DIET ANALYSIS OF THE COYOTE (*CANIS LATRANS*) IN METROPOLITAN PARK SYSTEMS OF NORTHEAST OHIO

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ABSTRACT

The coyote (Canis latrans) is not native to the greater Cleveland area, with the first documented sighting here in the late 1980s. Coyote populations here apparently have been increasing in the past two decades. Its position as a top predator in the local ecological community likely bears important consequences. The impact of the coyote on other, native species (e.g. the white-tailed deer) is largely unknown but may be significant. Its general ecology here is not well known, and concerns about the coyote are likely to increase, especially if its populations continue to grow. Coyotes are known to use a variety of habitats and are able to survive, and even thrive, in habitats with low to high levels of human density. Although formally classified as carnivores, coyotes have a broad diet. Generally considered an opportunistic predator, coyote diets show marked regional and seasonal variation, and variation associated with specific habitats and levels of human density, commonly reflecting availability in the area.

The goal of this study was to identify the major items and seasonal differences in the diet of coyotes along an urban-rural gradient within two metropolitan park systems in northeast Ohio: the Cleveland Metroparks and the Cuyahoga Valley National Park. Coyote scat was collected every four to six weeks at selected sites in the parks, and returned to the lab to be dried, autoclaved, and dissected. Major diet components across sites within the park systems were identified using published keys and comparison to reference collections. Diet components were analyzed seasonally and across sites along

the urban-rural gradient.

A total of 1760 prey items were found and identified in the 944 samples dissected. Small mammals (*Microtus, Peromyscus, Blarina,* other shrew and unknown small mammal) were the largest component across sites and seasons, comprising 27% of prey items found in scat samples. White-tailed deer (*Odocoileus virginianus)* was also a large component, comprising 24% of prey items found. Vegetation (fruits, other plant) overall was 17%, with higher amounts in fall than any other season. Rabbit (*Sylvilagus floridanus)* and raccoon (*Procyon lotor*) were 8% and 6% respectively, with squirrel and chipmunk (*Sciuus*, *Tamiasciurus hudsonicus, Tamias striatus*) comprising 4% of overall prey items found. Other prey items comprised the remaining 14% of total prey items, consisting of 10 prey items categories ranging from 2.4% to .06% of the overall prey items found. These 10 categories included bird, insect, woodchuck (*Marmota monax*), muskrat (*Ondatra zibethicus*), other mammal, dirt/sand, synthetic materials, reptiles/fish, and snail. Coyotes in the Cleveland Park Systems have a broad diet that varies across seasons. Analyses detected significant differences (f=3.87, df=18, 122, P<0.001) across seasons with regard to the consumption of small mammals, white-tailed deer, vegetation, and raccoon. No statistical difference existed between prey items consumed across sites along urban-rural gradient (f=0.729, df=12, 86, P=0.278).

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CHAPTER I

INTRODUCTION

Although the coyote (*Canis latrans*) has been a part of North American folklore and heritage since pre-Euporean settlement, much remains to be known about its ecology and behavior, particularly in the eastern United States and urbanized areas. Historically restricted mainly to prairie regions west of the Mississippi River (Moore and Parker, 1992), the range of the coyote has increased since the late 19th century and now includes a variety of habitats, including densely populated urban areas and suburbs of large cities throughout North America. In much of the eastern United States, coyotes have become the dominant large predator, and understanding their ecology is important in gaining an appreciation of their ability to affect ecological communities (Atwood et al., 2004). Lack of knowledge about coyote ecology in the eastern United States and urban areas makes it difficult to predict how coyotes may behave in these areas, how to appropriately plan management of coyotes, and how extensively coyotes may be affecting other species. Equally important is the challenge of properly educating the public to handle the inevitable interactions that will occur as coyote populations increase throughout the eastern United States.

Research has shown that coyotes use a wide range of habitat types across a wide range of areas with different levels of human activity (Gibeau, 1993). Coyotes appear to use urban habitats in proportion to availability, and coyotes are apparently neither attracted to nor repelled by urban areas, although human disturbance may affect daily movements, activity patterns, and foraging habitats (Dumond et al., 2001; Gibeau, 1993; Grinder and Krausman, 1998; Shargo, 1988). This is particularly true in urban areas, where garbage, pet foods, and pets may be readily available food resources. However, in a study analyzing coyote ecology along a suburban to rural gradient, Atwood et al. (2004) showed that coyotes in both suburban and rural areas established home ranges that minimized exposure to human development. Coyotes in urban areas tend to have small home ranges (Atkinson and Shakleton, 1991), which may be an indicator of abundant food sources (Quinn, 1997). Despite the tendency of coyotes to avoid humans and areas of high human density, the concern of potential habituation of coyotes to human presence, in turn leading to increased sightings of coyotes and potential conflicts with coyotes and people, remains an issue to natural resource managers and health and human service agencies. In urban areas of southern California, there had been an increase of coyote attacks on pets and people (Baker and Timm, 1998), making coyote-human conflicts considered relatively common in the area in the late 1990's. However, after a public intervention and education/trapping control project was initiated, coyote-human conflicts are now considered relatively uncommon.

The presence of coyotes in areas where they have expanded their range may have effects on species native to those areas. Coyotes may directly compete with some species for resources and may affect other species through top-down influence. Gompper (2002) identified several of these potential inter-specific relationships: competition with other large or smaller carnivores (such as bobcat [*Lynx rufus*] or red fox [*Vulpes vulpes*]), interactions with mesopredators (midsize predators such as raccoons [*Procyon lotor*] which prey on birds and their nests), and the possibility of mesopredator release occurring in the absence of coyotes. Coyotes can effect the population, distribution, and management efforts of their prey. In addition, coyotes have the potential to serve as disease vectors for other species of mammals, including humans.

Coyotes are territorial and use scent-marking, or the deposition of urine and feces, to mark territorial boundaries (Springer and Smith, 1981). Coyotes have been documented scent-marking in greater frequency on the periphery of their territories than in the interior (Gese and Ruff, 1997). Territorial coyotes, or those living within and maintaining a home range territory, have been observed scent-marking with greater frequency than individuals who are transient or dispersing to new areas (Barrette and Messier, 1980). Deposition of scat allows researchers to visit sites regularly to assess diet.

Little is known about the ecology of eastern coyotes in urban areas and eastern United States. Diet analyses of coyotes have found that, while classified as carnivores, coyotes are highly omnivorous and generally considered opportunistic predators (Bowyer et al., 1983; Beckoff, 1977). Coyote diet may vary greatly by season, region and habitat type (Todd, 1985). In winter, carrion of large game animals, such as the white-tailed deer (*Odocoileus virginianus)*, becomes an important food item, while in spring, summer, and fall, small mammals increase in frequency (Beckoff, 1977). Fruit and plant material also increase in frequency in many regions as they become available in late summer and autumn. (Richer et al., 2002; Witmer et al., 1995; Atkinson and Shakleton, 1991; Smith, 1990; Andelt et al., 1987; Bowyer et al., 1983). As fruits become available, coyotes consume increasing amounts of apples and berries (Kamler et al., 2002; Quinn, 1997; Parker, 1986; Bowyer et al., 1983). In some regions, fruit may become a primary item in coyote diets. Their diets change in response to shifts in prey abundance, as well as seasonal and successional changes in plant communities (Atkinson et al., 1987).

Small mammals, especially rodents, rabbits, and deer are often of primary importance in coyote diets (Prugh, 2005; Richer et al., 2002; Dumond and Villard, 2001; Atkinson and Shakleton, 1991; Shargo, 1988; Andelt et al., 1987). In Pennsylvania, Witmer et al. (1995) found that white-tailed deer were the dominant prey or scavenged item. In urban areas of Washington, Quinn (1997) found that fruit and mammals were the most abundant items in the diet of coyotes, both being consumed as seasonal availability increased. Many of these items were also made more available to coyotes by human alteration of land cover, showing that coyote diet can be altered by the presence of humans.

Coyotes in Ohio

The earliest documented reports of coyotes in the state occurred in 1919, with populations increasing through the 1900s. Prior to the 20th century, coyotes were generally located west of the Mississippi River, with only small populations found to the east (Ohio Division of Wildlife, 1999). By 1988, coyotes were present in all 88 Ohio counties (Weeks et al., 1990) and since the early 1990s there has been an increase in sighting of coyotes in northeastern Ohio, and conflicts with humans are increasing. Still, research on coyotes in Ohio is rare, and little information exists on the diets of coyotes in urban areas. Cepek's (2004) work, conducted within northeast Ohio's park systems, included a limited diet analysis of coyotes within the Cuyahoga Valley National Park; he recommended a more thorough examination of coyotes living in the area, including a seasonal analysis of diet.

The purpose of this study was to examine the diet of coyotes in a metropolitan area of northeast Ohio to determine: (1) the general components of their diet in an urban setting; (2) how diet varies across seasons; and (3) how diet varies across an urban-rural gradient within the greater Cleveland area park systems. Based on previous research conducted in other regions of the country, coyote diet was predicted to vary across the urban-rural gradient and between seasons.

