#### 2019 Project Abstract

For the Period Ending June 30, 2022

PROJECT TITLE: Mapping habitat use and disease of urban carnivores
PROJECT MANAGER: Dr. Nicholas McCann
AFFILIATION: University of Minnesota; College of Food, Agricultural and Natural Resource
Sciences/Department of Fisheries, Wildlife and Conservation Biology
MAILING ADDRESS: B52 Skok Hall, 2003 Upper Buford Circle
CITY/STATE/ZIP: Saint Paul/Minnesota/55108
PHONE: (763) 286-2215
E-MAIL: mccan062@umn.edu
WEBSITE: N/A
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03g

APPROPRIATION AMOUNT: \$500,000 AMOUNT SPENT: \$496,543 AMOUNT REMAINING: \$3,457

#### Sound bite of Project Outcomes and Results

This study provides information to residents and managers about coyotes and foxes. Our results reveal key insights, including about habitat requirements, the expansion of coyotes, and relationships between disease prevalence and free-roaming cats. They suggest outreach efforts to reduce free-roaming pets and management to increase natural vegetation in residential greenspaces.

#### **Overall Project Outcome and Results**

- 1. Coyotes and foxes have not been studied in the Twin Cities Metro Area.
- 2. We captured, collared, and collected biological samples from 17 coyotes, 16 red foxes, and two gray foxes across the TCMA to assess space-use, survival, diet, and disease.
- 3. We found that coyote survival was greater than for red foxes, suggesting higher population growth. Canid attacks caused most fox mortalities, likely reflecting coyote population expansion and the presence of free-roaming dogs. Coyote and fox diets consisted of natural foods, with few individuals exhibiting diets associated with people. *Toxoplasmosis gondii*, a cat feces-transmitted a pathogen found in both coyotes and foxes, was especially frequent in red foxes, potentially due to fox selection of residential areas with more free-roaming cats. Higher heavy metal content in the hair of coyotes was likely a result of using industrial areas. Home range sizes suggest coyotes found resources more easily than red foxes. Den sites reflected the more general differences space-use; coyotes denned in non-residential areas while fox dens were in residential. We estimated 0.27 coyotes/km<sup>2</sup> and 0.21 red foxes/km<sup>2</sup>; lower than in other cities.
- 2. Overall, our results suggest coyotes expanded into areas once occupied by red foxes, but both species rarely became nuisances. Outreach promoting leashing pets and keeping cats inside is likely to improve the health of pets, coyotes, and foxes. Communicating the smaller-than-expected weight (males=14.3 kg [31.5 lbs.]; females=11.9 kg [26.2 lbs.]) and low risk of attack should reduce negative perceptions of coyotes. Improving natural habitat in residential greenspaces is likely to benefit red foxes.
- 3. This study's results provide much-needed information to residents and wildlife managers about two charismatic species that are relatively unstudied in Minnesota.

#### **Project Results Use and Dissemination**

We delivered 17 presentations to colleges (e.g., Anoka Ramsey Community College and Macalester College), grade schools, and municipalities (e.g., Cities of Bloomington). We also provided 12 interviews to news outlets and podcasts (e.g., MPR, BBC, and Three Rivers Park District's "Wandering Naturalist" podcast), content for two

Friends of the Mississippi River newsletters, and led over 60 volunteers into the field and coordinated with two UMN courses (60 students total). To further disseminate information, we created a <u>University website</u>, <u>Facebook page</u>, and <u>iNaturalist page</u> for the project, and we have drafted one scientific manuscript (set to be published this year).



Today's Date: August 15, 2022

Final report

Date of Work Plan Approval: June 5, 2019

Project Completion Date: June 30, 2022

PROJECT TITLE: Mapping habitat use and disease of urban carnivores
Project Manager: Dr. Nicholas McCann
Organization: University of Minnesota
College/Department/Division: College of Food, Agricultural and Natural Resource
Sciences/Department of Fisheries, Wildlife and Conservation Biology
Mailing Address: B52 Skok Hall, 2003 Upper Buford Circle
City/State/Zip Code: Saint Paul/Minnesota/55108
Telephone Number: (763) 286-2215

Email Address: mccan062@umn.edu

Web Address: N/A

**Location:** The Metro Region and the Minneapolis-St. Paul Metropolitan Statistical Area; including the following counties: Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington.

