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Wildlife Exposure Profiles

Tennessee Valley Authority
Ash Recovery Project
Kingston, Tennessee

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List of Acronyms

AE	assimilation efficiency
BERA	Baseline Ecological Risk Assessment
BW	body weight
CBP	Chesapeake Bay Program
CEC	Commission for Environmental Cooperation
cm	centimeters
CMNH	Cleveland Museum of Natural History
COPECs	constituents of potential ecological concern
DMI	dry matter intake
DW	dry weight
FBNWR	Friends of Blackwater National Wildlife Refuge
FIR	food ingestion rate
FMR	free-living metabolic rate
g	gram
g/g	grams per gram
g/kg	grams per kilogram
GE	gross energy
ha	hectares
kcal/g	kilocalorie per gram
kg	kilogram
km	kilometers
L	liters
lbs	pounds
ME_k	metabolic energy of kth prey item
mm	millimeters
mph	miles per hour
NCSU	North Carolina State University
NFMR	normalized free-living metabolic rate
NIR	normalized ingestion rate
P_k	proportion of diet of kth prey item
ROIs	receptors of interest
SIBR	Small Business Innovation Research
TBWG	Tennessee Bat Working Group
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WW	wet weight

1. Introduction

This document presents wildlife exposure profiles for receptors of interest at the Tennessee Valley Authority (TVA) Kingston Ash Recovery Area. A major release of ash into the Emory River occurred on December 2008 following a failure of a dike at the TVA Kingston Fossil Plant in Kingston, Tennessee. ARCADIS has prepared this document in support of the Baseline Ecological Risk Assessment (BERA) being conducted to investigate potential ecological impacts. When possible, these profiles are tailored to the Kingston, Tennessee area and southeastern region of the United States.

Tennessee is located within the Eastern Temperate Forests Ecoregion. The Eastern Temperate Forests form a dense forest canopy consisting mostly of tall broadleaf, deciduous trees and needle-leaf conifers. Beech-maple and maple-basswood forest types occur widely especially in the eastern reaches of this region, mixed oak-hickory associations are common in the Upper Midwest, changing into oak-hickory-pine mixed forests in the south and the Appalachians. The region has extremely diverse populations of mammals, birds, fish, reptiles and amphibians (CEC 2008).

Tennessee's habitats range from the wetlands and bottomland hardwoods of western Tennessee, cedar glade and grassland barrens of middle Tennessee to the high elevation spruce-fir forests of the mountainous east. Aquatic environments range from the oxbows and sloughs of the Mississippi River to the spring and subterranean habitats of the Middle Tennessee barrens and Cumberland Plateau to the cold mountain streams of the Appalachian Mountains (TWRA 2005).

The receptors of interest (ROIs) identified in the BERA include muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor)*, mink (*Neovison vison*), wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), killdeer (*Charadrius vociferous*), great blue heron (*Ardea herodias*), osprey (*Pandion haliaetus*), tree swallow (*Tachycineta bicolor*) and gray bat (*Myotis grisescens*). Each exposure profile includes a general physical description, the receptor's distribution in Tennessee, its habitat and home range/foraging range, breeding and nesting behaviors, and dietary information including food ingestion rates (FIR).

Exposure of wildlife receptors will be evaluated in the BERA by calculating the average daily intake of constituents of potential ecological concern (COPECs), generally based on the methodology described by the United States Environmental Protection Agency (USEPA) (1993) in the *Wildlife Exposure Factors Handbook*. Daily intake calculations are required because wildlife are exposed via multiple pathways, including diet, surface water consumption, and incidental sediment ingestion.

Nagy (2001) provides food intake rates for mammals, birds, and reptiles. These rates are estimated from predictive allometric regression equations based on metabolic rates for each species or for general groups of species. The equations are in the exponential form:

$$y = a\ (grams\ body\ mass)^b$$

Where *y* is grams (g) dry matter intake (DMI) per day; and *a* and *b* are inputs provided in Nagy (2001). Body mass input values used in the calculation are average body weights (BW) calculated for each receptor. BWs are presented in Table 1[1].

Rates in dry weight are converted to wet weight (WW), or vice versa, assuming an average moisture content of 86 percent for plants, 9.3 percent for seeds, 77 percent for invertebrates, 72 percent for fish, and 68 percent for mammals (USEPA 1993).

FIRs for several of the ROIs are also provided in USEPA (1993). FIRs are not listed in USEPA (1993) for the raccoon, mallard, killdeer and tree swallow. For these receptors, FIRs can be calculated based on their metabolic rate and the metabolic energy provided by their prey, as described in USEPA (1993) and as shown in the following equations.

$$FIR = NIR_{total} \times BW \times 0.001$$

Where:
NIR_{total} = total normalized ingestion rate [gram/kilogram (g/kg)-day]; and
BW = body weight [kilograms (kg)].

$$NIR_{total} = \frac{NFMR}{\sum \left(P_k \times ME_k \right)}$$

Where:
NFMR = normalized free-living metabolic rate of predator [kilocalorie(kcal)/kg-day],
P_k = proportion of diet of kth prey item (unitless), and
ME_k = metabolic energy of kth prey item [kilocalorie per gram (kcal/g) WW].

$$ME = GE \times AE$$

Where:
GE = gross energy (kcal/g WW), and
AE = assimilation efficiency (unitless).

Soil and/or sediment are ingested both intentionally and incidentally by many species of wildlife and can be a significant exposure pathway for some contaminants (USEPA 1993). Sediment ingestion is assumed to occur only if the ROI's feeding strategy promotes the incidental ingestion of soil or sediment (e.g., muskrat,

[1] Average body weights as calculated in Table 1 were used in the deterministic uptake models. The entire body weight distribution for adult receptors obtained from the literature was used in the probabilistic uptake models.

raccoon, mink, wood duck, mallard, killdeer, and great blue heron). The BERA will evaluate inundated sediment and exposed sediment after reservoir drawdown. Therefore, exposure to terrestrial media will be based on exposure to exposed sediment during the drawdown period. All wildlife receptors are assumed to ingest surface water.

The following sections provide species-specific exposure parameters for wildlife ROIs, including BWs, ingestion rates, and dietary preferences.

2. Muskrat

2.1 Description

Muskrats are semi-aquatic rodents with soft brownish fur, and are considered the most valuable of the fur-bearing mammals in North America (Allen and Hoffman 1984). Males weigh slightly more and are generally a little larger than females. They have a broad head with small ears and eyes. Their body is supported by short legs, and the back feet are webbed. The scaly, black tail serves as a rudder when they swim. Typical length ranges from 40 to 65 centimeters (cm), and the average weight is 1.177 kg.

2.2 Distribution in North America and Tennessee

Muskrat distribution includes all of the United States, with the exception of the arid southeastern United States between Central Texas and California (USGS 2011b). They are year-round residents of Tennessee (TWRA 2011).

2.3 Habitat

Muskrat are semi-aquatic, and inhabit fresh and saltwater wetlands including marshes, ponds, and rivers (USGS 2011b). Muskrat are herbivorous by preference and the greatest populations are found in wetlands and waters with dense emergent vegetation neighbored by upland herbaceous vegetation. They have also been reported to prefer wetlands and river/stream banks bordered by agricultural fields over shorelines adjacent to wooded areas (Allen and Hoffman 1984).

Availability of plants for lodge and den construction influence preferred habitats (Allen and Hoffman 1984). Lodges and dens are built in banks or earthen dams within 1 meter of still or slow flowing surface waters. Water depth at lodges is reported to range from 0.2 to 0.4 meters.

Muskrat may inhabit lodges or dens and studies indicate that these may be as closely spaced as 40 meters with an average distance between lodges of 110 meters. Lodges are conical structures up to 0.9 meter (3 feet) high constructed on firm ground with underwater entrances. Separate main dwellings and a smaller feeding lodge are often built. Lodges are made of vegetation found around the lodge site. Dens are burrows dug into banks of aquatic habitats or earthen berms. Their ability to build and utilize two types of shelter allows muskrat to be versatile with habitat selection.

The muskrat home range is relatively small as they typically forage 7 to 30 meters from their main dwelling, and they are seldom reported over 150 meters from their lodges (Allen and Hoffman 1984; USGS 2011b; TWRA 2011). Willner et al. (1980), as cited in USEPA (1993), reported a similar foraging area of 5 to 10 meters from a feeding house. MacArthur (1978) as cited in USEPA (1993) reports that muskrat forage

within 15 meters of their main dwelling 50 percent of the time and are rarely more than 150 meters from their dwelling. Some additional studies indicate home ranges along river banks extend up to 200 to 400 meters along the bank; however many studies indicate that foraging ranges are limited to less than 15 meters (CBP 2011; Allen and Hoffman 1984).

2.4 Reproduction

Habitat requirements for reproduction are the same as shelter and cover requirements described in Section 2.3. Muskrat are generally solitary, forming pairs only when breeding (USGS 2011b, Allen and Hoffman 1984). They can produce up to six litters per year, depending on the geographic area (USGS 2011b). In Tennessee, muskrat average three litters of three to six kits per year (TWRA 2011). The time of gestation is less than 4 weeks, and young are only cared for by the mother for 4 weeks before they are independent (CBP 2011).

2.5 Diet and Ingestion Rates

Emergent vegetation (e.g., cattails, cordgrass, and bulrush) is the principal food item of muskrat in the southeastern United States (Perry 1982; USEPA 1993). However, in stream and river habitats, muskrats will eat a greater variety of foods (e.g., fish, frogs, crayfish, and mollusks), as compared to muskrats in marsh habitats (Neves and Odom 1989). During freezing weather, muskrats will eat almost anything, including dead fish, frogs, and wood (TWRA 2011). However, for the purposes of the BERA, it will be assumed that the total diet (100 percent) is comprised of vegetation.

Nagy (2001) provides a couple possible equations for predicting food requirements of muskrat. The regression equation for “all mammals” is appropriate for use in the BERA. Based on a BW of 1.177 kg, the all mammal DMI or Total FIR is 0.062 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of emergent vegetation, if available. If site-specific information is not available, an average moisture content of 86 percent based on a diet of plants (USEPA 1993) was used.

USEPA (1993) reports an alternate FIR of 0.30 grams per gram (g/g)-day for the muskrat. This ingestion rate is the average of two rates reported by Svihla and Svihla (1931) and is similar to the Nagy rate when converted to dry weight (DW) (0.049 kg/day based on a BW of 1.177 kg).

For consistency in the BERA, the Nagy (2001) FIR calculated using the “all mammal” allometric equation (0.062 kg/day based on a BW of 1.177 kg) is selected as the appropriate ingestion rate for muskrat at the site.

An incidental sediment ingestion rate was calculated for the muskrat using an estimate of 9.4 percent soil in the diet. This percentage is based on that for the raccoon (Beyer et al. 1994) because no information for soil intake by muskrats was found in the literature.

To determine a water ingestion rate for the muskrat, an allometric relationship for mammals (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.099\ BW^{0.90}\ \textit{(kg).}$$

A BW of 1.177 kg results in a water ingestion rate of 0.114 liter (L)/day. Selected dietary exposure parameters are provided in Table 2.

3. Raccoon

3.1 General Description

Raccoons are the State Mammal of Tennessee and are easily recognized by their black “masks”, gray pelts, and four to seven dark rings on their tales (TWRA 2011). The Tennessee Wildlife Resources Agency (TWRA) notes that the average weight of a raccoon ranges from 12 to 30 pounds (lbs) (5.4 to 13.6 kg) (TWRA 2011).

Surveys conducted at the TVA’s Kingston site documented weights for each sex, presented in Table 3. The weights for adult females ranged from 3.21 to 5.38 kg, with an average of 4.55 kg. Males in the survey weighed between 3.89 and 7.89 kg, and averaged 6.11 kg (Souza 2010). For purposes of the BERA, the site-specific average adult BW of 5.44 kg is selected (Table 1).

Raccoons are nocturnal animals that are dormant in dens or daytime nests during the day and in dens during wintertime (TWRA 2011, SIBR 2011). Raccoons are well adapted to life in rural, undeveloped, and suburban/urban settings (SIBR 2011). Raccoons may be attracted to urban/ suburban areas where scavenging opportunities and cover are abundant (TWRA 2011). When they are active in close proximity to humans, they are often viewed as pests, as they prey on domestic animals, or consume cultivated crops. They may also carry diseases such as trichinosis, rabies, leptospirosis, tularemia, Chagas disease, and canine distemper (SIBR 2011).

