatory action or response.		●	●								BWM

[1]*Regions* – regional office and field staff; *BWM* – Bureau of Wildlife Management; *BHM* – Bureau of Wildlife Habitat Management; *BI&E* – Bureau of Information and Education; *BATS* – Bureau of Automated Technology Services.

APPENDIX 6. Summary of public comments.