Total Project Budget: \$500,000 Amount Spent: \$496,543

Balance: \$3,457

Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03g

**Appropriation Language:** \$500,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to map habitat use and diseases of urban foxes and coyotes, evaluate risks these animals may pose to people and pets, and generate information needed to reduce human-wildlife conflicts.

#### I. PROJECT STATEMENT:

Foxes and coyotes are becoming increasingly common in urban landscapes; however, little is known about these animals in the Twin Cities Metro Area (TCMA). Area residents now have opportunities to spot these wildlife species in parks and other green spaces close to their homes, but this proximity can also generate concern about where foxes and coyotes live, how many there are, and if they carry diseases that can infect pets and people. This study will help to address these concerns by demystifying the behavior of these urban carnivores while also identifying areas that can be managed to reduce potential conflicts. Our team will focus on two objectives:

1) Identify the abundance, distribution, and diet of three species of wild canids (coyotes, red foxes, and gray foxes) in the Twin Cities Metro Area.

## 2) Determine the prevalence of diseases within these wildlife populations and whether the movement patterns of these animals may create hotspots of risk to pets or people.

We will map the habitat use and assess the diets of foxes and coyotes along a gradient of urban land use in the TCMA to understand how these animals exploit resources in human-dominated landscapes. At the same time, we will measure disease prevalence in our study animals which will help to assess the risk of disease transmission between foxes, coyotes, pets, and people. Diseases such as rabies are present in Twin Cities Metro Area wildlife (including foxes), but we do not know how prevalent diseases are, so we cannot estimate risk; this study will be the first to quantify the prevalence of diseases that infect foxes and coyotes in Minnesota. Mapping patterns of habitat use along with diet composition and disease prevalence will help managers reduce human- wildlife conflicts and inform efforts to manage and acquire ecologically-valuable green spaces.

Most Minnesota residents live in urban areas but do not know much about the wildlife that lives near them. By working with the Three Rivers Parks District and a diverse coalition of non-profit organizations (including the Minnesota Land Trust, Friends of the Mississippi River, and the Minnesota Trappers Association), we will provide information that will help influence the public perceptions and management of three native wildlife species in the TCMA. Further, this project will provide a fantastic training opportunity for the UMN Fisheries, Wildlife, and Conservation Biology Club. This group will be tracking our study animals within the community and will be able to talk with and answer questions from residents in the area. This will help further educate the public about wildlife and train these students in the skills necessary to be effective wildlife managers.

#### **II. OVERALL PROJECT STATUS UPDATES:**

#### First Update March 1, 2020

We hired and trained a PhD student (Geoffrey Miller), developed protocols and acquired equipment, scouted numerous sites throughout the study area for animal sign (e.g., tracks and scat), and developed partnerships with multiple cities and organizations (e.g., the City of Bloomington). We captured and processed 9 coyotes (6 males and 3 females) and 4 red foxes (3 males and 1 female) and are revising methods for live-trapping foxes to achieve greater success.

We created a University website (tccfp.umn.edu), Facebook page (@tccfp), and iNaturalist page (inaturalist.org/projects/tccfp) for the project. The Facebook page has 85 followers and the iNaturalist

page has 419 members who have submitted 809 coyote and fox observations. Nick McCann delivered presentations to the City of North Oaks, Bloomington, and the Highland District Council (Saint Paul) and was interviewed by MPR and WCCO.

We had 29 volunteers out to check, maintain, and set live-traps. This included graduate students from multiple University Departments (Fisheries, Wildlife and Conservation Biology, Veterinary Medicine, and Ecology, Evolution and Behavior), FWCB undergraduate students, post-doctoral fellows, and a program coordinator from a water management organization. An animal control officer, private landowner, railroad manager, and visiting researcher attended study animal processing. FWCB Club undergraduate students helped constructed cable restraint anchors and 1 FWCB undergraduate and 1 recent FWCB graduate worked as interns on the project.

#### AMENDMENT REQUEST March 1, 2020

We are requesting funds be shifted from the personnel budget line to equipment/tools/supplies.

- Personnel budget would be reduced by \$1,000 to a revised budget of \$376,294.
- Equipment/tools/supplies budget would increase by \$1,000 to a revised budget of \$6,490.

These changes are being requested because more equipment is needed to accomplish Activities 1 and 2. To

pay for these costs, we will use savings accomplished from our being able to reduce student intern salaries.

#### Amendment Approved by LCCMR 3/6/2020

#### AMENDMENT REQUEST July 9, 2020

We are requesting funds be shifted from the Professional/Technical/Service Contracts to Equipment/Tools/Supplies and Travel Expenses in Minnesota.