CHAPTER II

STUDY AREA

Cleveland Metroparks and Cuyahoga Valley National Park are located in northeast Ohio within the metropolitan areas of Cleveland and Akron. Cleveland Metroparks (CMP) encircles the city of Cleveland, while Cuyahoga Valley National Park (CVNP) lies between the two cities (see Figure 1). Both are situated in the Cleveland-Akron-Elyria Combined Statistical Area, which is the 14th largest in the country, with a population of over 2.9 million people. The metropolitan areas lie about 100 km west of the Pennsylvania border, while the Cleveland metropolitan area is bordered by Lake Erie to the north. A humid continental climate exists with cold winters; wet, cool springs; warm, humid summers; and cool, usually dry, autumns. The northern potion of the study area (particularly in the eastern portion) is subject to lake effect snowfalls, influenced by Lake Erie, causing snow depths to vary greatly across the study area. On average, July is the warmest month of the year, with a mean temperature of 71.9°F (22.2°C) and January the coldest, with a mean temperature of 21.7°F (-3.5°C). The predominant forest is oak-hickory-beech-maple, although ridges to the extreme northeast and also some southern portions of the study area support other diverse vegetation such as hemlock and ash. The study area is a mosaic of park area; forests and woodlots; residential neighborhoods;

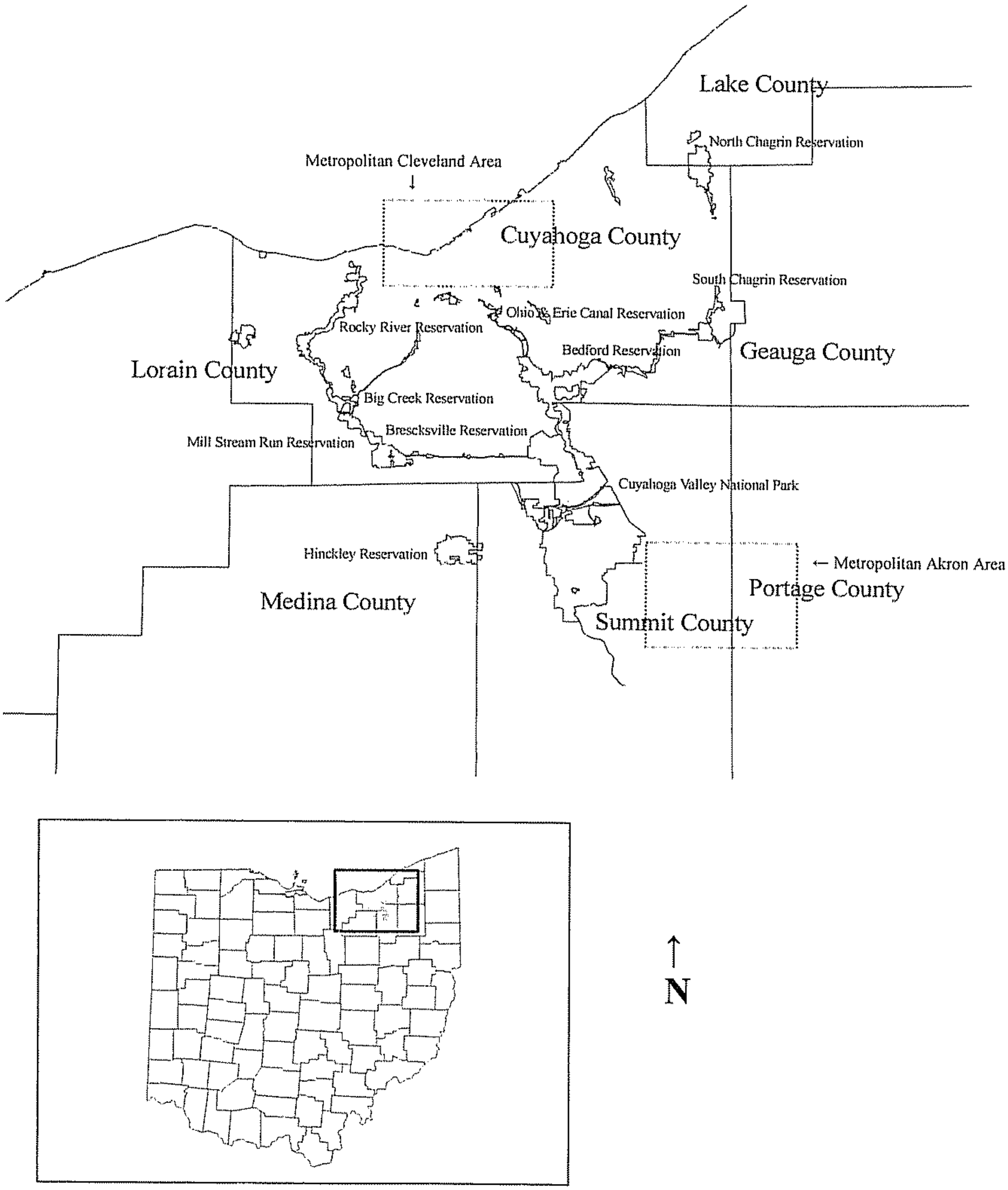


Figure 1. Map of study area and park reservations within northeast Ohio

industrial areas; commercial properties; open land; rural/agricultural fields; open water in ponds, rivers, and streams; and wetlands. Many highways and secondary roads transect the area. Three major river systems drain the area: the Rocky River to the west, Cuyahoga River located centrally, and Chagrin River to the east.

Established in 1917, Cleveland Metroparks (CMP) is the oldest park district in the state of Ohio. The CMP encompasses over 8,400 hectares in 16 reservations around the greater Cleveland area. The parks system is often referred to as the "Emerald Necklace" because the reservations encircle the city. The parks contain numerous hiking and bridle trails, picnic areas, golf courses, fishing areas, wildlife areas, outdoor education facilities, and recreational program facilities. The CMP also has over 160 km of roadways that wind throughout and connect the mostly forested reservations. Residential, commercial, and some industrial areas surround many of the reservations. Stressing conservation, education, and recreation, the park contains sites for both active and passive recreation. Established by an act of Congress in 1974, the Cuyahoga Valley National Park (CVNP) encompasses over 13,300 hectares along 35 kilometers of the Cuyahoga River. The park contains over 200 km of public trails, as well as wildlife areas, hiking trails, picnic areas, a music center, theater, farms, ski resorts, a water park, and scout camps. Several reservations of adjacent Cleveland Metroparks lie within the legislative boundaries of the national park. The park has some residential and commercial properties along and within its boundaries, particularly to the south.

CHAPTER III

METHODS

The most practical and least invasive way to study the diet of coyotes is through the regular collection and analysis of their scat. Coyote scats were collected along pre-selected collection transects, or "scat lines" from July 2002 to July 2005 (4 samples were collected in June 2001). Scat lines were selected at random in accessible and "open area" locations within the parks; however, to determine if coyotes were currently using sites for fecal deposit, scat lines were initially observed for scat deposits three times over 12-16 weeks. If scat was not found along a line after three initial searches, the site was eliminated. Each park system had a total of 21 scat lines. Most scat lines were located along utility rights-of-way, roads, existing trails, or hiking and bridle paths, and were located within park boundaries. All scat lines were walked every four to six weeks. Scats were collected during all four seasons, which were divided as follows for analysis: winter (December-February); spring (March-May); summer (June-August); and fall (September-November). Collected scats were stored in paper bags and labeled with site name, date, time of collection, and names of collectors.

To help ensure that scat deposited at different sites represented different individuals (and hence, statistical independence of sites), it was necessary to estimate typical distances traveled by coyotes in urban areas. Home ranges of coyotes vary greatly, from 1 km^2 to over 100 km^2. In suburban Chicago, Gehrt (2003) found that home range of coyotes varied from 9 km^2 to 59 km^2, depending on whether the animal was a member of a group or a solitary coyote. Atkinson and Shakleton (1991) found a mean home range of 10.8 km^2 for urban coyotes. Grinder and Krausman (2001) found most urban coyotes home ranges varied between 10 and 31 km^2 in urban areas, with individual ranges as low as 1.1 km^2 and as high as 118 km^2. For this study, coyote home range was assumed to be approximately 20 km^2, based on literature and level of urbanization of our study area. This assumed home range size provided a conservative estimate to determine site independence; that is, scat collected at each site was deposited by a unique set of coyotes. Scat lines were grouped together as the same site if lines were ≤ 2.5 km apart. Scat lines > 2.5 km apart were considered independent sites. The 2.5 km distance was measured from the midpoint of the scat line, and assumes coyote scent-marking on the periphery of a territory, as coyotes have been documented scent-marking in greater frequency on the periphery of their territories than in the interior (Gese and Ruff, 1997). This grouping of sites resulted in 16 independent collection sites within the park systems (see Figure 2).

Variation in diet along an urban-rural gradient within the park systems was of primary interest in this study. Placement of sites along the urban-rural gradient reflects the most urban to most rural sites within the park systems, instead of the most urban to rural areas in northeast Ohio. For the purpose of analysis along an urban-rural gradient, scat lines (n=42) were grouped into a total of 16 independent sites, and sites were scored along an urban-rural gradient using an existing GIS land cover classification map