3.2 Distribution in North America and Tennessee

Raccoons are widespread in urban, suburban, and rural environments (Nixon et al. 2009). They are non-migratory and occur in most temperate habitats except alpine or arid habitats (SIBR 2011). Population densities in California have been reported as one raccoon per five to 43 hectares (ha) (12 to 106 acres) (SIBR 2011). Ranges may overlap, although observations of radio marked raccoons indicate that individuals avoid each other most of the year, with the exception of mother-young groupings.

3.3 Habitat

Raccoons have daily nest sites, but will also use dens. Daily nest sites are often used in mild weather. Dens are made in natural features such as tree cavities, snags, logs, rocks, or dense vegetation and also in man-made structures such as abandoned buildings (SIBR 2011). Nesting dens in trees are typically 6.1 to 12.2 meters aboveground (SIBR 2011).

A permanent water source is a habitat requirement for the raccoon. Foraging habitat includes riparian and other wetlands, forest, and shrub cover (SIBR 2011). In Tennessee, raccoons are associated with hardwood

swamps, marshes, and bottomland forests; and foraging habitats are typically in or near waterways (TWRA 2011).

Summertime “bed to bed” movements in North Dakota have been estimated up to 3.2 kilometers (km) for adult males, 2.4 km for yearling males, 1.6 km for adult females, and 1.5 km for barren females. Other studies report smaller daily movements ranging from 232 to 956 meters (Nixon et al. 2009).

Juvenile raccoons tend to range farther than mature raccoons, with dispersal rates declining abruptly in females over 1 year and more slowly in maturing males. Male adults and juveniles in Illinois were documented to range 32 km to 42 km away from their original study area (Nixon et al. 2009).

3.4 Reproduction

February is the beginning of mating season and litters are born in April and May after 62 days of gestation. Litters generally consist of 2 to 3 cubs, born with eyes and ears closed. Responsibility for rearing the young falls solely on the mother. Young are fed exclusively on mothers’ milk for the first 7 weeks, after which they begin to leave the den. Young may stay with the mother through the fall and winter months (Iowa State University 1995; TWRA 2011). Nixon et al.(2009) estimates average losses of young through death or dispersal at 26 percent.

3.5 Diet and Ingestion Rates

The raccoon is an opportunistic omnivore with a varying relative preference for plant and animal matter in its diet (USEPA 1993). TWRA (2011) reports that the raccoon diet includes a variety of berries, nuts, frogs, insects, grains, crayfish, eggs, and small animals. For purposes of the BERA, dietary preferences are estimated based on a study conducted in Tennessee (Tabatabai and Kennedy 1988, as cited in USEPA 1993). In addition, exposure assumptions are based on the raccoon’s dietary preferences in the spring (i.e., breeding season). This approach is conservative, because raccoons consume a higher proportion of animal matter during the spring, and animal matter typically contains higher COPEC concentrations than plants. The raccoon’s diet is assumed to be comprised of 58 percent plant matter, 29 percent insects (including “other terrestrial items” category), 10 percent macro-benthic invertebrates, 2 percent animal matter, and 1 percent fish. Data are not available on the length of fish preferred as prey by raccoons but it is assumed to be similar in size to those consumed by mink (i.e., 40 to 250 millimeters (mm) (Chanin 1981; Wise et al. 1981; Erlinge 1969; Cuthbert 1979; Allen 1986a; Hamilton 1940).

Nagy (2001) provides multiple equations for predicting food requirements of the raccoon. The regression equation for “all mammals” is appropriate for use in the BERA. Based on a BW of 5.44 kg, the all mammal Total FIR is 0.194 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of

86 percent based on a diet of plants (USEPA 1993), a moisture content of 77 percent based on a diet of invertebrates, a moisture content of 68 percent based on a diet of small mammals, and a moisture content of 72 percent based on a diet of fish was used.

A FIR specific for raccoons can also be derived based on the proportion of diet composed of plants, insects, other invertebrates, small mammals and fish, the gross energy in each food group, the efficiency with which raccoons assimilate the gross energy in each food group, and the normalized free-living metabolic rate of raccoons. These inputs are discussed below.

Gross energy of plants, invertebrates, small mammals and fish – Gross energy calculations are based on the aquatic component of the raccoon's diet. A gross energy of 1.3 kcal/g WW (USEPA 1993) is selected for terrestrial plants. A gross energy of 1.2 kcal/g WW is selected for terrestrial invertebrates (USEPA 1993) based on the mean of values reported for terrestrial invertebrates in multiple studies reviewed by USEPA (1993). A gross energy of 0.95 kcal/g WW is selected for macro-benthic invertebrates, based on the mean of values reported for aquatic invertebrates in multiple studies reviewed by USEPA (1993). A gross energy of 1.2 kcal/g WW is selected for fish, based on data on bony fishes reported by Thayer et al. (1973), as cited in USEPA (1993). A gross energy of 1.7 kcal/g WW (USEPA 1993) is used to represent animal prey obtained from the terrestrial environment.

Assimilation efficiency for plants, invertebrates, small mammals, and fish – Assimilation efficiency is calculated for the aquatic and terrestrial components of the raccoon's diet. An assimilation efficiency of 76 percent is used for plants, based on the USEPA (1993) value reported for small mammals consuming plants. A value of 87 percent is used for invertebrates, based on the USEPA (1993) value selected from multiple studies for small mammals consuming insects. An assimilation efficiency of 91 percent is selected for fish, based on USEPA's (1993) calculated value for mammals consuming fish. A value of 84 percent is used for small mammals, based on the USEPA (1993) value reported for mammals consuming small mammals. These values are used as the assimilation efficiencies for plants, aquatic prey, and terrestrial prey.

Normalized free-living metabolic rate – The selected free-living metabolic rate (FMR) of 185 kcal/kg-day represents the mean of estimated values for free-living adult male and female raccoons, as reported by USEPA (1993).

The resulting normalized ingestion rate (NIR) for the raccoon based on the metabolic energy of prey items is 0.19 g/g-day WW or 1.033 kg/day WW (based on a BW of 5.44 kg). When converted to DW, this rate is similar to the rate calculated using the Nagy (2001) allometric equation. The NIR calculation is provided in Table 4.

For consistency in the BERA, the Nagy (2001) FIR calculated using the “all mammal” allometric equation (0.194 kg/day based on the average BW of 5.44 kg) is selected as the appropriate ingestion rate for the raccoon at the site.

It is assumed that the rates of sediment ingestion by raccoons are equal to the rates reported by Beyer, et al. (1994) for soil plus sediment. The sediment ingestion rate corresponds to Beyer et al.’s (1994) estimate that soil and sediment in the diet of raccoons is 9.4 percent of the FIR. This estimate is conservative, because sediment ingestion is used as a surrogate for the ingestion of sediment plus soil, including soil that is ingested from areas unaffected by COPECs.

USEPA (1993) reports a water ingestion rate of 0.082 g/g-day for adult male raccoons and 0.083 g/g-day for adult female raccoons. To develop a water ingestion rate for the raccoon, an allometric relationship for mammals (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.099\ BW^{0.90}\ \textit{(kg).}$$

An average BW of 5.44 kg results in a water ingestion rate of 0.45 L/day. (0.082 g/g-day). Selected dietary exposure parameters are provided in Table 2.

4. Mink

4.1 Description

Mink are nocturnal, semi-aquatic, predatory mammals. They are dark brown with white spots on the underside of their chests and stomachs. They have a long, thin neck and body on sturdy, short legs. The average BW calculated for adult mink is 1.11 kg (Table 1). They measure 46 to 70 cm in total length with one-third to one-half of their length consisting of the bushy tail (USGS 2011a; Allen 1986a).

4.2 Distribution in North America and Tennessee

Mink occur throughout most of the United States except for desert areas of the southwest. Mink tend to be solitary. Population densities are generally 0.01 to 0.10 mink per hectare (USGS 2011a).

4.3 Habitat

Mink prefer habitat consisting of brushy/ woody cover adjacent to water or wetlands and generally avoid open areas. They utilize a variety of wetland habitats such as river banks, streams, marshes, swamps, lakes, and ditches in all salinity ranges. Foraging and hunting often occur on or near water, as mink utilize their swimming skills to find prey. Mink may also utilize upland areas for foraging. Mink are adaptable to human disturbance, but may change territories once food sources are affected (Allen 1986a; USGS 2011a).

Suitable den sites may limit types of habitats utilized by mink. Dens are constructed in tree roots or old beaver lodges and are generally within 100 meters of water; however, dens farther away have been documented (Allen 1986a; USGS 2011a). Mink have also been known to utilize former muskrat dens (TWRA 2011). Males choose easily accessible dens and move frequently. Typical daily movements have been reported to not exceed 300 meters along the shoreline of its respective body of water, although home ranges increase depending on availability of food and cover. A male's typical home range is 1.8 to 5 km from their home den; females tend to have smaller home ranges (Allen 1986a; USGS 2011a).

4.4 Reproduction

Males and females only associate during breeding season. Females will care for their young and live as a family unit with the pups, which is an exception to their typically solitary lifestyle (USGS 2011a; CMNH 2011). Females have litters of two to six young, which are typically born in April or May (TWRA 2011). Young do not leave the nest until after weaning, which occurs between 8 and 9 weeks. Young are fully grown and independent at 5 months old (CMNH 2011).

4.5 Diet and Ingestion Rates

Mink are opportunistic feeders, consuming virtually any type of food they can find, including plants, aquatic invertebrates, small mammals and birds, and amphibians (USEPA 1993). As a result, the actual proportions of food types in the diets of mink can be highly variable. Small mammals are typically the most important prey item for mink (USEPA 1993) although in some cases mink can consume primarily fish in productive stream habitats (Alexander 1977, as cited in USEPA 1993). Because of the large river system adjacent to the site, it is expected that at least half the diet of a mink foraging in that area would consist of aquatic prey. For the purposes of the BERA, it is conservatively assumed that the fractions of total diet are comprised of fish (73 percent), invertebrates (10 percent; including "unidentified" diet category), plants (9 percent), birds and small mammals (5.5 percent), and amphibians (2.5 percent). These fractions represent year-round averages reported by USEPA (1993) for mink located in a Michigan river system (Alexander 1977). Fish consumed by mink are assumed to range in length from 40 to 250 mm, based on data reported by Chanin (1981), Wise et al. (1981), Erlinge (1969), Cuthbert (1979), Allen (1986a) and Hamilton (1940).

The Nagy (2001), allometric equation for "all mammals" was used to determine an estimated FIR for mink. Based on an average BW of 1.11 kg, the Total FIR is 0.059 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, a moisture content of 72 percent based on a diet of fish, a moisture content of 77 percent based on diet of invertebrates, a moisture content of 86 percent based on a diet of plants (USEPA 1993), and a moisture content of 68 percent based on a diet of mammals were used.

USEPA (1993) reports an alternate FIR of 0.22 g/g-day WW for adult male mink (year-round). This rate, when converted to DW, is similar to those calculated using the Nagy equations. To be consistent throughout the BERA, the FIR calculated using the "all mammal" allometric equation (0.059 kg/day, based on a BW of 1.11 kg) is selected as the appropriate ingestion rate for mink at the site. Although incidental ingestion of sediment is considered negligible for the mink, a conservative assumption of 2 percent will be used in the BERA.

The water ingestion rate of 0.10 g/g-day is reported in USEPA (1993) and represents the average of values for male and female wild mink. This value is assumed to be more representative of wild mink than the alternate literature-based value presented, which is for farm-raised mink. To develop a water ingestion rate for the mink, an allometric relationship for mammals (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.099\ BW^{0.90}\ \textit{(kg).}$$

A BW of 1.11 kg results in a water ingestion rate of 0.108 L/day (0.097 g/g-day). Selected dietary exposure parameters are provided in Table 2.

5. Wood Duck

5.1 Description

Many consider the wood duck to be the most beautiful of North America's waterfowl (TWRA 2011). Male wood ducks have bright green and white heads, red bill and eye, a black back, reddish chest, and golden sides. Females are duller colored with gray-brown over their bodies and a white patch around their eye. Both males and females have a crest; the male's crest is long and the female's is bushy. However, in June through September the male's body plumage is similar to the female, termed "eclipse plumage" (TWRA 2011). Wood ducks measure approximately 48 cm (19 inches) (female) to 50.8 cm (20 inches) (male) and weigh an average of 0.668 kg.