- Professional/Technical/Service Contracts would be reduced by \$12,000.
- Equipment/Tools/Supplies budget would increase by \$10,500.
- Travel Expenses in Minnesota would increase by \$1,500.

These changes are being requested because more equipment and travel is needed to accomplish Activities 1 and 2. Equipment and supplies have proven to be more expensive than originally budgeted, and study animals have been harder to find and capture than was expected – leading to more driving to scout for and live trap study animals. To pay for these costs, we will use savings accomplished from cheaper data download costs for satellite collars.

#### Amendment Approved by LCCMR 7/17/2020

#### Second Update September 1, 2020

We visited 50 locations used by 7 coyotes as den and rendezvous sites to measure plants and other features that serve as hiding cover for coyotes. We continued to monitor survival of collared study animals. Three study animals have died (including 1 fox following infection of was likely sarcoptic mange). We made preparations for the next live-capture season; including purchase of equipment, contacting municipalities, and scouting. Our Facebook page membership has increased to 184 followers. Our iNaturalist page has increased to 506 members. Nick McCann delivered a presentation to a Macalester College ethics class and co-presented with PhD student Geoff Miller to a University of Minnesota class. Nick McCann was interviewed by BioGraphic Magazine. We made plans for >30 students from a University of Minnesota course to deploy trail cameras to help locate study animals for

this project.

#### AMENDMENT REQUEST August 31, 2020

We are requesting funds be shifted from Personnel (Wages and Benefits) and Equipment/Tools/Supplies to Travel Expenses in Minnesota.

- Personnel (Wages and Benefits) would be reduced by \$3,448.
- Equipment/Tools/Supplies budget would be reduced by \$1,621.
- Travel Expenses in Minnesota would increase by \$5,069.

These changes are being requested because more travel is needed to accomplish Activities 1 and 2. Study animals have been harder to find and capture than was expected – leading to more driving to scout for and live trap study animals. To pay for these costs, we will use savings accomplished from negotiating with the manufacturer of the GPS collars we use and also by eliminating part-time personnel.

#### Amendment Approved by LCCMR 10/21/2020

#### Third Update March 30, 2021

We investigated >200 sites throughout the study area for animal sign (e.g., tracks and scat). Livetrapping occurred from September through the end of February, resulting in capture and processing of an additional 6 coyotes, 11 red foxes, and 1 gray fox. We collected biological samples from each coyote and fox, and stored samples pending further analysis. We added content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist pages. Facebook page membership has increased to 347 followers and iNaturalist has increased to 588 members who have submitted 1,181 coyote and fox observations. Project presentations were delivered to a community college, the University of Minnesota, and 2 elementary school groups. Project interviews were conducted by the BBC, the University of Minnesota, and the Field Regina Northrop Neighborhood Group. A University of Minnesota Undergraduate course deployed trail cameras to help locate coyotes and foxes. A recent undergraduate volunteered on the project, 1 regional wildlife ecologist attended a coyote processing, and a University of Minnesota Professor attended fieldwork to learn about human-wildlife interactions.

#### AMENDMENT REQUEST March 30, 2021

We are requesting funds be shifted from Professional/Technical/Service Contracts to Travel Expenses in Minnesota.

- Professional/Technical/Service Contracts would be reduced by \$9,000.
- Travel Expenses in Minnesota would increase by \$9,000.

These changes are being requested because more travel is needed to accomplish Activities 1 and 2. Study animals have been harder to find and capture than was expected – leading to extended field seasons, and thus more driving to scout for and live trap study animals. To pay for these costs, we will use savings accomplished by identifying a less expensive veterinary diagnostics lab at which to complete testing of biological samples.

### Amendment Approved by LCCMR 4/8/2021

#### Fourth Update September 1, 2021

We visited 38 locations used by coyotes and foxes to measured plants and other features that serve as hiding cover, monitored survival of collared study animals, and made preparations for the next live-

capture season. We also submitted blood serum samples for testing, with preliminary findings suggesting relatively high prevalence of some diseases. We continue to add content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist page. Our Facebook page membership has increased to 405 followers. Our iNaturalist page has increased to 615 members who have submitted 1,285 coyote and fox observations. Outreach efforts included presentations to Anoka-Ramsey Community College, Macalester College, the City of Shoreview, Minneapolis Master Naturalists, and 3 elementary classes, as well as interviews for 3 news outlets.