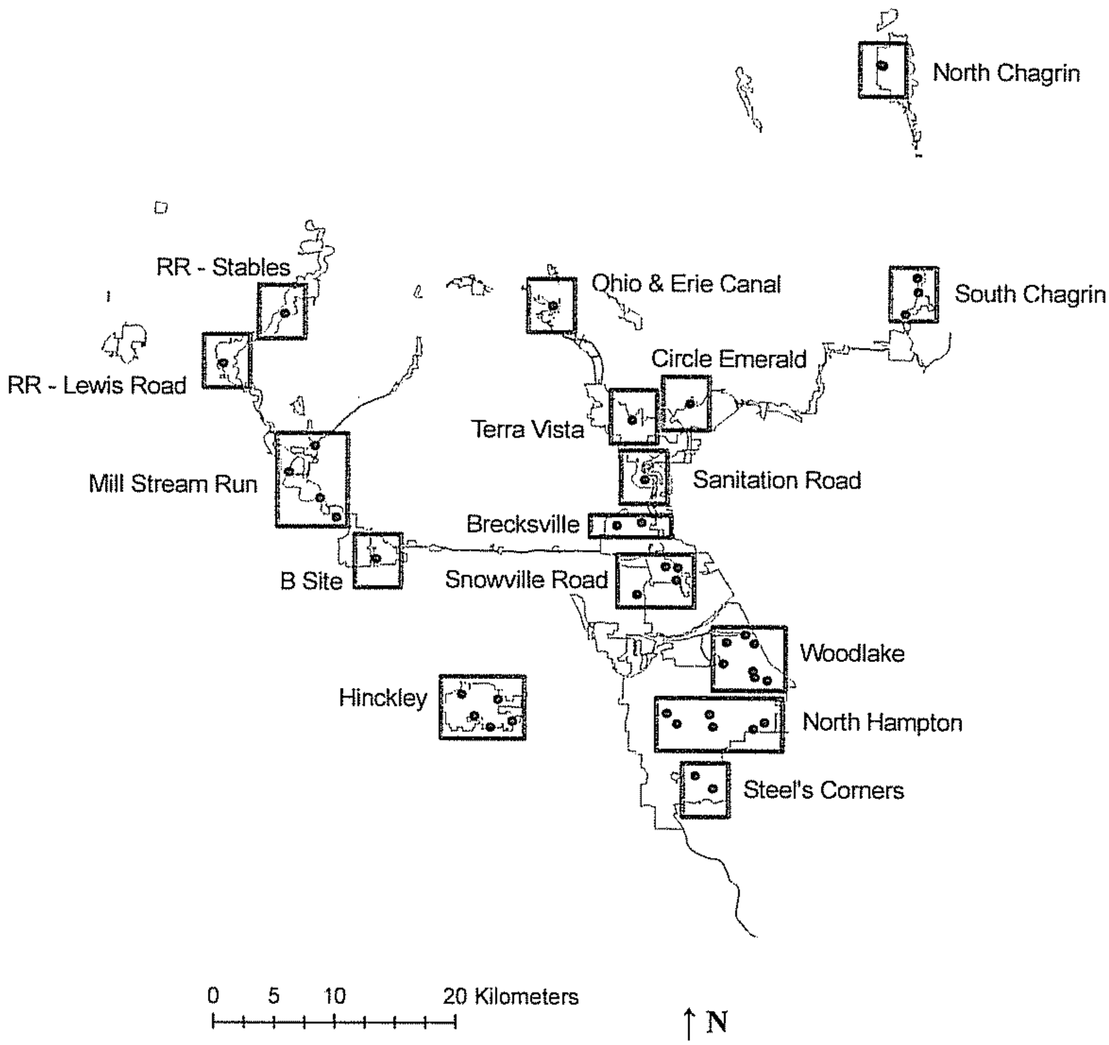


Figure 2. Map of 42 scat collection transects grouped into 16 independent site (>2.5 km distance apart)

(Frohn, 2003). Urban-rural classification was determined using a 5 km diameter buffer around the midpoint of each scat line transect or area. The scoring consisted of using a GIS-based analysis of land cover and ranking sites according to the average of the total percent of land cover around the midpoint of the transect which was classified as "Residential" and "Commercial/Industrial/Transportation" within the 25 km^2 buffer area. In the case of a site containing more than one transect, the classification scores among scat lines were averaged to calculate the overall classification score for the site. Sites containing more than 25% Residential-Commercial-Industrial-Transportation land cover were classified as "urban"; 10-24.9% were classified as "suburban"; and < 10% were classified as "rural" (see Figure 3).

When collecting samples, coyote feces were identified by evaluation of size and general appearance, and expected location of deposit along an existing path or right of way. For further identification during processing and dissection, any scat which was considered questionable due to small size or a visibly high percentage of commercial dog food was discarded to reduce the probability of including red fox (*Vulpes vulpes)* or domestic dog *(Canis familiaris)* scat in the study. Many scats were deposited at the junction of two paths, and they were often deposited within close proximity of scats collected from previous site visits. Scats were labeled in the field, returned to the lab, and autoclaved (120°C for 15 minutes) to kill *Echinococcus* and other pathogens that might have been present. Scats were then dried at 50°C in a drying oven until thoroughly dry (24-48 hrs),labeled, weighed, and stored in plastic air-tight containers until dissection.

For content analysis, scats were soaked in a mild bio-degradable soap and water solution, stirred to aid in breaking up formed feces but not destroying prey contents,

Site Name, # Scat Collection Lines	Urban-Rural Score % Urban Land Cover	Statistical Category
— Ohio & Erie Canal (1)	39 8	Urban
— RR – Stables (1)	37 1	Urban
— RR - Lewis Road (1)	33.7	Urban
— Mill Stream Run (4)	28 8	Urban
— Circle Emerald (1)	27 2	Urban
B Site (1)	22 7	Suburban
North Chagrin (2)	19.7	Suburban
Terra Vista (1)	19	Suburban
— Sanitation Road (1)	13.7	Suburban
— Brecksville (2)	11 9	Suburban
— Steel's Corners (2)	11 9	Suburban
— South Chagrin (3)	10.5	Suburban
— Woodlake (7)	8.2	Rural
— Snowville Road (4)	8	Rural
— Hinckley (5)	6 8	Rural
— North Hampton (6)	6.5	Rural

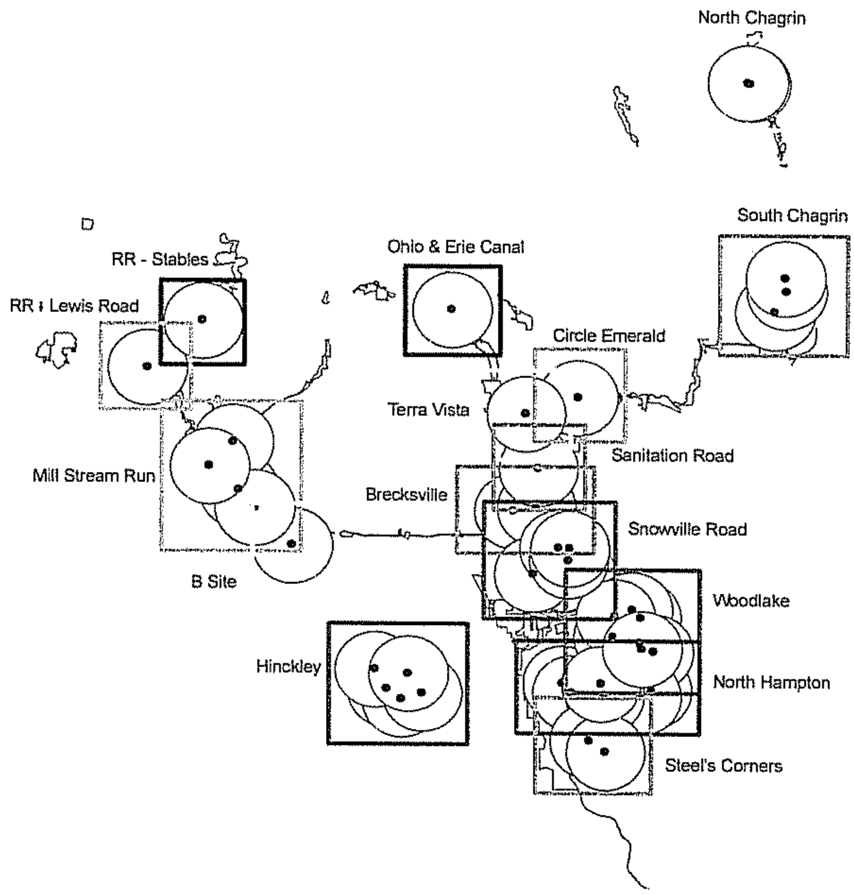


Figure 3. Sites positioned along urban-rural gradient showing 25 km^2 buffer. Colors indicate position along gradient, red being most urban and blue most rural. A tree category breakdown was used for statistical analysis.

rinsed under warm water through a nylon stocking, and then air-dried in filters. For identification, samples were spread in a large dissecting dish filled with warm water to separate bones and teeth from hair and other contents. A sample of all types of hair or fur present was removed for identification, and any bone, tooth, claw, or other material that was present was removed to aid in identifying prey. Mammals were identified by hair, teeth, and claws; birds by presence of feathers or beaks. Fruits and plant material were identified by seeds and plant tissue and were only scored if plant matter comprised a visual estimate of 25% or more of the scat sample to avoid scoring incidental ingestion. In addition, plant material adhering to the outside of the scat was removed prior to dissection to avoid scoring plant matter that became attached to the scat after deposit. Fish were recognized by the presence and identification of scales; reptiles and amphibians by the presence of skin, scales, and/or claws; and insects by exoskeleton fragments, legs, and wings. Synthetic materials were readily recognizable. Reference collections housed at the Cleveland Museum of Natural History, as well as a reference collection of hair, teeth, and claws collected from road-killed specimens, were used to identify prey items. Insects in scats were compared to reference collections from the museum, and those identified as "incidental" or "post-deposit" were not included in the analyses. Published keys and guides (Gottschang, 1981; Moore, Spence, and Dugnolle, 1974; Kurta, 1995; Adorjan and Kolenosky, 1969) served as identification, specifically for incisor and cheek tooth morphology of small mammals and guard hair identification. Prey items were identified to the lowest taxon possible.

For statistical analysis, the 6 most common prey item categories across all seasons and sites, which included approximately 86% of the prey items overall in the samples, were included. These categories were: (1) small mammals, (2) white-tailed deer, (3) vegetation, (4) eastern cottontail (*Sylvilagus floridanus*) , (5) raccoon, and (6) squirrel/chipmunk (*Sciurus niger, Sciurus carolinensis, Tamias striatus, Tamiassciurus hudsonicus,* and *Glaucomys volans*). Seasonally, these six categories combined made up 88%, 81%, 83% and 92% of the total prey items in spring, summer, fall, and winter, respectively.

SPSS 10.0 (SPSS, Inc., Chicago, Illinois) was used to analyze data statistically. Multivariate analysis of variance (MANOVA) was used to test for simultaneous effects of season and urban-rural gradient on prey selection by coyotes (significance level = 0.05). If significant effects were found, Bonferroni multiple comparisons tests were used to examine differences among seasons for each prey type. This is a conservative test that holds the experimentwise error rate to ≤ 0.05, making one less likely to commit type I statistical error when some of the assumptions of MANOVA are violated (e.g. multivariate normality). A Kruskal-Wallis (non-parametric univariate) test also was used to examine seasonal and urbanization differences. Because results of the Kruskal-Wallis test were virtually identical to those of MANOVA, only test statistics from MANOVA are reported.