5.2 Distribution in North America and Tennessee

The most common nesting duck in Tennessee is the wood duck, but it was almost hunted to extinction in the early 1900s. A combination of the protection of the Migratory Bird Treaty Act of 1918, additional wetland and open water habitat created by recovering beaver populations, and increased erection of nest boxes helped the population recover (TWRA 2011; Nicholson 1997).

For the interior United States population of wood ducks, the range extends on the east coast from Nova Scotia west to the north central United States and south to Florida and the Gulf of Mexico. Wood ducks are uncommon to locally common across Tennessee during the breeding season, with smaller numbers present in the winter (TWRA 2011).

5.3 Habitat

Wood ducks inhabit forested wetlands, riparian habitats, and freshwater marshes (TWRA 2011). Wood duck broods inhabit wetlands vegetated with a mixture of emergent herbaceous plants, shrubs, tree falls, and open water. Wood duck's need for cover and food are generally met between the shoreline and a water depth of 1.8 meters (6 feet) (McGilvrey 1968).

Available habitat loss in the mid-1900s was caused by impounding water for reservoirs and the channelization and draining of wetlands which decreased available riparian wooded areas. By the late 1970s, habitat began to recover due to maturing bottomland and riparian forests and nest box programs.

Due to the migratory and mobile nature of the wood duck, home range is difficult to define. The average feeding radius is 40 to 48 km (25 to 30 miles) every day (NCSU 2011).

5.4 Reproduction

The breeding range of the wood duck includes southern Canada, the eastern United States, Pacific Coast, and some inland locations. They migrate to the southwestern United States and the southern three-quarters of their breeding range for winter. Pairing occurs during winter and nest sites are selected in late February.

Wood duck nests are located in cavities usually near or over water; however, nest boxes are also accepted by wood ducks. Nesting preference is for older and larger trees in second-growth forests; sycamore and beech trees are often used. Cavities abandoned by pileated woodpeckers are often used as nest sites. Females show fidelity to previous nest sites or to the general area where they were reared.

Twelve eggs are usually laid, but clutch size ranges from 10 to 15. Incubation lasts 28 to 37 days, and is performed by the female. Young can leave the nest within 2 days and are cared for by the female (Ducks Unlimited 2011; TWRA 2011). Broods stay with the female for approximately 5 weeks, and young can usually fly by 9 weeks (Nicholson 1997).

Water is critical in wood duck breeding and brood-rearing habitat from mid-January to late September in the southern United States. Water in most of the breeding habitat should be from 7.5 to 45 cm (3 to 18 inches) deep, still or slow-moving, and sheltered from the wind (Sousa and Farmer 1983). A water current of 4.8 km/hour [3 miles per hour (mph)] has been estimated as the maximum tolerable stream flow for breeding wood ducks, although broods seldom use areas with currents greater than 1.6 km/hr (1 mph) (McGilvrey 1968).

5.5 Diet and Ingestion Rates

The wood duck diet consists of seeds, acorns, aquatic and terrestrial insects, and other invertebrates (TWRA 2011; Sibley 2003). While acorns are the primary winter foods, the seeds of bald cypress, hickory, sweet gum, buttonbush, arrow-arum, bur-reed, and wild rice are also common winter foods (Sargeant et al.1993). Wood ducks feed primarily in shallow water areas, but will also forage on the forest floor for seeds, acorns, and nuts. During winter, nearly 100 percent of the diet of wood ducks consists of plant foods, of which 75 percent may be acorns. An increase in animal foods in the diet (to about 35 percent) occurs in both sexes in early spring. This percentage remains constant for the male wood duck through summer and fall, but increases to about 80 percent for the female during egg laying (Dugger and Fredrickson 1992).

Exposure assumptions for the BERA will be based on the wood duck's dietary preferences in the spring (i.e., breeding season). This approach is conservative, because wood ducks consume a higher proportion of animal matter during the spring, and animal matter typically contains higher COPEC concentrations than plants. The wood duck's diet is assumed to be comprised of 67 percent plant matter (average proportion

measured for female and male wood ducks over annual cycle as presented graphically by Dugger and Fredrickson (1992) and 33 percent macro-benthic invertebrates.

Nagy (2001) provides allometric equations for predicting food requirements of the wood duck. The allometric equation for “all birds” is appropriate for use in the BERA. Based on a BW of 0.668 kg, the Total FIR is 0.055 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of 86 percent based on a diet of plants (USEPA 1993) and a moisture content of 77 percent based on diet of invertebrates was used.

Beyer et al. (1997) reported that wood ducks feeding on aquatic plants ingested relatively little sediment (estimated at less than 2 percent of the diet on average). For the BERA, sediment ingestion by wood ducks will be estimated at 2 percent of their Total FIR.

The water ingestion rate for the wood duck is assumed to be similar to that of the mallard (0.057g/g-day). This rate is the mean of estimated values for adult male and female mallards as reported in USEPA (1993). To develop a water ingestion rate for the wood duck, an allometric relationship for birds (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.059\ BW^{0.67}\ \textit{(kg).}$$

A BW of 0.668 kg results in a water ingestion rate of 0.045 L/day (0.067 g/g-day). Selected dietary exposure parameters are provided in Table 2.

6. Mallard Duck

6.1 Description

Mallards are likely the most familiar duck in the United States. Males have green heads, yellow bills, and curled black tail feathers that are unique to the species. Females are brown and black mottled all over and have an orange bill (TWRA 2011). Male mallards average 62.7 cm (24.7 inches) long while female mallards average 58 cm (23 inches) long (Ducks Unlimited 2011). The average adult BW used in the BERA is 1.158 kg (Table 1).

6.2 Distribution in North America and Tennessee

Mallards are the most abundant and widespread ducks in North America with their highest abundance between the Appalachian and Rocky Mountains (Ducks Unlimited 2011). They breed in the northern portion of the United States and across Canada. Wintering habitat consists of open water anywhere in the 48 contiguous states, but the primary wintering grounds are located in the Mississippi valley south of Cape Girardeau, Missouri (Allen 1986b; TWRA 2011).

In Tennessee, mallards are common migrants and winter residents, but uncommon summer residents. The highest population of mallards in the state occurs in the non-breeding months of October through February. However, the breeding population has increased since the middle 20th century. It is believed that the breeding population originated from captive or domesticated mallards or crippled wild ducks supplemented by stocking efforts intended to establish a huntable population. During the 1970s, TVA and TWRA attempted a release program as part of the stocking efforts (TWRA 2011; Nicholson 1997).

6.3 Habitat

A variety of habitats are used by mallards; however, wetland complexes are generally preferred by most of the population. The optimal winter habitat contains a diversity of wetland types within a relatively small area (Allen 1986b). Mallards are found in ponds, lakes, agricultural fields, shallow marshes, and oak-hickory dominated forested wetlands (Ducks Unlimited 2011, TWRA 2011). As dabblers, mallards prefer water less than 40 cm deep for foraging (Allen 1986b).

The mallard home range depends on the available habitat. Kirby et al.(1985), as cited in USEPA 1993, reported a home range of 540 ha to 620 ha for females and males, respectively, in a wetlands and river system.

6.4 Reproduction

Tennessee is outside of the historic breeding area of the mallard; however, breeding does occur in the state as described in Section 6.2. Breeding habitat consists of shallow ponds that are surrounded by grasslands or wetlands (Nicholson 1997).

Nests are built from plant materials gathered by the female and lined with down. Sites include fallen logs, islands in marshes or brushy areas adjacent to reservoirs. In Tennessee, eggs are laid from late February to May and incubated and reared by the female. Clutch sizes range from 9 to 14 eggs; however, clutches of 7 to 10 eggs are common in most areas outside of Tennessee. Eggs are incubated for 27 to 28 days. Young can usually leave the nest in 2 days and can fly in approximately 8 weeks (Nicholson 1997).

6.5 Diet and Ingestion Rates

The mallard duck diet consists of insects, aquatic invertebrates, seeds, acorns, aquatic vegetation, and grain (TWRA 2011). And while plants and seeds may comprise up to 92 percent of the mallard's diet in winter (Dillon 1959; Sibley 2003), during the spring and summer months plants make up only 11 percent to 33 percent (mean=25 percent) of their diet (Swanson et al., 1985). Invertebrates make up the balance of the mallard's diet. Because susceptibility to COPECs is likely to be enhanced during the breeding season (spring), a dietary composition of 25 percent plants and 75 percent invertebrates will be employed in the BERA.

Nagy (2001) provides allometric equations for predicting food requirements of the mallard. The allometric equation for "all birds" is appropriate for use in the BERA. Based on a BW of 1.158 kg, the all bird Total FIR is 0.08 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of 86 percent based on a diet of plants (USEPA 1993) and a moisture content of 77percent based on diet of invertebrates will be used.

An alternative FIR specific for mallards can be derived based on the proportion of diet composed of plants and invertebrates, the gross energy in each food group, the efficiency with which mallards assimilate the gross energy in each food group, and the NFMR of mallards. These inputs are discussed below.

Gross energy of plants and invertebrates – Gross energy calculations are based on the aquatic component of the mallard's diet. A gross energy of 0.51 kcal/g WW is selected for plants and is equal to the midpoint of the range reported by USEPA (1993) for algae. A gross energy of 0.95 kcal/g WW for invertebrates (USEPA 1993) is equal to the mean of values reported by USEPA (1993) for aquatic invertebrates. Both values are based on USEPA's (1993) compilation and review of multiple studies.

Assimilation efficiency for plants and invertebrates – The assimilation efficiency of 23 percent is based on USEPA's (1993) reported value for ducks consuming aquatic vegetation. An assimilation efficiency of 77 percent is based on USEPA's (1993) reported value for waterfowl consuming aquatic invertebrates.

Normalized free-living metabolic rate – A metabolic rate of 196 kcal/kg-day is equal to the mean of estimated values for adult male and female mallards (USEPA 1993).

The resulting NIR for the mallard based on the metabolic energy of prey items is 0.34 g/g-day WW or 0.39 kg/day (based on a BW of 1.158 kg). This rate, when converted to DW, is similar to the rate calculated using the Nagy (2001) allometric equation. The NIR calculation is provided in Table 4.

For consistency in the BERA, the Nagy (2001) FIR calculated using the "all birds" allometric equation (0.08 kg/day based on a BW of 1.158 kg) is selected as the appropriate ingestion rate for mallard ducks at the site. For the BERA, sediment ingestion by mallards is estimated based on Beyer et al. (1994), which reports that incidental sediment consumption by mallards is 3.3 percent of their total FIR.

USEPA reports a water ingestion rate of 0.057 g/g-day for the mallard, which is the mean of estimated values for adult male and female mallards (USEPA 1993). To develop a water ingestion rate for the mallard, an allometric relationship for birds (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.059\ BW^{0.67}\ \textit{(kg).}$$

A BW of 1.158 kg results in a water ingestion rate of 0.065 L/day (0.056 g/g-day). Selected dietary exposure parameters are provided in Table 2.

7. Killdeer

7.1 Description

Killdeer are shorebirds with large, round heads, large eyes, and short bills characteristic of plovers. They are slender birds with long, pointed tails and long wings. Black and white patches mark their brown face. Both males and females are brownish-tan with white underneath, and two black bars on their chest (Cornell Lab of Ornithology 2011b). The two black bars are a distinctive identifier for killdeer (TWRA 2011). Killdeer are medium-sized shorebirds with moderately long legs that range from 20 to 28 cm (7.9 to 11 inches) long, have a wingspan of 45.9 to 48 cm (18.1 to 18.9 inches), and weigh an average of 95 g (Cornell Lab of Ornithology 2011b).

7.2 Distribution in North America and Tennessee

Killdeer are a widespread and recognizable North American shorebird due to their tendency to use man-made habitats located relatively far away from typical shoreline habitats (TWRA 2011). They breed from Alaska, through Canada, and south through Mexico. Wintering habitat extends from southern Alaska to northern South America. They are year-round residents throughout most of the United States. In Tennessee, killdeer are considered year-round residents, except for the Appalachian Mountains in the eastern end of the state, where their residence is primarily during summer for breeding. Their population is believed to be increasing in the state (TWRA 2011; Cornell Lab of Ornithology 2011b).