#### Fifth Update March 1, 2022

We conducted live-trapping from September through November, resulting in capture and processing of an additional 3 coyotes, 1 red fox, and 1 gray fox. Biological samples (blood and hair) were submitted for lab analysis. We added content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist pages, and started engaging the public using Twitter. Facebook page membership has increased to 430 followers and Twitter users logged 842 user impressions about project tweets. Additional outreach included delivery of project presentations to a community college and interviews with PBS, Three Rivers Park District's "Wandering Naturalist" podcast, and MSP Magazine, and attendance of 2 volunteers at a processing. GIS and statistical analysis of all datasets has begun.

#### AMENDMENT REQUEST May 24, 2022

We are requesting funds be shifted from Professional/Technical/Service Contracts to Equipment/Tools/Supplies and Travel Expenses in Minnesota.

- Professional/Technical/Service Contracts would be reduced by \$3,680.
- Equipment/Tools/Supplies budget would increase by \$2,000.
- Travel Expenses in Minnesota would increase by \$1,680.

These changes are being requested because more travel is needed to accomplish Activities 1 and 2. Study animals were harder to find and capture than was expected – leading to more driving to scout for and live trap study animals. We also increased spring/summer data collection around fox and coyote dens and other areas they use frequently to accomplish Activities 1 and 2; this requires more mileage and also additional trail cameras with associated supplies (batteries, SD cards, and locks). To pay for these costs, we will use savings accomplished by identifying a less expensive diagnostics lab for testing of stable isotopes and other biological samples, and by reducing GPS collar downloads.

#### Amendment Approved by LCCMR 5/26/22

#### Final Report between project end (June 30) and August 15, 2022

- 1. Coyotes and foxes have not been studied in the Twin Cities Metro Area (TCMA).
- 2. We captured, collared, and collected biological samples from 17 coyotes, 16 red foxes, and 2 gray foxes across the TCMA to assess space-use, survival, diet, and disease.
- 3. We found that coyote survival was greater than for red foxes, suggesting higher population growth. Canid attacks caused most fox mortalities, likely reflecting coyote population expansion and the presence of free-roaming dogs. Coyote and fox diets consisted of natural foods, with few individuals exhibiting diets associated with people. *Toxoplasmosis gondii*, a cat feces-transmitted a pathogen found in both coyotes and foxes, was especially frequent in red foxes, potentially due to fox selection of residential areas with more free-roaming cats. Higher heavy metal content in the hair of coyotes was likely a result of using industrial areas. Home range sizes suggest coyotes found resources more easily than red foxes. Den sites reflected the more general differences

space-use; coyotes denned in non-residential areas while fox dens were in residential. We estimated 0.27 coyotes/km<sup>2</sup> and 0.21 red foxes/km<sup>2</sup>; lower than in other cities.

- 4. Overall, our results suggest coyotes expanded into areas once occupied by red foxes, but both species rarely became nuisances. Outreach promoting leashing pets and keeping cats inside is likely to improve the health of pets, coyotes, and foxes. Communicating the smaller-than-expected weight (males=14.3 kg [31.5 lbs.]; females=11.9 kg [26.2 lbs.]) and low risk of attack should reduce negative perceptions of coyotes. Improving natural habitat in residential greenspaces is likely to benefit red foxes.
- 5. This study's results provide much-needed information to residents and wildlife managers about 2 charismatic species that are relatively unstudied in Minnesota.

#### **III. PROJECT ACTIVITIES AND OUTCOMES:**

## ACTIVITY 1 Title: Map areas used by foxes and coyotes to assess habitat needs and reduce conflicts with people

**Description:** We will map the areas that foxes and coyotes use and identify the habitats that they need. We will use best practices to capture individual gray foxes, red foxes, and coyotes (15 of each species for a total of 45 study animals). We will attach a GPS collar to each fox and coyote we capture before releasing it. GPS collars will be programmed to collect multiple locations (2,000 locations per year) from each study animal and transmit these locations to us via satellite each week. Locations will be analyzed using GIS software to identify habitat needs, quantify survival rates, determine home range areas, and estimate population sizes. We will determine how much "human food" foxes and coyotes eat by collecting hair samples from each study animal that we capture and examining fecal samples when available. Stable isotope analysis of hair samples will tell us how often they eat cornbased foods that are common in human diets but rare in the natural diets of foxes and coyotes.