CHAPTER IV

RESULTS AND DISCUSSION

Coyotes in the Cleveland-Akron park systems ate a diverse variety of prey items. However, across most sites and seasons, the prey items fell into six main categories. 944 coyote scat samples were collected between June 2002 and July 2005, yielding 1760 prey items for analysis. Coyote diet was quantified using the contents from 944 scats samples collected in Cleveland Metroparks and Cuyahoga Valley National Park. Most coyote scats contained more than one type of prey item. Coyotes marked territories on a regular basis, often only a few meters from where the last scat sample had been collected on a previous visit. Prey items were broken down into six main categories and one "other" category (see Table I). Small mammals were prominently represented in the diet of coyotes, being found in 51.9% of scats (frequency of occurrence, see Table II) and represented 27.8% of all prey items (Figure 4). Seasonally, small mammals occurred more in spring than any other season, constituting 36.2%, 16.5%, 25.9%, and 28.3% of prey items in spring, summer, fall, and winter, respectively (see Figures 5-8). White-tailed deer also constituted a large portion of coyote diet in the study area, being found in 43.9% of scat (frequency of occurrence), representing 23.5% of all prey items, and 26.8%, 27.6%, 12.8%, and 27.1% of all items in spring, summer, fall, and winter,

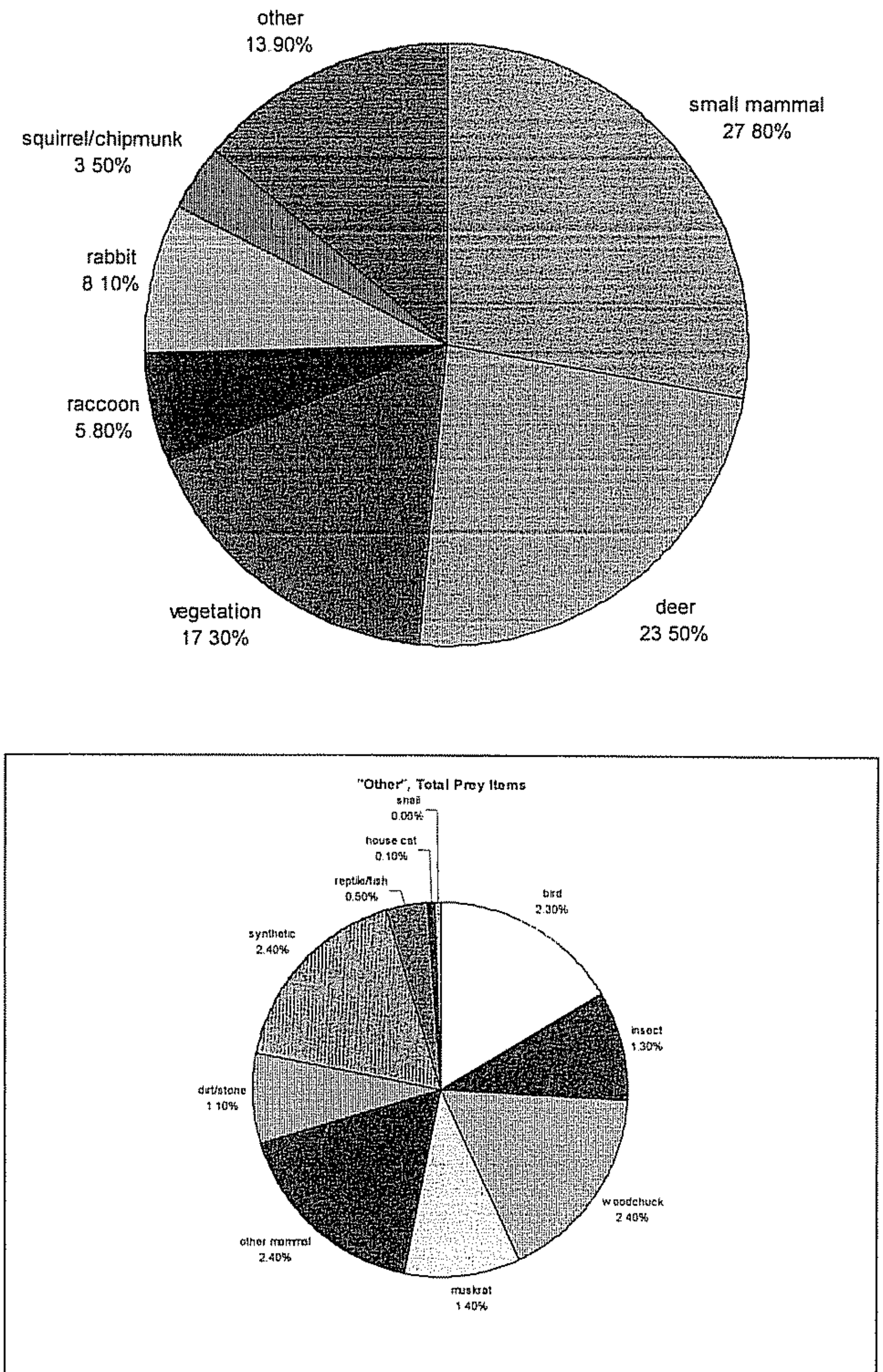
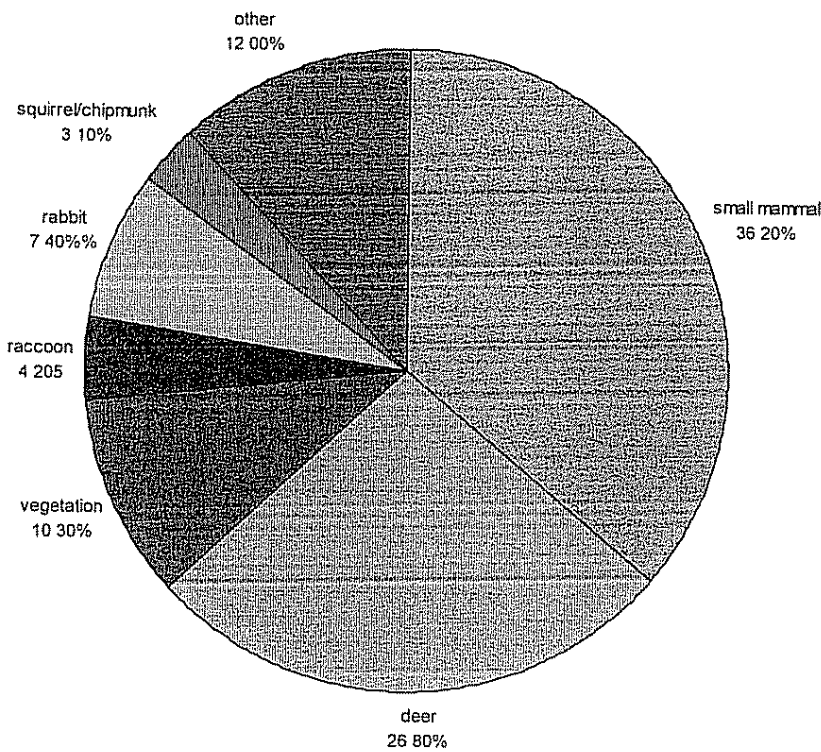


Figure 4. General diet of coyotes in the greater Cleveland park systems (Total prey items =1760)



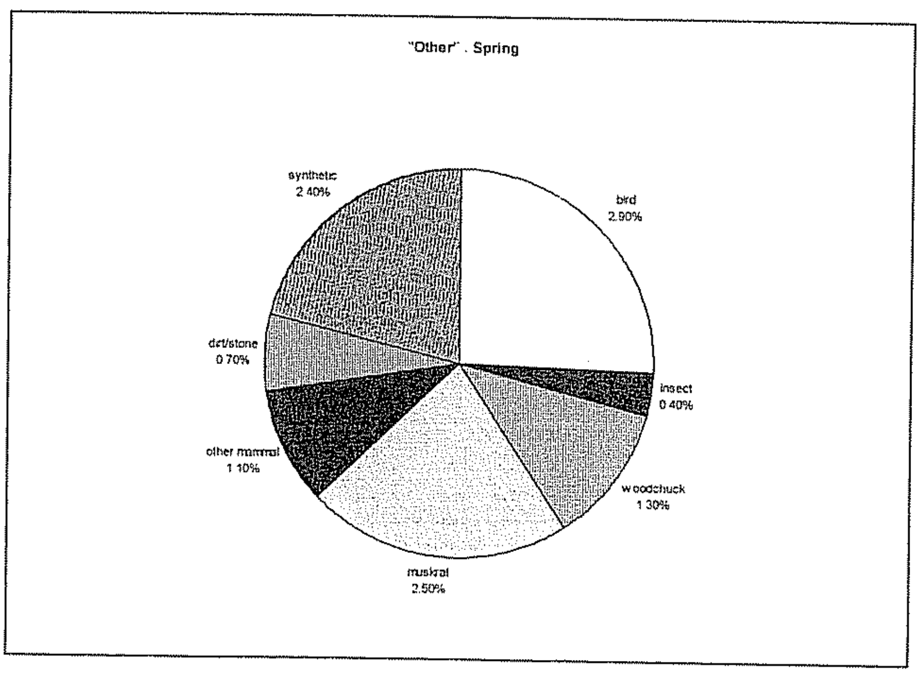
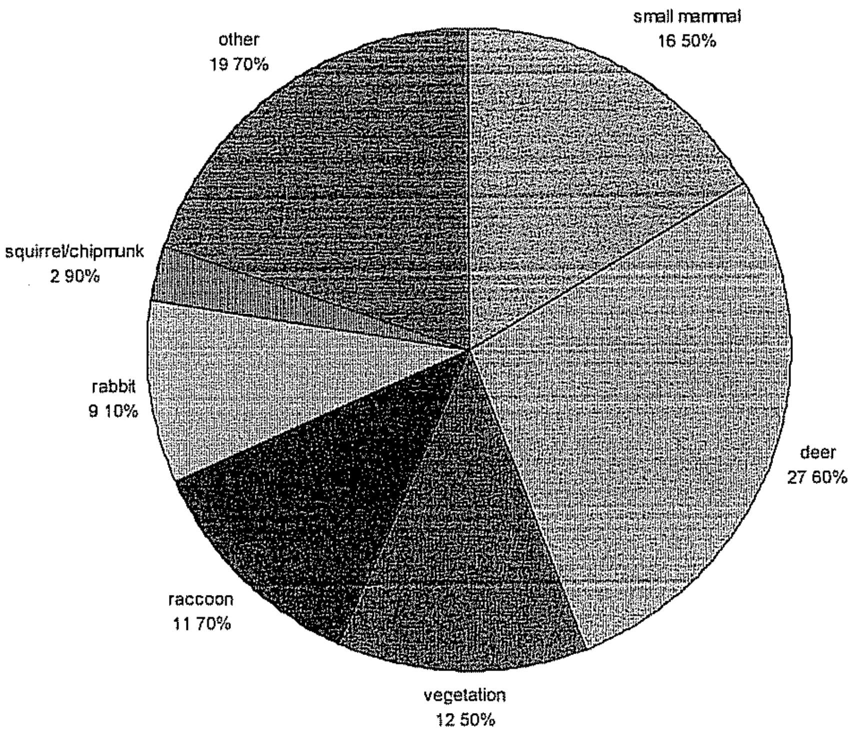