7.3 Habitat

Killdeer are noted to be the “least water-associated of all shorebirds” (Cornell Lab of Ornithology 2011b). They spend their time on open ground with short to absent vegetative cover. They have adapted readily to man-altered environments, inhabiting and foraging in lawns, golf courses, driveways, parking lots, gravel-covered roofs, and agricultural fields and pastures. Similar to other shorebirds, killdeer can also be found on sandbars and mudflats (Cornell Lab of Ornithology 2011b). Killdeer in Tennessee commonly nest along lakes and ponds, and in man-made or man-altered habitats (TWRA 2011). Killdeer can benefit from impoundment drawdown regimes that expose mudflats and invertebrate food sources (USFWS 1992). TVA’s winter and spring drawdown schedules can provide habitat for killdeer and other shorebirds (USFWS 2009).

Plissner et al. (2000) evaluated space use by killdeer living in wetlands in California. Mean home range sizes ranged from 1.7 ha (female during post-nesting) to 5.5 ha (male during nesting), with an average home range of 4.2 ha (10 acres).

7.4 Reproduction

The killdeer breeding season in Tennessee extends from late winter to mid-summer. This long season allows time to raise two broods per season. Nests have minimal construction, consisting of a “scrape” in the ground located in an open area. Nests are constructed by the male. Clutch sizes range from three to five eggs, with an average of four eggs per clutch. Males and females share responsibility over the 24 to 28 days of incubation, with the male typically responsible for incubating at night. Both parents tend the young, who are able to leave the nest just hours after they hatch. Killdeer young are independent at 40-days old (TWRA 2011).

7.5 Diet and Ingestion Rates

The killdeer’s diet consists of terrestrial invertebrates, especially earthworms, grasshoppers, beetles and snails (TWRA 2011). Studies to support the information from TWRA are discussed below.

Rundle (1982) compared esophageal and gizzard analysis in four species of shorebirds, including killdeer, and found that the three main taxonomic groups eaten by killdeer are Coleoptera adults (40 percent occurrence), Diptera larvae (40 percent occurrence), and Coleoptera larvae (20 percent occurrence). A 1995 Wilson Bulletin (Fair et al. 1995) study conducted in North Dakota reported a diet dominated by terrestrial invertebrates (over 80 percent of the diet); and Baldwin (1971) reported a similar diet consisting of over 83 percent terrestrial invertebrates. Therefore, for the purposes of the BERA, a dietary composition based on 80 percent terrestrial invertebrates and 20 percent aquatic invertebrates will be employed.

Nagy (2001) provides allometric equations for predicting food requirements of the killdeer. The allometric equation for “all birds” is appropriate for use in the BERA. Based on a BW of 0.095 kg, the all bird Total FIR is 0.014 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of 71 percent based on diet of terrestrial invertebrates and 77 percent for aquatic invertebrates was used.

A FIR specific for killdeer can also be derived based on the proportion of diet composed of terrestrial and aquatic invertebrates, the gross energy in each food group, the efficiency with which killdeer assimilate the gross energy in each food group, and the NFMR of killdeer. These inputs are discussed below.

Gross energy of invertebrates – Gross energy calculations are based on the aquatic and terrestrial component of the killdeer diet. A gross energy of 1.3 kcal/g WW is selected for terrestrial invertebrates and is equal to the midpoint of the range reported by USEPA (1993). A gross energy of 0.95 kcal/g WW for aquatic invertebrates (USEPA 1993) is equal to the mean of values reported by USEPA (1993). Both values are based on USEPA’s (1993) compilation and review of multiple studies.

Assimilation efficiency for invertebrates – The assimilation efficiency of 72 percent is based on USEPA's (1993) reported value for birds consuming terrestrial invertebrates. An assimilation efficiency of 77 percent is based on USEPA's (1993) reported value for birds consuming aquatic invertebrates.

Normalized free-living metabolic rate – Using a FMR for non-passerines, a metabolic rate of 365 kcal/kg-day was calculated. This rate is based on the mean BW of 0.095 kg for the killdeer.

The resulting NIR for killdeer based on the metabolic energy of prey items is 0.41 g/g-day WW or 0.04 kg/day WW (based on a BW of 0.095 kg). When converted to DW using a moisture content of 72 percent, the ingestion rate is 0.011 kg/day, which is similar to those calculated using the Nagy (2001) allometric equations. The NIR calculation is provided in Table 4.

For consistency, the Nagy (2001) FIR calculated using the "all birds" allometric equation (0.014 kg/day, based on a BW of 0.095 kg) is selected as the appropriate ingestion rate for killdeer at the site. Although grit has rarely been observed in killdeer gizzards (Fair et al. 1995), ingestion of surface soil (i.e., exposed sediment) incidental to consuming food is expected to occur. The incidental soil ingestion rate for the American woodcock (10.4 percent of FIR) will be used in the BERA for the killdeer based on a similar diet; however, 10.4 percent likely overestimates the percent soil in diet for the killdeer since woodcocks reportedly ingest a larger percentage of earthworms as compared to the killdeer.

A water ingestion rate for the killdeer was estimated using an allometric relationship for birds (USEPA 1993).

$$\textit{Water Ingestion (L/day)} = 0.059\ BW^{0.67}\ \textit{(kg).}$$

A BW of 0.095 kg results in a water ingestion rate of 0.012 L/day. Selected dietary exposure parameters are provided in Table 2.

8. Great Blue Heron

8.1 Description

Great blue heron are mostly gray with a yellow bill, white head, and black stripe over the eye that ends in a plume on the back of the head and neck. They have long legs and a long, curved neck. Males and females of this species look alike (TWRA 2011). An adult great blue heron is typically 97 to 137 cm (38.2 to 53.9 inches) long, with a potential wing span ranging from 167 to 201 cm (65.7 to 79.1 inches) (Cornell Lab of Ornithology 2011d). Adult herons weigh an average of 2,254 g.

8.2 Distribution in North America and Tennessee

Great blue heron are familiar, year-round residents of Tennessee and most of the United States. Typically, only migrants are observed in the northern Midwest, Rocky Mountains, and arid portions of California and extreme southwest. Some great blue heron migrate to Central or South America for wintering (Cornell Lab of Ornithology 2011d). From 1976 to 1986, great blue herons were listed as “in need of management” in Tennessee. However, the population increased in the middle 1980s and has continued to increase in the state (TWRA 2011). By the late 1980s and early 1990s, great blue heron nesting colonies in Tennessee were located at Reelfoot Lake near Kentucky Lake, the mouth of the Duck River, the Tennessee River reservoirs near Knoxville, and along the Obion River, Forked River, Deer River, Hatchie River, and Big Sandy River (Nicholson 1997).

8.3 Habitat

Great blue heron are found along freshwater, estuarine, and marine shoreline habitats or wetlands (Cornell Lab of Ornithology 2011d). Favored habitat in Tennessee consists of shorelines of lakes, rivers, ponds, and streams, and they are sometimes found in grassy fields near surface water (TWRA 2011). Great blue heron are versatile in the types of habitats they utilize; availability of natural cover (i.e., vegetation) is not a limiting factor for utilization of habitat for foraging and nesting (Short and Cooper 1985).

Great blue heron in South Dakota rivers and streams were observed to travel up to 24.4 km from the colony to forage, however, the mean distance was just 3.1 km (Dowd and Flake 1985, as cited in USEPA 1993). Fifteen to 20 km is the farthest great blue heron regularly travel between foraging areas and colonies (Gibbs et al. 1987, as cited in USEPA 1993; Gibbs 1991, as cited in USEPA 1993; Peifer 1979 as cited in USEPA 1993).

8.4 Reproduction

Nests are usually located in tall trees near water, such as on islands or forested swamps. Heron usually nest in isolated colonies; however, individual pairs may be found nesting as well. Nesting colonies are usually isolated from human disturbance, and can have populations of hundreds of pairs of mixed heron species. Nests are large platforms made of sticks mounted at heights of 3 to 9 meters (10 to 30 feet), and lined with moss, dry grass, twigs, or pine needles. Nests from previous years are often reoccupied by heron pairs (Cornell Lab of Ornithology 2011d; TWRA 2011; Short and Cooper 1985).

Adult herons of 2 years and older may mate and breed. Nesting activity can begin in Tennessee as early as January if days are warm. The peak time for egg-laying is mid-March. Typical clutch size is three to four eggs, and may be as many as seven eggs. Eggs are incubated for 28 days by both parents, and both parents also care for the nestlings. Fledging occurs at approximately 60 days old, but the fledglings will continue to return to the nest for feeding for some weeks after fledging (Cornell Lab of Ornithology 2011d, TWRA 2011).

8.5 Diet and Ingestion Rates

The great blue heron feeds in shallow water during both night and day. Locating its prey by sight and stalking it, the great blue heron spears it with its long pointed beak and swallows it whole, head first. With legs longer than other herons, the great blue heron can exploit water that is deeper giving it an advantage when it comes to feeding (Nashville Outdoors 2010). Fishing requires water depths up to 0.5 meters with a firm substrate (Short and Cooper 1985).

As reported in the Atlas of Breeding Birds of Tennessee (Nicholson 1997), the great blue heron diet consists of fish as well as other primarily aquatic animals including crustaceans, amphibians, and insects. Various studies cited by USEPA (1993) and others (e.g., Short and Cooper 1985) on dietary composition consistently show a diet for great blue heron that is dominated by fish (94 percent to 100 percent). The mean value of 98 percent diet as fish (as reported in USEPA 1993) will be applied in the BERA. Great blue heron are assumed to consume fish ranging in size from 50 to 300 mm, based on Henning et al.'s (1999) analysis. In addition to crustaceans and amphibians, other prey items reported include snakes, birds, and mammals. Benthic invertebrates are used as a surrogate for the remaining 2 percent of the diet composed of these other prey items.

The Nagy (2001), allometric equations for predicting food requirements can be used for the great blue heron. The allometric equation for "all birds" is appropriate for use in the BERA. Based on a BW of 2.254 kg, the all bird Total FIR is 0.126 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture

content of 71 percent based on a diet of fish (USEPA 1993) and a moisture content of 77 percent based on diet of invertebrates was used.

USEPA (1993) cites an alternative FIR of 0.18 g/g-day WW as reported by Kushlan (1978). This FIR applies to adult male and female great blue heron. When converted to DW, this rate is similar to the rates calculated using the Nagy (2001) allometric equations.

For consistency throughout the BERA, the Nagy (2001) FIR calculated using the “all birds” allometric equation (0.126 kg/day, based on an average BW of 2.254 kg) is selected as the appropriate ingestion rate for the great blue heron at the site. Although incidental ingestion of sediment is considered negligible for the great blue heron, a conservative assumption of 1 percent will be used in the BERA.

A water ingestion rate of 0.045 g/g-day is the value estimated by USEPA (1993) for adult male and female great blue heron. To develop a water ingestion rate for the great blue heron, an allometric relationship for birds (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.059\ BW^{0.67}\ \textit{(kg).}$$

A BW of 2.254 kg results in a water ingestion rate of 0.101 L/day (0.045 g/g-day). Selected dietary exposure parameters are provided in Table 2.

9. Osprey

9.1 Description

Ospreys are piscivorous birds that are among the largest birds of prey in North America. An adult osprey's average weight is 1.662 kg, and their wing span can grow to over 5 feet (Cornell Lab of Ornithology 2011a; Nicholson 1997; FBNWR 2011). Juveniles, males, and females have similar markings. They have a white head with a prominent stripe through the eye, white undersides, and dark brown backs. Wings have a brown and white pattern, and are long and narrow, bent at the wrist (TWRA 2011).

9.2 Distribution in North America and Tennessee

The osprey is distributed throughout the world. The largest breeding populations in the United States are found along the Atlantic coast, Florida and the Gulf of Mexico, Pacific Northwest, western interior, and the Great Lakes. Breeding osprey from North America winter in Central and South America, and are therefore rare in Tennessee during the winter. Osprey will return to their nest sites over many years, and band studies indicate that approximately 90 percent of adult ospreys return to the state or adjacent state where they were hatched. Females are believed to range farther than males (Vana-Miller 1987; TWRA 2011).