#### ACTIVITY 1 ENRTF BUDGET: \$429,265

Outcome	Completion Date
1. Identify study sites, acquire equipment, and train staff	September 30, 2019
2. Capture and process foxes and coyotes – season 1	February 28, 2020
3. Capture and process foxes and coyotes – season 2	February 28, 2021
4. Submit hair samples for stable isotope analysis	March 31, 2021
5. Final report and activity results submitted	June 30, 2022

#### First Update March 1, 2020

We advertised, interviewed, and hired a PhD student for the project (Geoffrey Miller), and trained him in field techniques needed for capturing and processing coyotes and foxes. We developed protocols and acquired equipment (collars, cable restraints, immobilization drugs, etc.) for capturing and processing coyotes and foxes after consulting with other researchers and fur trappers. We scouted >50 sites throughout the study area for animal sign (e.g., tracks and scat) and contacted cities for access to some public areas. We met with and developed partnerships with multiple organizations, including the City of Bloomington, Minnesota Valley NWR, and Westwood Hills Nature Center (St. Louis Park).

Live-trapping occurred from late November through the end of February. We captured and processed 9 coyotes (6 males and 3 females). One male coyote was released without a collar because we captured a member of his pack at the same site and want locational data to remain independent. One male coyote

dispersed to Wisconsin and was shot and killed by a hunter; we retrieved the carcass and collar. Additionally, we captured and processed 4 red foxes (3 males and 1 female). We plan to revise our methods for live-trapping foxes to achieve greater success.

#### Second Update September 1, 2020

PhD student Geoff Miller visited 50 locations used by 7 coyotes as den and rendezvous sites. Geoff measured plants and other features that serve as hiding cover for coyotes. These measurements will help to create maps depicting locations that coyotes are likely to use for den/rendezvous sites around the Twin Cities Metro Area; areas where they may conflict with people. We continued to monitor survival of collared study animals. Three study animals have died (including 1 that was euthanized by animal control due to apparent mange) and we collected biological samples for diet analysis from 2 of them. We made preparations for the next live-capture season. Preparations included purchasing equipment and supplies, contacting multiple municipalities (e.g., working with Saint Paul and Fridley to gain permission to live-trap), and scouting >20 sites. Planning is ongoing.

#### Third Update March 1, 2021

We scouted >200 sites throughout the study area for animal sign (e.g., tracks and scat). We revised our methods for live-trapping foxes and met with Minnesota Trappers Association members for guidance. Live-trapping occurred from September through the end of February. We captured and processed 6 coyotes, 11 red foxes, and 1 gray fox. An additional red fox we captured was not processed as it was killed before we arrived to process it; evidence at the scene suggested it was killed by a transient coyote. We plan to conduct an additional live-trapping season during fall 2021 to deploy additional collars.

#### Fourth Update September 1, 2021

PhD student Geoff Miller visited 38 locations used by coyotes and foxes to measured plants and other features that serve as hiding cover. We monitored survival of collared study animals. We made preparations for the next live-capture season. Preparations included purchasing equipment and supplies and scouting >10 sites.

#### Fifth Update March 1, 2022

Live-trapping occurred from September through November, resulting in capture and processing of an additional 3 coyotes, 1 red fox, and 1 gray fox. We initiated GIS and statistical analysis.

#### Final Report between project end (June 30) and August 15, 2022

We captured, GPS collared, and biological collected samples (hair, blood, and scat) from coyotes, red foxes, and gray foxes across the urban-rural gradient in the Minneapolis-Saint Paul Metropolitan Area (hereafter the Twin Cities Metro Area; TCMA; Figure 1).



**Figure 1.** The 7-county Twin Cities Metro Area (TCMA) where we studied coyotes, red foxes, and gray foxes across a range of human densities. Darker gray shading corresponds with greater human density (people / km<sup>2</sup>; US Census Bureau 2010). Inset depicts the Minnesota border. The dashed outline is the study area within the TCMA where we captured study animals; a 100% minimum convex polygon of locations of non-dispersing individuals.

Overall, we processed 17 coyotes, 16 red foxes, and 2 gray foxes (Figure 2). All were returned safely to the wild once they recovered from anesthesia.



**Figure 2.** Female red fox (F9) being fitted with a GPS tracking collar. We immobilized this fox for processing and released it unharmed thereafter.

We found that coyote survival was greater than for red foxes (Figure 3), suggesting higher population growth for coyotes than for red foxes. Coyote and free-roaming dog attacks caused at least 20% of red fox mortalities, which was more than we expected, and likely reflects expansion of coyotes into areas previously occupied by foxes and also the presence of free-roaming dogs in residential areas.