Figure 5. General diet of coyotes in the greater Cleveland park systems, spring (# Prey Items = 552)



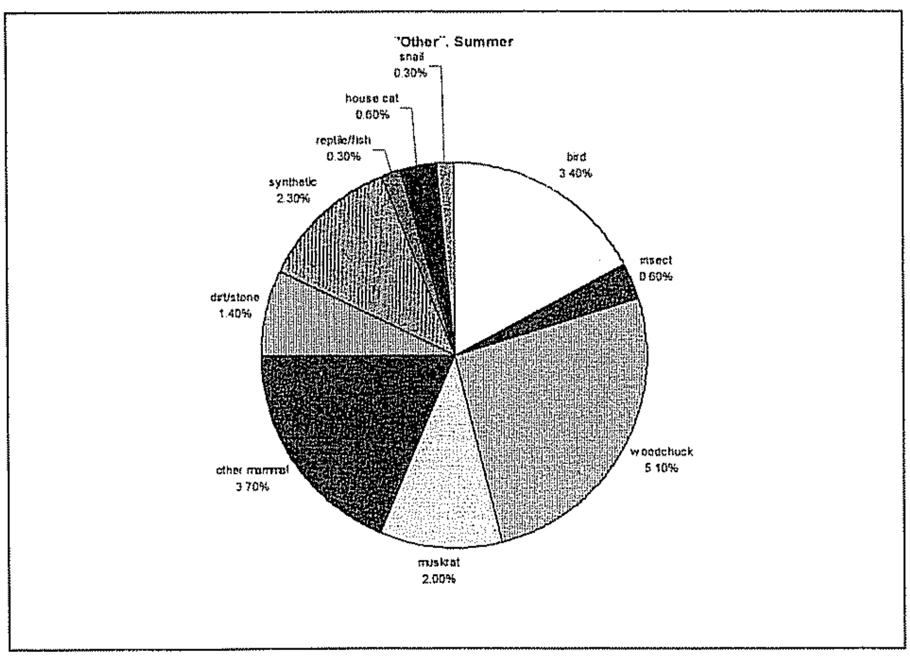
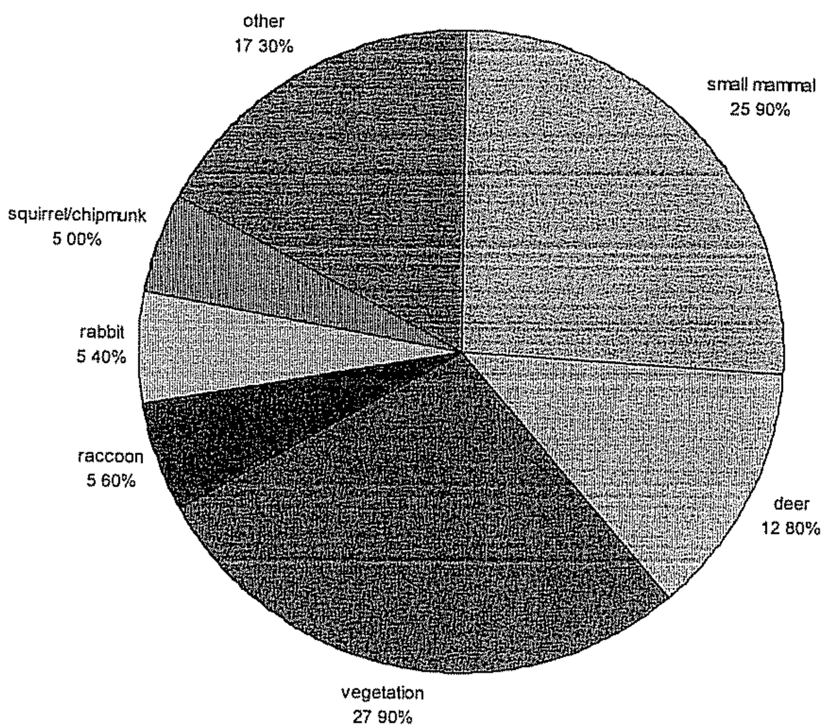


Figure 6. General diet of coyotes in the greater Cleveland park systems, summer (# Prey Items = 351)



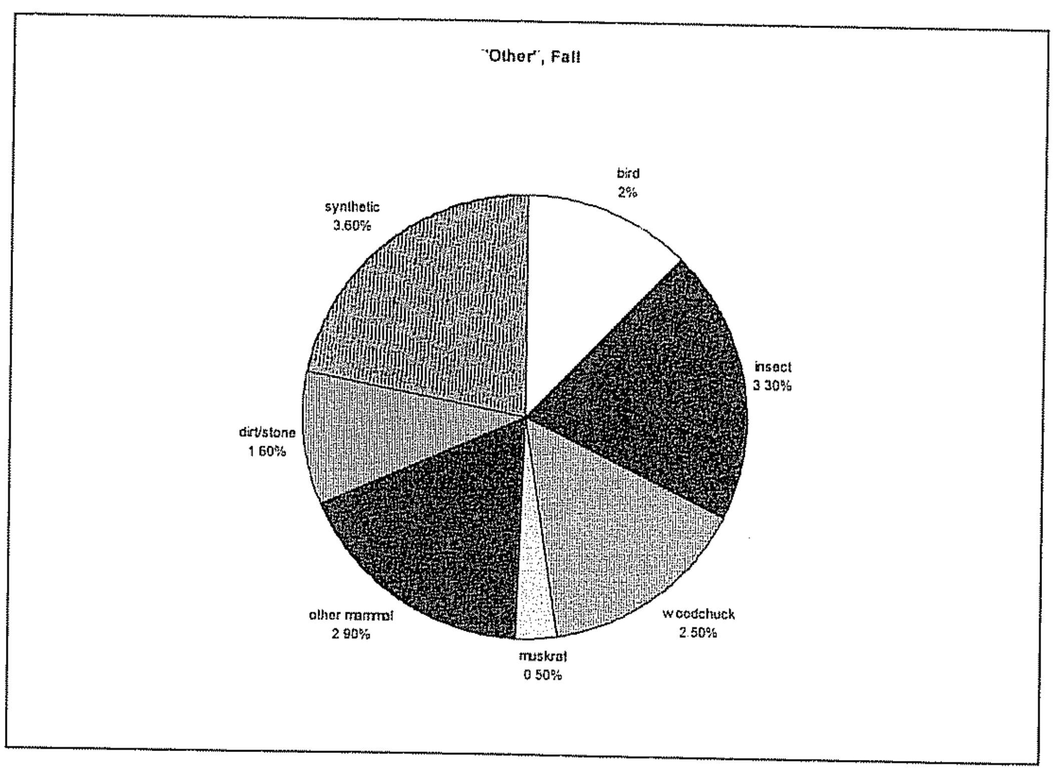
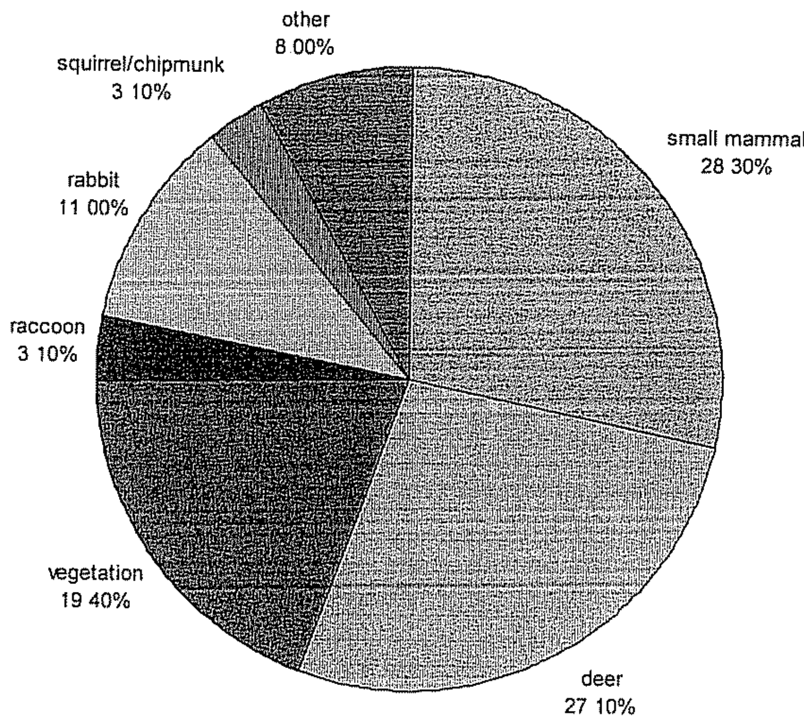


Figure 7. General diet of coyotes in the greater Cleveland park systems, fall (# Prey Items = 444)