Breeding ospreys were rare in Tennessee prior to construction of reservoirs in the first half of the 20th century (TWRA 2011). They were listed as endangered in Tennessee in 1975. A "hacking" (release) program was initiated in 1979 by TVA and TWRA and supplemented by the construction of nesting platforms. One hundred sixty-five young ospreys were released to 16 sites in Tennessee between 1980 and 1988. Active nests in Tennessee increased from three in 1980 to 131 in 1999 (TWRA 2011; Nicholson 1997). This number has increased dramatically in the last decade. In 2005, TVA reported 130 nests on Watt's Bar Reservoir (Meigs and Rhea County) alone (TVA River Neighbors 2006).

9.3 Habitat

Ospreys are commonly found along rivers, lakes, coasts, and estuaries but may also be found in smaller water bodies where fish are available. Reservoirs provide favorable foraging conditions for osprey as they often have improved water clarity over rivers, due to larger areas of shallow open water with low flow. Availability of fish at reservoirs attracts nesting osprey at the edge of their breeding range (Vana-Miller 1987; TWRA 2011; Nicholson 1997).

Ospreys are year-round residents in the most southern parts of their range (e.g., south Florida, Mexico) but are migratory over the rest of their range in the United States and Canada (Poole 1989 as cited in USEPA 1993). Their foraging area ranges from 0.7 to 2.7 km as reported by Dunstan (1973), as cited in USEPA 1993, for adult male osprey foraging near lakes in Minnesota.

9.4 Reproduction

Osprey nests are constructed from branches, sticks, and twigs with smaller twigs, grasses, and other scavenged material as lining. Ospreys tend to return to the same nest site from previous years. The same nest is used over several years, and repaired or added on to every year. An older nest can have a 7-foot diameter and be 5 feet deep (TWRA 2011).

Ospreys begin nesting when they reach 3 years old (TWRA 2011; Nicholson 1997). Nest sites can be natural or man-made sites that offer stability and maximum visibility. Osprey will nest on a variety of structures, snags, rock pinnacles, towers, or dead or live trees which are typically the highest structures in the area that provide an unobstructed view. Shortage of nest sites may limit available breeding habitat, and artificial nesting structures may enable use of these habitats (TWRA 2011; Vana-Miller 1987).

Osprey pairs are monogamous. Clutch sizes are typically three eggs, but range from two to four eggs. Egg laying in Tennessee occurs in middle to late March, and clutches of two or three eggs are most commonly reported. Eggs are incubated for 32 to 43 days by both parents. Fledging occurs when young are 44 to 59 days old. In Tennessee, fledging usually occurs in late June or early July. Both parents care for the young. The females stay with the young until they are old enough to remain in the nest alone. At that point, both parents will forage for food (TWRA 2011; Nicholson 1997).

9.5 Diet and Ingestion Rates

Ospreys are almost completely piscivorous, although they have been observed on occasion taking other prey including birds, frogs, and crustaceans (Brown and Amadon 1968, as cited in USEPA 1993). Consumed fish are typically 12.7 to 40.6 cm (5 to 16 in) in size (TWRA 2011). Their prey preferences change seasonally with the abundance of the local fish (Edwards 1988; Greene et al. 1983 as cited in USEPA 1993). Osprey occasionally will pick up dead fish but only if it is fresh (Bent 1937 as cited in USEPA 1993). Osprey are most successful catching species of slow-moving fish that eat benthic organisms in shallow waters and fish that remain near the water's surface (Poole 1989 as cited in USEPA 1993). Ospreys consume all parts of a fish except the larger bones (Bent 1937 as cited in USEPA 1993). For the purposes of the BERA, it is assumed that 100 percent of the osprey diet is comprised of fish.

The Nagy (2001), allometric equations for predicting food requirements can be used for the osprey. The allometric equation for “all birds” is appropriate for use in the BERA. Based on a BW of 1.662 kg, the Total FIR is 0.102 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of 71 percent based on a diet of fish (USEPA 1993) was used.

USEPA (1993) cites an alternative FIR of 0.21 g/g-day WW as reported by Poole (1989). This FIR applies to adult female osprey during courtship. When converted to DW, this ingestion rate is similar to FIRs calculated using the Nagy (2001) allometric equations.

For consistency throughout the BERA, the Nagy (2001) FIR calculated using the “all birds” allometric equation (0.102 kg/day, based on a BW of 1.662 kg/day) is selected as the appropriate ingestion rate for osprey at the site. Incidental ingestion of sediment is considered negligible for the osprey.

A water ingestion rate of 0.052 g/g-day is the value estimated by USEPA (1993) for adult male and female osprey. To develop a water ingestion rate for the osprey, an allometric relationship for birds (USEPA 1993) was used.

$$\textit{Water Ingestion (L/day)} = 0.059\ BW^{0.67}\ \textit{(kg).}$$

A BW of 1.662 kg results in a water ingestion rate of 0.083 L/day (0.049 g/g-day). Selected dietary exposure parameters are provided in Table 2.

10. Tree Swallow

10.1 Description

The tree swallow is a small insectivorous perching bird and a member of the swallow family (Family *Hirundinidae*). Male and female tree swallow plumage is similar; except females do not get their adult plumage until 2 years of age. Female plumage in the first year is dull brown-black (Nicholson 1997). Juvenile plumage is sooty gray above and dull white below with a light grayish band on the chest. Mature plumage consists of white below with glossy greenish-blue above and a notched tail. Faces are dark with white throat and cheeks. Tree swallows are approximately 14.6 cm (5.75 inches) long with a 36.8 cm (14.5 inches) wingspan. Their average weight is 20.5 g and typically ranges from 16 to 25 g (TWRA 2011, Cornell Lab of Ornithology 2011c).

10.2 Distribution in North America and Tennessee

Tree swallows breed across North America, and non-breeding habitat includes the southern coasts of the United States and into Mexico. Relatively little is known about migratory and winter ranges; however it is believed that tree swallows winter farther north than most other swallows (TWRA 2011; Winkler et al. 2011) and return to the nesting grounds weeks before other swallows return in the spring. Breeding south of the Ohio River was uncommon until relatively recently; Tennessee is at the southern edge of the tree swallow breeding range (Cornell Lab of Ornithology 2011c). Tree swallows are still considered to be an uncommon summer resident in the state, although their population is increasing. They are usually present in Tennessee between mid-March and October, typically near small bodies of water and swamps. Migrants are locally abundant to fairly common in the spring, with increased abundance near the Mississippi River (Nicholson 1997).

The first recorded tree swallow nest in Tennessee was in 1918, but no additional nests were documented until 1968. The 1968 nesting was centered in Anderson County and Maury County. By 1982, 13 counties had reported tree swallow nesting. In the early 1980s, the highest concentration of tree swallows was reported at Reelfoot Lake, and near the mouth of the Duck River near the Kentucky Reservoir. By the 1990s, one third of the counties in Tennessee reported tree swallow nesting. The reason(s) behind the tree swallow expansion into Tennessee is unexplained; however, contributing factors may be construction of ponds and reservoirs in the early 1900s. It is also notable that the range expansion occurred simultaneously with breeding expansion into other southeastern states (Nicholson 1997).

10.3 Habitat

Tree swallow habitat utilized for foraging and resting includes open fields, marshes, and meadows. Trees are used for nesting and roosting (Winkler et al. 2011). Nesting habitat for tree swallows in Tennessee

consists of tree cavities near water, and species such as woodpeckers that excavate these cavities are relied upon. Preferred nest sites are cavities of dead trees, such as old woodpecker holes that are approximately 12 meters high. Bird nesting boxes may also be used (TWRA 2011; Nicholson 1997). Tennessee's ponds and reservoirs are attractive habitat for tree swallows, as most nests are recorded within 400 meters of water (Nicholson 1997).

Tree swallows forage over open fields approximately 100 to 200 meters from the breeding area (McCarty and Winkler 1999). Roosting habitat can include marshes or wooded areas. Outside of nesting season, tree swallows gather and fly in flocks that number up to hundreds of thousands of individuals just before sunset, gradually descending in groups to the roost site (Cornell Laboratory of Ornithology 2011c).

10.4 Reproduction

Tree swallows are monogamous. They arrive at breeding habitats as early as late March, when they begin to search for nesting habitat (Cornell Laboratory of Ornithology 2011c). They do not typically return to their hatching grounds for breeding (TWRA 2011). Nesting activity begins in April and egg laying peaks in mid-May with clutches born through June. Nests are cup-shaped, loosely built and constructed from dead grasses with a feather lining. The feathers are often from other bird species. Clutches are usually four to six eggs with an average of five eggs. Incubation is performed by the female for 13 to 16 days, and young fledge in 20 days. Females and males share responsibility for feeding the nestlings (Nicholson 1997; TWRA 2011).

10.5 Diet and Ingestion Rates

Tree swallows forage over fields and water for berries and emergent insects (TWRA 2011; Sibley 2003). Tree swallows prefer woodland edges and open fields near streams and wetlands, so that they can feed on flying insects. Tree swallows are the only member of the swallow family that also feed on berries when insects are limited. This trait enables the tree swallow to overwinter in harsher climates and make early spring returns to their breeding habitat.

According to a study conducted by McCarty and Winkler (1999), a typical tree swallow diet consists of insects from at least 11 orders, ranging in size from less than 1 mm to more than 50 mm. True flies (Family Diptera) provide a large portion of the tree swallow diet, while true bugs (Family Hemiptera) and dragonflies and damselflies (Family Odonata) also comprise a substantial portion of the tree swallow diet (McCarty and Winkler 1999). An analysis of food items delivered to nestlings consisted of Diptera (46 percent), Homoptera (26 percent), Ephemeroptera (11 percent), Odonata (5 percent), Coleoptera (4 percent), Molluska (4 percent), Aranae (2 percent), Psocoptera (1 percent), Hymenoptera (1 percent), plus trace amounts of Hemiptera, Neuroptera, Trichoptera, and Lepidoptera (Blancher et al. 1987, as cited

in McCarty and Winkler 1999). For the purposes of the BERA, it is assumed that 100 percent of the tree swallow diet is comprised of adult emergent aquatic invertebrates.

Nagy (2001) provides allometric equations for predicting food requirements of the tree swallow. The allometric equation for “all birds” is appropriate for use in the BERA. Based on a BW of 0.0205 kg, the all bird Total FIR is 0.005 kg/day. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of 71 percent based on diet of terrestrial invertebrates was used.

A FIR specific for tree swallows can also be derived based on the proportion of diet composed of emergent aquatic invertebrates, the gross energy in each food group, the efficiency with which tree swallows assimilate the gross energy in each food group, and the NFMR of tree swallow. These inputs are discussed below.

Gross energy of invertebrates – Gross energy calculations are based on the terrestrial component of the tree swallow diet. A gross energy of 1.6 kcal/g WW is selected for non-earthworm terrestrial invertebrates (grasshoppers and adults beetles) and is equal to the average of the values reported by USEPA (1993). This value is based on USEPA’s (1993) compilation and review of multiple studies.

Assimilation efficiency for invertebrates – The assimilation efficiency of 72 percent is based on USEPA’s (1993) reported value for birds consuming terrestrial insects.

Normalized free-living metabolic rate –Using a FMR for passerines, a metabolic rate of 995 kcal/kg-day was calculated. This rate is based on the mean BW of 0.0205 kg for the tree swallow.

The resulting NIR for the tree swallow based on the metabolic energy of prey items is 0.86 g/g-day WW or 0.017 kg/day WW (based on a mean BW of 0.0205 kg). When converted to DW using 72 percent moisture, the ingestion rate is 0.005 kg/day. This FIR is similar to the rate calculated using the Nagy (2001) allometric equation. The NIR calculation is provided in Table 4.

For consistency, the Nagy (2001) bird FIR calculated using the “all birds” allometric equation (0.005 kg/day based on a BW of 0.0205 kg) is selected as the appropriate ingestion rate for tree swallows at the site.

Based on the foraging habits of tree swallows [prey captured while in flight between 0 and 12 meters above the ground (McCarty and Winkler 1999)] ingestion of exposed sediment incidental to consuming food is expected to be negligible. A water ingestion rate for the tree swallow was estimated using an allometric relationship for birds (USEPA 1993).

$$\textit{Water Ingestion (L/day)} = 0.059\ BW^{0.67}\ \textit{(kg).}$$

A BW of 0.0205 kg results in a water ingestion rate of 0.004 L/day. Selected dietary exposure parameters are provided in Table 2.