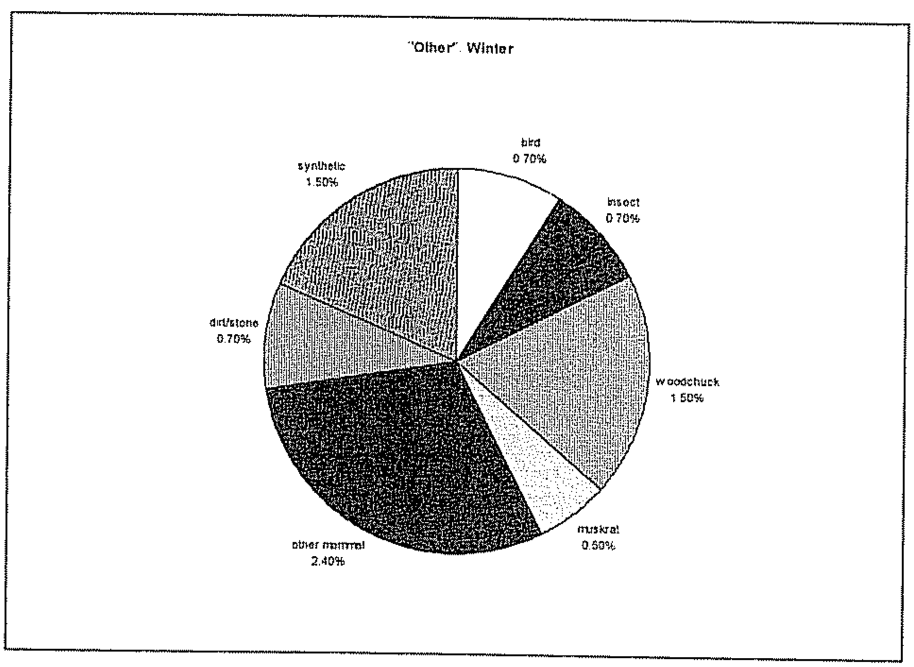


Figure 8. General diet of coyotes in the greater Cleveland park systems, winter(# Prey Items = 413)

Table I. Breakdown of categories used in analysis of prey items consumed by coyotes

	Specific prey items contained within categories
Small Mammal:	*Microtus*, *Peromyscus*, *Blarina*, *Sorex*/other shrew, jumping mouse, unidentified species of small mammal
Deer:	*Odocoileus virginianus*
Vegetation:	Fruit, Grass, Corn, Bird seed, unidentified plant matter
Raccoon:	*Procyon lotor*
Rabbit :	*Sylvilagus floridanus*
Squirrel/Chipmunk:	*Sciurus, Tamisciurus, Tamis,* unidentified species of squirrel
"Other" category:	
Woodchuck	*Marmota monax*
Muskrat	*Ondatra zibethicus*
Other mammal	Oppossum (*Didelphis virginiana)*
	Mink (*Mustela vison)*
	Beaver (*Castor Canadensis)*
	House Cat (*Felis catus)*
	Mammal unknown – unidentified species of mammal
Bird	Bird, egg shell
Insect	All insects
Reptile/Fish	Snake, turtle, fish
Synthetic material	All synthetic materials
Dirt/stones	All dirt/stone materials
Snail	Snail shell

Table II. Frequency of occurrence of prey items found in the scats of coyotes in northeast Ohio, across seasons and sites

Prey Item	**# Occurrences in scat samples (n=1760)**	**Frequency of occurrence in scat samples(n= 944)**
Small Mammal	490	51.9%
White-tailed Deer	414	43.9%
Vegetation	305	32.3%
Eastern Cottontail	142	15.0%
Raccoon	102	10.8%
Squirrel/Chipmunk	62	6.6%
"Other" Category	245	25.9%
Synthetic Material	43	4.5%
Woodchuck	42	4.4%
Muskrat	25	2.6%
Other Mammal	42	4.4%
Bird	40	4.2%
Insect	22	2.3%
Dirt/stone	19	2.0%
Reptile/fish	9	0.9%
House Cat	2	0.2%
Snail	1	0.1%

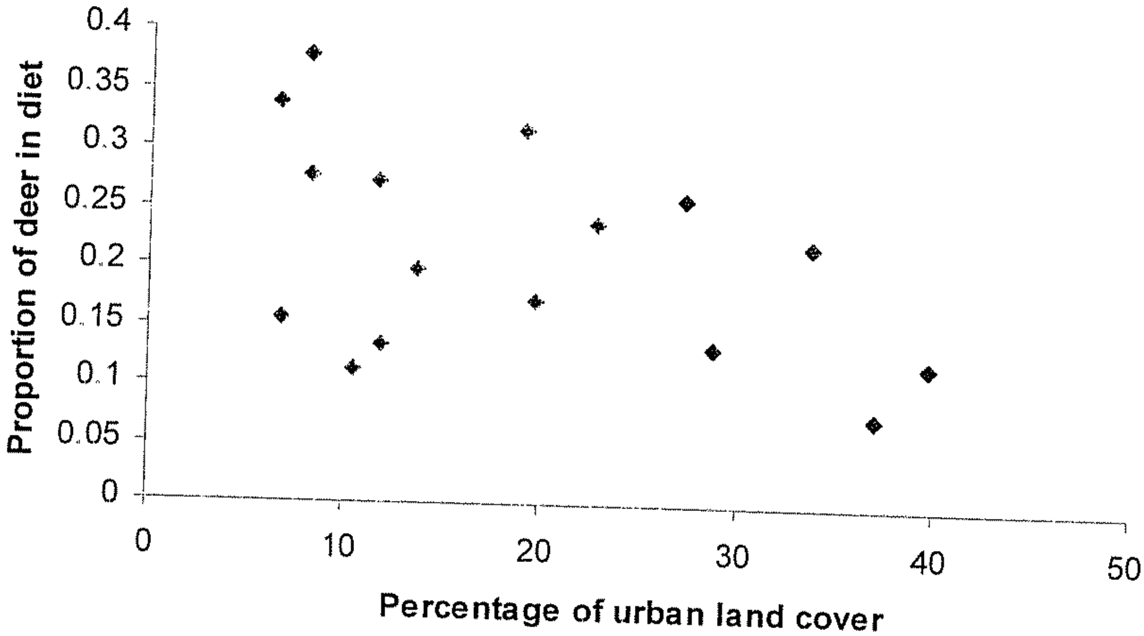
respectively. Vegetation was also a predominant item, especially in fall when coyotes can forage on seasonally available fruits. Vegetation was found in 32.3% scats (frequency of occurrence) and representing 17.3% of all prey items.

Eastern cottontail was found in 15% of scats (frequency of occurrence), and represented 8.1% of all prey items found. Seasonally, cottontails made up 7.4%, 9.1%, 5.4%, and 11.0% of all prey items in spring, summer, fall, and winter, respectively. Raccoon was a consistent item in the diet of coyotes, being found in 10.8% of scat samples (frequency of occurrence), and representing 5.8% overall of prey items, and were present as 4.2%, 11.7%, 5.6%, and 3.1% of prey items in spring, summer, fall, and winter, respectively. Finally, squirrels/ chipmunks were the final major prey items, being found in 6.6% of scats collected (frequency of occurrence), representing 3.5% of overall prey items, and seasonally squirrel/chipmunks made up 3.1%, 2.9%, 5.0%, and 3.1% of the coyote diet in spring, summer, fall, and winter, respectively.

Other prey items were categorized into a separate "other" category, with 25.9% of scat samples containing an item falling in this category. These items each made up less than 2.4% each of the total prey items of coyotes, or a combined 13.9% of total prey items. There was seasonal variability in the percentage of these items in the diet, most likely due to seasonal availability. These prey items include: woodchuck (*Marmota monax*; 2.4% of prey items); muskrat (*Ondatra zibethicus*; 1.4%); other mammal(2.4%); bird (2.3%); insect (1.3%); synthetic material (2.4%); dirt/stone (1.1%); reptile/fish (0.50%); and snail (0.06%). While the percentage of these items in small, it remains an important insight into the diversity of the diet of coyotes in this area and is therefore included in the general results.

Analysis of diet differences across seasons and along the urban-rural gradient showed several significant differences in the diet of coyotes in prey items across seasons (MANOVA; Wilk's λ =0.278; F=3.87; df=18, 122; P< 0.001), but no differences across the urban-rural gradient (MANOVA; Wilk's λ=0.729; F=1.22; df=12, 86; P=0.278). While no significant difference was found, there was a weak correlation between the prevalence of white-tailed deer in the diet and the amount of urbanization surrounding the collection site (see Figure 9) using Pearson's correlation test. Sites that were classified as more urban had slightly lower consumption rates of white-tailed deer than sites classified as more rural. However, this correlation is weak and likely will have little implication for natural resource managers. While coyotes in the greater Cleveland area park systems are eating similar prey regardless of the location along the gradient regarding urban land cover (see Figures 9-11), the analyses suggest a possible correlation of deer consumption by predators and level of urbanization, and this should be considered for future study. In contrast to the urban-rural gradient analysis, prey consumed by coyotes showed a strong seasonal pattern (MANOVA; Wilk's λ=0.278; F=3.87; df= 18, 122; P<0.001). Significant differences were found between seasons for the major prey item categories. Small mammals showed significant differences between spring and summer consumption (MANOVA; Wilk's λ= 0.405; F=5.95; df=3, 48; P <0.001). The proportion of small mammals consumed by coyotes in the summer was lower than any other season, significantly less than in the spring. This may be due in part to higher amounts of other prey available in the summer, including other mammals. Also increase in vegetative cover may make it more difficult for coyotes to capture small mammals in the summer.