11. Gray Bat

11.1 Description

Gray bats may live 15 years or more. They are grayish brown and have uni-colored dorsal fur, which is unique to their range (USFWS 2011). Gray bats are medium-sized bats with a wingspan of 27 to 30 cm and typically weigh between 8 and 11 g (TBWG 2011). The average weight used in the BERA is 9.5 g (Table 1).

11.2 Distribution in North America and Tennessee

Gray bats are usually found in the states of Arkansas, Missouri, Kentucky, Tennessee, and Alabama, but may be found in adjacent states as well. They are listed as an endangered species both federally and in Tennessee. In Tennessee, 95 percent of the gray bat population resides in eight caves, including Hubbards Cave in Warren County, making the species very susceptible to adverse impacts from habitat disturbance. Gray bats are particularly susceptible to habitat loss due to flooding of caves from natural floods or impoundment creation, pesticide impacts, and human disturbance during maternity or hibernation periods (TBWR 2011; The Nature Conservancy 2011).

11.3 Habitat

Gray bats usually reside in limestone caves, and use different caves for summer and winter habitats. Hibernation occurs in large rooms of deep, vertical caves; these caves must be configured to trap cold air and maintain themselves at temperatures between 42° to 52° Fahrenheit. Hibernation begins in November and hibernation populations in an individual cave can reach 1 million individuals. Females congregate in summertime maternity colonies, residing in caves that have the appropriate structure to trap warmer air between 58° and 77° Fahrenheit. The population of maternity colonies can be up to 250,000 individuals. Smaller bachelor colonies are formed by males and non-mated females during the summertime. Summertime caves are located near foraging habitat, which consists of rivers and lakes. Because of the unique configuration requirements, less than 5 percent of cave habitats are appropriate for gray bats. Gray bats may fly up to 19 km (12 miles) from their colonies to forage (TBWR 2011; USFWS 2011).

11.4 Reproduction

Females enter their hibernation caves immediately after mating in September and October. Sperm is stored within the females during the winter who become pregnant once they emerge from hibernation. One young per female is born in May or early June. Young fly at approximately 20 to 25 days old (TWRA 2011).

11.5 Diet and Ingestion Rates

Mayflies are an important part of the gray bat diet, but gray bats also consume a variety of other insects (TWRA 2011). For the purposes of the BERA, it is assumed that 100 percent of the gray bat diet is comprised of adult emergent aquatic invertebrates.

The Nagy (2001) allometric equation for “all mammals” was used to determine an estimated FIR for the gray bat. Based on a BW of 0.0095 kg, the FIR is 0.0017 kg/day DW. Another possible FIR is the one presented in Nagy (2001) for the little brown bat which is similar in size and diet to the gray bat and occurs in Tennessee. Nagy calculated a FIR of 1.6 g/day DW or 0.0016 kg/day DW for the little brown bat. This is consistent with the rate calculated above using the all mammals allometric equation. The ingestion rate was converted to WW by using site-specific moisture content of prey items, if available. If site-specific information is not available, an average moisture content of 61 percent based on a diet of insects (USEPA 1993) was used. Due to its foraging habits, incidental soil (i.e., exposed sediment) ingestion is expected to be negligible for gray bats.

A water ingestion rate was generated using the following allometric equation for all mammals (USEPA 1993).

$$\textit{Water Ingestion (L/day)} = 0.099\ BW^{0.900}\ \textit{(kg).}$$

A BW of 0.0095 kg results in a water ingestion rate of 0.0015 L/day. Selected dietary exposure parameters are provided in Table 2.

12. References

Allen, A.W. 1986a. Habitat Suitability Index Models: Mink, revised. U.S. Fish and Wildlife Service Biological Report. 82(10.127). 23 pp.

Allen, A.W. 1986b. Habitat Suitability Index Models: Mallard (Winter Habitat, Lower Mississippi Valley). U.S. Fish and Wildlife Service Biological Report 82(10.132). 37 pages.

Allen, A.W. and R.D. Hoffman. 1984. Habitat Suitability Index Models: Muskrat. U.S. Fish and Wildlife Service. FWS/OBS-82/10.46. 27 pp.

Alexander, G. 1977. Food of vertebrate predators on trout waters in north central lower Michigan. Michigan Academician 10: 181-195.Government Printing Office; Smithsonian Inst. U.S. Nat. Mus., Bull. 135.

Baldwin, P.H. 1971. Diet of the Killdeer at the Pawnee National Grassland and a comparison with the mountain plover, 1970-1971. Tech. Rept. 135. Grassland Biome U.S. International Program.

Baldwin, S.P. and S.C. Kendeigh. 1938. Variations in the Weight of Birds. The Auk. 55(3):416-467.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1: Order Falconiformes. Washington, DC: U.S. Government Printing Office; Smithsonian Inst. U.S. Nat. Mus., Bull. 167.

Beyer W.N, E.E. Connor, and S.Gerould.1994. Estimates of soil ingestion by wildlife. J Wildl Manage 58:375-382.

Beyer, W.N., L.J. Blus, C.J. Henny, and D. Audet. 1997. The role of sediment ingestion in exposing wood ducks to lead. Ecotoxicology 6, 181-186 (1997).

Blancher, P.J., C.L. Furlonger, and D.K. McNicol. 1987. Diet of nestling Tree Swallows (*Tachycineta bicolor*) near Sudbury, Ontario, Summer 1986. Canadian Wildl. Serv. Tech. Rep. Series 31:1-14.

Brown, L. and D. Amadon. 1968. Eagles, hawks, and falcons of the world, v. 1. New York, NY: McGraw-Hill.

Burness, G.P., R.C. Edenberg, and P.W. Hochachka. 2001. Physiological and biochemical correlates of brood size and energy expenditure in tree swallows. J. Exp Biol. 204:1491-1501.

Burness, G.P., R.C. Edenberg, and P.W. Hochachka. 1998. Interindividual Variability in Body Composition and Resting Oxygen Consumption Rate in Breeding Tree Swallows, *Tachycineta bicolor*. Physiological Zoology. 71(3):247-256.

Chanin, P. 1981. The diet of the Otter and its relations with the feral mink in two areas of southwest England. Acta Therilogica 26(5):83-95.

Chesapeake Bay Program (CBP). 2011. Chesapeake Bay Program-Bay Field Guide: Muskrat. Accessed at http://www.chesapeakebay.net/bfg_muskrat.aspx?menuitem=14442 on July 12, 2011.

Cleveland Museum of Natural History (CMNH). 2011. Mink. Accessed at http://www.cmnh.org/site/ClassesandPrograms/ScienceResourceCenter/MaterialsForLoan/Dioramas.aspx on July 10, 2011.

Commission for Environmental Cooperation (CEC). 2008. "Eastern Temperate Forests ecoregion". In: Encyclopedia of Earth. Eds. Mark McGinley (Topic Editor), Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). First published in the Encyclopedia of Earth October 16, 2008; Last revised Date October 16, 2008; Retrieved June 12, 2011. http://www.eoearth.org/article/Eastern_Temperate_Forests_ecoregion_(CEC).

Cornell Lab or Ornithology. 2011a. All About Birds: Osprey. Retrieved at http://www.allaboutbirds.org/guide/Osprey/lifehistory on July, 10 2011.

Cornell Lab of Ornithology. 2011b. All About Birds: Killdeer. Accessed at http://www.allaboutbirds.org/guide/Killdeer/lifehistory on July 10, 2011

Cornell Lab of Ornithology. 2011c. All About Birds: Tree Swallow. Accessed at http://www.allaboutbirds.org/guide/Tree_Swallow/lifehistory on July 10, 2011.

Cornell Lab of Ornithology. 2011d. All About Birds: Great Blue Heron. Accessed at http://www.allaboutbirds.org/guide/Great_Blue_Heron/lifehistory on July 10, 2011.

Cuthbert, J.H. 1979. Food studies of feral mink *Mustela vison* in Scotland. Fish Mgmt. 10(1):17-25.

Dawson, R.D. 2004. Does fresh vegetation protect avian nests from ectoparasites? An experiment with tree swallows. Can. J. Zool. 82:1005-10.

Delnicky, D. and K.J. Reinecke. 1986. Mid-winter food use and body weights of Mallards and Wood Ducks in Mississippi. J. Wildl. Manage. 50:43-51.

Dillon, O.W. 1959. Food habits of wild mallard ducks in three Louisiana parishes. Trans. North Am. Wildl. Nat. Resour. Conf. 24: 374-382.

Dowd, E. and L.D. Flake. 1985. Foraging habitats and movements of nesting great blue herons in a prairie river ecosystem, South Dakota. J. Field Ornithol. 56: 379-387.

Ducks Unlimited. 2011. http://www.ducks.org/hunting/waterfowl-id/wood-duck. Accessed July 2011.

Dugger. K.M. and L.H. Fredrickson. 1992. Life History and Habitat Needs of the Wood Duck. Waterfowl Management Handbook. Fish and Wildlife Leaflet 13.1.6. United States Department of the Interior Fish and Wildlife Service. http://www.nwrc.usgs.gov/wdb/pub/wmh/13_1_6.pdf.

Dunning, J.B. (Ed). 2008. CRC Handbook of Avian Body Masses. 2nd Edition. Boca Raton: CRC Press.

Dunstan, T.C. 1973. The biology of ospreys in Minnesota. Loon 45: 108-113.

Edwards, T.C., Jr. 1988. Temporal variation in prey preference patterns of adult ospreys. Auk 105: 244-251.

Erlinge, S. 1969. Food habits of the otter Lutra lutra and the mink Mustela vision in a trout water in southern Sweden. Oikos 20:1-7.

Fair, J.M., P.L. Kennedy, and L.C. Mcewen. 1995. Diet of nesting Killdeer in North Dakota. Wilson Ornithological Society. Wilson Bulletin 107(l), 1995, pp. 174-178.

Friends of Blackwater National Wildlife Refuge (FBNWR). 2011. Ospreys at Blackwater. Accessed at www.friendsblackwater.org/osprey.html on April 2011.

Gibbs, J.P. 1991. Spatial relationships between nesting colonies and foraging areas of great blue herons. Auk 108: 764-770.

Gibbs, J.P., S. Woodward, M.L. Hunter, et al. 1987. Determinants of great blue heron colony distribution in coastal Maine. Auk 104: 38-47.

Greene, E.P.; A.E. Greene, and B. Freedman. 1983. Foraging behavior and prey selection by ospreys in coastal habitats in Nova Scotia, Canada. In: Bird, D. M.; Seymour, N. R.; Gerrard, J. M., eds. Biology and management of bald eagles and ospreys. St. Anne de Bellvue, Quebec: Harpell Press; pp. 257-267.

Hamilton, W.J. 1940. The summer food of minks and raccoons on the Montezuma Marsh, New York. J. Wild. Mgmt. 4(1): 80-84.

Harding, A.R. (Ed). 1906. Mink Trapping. Columbus: A.R. Harding Publishing Co. pg. 20-32.

Henning, M.H., N.M. Shear Weinberg, N.D. Wilson, and T.J. Iannuzzi. 1999. Distributions for key exposure factors controlling the uptake of xenobiotic chemicals in great blue herons (Ardea herodias) through ingestion of fish. Human Ecol. Risk Assess. 5(1):125-144.

Henny, C.J. 1986. Osprey (*Pandion haliaetus*). Section 4.3.1, U.S. Army Corps of Engineers Wildlife Resources Management Manual. Technical Report EL-86-5 [NTIS No. AD A171 604].

Hornshaw, T.C., R.J. Aulerich, and H.E. Johnson. 1983. Feeding great lakes fish to mink: Effects on mink and accumulation and elimination of PCBs by mink. Jrnl. Toxicology and Environmental Health. 11(4-6):933-946.

Iowa State University. 1995. Managing Iowa Wildlife: Raccoons. Iowa State University, University Extension. Ames, Iowa. PM-1302e. June 1995.

Kempenaers, B., B. Congdon, P. Boag, and R.J. Robertson. 1999. Extrapair paternity and egg hatchability in tree swallows: evidence for the genetic compatibility hypothesis? Behavioral Ecology. 10(3):304-11.