Within the small mammal category, percentage of consumption of more specific



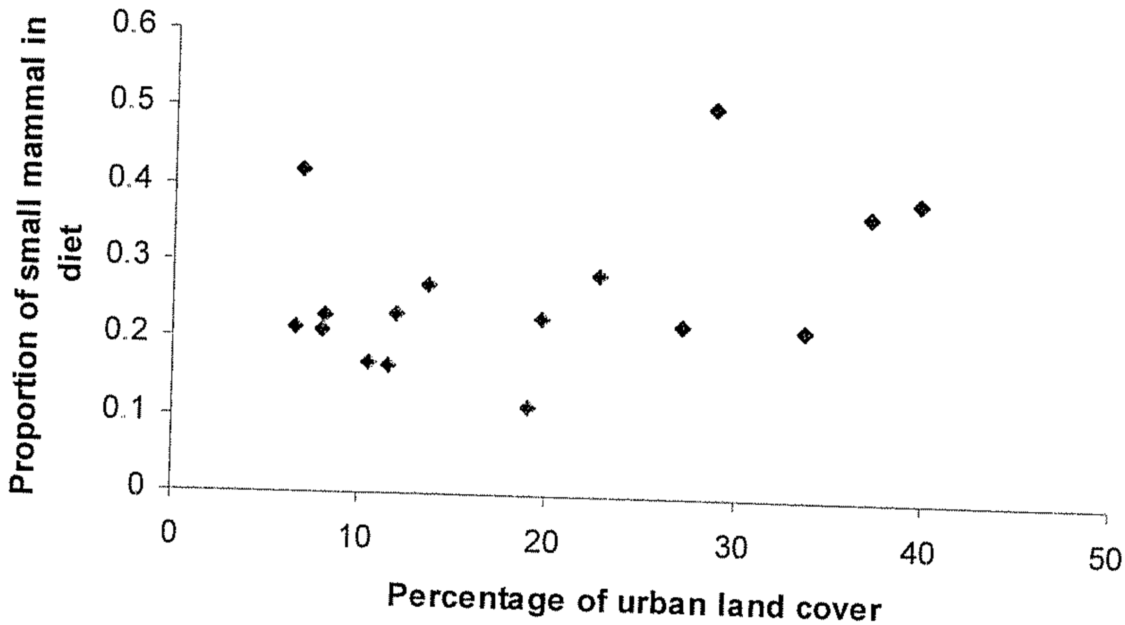
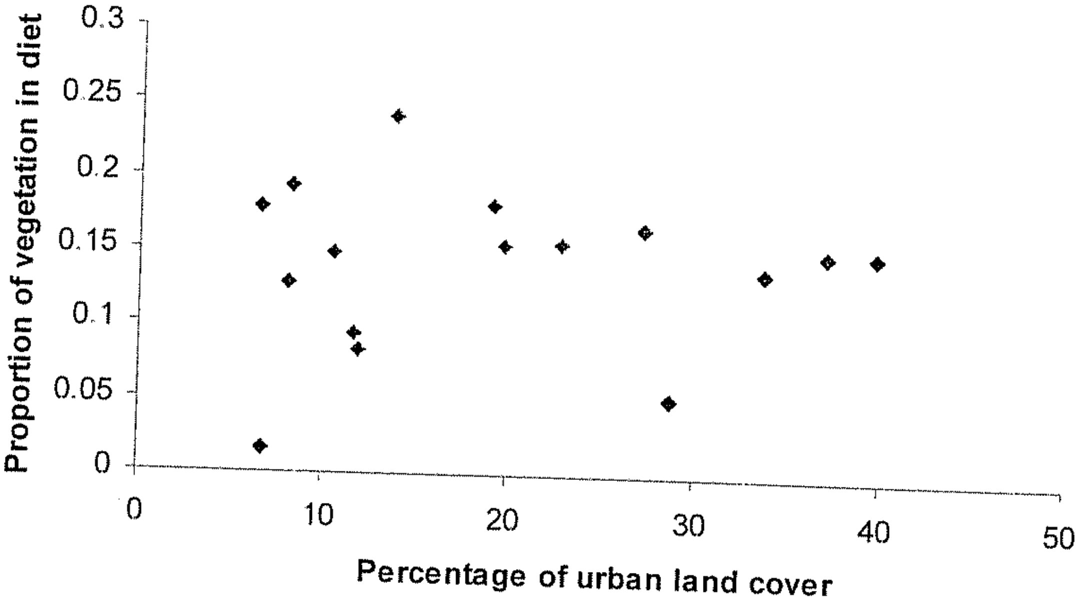


Figure 9. Relationship between land cover composition and diet of coyotes: deer and small mammals. Symbols in blue indicate most rural sites, green indicates suburban areas, red indicates highest percentage of urban land cover.



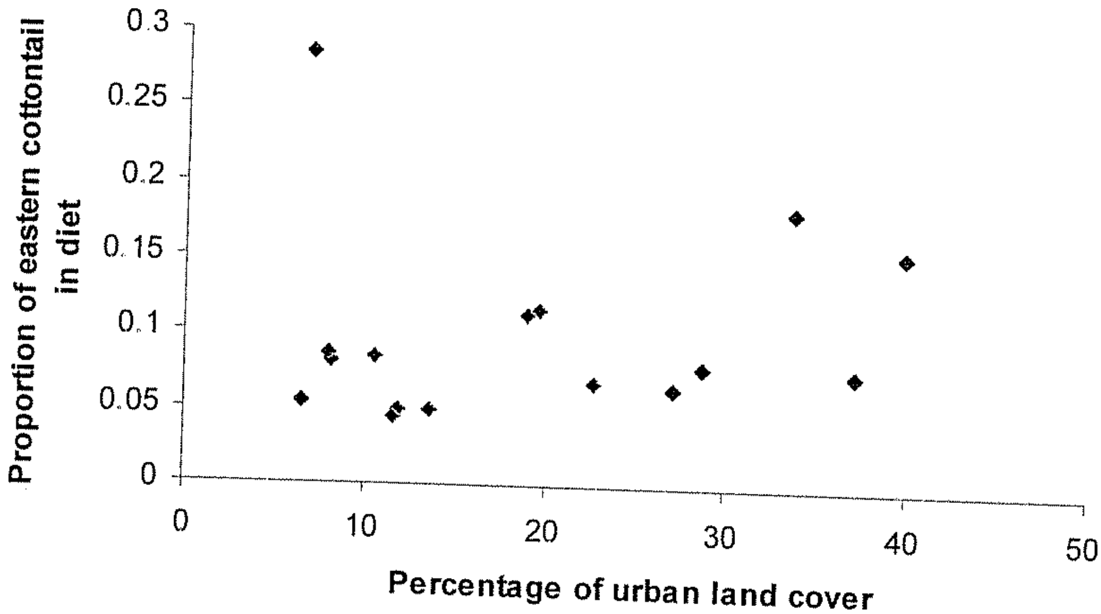
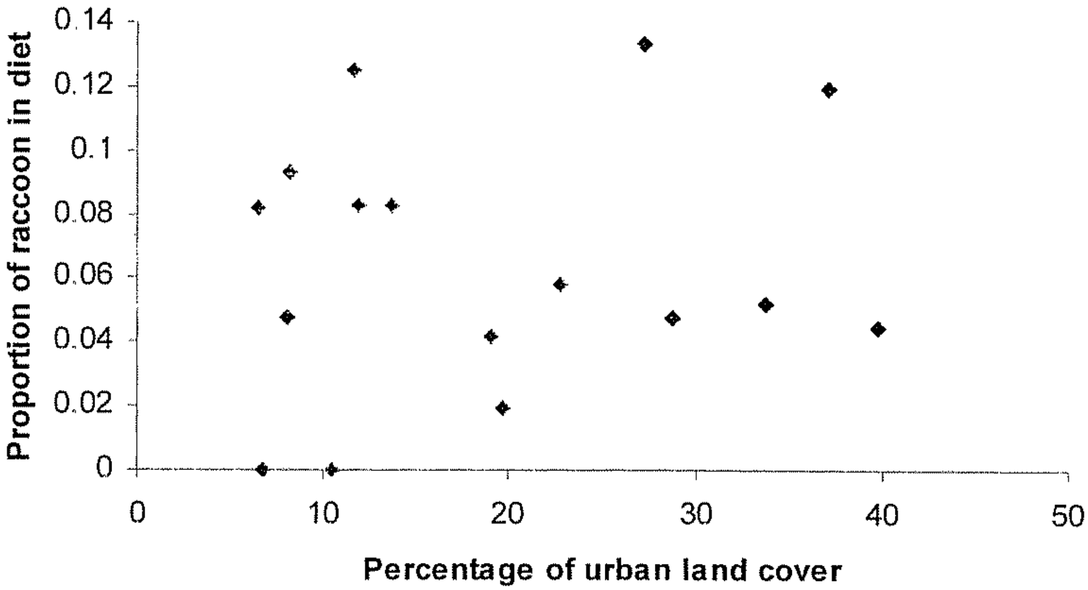


Figure 10. Relationship between land cover composition and diet of coyotes: vegetation and eastern cottontail. Symbols in blue indicate most rural sites, green indicates suburban areas, red indicates highest percentage of urban land cover.



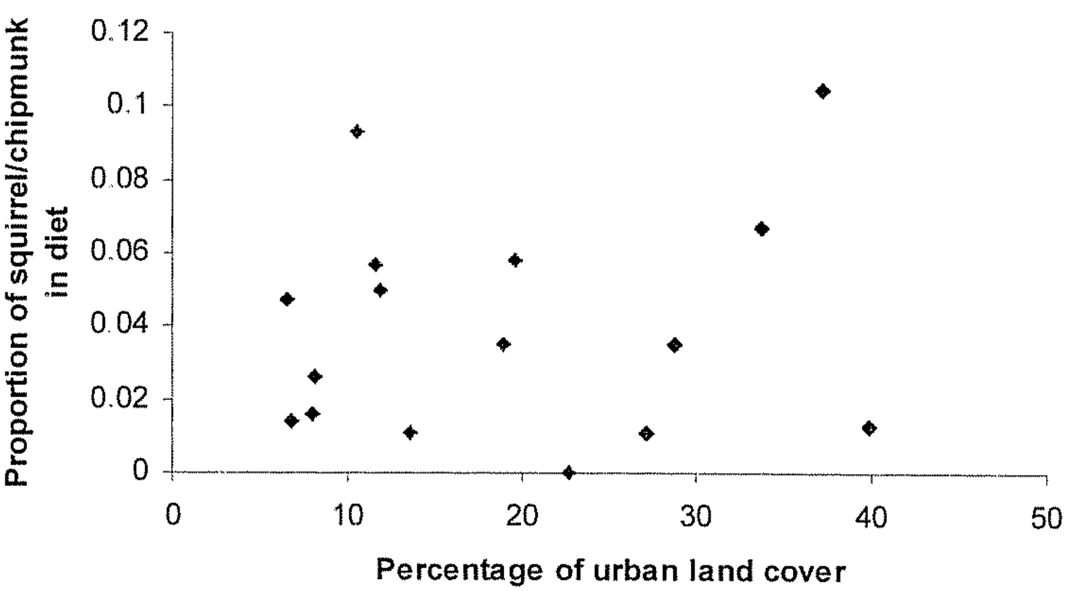


Figure 11. Relationship between land cover composition and diet of coyotes: raccoon and squirrel/chipmunk. Symbols in blue indicate most rural sites, green indicates suburban areas, red indicates highest percentage of urban land cover.

groups was 68.7% *Microtus,* 3.3% *Peromyscus*, 0.6% jumping mouse, 3.1% shrew, and 24.3% unknown small mammal. This shows the high rate at which coyotes are eating *Microtus* compared to other species of small mammals. *Microtus* are larger than many small mammals, are common across northeast Ohio, and are also possibly easier for coyotes to track due to their travel tunnels, apparent in fields through thick vegetation in fall and snow in winter.

In addition, white-tailed deer were consumed at a significantly lower level in the fall than any other season, with significant differences (MANOVA; Wilk's λ=0.244; F=3.86; df=3, 48, P=0.32) between fall and winter, and fall and summer. This may be due to increased availability of fruits in fall, and increased vulnerability of deer, particularly fawns, in early summer. Deer may also be vulnerable in winter when snowfall becomes deep or food sources become scarce.

Vegetation was consumed at a significantly higher level (MANOVA; Wilk's λ=0.331; F=10.19; df=3, 48; $P<0.005$) in fall than any other season. This was likely due to the increased amount of fruit during the fall months. Raccoons were consumed at a higher level (MANOVA; Wilk's λ=0.04; F=1.71; df=3, 48; $P<0.05$) in summer than winter. Because raccoons are less active during winter months, and newly born young are more vulnerable during summer, this seasonal difference probably reflects the availability of raccoons to coyotes. Neither rabbit nor squirrels/chipmunks showed differences seasonal consumption rates.

Diets of coyotes are relatively easy to quantify because scats are regularly deposited on trails, roads, and rights-of-way. The diet of an opportunistic forager may, however, be highly dependent upon the bounds of the study area. In this study, transects walked were either within park boundaries or immediately adjacent to and continuous with park property. Park management, therefore, may influence the sorts of prey items available to coyotes. Human activity in the park may influence coyote behaviorial patterns. Management of natural areas may promote certain species, such as white-tailed deer, birds, and small mammals, which may differ dramatically from surrounding urban, suburban, or rural land uses. Road-killed animals consistently found around metropolitan areas provide food resources for coyotes, particularly white-tailed deer and raccoons.

Small mammals consistently comprise a large proportion of the diet of coyotes (Kamler et al., 2002) and this same pattern was observed in this study. Consumption of deer (Whitmer et al., 1995; Springer and Smith, 1981) and rabbits (Parker, 1986) often a staple in coyote diets, also was observed in northeast Ohio. Domesticated animals often are present in coyote diets, but this was not obvious in this study. The lack of availability of domesticated animals such as sheep, poultry, and livestock in the Cleveland park systems probably accounts for the lack of this prey item in this study. Although farms that raise domesticated animals (such as horses and poultry) and several residential areas with the potential of dogs and cats being available as prey items are adjacent to the parks, coyotes do not appear to be regularly using this potential food resource.

The behavior and ecology of some species may also influence their availability as prey. During the winter months, raccoon and woodchuck have periods of inactivity, possibly making them less available to coyotes. During spring, the young of several species are newly born and vulnerable. Although no statistical significance was shown, groundhogs were found in 1.3%, 5.1%, 2.5%, and 1.5% of the scats in spring, summer, fall, and winter, respectively. This may reflect simply their seasonal availability to coyotes. The density of deer at the sites may also have an effect on their consumption rate by coyotes.

Coyotes in the Cleveland-Akron park systems appear to be consuming food items in an opportunistic fashion, though the scarcity of some prey items in scats, such as skunks and shrews, may reflect a preference for other prey types (i.e. small mammals, deer, fruit). Nonetheless, the general content of the scat suggests a preference for food items that are abundant and easy to access. This suggests that coyotes in northeast Ohio feed opportunistically but selectively as seen in other areas. In urban Washington, Quinn (1997) found that coyotes ate large amounts of apple during periods of high availability. That study also suggested that prey consumption was related to habitat, i.e., greater amounts of cat in residential areas. Food habits of coyotes in forest and farmland of Alberta also suggest the diets of coyotes vary according to local availability (Todd, 1985). Parker (1986) showed a diet that varied by seasonal availability in New Brunswick. In an agricultural area of British Columbia (Atkinson and Shakleton, 1991) coyotes ate primarily voles. Therefore, coyotes take advantage of resources available both regionally and seasonally, and an opportunistic feeding pattern appears to be reflected in the data collected in northeast Ohio as well.

CHAPTER V

MANAGEMENT IMPLICATIONS

Coyotes in the Cleveland Metroparks and the Cuyahoga Valley National Park are eating a wide variety of foods as prey and resources become seasonally and spatially available to them. Consistently across sites, coyotes are eating small mammals (particularly *Microtus*), white-tailed deer, vegetation (particularly fruit), eastern cottontail, and raccoons. As populations of prey species for coyotes grow or cycle, the diet of coyotes will most likely reflect these changes. In the Cleveland area, deer populations are high. Coyotes are consuming deer, but it remains questionable if the consumption levels are high enough to impact deer populations at this time. In a rural area of Pennsylvania, Witmer et al. (1995) found that deer was the most important prey item to coyotes. Deer increased as a prey source for coyotes in eastern Canada in late winter, when deer were more vulnerable due to snow depth and increased physical weakness (Patterson and Messier, 2000). Area resource managers should be aware of this potential and monitor coyote diets regularly to assess potential impacts on deer populations. In addition, coyotes are known to scavenge and take advantage of road-killed deer in this study area, and they likely will continue to scavenge deer. Coyotes may also need to be considered when managing an area for small mammal populations because they are likely to continue using small mammals as a primary prey source. This has been shown to be consistent behavior across many regions in the U.S. Also, the use of rabbits is likely to continue, as this did not appear to be affected across seasons and sites in our area.

Park managers consistently need to be aware that coyotes will take advantage of available resources, and this includes resources provided by humans. Picnic areas should be monitored closely and kept as coyote-proofed as possible, as they consume synthetic materials and garbage when available. Although the data from this study show coyotes are not currently preying heavily upon domesticated animals and pets, good management practices dictate that pets and pet food within or near park areas should not be made available to coyotes. House cat was only found in two scat samples in this study, but coyotes are known to kill and consume cats and dogs (Quinn, 1997). As park managers strive to maintain healthy community relations, public education about the potential risk of pets becoming prey items may become important in our study area.

To date, few coyote diet studies have been completed in Ohio and the whole of the eastern U.S. specifically those including urban areas. Continued research on diet and ecology of coyotes is necessary to further our knowledge and understanding of the impacts coyotes can have and to predict their influences on urban ecosystems and management of wildlife populations and habitat. Since collecting scat and identifying prey items in coyote diet is a relatively easy and non-invasive way to identify potential impacts of coyotes on prey species, it is recommended that the diet of coyotes continue to be monitored and evaluated in our area. This will ensure area resource managers will be able to identify possible changes in major prey items and impacts on prey species, allowing the most appropriate management decisions regarding the coyote and prey species of concern.

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http://en.wikipedia.org/wiki/Cleveland,_Ohio

http://en.wikipedia.org/wiki/Akron%2C_Ohio

APPENDICES

Appendix A. Original 42 scat transect names, location, and site grouping.

Transect Name	Easting	Northing	Site Name
B Site	434606	4571870	B Site
Br Meadows	448535	4573956	Brecksville
Chippewa Creek	449981	4574130	Brecksville
Circle Emerald	452744	4581414	Circle Emerald
Brooklyn Ex Cabin	440356	4562262	Hinckley
Judges Lake	441267	4561563	Hinckley
Parker Road	442559	4561935	Hinckley
Redwing Cabin	439623	4563577	Hinckley
Top of Ledges	441717	4563265	Hinckley
Albion Road	431331	4575581	Mill Stream Run
Big Creek	431046	4578767	Mill Stream Run
Strongsville WL	432306	4574404	Mill Stream Run
Whitney Rd WL	429516	4577199	Mill Stream Run
All-Purpose Trail	463820	4602113	North Chagrin
Maintenence area	463669	4602196	North Chagrin
Armington Pond	457097	4561927	North Hampton
Env Ed Center	451452	4562475	North Hampton
Everett Road	452041	4561817	North Hampton
Humane Society	456430	4561526	North Hampton
N Hampton Horse Trail	454118	4561647	North Hampton
Wetmore Bridle Trail	453905	4562407	North Hampton
O&E Canal	444826	4587356	Ohio & Erie Canal
LRRR	425703	4583805	RR-Lewis Road
RR Stables	429247	4586863	RR-Stables
Sanitation Road	450142	4576742	Sanitation Road
AP Firetower Field	456501	4566757	Snowville Road
Dewey Road	449715	4569739	Snowville Road
Riverview Pipeline	451361	4571453	Snowville Road
Snowville Quarry	451962	4570620	Snowville Road
Jackson Field	465173	4586954	South Chagrin
Old Field	465911	4588310	South Chagrin
Polo Field	465851	4589187	South Chagrin
Steel's Corners	453094	4558640	Steel's Corners
Top O' World	454109	4557881	Steel's Corners
Terra Vista	449406	4580387	Terra Vista
Valley Bridle Trail	452056	4571393	Woodlake
303 opposite Woodlake	456410	4565076	Woodlake
Boston Mills & TP	455968	4567289	Woodlake
Happy Days	457248	4564487	Woodlake
Pine Lane	454711	4565516	Woodlake
Pine Lane @ TP	454885	4566838	Woodlake
Woodlake	456530	4564696	Woodlake

Appendix B. Number of scat samples found at each site and season.

Site	Spring	Summer	Fall	Winter	Total
Bsite	15	7	21	5	48
Brecksville	5	15	5	0	25
Circle Emerald	19	27	36	67	149
Hinckley	30	5	47	2	84
MSR	22	50	11	10	93
NChagrin	13	0	13	13	39
Nhampton	102	25	36	40	203
O&E Canal	6	19	38	8	71
RR-Lewis Road	9	33	40	11	93
RR-Stables	19	17	15	24	75
Sanitation Rd	84	78	23	19	204
Snowville Rd	74	42	60	16	192
Schagrin	11	0	9	13	33
Steel's Corners	28	4	0	26	58
Terra Vista	23	14	73	78	188
Woodlake	92	15	17	81	206
Total	**552**	**351**	**444**	**413**	**1760**