Kirby, R.E., J.H. Riechmann, and L.M. Cowardin. 1985. Home range and habitat use of forest-dwelling mallards in Minnesota. Wilson Bull. 97: 215-219.

Kushlan, J.A. 1978. Feeding ecology of wading birds. In: Sprunt, A.; Ogden, J.; Winckler, S., eds. Wading birds. Natl. Audubon Soc. Res. Rep. 7; pp. 249-296.

MacArthur, R.A. 1978. Winter movements and home range of the muskrat. Can. Field-Nat. 92: 345-349.

McCarty. J.P. and D.W. Winkler. 1999. Foraging ecology and diet tree swallows feeding selectivity of nestlings. The Cooper Ornithological Society The Condor 101 :246-254.

McGilvrey, F.B. (compiler). 1968. A guide to wood duck production habitat requirements. Bur. of Sport Fish. and Wildl., Resour. Publ. 60. 32 pp.

Nagy, K.A. 2001. Food requirements of wild animals: Predictive equations for free-living mammals, reptiles and birds. Nutr. Abstr. Rev. B 71,21R -32R.

The Nature Conservancy. 2011. Tennessee: Hubbards Cave. Accessed at http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/tennessee/placesweprotect/ on July 26, 2011.

Nashville Outdoors. 2010. Website. http://www.nashvilleoutdoors.net/great-blue-heron.html.

Nelson, A.L. and A.C. Martin. 1953. Gamebird Weights. Jrnl Wildlife Management. 17(1);36-42.

Neves, R.J. and M.C. Odom. 1989. Muskrat Predation on Endangered Freshwater Mussels in Virginia. J.Wildl.Manage.53(4):934-941.

Nicholson, Charles. 1997. Atlas of the Breeding Birds of Tennessee. “Wood Duck (*Aix Sponsa*).” Knoxville, Tennessee. The University of Knoxville Press.

Nixon, C.M., P.C. Mankin, T.L. Esker, J.B. Sullivan, and A.K. Rothering. 2009. Aspects of Raccoon Life History in West Central Illinois. Transactions of the Illinois State Academy of Science. January 1, 2009.

North Carolina State University (NCSU). 2011. Working with Wildlife #6 – Wood Duck. North Carolina Cooperative Extension Service. http://www.ces.ncsu.edu/forestry/pdf/www/www06.pdf.

Peifer, R.W. 1979. Great blue herons foraging for small mammals. Wilson Bull. 91: 630-631.

Perry, W. 1982. Muskrats (ondatra zibethicus and Neofiber alleni). Pages 290-325 in J.A. Chapman and G.A. Feldhamer, eds., Wild mammals of North America. Johns Hopkins University. Press, Baltimore, Md.

Plissner, J.H., L.W. Oring, and S.M. Haig. 2000. Space Use of Killdeer at a Great Basin Breeding Area. Journal of Wildlife Management. 64(2):421-429.

Poole, A.F. 1989. Ospreys: a natural and unnatural history. Cambridge, MA: Cambridge University Press.

Prevost, Y.A. 1977. Feeding ecology of Ospreys in Antigonish County, Nova Scotia. Unpublished M.S. thesis, Montreal, Quebec, Macdonald College of McGill Univ.

Purdue, J.R. and H. Haines. 1977. Salt water tolerance and water turnover in the Snowy Plover. Auk 94(2):248-255.

Quinney, E. 1982. Growth, diet, and mortality of nestling Great Blue Herons. Wilson Bull. 94:571-577.

Robertson R.J. and W.B. Rendell. 1994. A long-term study of reproductive performance in tree swallows: the influence of age and senescene on output. Journal of Animal Ecology. 70(6):1014-1031.

Rundle, W.D. 1982. A case for esophageal analysis in shorebird food studies. J. Field Ornithol. 53:249-257.

Sargeant, Alan B., Raymond J. Greenwood, Marsha A. Sovada, and Terry L. Shaffer. 1993. Distribution and abundance of predators that affect duck production - Prairie Pothole Region. U.S. Fish and Wildlife Service, Resource Publication 194. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/birds/predator/index.htm (Version 29MAR1997).

Sather, J.H. 1958. Biology of the Great Plains muskrat in Nebraska. Wildl. Monogr.2.35.

Schacher, W.H. and M.R. Pelton. 1976. Sex ratios, morphology, and condition parameters of muskrats in East Tennessee. Proceedings of the Southeastern Association of Fish and Wildlife Agencies. 30:660-66.

Short, H.L. and R.J. Cooper. 1985. Habitat Suitability Index Models: Great Blue Heron. U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C. Biological Report 82(10.99). July 1985.

Sibley, D.A. 2003. The Sibley Field Guide to Birds of Eastern North America. Alfred A. Knopf, New York.

Small Business Innovation Research (SIBR). 2011. California Animal Facts: Raccoon. Accessed at http://www.sibr.com/mammals/M153.html on June 15, 2011.

Sousa, P.J. and A.H. Farmer. 1983. Habitat Suitability Index Models: Wood Duck. U.S. Fish and Wildlife Service, U.S. Department of the Interior. FWS/OBS-82/10.43. July.

Souza, M.J. 2010. Raccoon Basic Data. Unpublished. Department of Comparative Medicine. University of Tennessee, College of Veterinary Medicine. Knoxville, TN.

Stegeman, L.C. 1955. Weights of Some Small Birds in Central New York. Bird Banding (16):19-27.

Svihla, A. and R.D. Svihla. 1931. The Louisiana muskrat. J. Mammal. 12: 12-28.

Swanson, G.A., M.I. Meyer, and V.A. Adomaitis. 1985. Foods consumed by breeding mallards on wetlands of south-central North Dakota. J. Wildl. Manage. 49: 197-203.

Tabatabai, F.R. and M.L. Kennedy. 1988. Food habits of the raccoon (Procyon lotor) in Tennessee. J. Tenn. Acad. Sci. 63: 89-94.

Tennessee Bat Working Group (TBWG). 2011. Gray Bat. Accessed at http://www.state.tn.us/twra/tnbwg/graybat.html on July 13, 2011.

Tennessee Valley Authority (TVA) River Neighbors. 2006. http://www.tva.gov/river/neighbors/aug06/ospreys.htm

Tennessee Wildlife Resources Agency (TWRA). 2005. Tennessee's Comprehensive Wildlife Conservation Strategy. TWRA: Nashville, Tennessee.

Tennessee Wildlife Resources Agency (TWRA). 2011. Tennessee Wildlife Resources Agency. http://www.tnwatchablewildlife.org/birds.cfm. Accessed on June 26, 2011.

Thayer, G.W., W.E. Schaaf, J.W. Angelovic, et al. 1973. Caloric measurements of some estuarine organisms. Fishery Bull. 71: 289-296.

U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. Washington, D.C., EPA/600/R-93/187.

U.S. Fish and Wildlife Service (USFWS). 1992. 13.2.14. Management of Habitat for Breeding and Migrating Shorebirds in the Midwest. Fish and Wildlife Leaflet 13. Washington, D.C. 1992.

U.S. Fish and Wildlife Service (USFWS). 2009. Tennessee National Wildlife Refuge, Southeast Region: Shorebirds. Accessed at http://www.fws.gov/tennesseerefuge/Shorebirds.htm. Last updated: December 7, 2009.

U.S. Fish and Wildlife Service (USFWS). 2011. Gray Bat (*Myotis grisescens*). Accessed at http://www.fws.gov/southwest/es/Oklahoma/graybat.htm on July 13, 2011.

U.S. Geological Survey (USGS). 2011a. Biological and Ecotoxicological Characteristics of Terrestrial Vertebrate Species Residing in Estuaries: Mink. Accessed at http://www.pwrc.usgs.gov/bioeco/mink.htm on July 10, 2011.

U.S. Geological Survey (USGS). 2011b. Biological and Ecotoxicological Characteristics of Terrestrial Vertebrate Species Residing in Estuaries: Muskrat. Accessed at http://www.pwrc.usgs.gov/bioeco/muskrat.htm on July 10, 2011.

Vana-Miller, Sandra L. 1987. Habitat Suitability Index Models: Osprey. U.S. Fish and Wildlife Service. Biological Report 82(10.154). 46 pages.

Whyte, R.J. and E.G. Bolen. 1984a. Impact of Winter Stress on Mallard Body Composition. The Condor. 86(4):477-482.

Whyte, R.J. and E.G. Bolen. 1984b. Variation in Winter Fat Depots and Condition Indices of Mallards. Journal Wildlife Management. 48(4):1370-1373.

Willner, G.R.; G.A. Feldhamer, E.E. Zucker, et al. (1980) Ondatra zibethicus. Mammalian species. No. 141. Amer. Soc. Mammal.; 8 pp.

Winkler, D.W., K.K. Hallinger, D.R. Ardia, R.J. Robertson, B.J. Stutchbury, and R.R. Cohen. 2011. Tree Swallow (Tachycineta bicolor), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/011.

Wise, M.H., I.J. Linn, and C.R. Kennedy. 1981. A comparison of the feeding biology of mink Mustela vison and otter Lutra lutra. J. Zool. Lond. 195: 181-213.

ARCADIS

Table 1. Body Weight Data for Wildlife Receptors of Interest
Tennessee Valley Authority Kingston, Tennessee

Gender, Age	Sample Size (n)	Weight (g)	Standard Deviation (g)	Coefficient of Variation	Sample Size Weight (g)	Comment	Source
Wood Duck (*Aix sponsa*)							
Male	1	589	--	--	589	assumed to be 1 individual	Baldwin and Kendeigh 1938
Male, adult	150	694	--	--	104100	mean of 150 individuals	Delnicki and Reinecke 1986
Female, adult	76	647	--	--	49172	mean of 76 individuals	
Male, adult	248	680.39	--	--	168736.72	mean of 248 individuals	Nelson and Martin 1953
Female, adult	163	635.1	--	--	103521.3	mean of 163 individuals	
Weighted Average [a]		**668**					
Mallard (*Anas platyrhynchos*)							
Male, adult	87	1237	118	0.0954	107619	mean of 87 individuals	Whyte 1984a
Female, adult	42	1088	105	0.0965	45696	mean of 42 individuals	
Male, adult	22	1203	--	--	26466	mean of 22 individuals, autumn	Whyte 1984b
Male, adult	37	1252	--	--	46324	mean of 37 individuals, early winter	
Male, adult	26	1247	--	--	32422	mean of 26 individuals, midwinter	
Male, adult	42	1215	--	--	51030	mean of 42 individuals, late winter	
Male, adult	37	1282	--	--	47434	mean of 37 individuals, early spring	
Female, adult	22	1084	--	--	23848	mean of 22 individuals, autumn	
Female, adult	25	1130	--	--	28250	mean of 25 individuals, early winter	
Female, adult	27	1115	--	--	30105	mean of 27 individuals, midwinter	
Female, adult	42	1088	--	--	45696	mean of 42 individuals, late winter	
Female, adult	45	1114	--	--	50130	mean of 45 individuals, early spring	
Male, adult	1308	1246	--	--	1629768	mean of 1308 individuals	Delnicki and Reinecke 1986
Female, adult	453	1095	--	--	496035	mean of 453 individuals	
Male, adult	3963	1224.7	--	--	4853486.1	mean of 3963 individuals	Nelson and Martin 1953
Female, adult	3169	1043.26	--	--	3306090.94	mean of 3169 individuals	
Weighted Average [a]		**1,158**					
Killdeer (*Charadrius vociferus*)							
Male, adult	1	121.8	--	--	121.8	weight for 1 individual; weight units not specified	Stegeman 1955
Female, adult	1	95.7	--	--	95.7		
Not specified	1	85	--	--	85	assumed to be 1 individual	Baldwin and Kendeigh 1938
Adult, male	10	92.1	10.4	0.1129	921	mean of 10 individuals	Dunning (ed) 2008
Adult, female	6	101	--	--	606	mean of 6 individuals	
Not specified	1	71	--	--	71.1	weight for 1 individual	Purdue and Haines 1977
Weighted Average [a]		**95**					

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Table 1. Body Weight Data for Wildlife Receptors of Interest
Tennessee Valley Authority Kingston, Tennessee

Gender, Age	Sample Size (n)	Weight (g)	Standard Deviation (g)	Coefficient of Variation	Sample Size Weight (g)	Comment	Source
Great Blue Heron (*Ardea herodias*)							
Males and females	37	2229.1	762.1	0.3419	82476.7	mean of group of 37	Quinney 1982
Not specified	1	1905	--	--	1905	assumed to be 1 individual	Baldwin and Kendeigh 1938
Adult, male	24	2480	290	0.1169	59520	mean of 24 individuals	Dunning (ed) 2008
Adult, female	29	2110	340	0.1611	61190	mean of 29 individuals	
Weighted Average [a]		**2,254**	**363.16**	**0.16**			
Osprey (*Pandion haliaetus*)							
Not specified	2	1797.5	--	--	3595	mean of 2 individuals	Baldwin and Kendeigh 1938
Male, adult	7	1437	100	0.0696	10059	mean of 7 individuals	Henny 1986
Female, adult	10	1798	96	0.0534	17980	mean of 10 individuals	
Not specified	1	1600	--	--	1600	estimate of body weight of adult osprey	Prevost 1977
Weighted Average [a]		**1,662**	**102.18**	**0.06**			
Muskrat (*Ondatra zibethicus*)							
Male, adult	40	1305.8	29.9	0.0229	52232	mean weight for 40 individuals, spring	Schacher and Pelton 1976
Male, adult	19	1336.6	28.1	0.0210	25395.4	mean weight for 19 individuals, summer	
Male, adult	11	1307.5	51.5	0.0394	14382.5	mean weight for 11 individuals, fall	
Male, adult	23	1325.8	45.9	0.0346	30493.4	mean weight for 23 individuals, winter	
Female, adult	12	1288.4	53.2	0.0413	15460.8	mean weight for 12 individuals, spring	
Female, adult	15	1352.1	55.9	0.0413	20281.5	mean weight for 15 individuals, summer	
Female, adult	13	1241.3	42.9	0.0346	16136.9	mean weight for 13 individuals, fall	
Female, adult	13	1221.3	54.2	0.0444	15876.9	mean weight for 13 individuals, winter	
Male, adult	198	1179.3	--	--	233501.4	mean weight for 198 individuals	Sather 1958
Female, adult	215	1088.6	--	--	234049	mean weight for 215 individuals	
Weighted Average [a]		**1,177**	**43.55**	**0.04**			

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Table 1. Body Weight Data for Wildlife Receptors of Interest
Tennessee Valley Authority Kingston, Tennessee

Gender, Age	Sample Size (n)	Weight (g)	Standard Deviation (g)	Coefficient of Variation	Sample Size Weight (g)	Comment	Source
Raccoon (*Procyon lotor*)							
Female, adult	1	4840	--	--	4840	weight for 1 individual	Nixon, et al. 2009
Female, adult	1	4310	--	--	4310	weight for 1 individual	
Female, adult	1	5380	--	--	5380	weight for 1 individual	
Female, adult	1	3210	--	--	3210	weight for 1 individual	
Female, adult	1	5060	--	--	5060	weight for 1 individual	
Female, adult	1	4490	--	--	4490	weight for 1 individual	
Male, adult	1	7330	--	--	7330	weight for 1 individual	
Male, adult	1	6130	--	--	6130	weight for 1 individual	
Male, adult	1	4500	--	--	4500	weight for 1 individual	
Male, adult	1	5850	--	--	5850	weight for 1 individual	
Male, adult	1	6880	--	--	6880	weight for 1 individual	
Male, adult	1	3890	--	--	3890	weight for 1 individual	
Male, adult	1	7890	--	--	7890	weight for 1 individual	
Male, adult	1	6400	--	--	6400	weight for 1 individual	
Weighted Average [a]		**5,440**	**1,363.27**				
Mink (*Neovison vison*)							
Male, 10 months	4	1734	349.7	0.2017	6936	mean weight for control fish diet, 4 individuals	Hornshaw et al. 1983
	4	1631	212.5	0.1303	6524	mean weight for carp diet, 4 individuals	
	3	1582	507.7	0.3209	4746	mean weight for sucker diet, 3 individuals	
	4	1840	176.4	0.0959	7360	mean weight for perch diet, 4 individuals	
	4	1505	232.3	0.1544	6020	mean weight for whitefish racks diet, 4 individuals	
	3	1420	302.8	0.2132	4260	mean weight for alewife fishmeal diet, 3 individuals	
Female, 10 months	12	974	202.2	0.2076	11688	mean weight for control fish diet, 12 individuals	
	9	904	110.5	0.1222	8136	mean weight for carp diet, 9 individuals	
	7	903	164.3	0.1819	6321	mean weight for sucker diet, 7 individuals	
	11	966	115.9	0.1200	10626	mean weight for perch diet, 11 individuals	
	11	992	129.2	0.1302	10912	mean weight for whitefish racks diet, 11 individuals	
	12	992	112.1	0.1130	11904	mean weight for alewife fishmeal diet, 12 individuals	
Female, 9 months	14	961	137	0.1426	13454	mean weight for standard mink diet, 14 individuals	
	9	942	155.1	0.1646	8478	mean weight for perch scraps and sucker diet, 9 individuals	
Not specified, adult	1	1360.89	--	--	1360.89	low end weight distribution for prime, large mink	Harding 1906
Not specified, adult	1	2267.96	--	--	2267.96	high end weight distribution for prime, large mink	
Weighted Average [a]		**1,110**	**164.79**	**0.15**			

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Table 1. Body Weight Data for Wildlife Receptors of Interest
Tennessee Valley Authority Kingston, Tennessee

Gender, Age	Sample Size (n)	Weight (g)	Standard Deviation (g)	Coefficient of Variation	Sample Size Weight (g)	Comment	Source
Tree Swallow (*Tachycineta bicolor*)							
Male, adult	9	18.4	0.7	0.0380	165.6	mean of 9 individuals in 1994	Burness, et al. 1998
Male, adult	16	18.4	1.11	0.0603	294.4	mean of 16 individuals in 1995	
Female, adult	10	16.9	0.9	0.0533	169	mean of 10 individuals in 1994	
Female, adult	16	17	0.96	0.0565	272	mean of 16 individuals in 1995	
Male, adult	17	19.35	1.1	0.0568	328.95	mean of 17 individuals	Burness, et al. 2001
Female, adult	29	18.25	1.17	0.0641	529.25	mean of 29 individuals	
Male, adult	13	19.3	0.3	0.0155	250.9	mean of 13 individuals fed Yarrow grass	Dawson 2004
Male, adult	9	19.7	0.3	0.0152	177.3	mean of 9 individuals fed Brome grass	
Male, adult	9	20.2	0.3	0.0149	181.8	mean of 9 individuals, control group	
Female, adult	14	19.4	0.3	0.0155	271.6	mean of 14 individuals fed Yarrow grass	
Female, adult	11	19.7	0.3	0.0152	216.7	mean of 11 individuals fed Brome grass	
Female, adult	9	19.9	0.4	0.0201	179.1	mean of 9 individuals, control group	
Male, adult	24	21	1.4	0.0667	504	mean of 24 individuals with an extra pair of young in nest	Kempenaers, et al. 1999
Male, adult	12	21.4	1.6	0.0748	256.8	mean of 12 individuals without an extra pair of young in nest	
Female, adult	29	20.5	1.4	0.0683	594.5	mean of 29 individuals with an extra pair of young in nest	
Female, adult	11	21	1.1	0.0524	231	mean of 11 individuals without an extra pair of young in nest	
Male, adult	55	21.1	0.2	0.0095	1160.5	mean of 55 individuals defending > 1 nest	Robertson and Rendell 1994
Male, adult	162	21.1	0.1	0.0047	3418.2	mean of 162 individuals defending a single nest	
Female, adult	70	20.8	0.2	0.0096	1456	mean of 70 individuals defending > 1 nest	
Female, adult	206	21	0.1	0.0048	4326	mean of 206 individuals defending a single nest	
Weighted Average [a]		**20.5**	**0.60**	**0.03**			
Grey Bat (*Myotis grisescens*)							
Not specified	NA	8	--	--			Tennessee Bat Working Group (TBWG) 2011
Not specified	NA	11	--	--			
Average		**9.5**	**2.12**				

g grams
NA - not available.
[a] weighted averages were calculated by summing the sample size weight and dividing by the sum of the sample size (n).

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Table 2. Selected Dietary Exposure Parameters

Tennessee Valley Authority Kingston, Tennessee

	Average Body Weight (grams)	Food Ingestion Rate (dry weight)	Incidental Sediment Ingestion Rate	Water Ingestion Rate
Wood Duck	668	54.9 g/day	2% FIR	0.045 L/day
Mallard Duck	1,158	80 g/day	3.3% FIR	0.065 L/day
Killdeer	95	14 g/day	10.4% FIR	0.012 L/day
Blue Heron	2,254	126 g/day	1% FIR	0.101 L/day
Osprey	1,662	102 g/day	Negligible	0.083 L/day
Muskrat	1,177	62 g/day	9.4% of FIR	0.114 L/day
Raccoon	5,440	194 g/day	9.4% of FIR	0.45 L/day
Mink	1,110	59 g/day	2% FIR	0.108 L/day
Tree Swallow	20.5	5.05 g/day	Negligible	0.004 L/day
Gray Bat	9.5	1.7 g/day	Negligible	0.0015 L/day

% = percent
FIR = food ingestion rate
kg = kilogram
L = liter
g = grams

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Table 3. 2009 Raccoon Data for Kingston Site

Tennessee Valley Authority **Kingston, Tennessee**

Date	ID	Age	Sex	Length in cm (head to rump)	Length in cm (head to tail)	Weight (kg)
10/2/2009	RAC0901	Adult	Female	55	78	4.84
10/29/2009	RAC0905	Adult	Female	53	75	4.31
11/4/2009	RAC0907	Adult	Female	53	72	5.38
11/5/2009	RAC0910	Adult	Female	49	65	3.21
11/10/2009	RAC0911	Adult	Female	53	72	5.06
11/13/2009	RAC0912	Adult	Female	49	68	4.49
12/2/2009	RAC0915	Juvenile	Female	51	71	3.95
10/20/2009	RAC0902	Adult	Male	57	80	7.33
10/27/2009	RAC0903	Adult	Male	57	78	6.13
10/28/2009	RAC0904	Adult	Male	52	73	4.5
11/3/2009	RAC0906	Adult	Male	59	78	5.85
11/4/2009	RAC0908	Adult	Male	62	84	6.88
11/5/2009	RAC0909	Adult	Male	54	74	3.89
11/17/2009	RAC0913	Adult	Male	60	79	7.89
11/18/2009	RAC0914	Adult	Male	58	79	6.4

cm = centimeters
kg = kilograms
Ref. Souza 2010.

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Table 4. Derivations of Food Ingestion Rates

Tennessee Valley Authority **Kingston, Tennessee**

	Prey type (unitless)	Proportion of Diet (unitless)	Gross Energy (kcal/g ww)	Assimilation Efficiency (unitless)	Metabolic Energy (kcal/g ww)	NFMR (kcal/kg-day)	NIR_{total} (g/kg-day)	NIR_{total} (g/g-day)
Mallard Duck	Plants	25%	0.51	23%	0.12			
	Invertebrates	75%	0.95	77%	0.73			
				ME_{avg}=	0.58			
						196	340	0.34
Killdeer	Benthic Invertebrates	20%	0.95	77%	0.73			
	Terrestrial Invertebrates	80%	1.3	72%	0.94			
				MEavg=	0.9			
						365	408	0.41
Raccoon	Fish	1%	1.2	91%	1.09			
	Terrestrial Invertebrates	29%	1.2	87%	1.04			
	Benthic Invertebrates	10%	0.95	87%	0.82			
	Plants	58%	1.3	76%	0.99			
	Small mammals	2%	1.7	84%	1.43			
				ME_{avg}=	1			
						185	185	0.19
Tree Swallow	Invertebrates	100%	1.6	72%	1.15			
				ME_{avg}=	1.15			
						995	863	0.86

% = percent
g/g = grams per gram
g/kg = grams per kilogram
kcal/g = kilocalories per gram
ME_{avg} = metabolic energy average
NFMR = normalized free-living metabolic rate
NIR_{total} = total normalized ingestion rate
ww = wet weight