**Figure 3.** Daily survival for coyote (A) and red fox (B) in the Twin Cities Metro Area from 2019–2022. Mating season was from Nov.–Feb. and Dec.–Mar. for red foxes and coyotes, respectively. Pup-rearing was from Mar.–June and Apr.–July, respectively.

Diets of coyotes and foxes consisted of primarily natural foods, with only 8% of individuals exhibiting corn-rich diets associated with human foods found in refuse (Figure 4). Wide dietary breadths show that coyotes and foxes relied on diverse food resources, as expected from a generalist forager, but with wider dietary breadth for coyotes.



**Figure 4.** Stable isotope ratios ( $\delta^{15}$ N and  $\delta^{13}$ C) for coyotes, red foxes, and gray foxes in the Twin Cities Metro Area. Black shapes represent mean (±SD; error bars)  $\delta^{15}$ N‰ and  $\delta^{13}$ C‰ pooled by species. The dashed line is the threshold for a high consumption of corn-rich food.

Home range size suggests greater resource availability for coyotes than for red foxes (Figure 5). Coyote home ranges were similar to other urban studies but red fox home ranges were much larger than has been reported. Because abundant resources result in smaller home ranges (and vice-versa), our results suggest that coyotes found resources more easily than red foxes.



**Figure 5.** Annual 95%  $KDE_C$  home range estimates for coyotes, gray foxes, and red foxes in the TCMA.

At the home range scale (second-order selection), coyotes selected areas with low road density and abundant wetlands (Figure 6). Red foxes, on the other hand, were more likely to select home ranges in residential areas, and also more likely to choose areas with high road density. Gray foxes were also more likely to choose home ranges within residential areas.



Landscape variable

**Figure 6.** Box plots of per-animal selection ratios (i.e., mean landcover variable an individual selected / mean available) for each landcover variable at each order of selection for red foxes (A–B) and coyotes (C–D) summarized by biological season. Selection ratios >1 (dashed line) indicate selection of a variable. Points above or below box plots indicate outliers, while numbers above box plots indicate the number of outliers beyond the extent of the y-axis range. Numbers within the box plot indicate whisker extent if beyond y-axis range.

Resource selection functions (RSFs) enabled us to map potential resource availability for coyotes and foxes across the TCMA (Figure 7). Maps show where foxes and coyotes are most likely to establish home ranges, with greater use of residential areas by red foxes.

**Red fox** 

Second-order selection

Coyote



Figure 7. Relative selection maps developed for coyotes (A, C, E) and red foxes (B, D, F) in the area west of the MSP Airport in the TCMA. Second-order maps depict the relative probability of a pixel being selected within a home range (A–B), third-order maps depict the relative probability of being selected within an individual's home range (C–D), and scale-integrated maps indicate the relative probability of a pixel being selected within a home range, given the probability that the pixel is within a home range (E–F).

Our results suggest that coyote and fox densities are relatively low. RSF-based density estimates were 0.27 coyotes/km<sup>2</sup> and 0.21 red foxes/km<sup>2</sup>, which is lower than in other urban settings and corresponds with estimates based on home range size ( $\leq$  3 foxes/km<sup>2</sup>). Our results also support the anecdotal observation that coyotes expanded into areas once occupied by red foxes. Fortunately, coyotes and foxes rarely became nuisances; 0 collared coyotes were reported as being in conflict with people and the only reported fox conflict was due to foxes leaving prey carcasses near a den.

Outreach stressing the importance of leashing pets and keeping cats inside is likely to improve the health of TCMA pets, coyotes, and foxes. Communicating the smaller-than-expected weight (males=14.3 kg [31.5 lbs.]; females=11.9 kg [26.2 lbs.]) and low risk of conflict is likely to reduce negative perceptions of coyotes. Management activities that improve natural habitat in residential greenspaces are likely to benefit red foxes. Whereas coyotes occupied many of the large greenspaces, red foxes often selected green spaces in residential areas. This study's results provide much-needed information to Minnesota residents and wildlife managers, and also provide a foundation for future studies that extend into other areas in and beyond the TCMA.

#### ACTIVITY 2 Title: Map infectious diseases to assess risk for wildlife, pets, and people

**Description:** We will determine which diseases infect coyotes and foxes. We will test for multiple diseases that threaten not only the health of foxes and coyotes, but also people and their pets. We will collect biological samples (blood and feces) from each fox and coyote that we capture during Activity 1 (a total of 45 individual study animals). Each of the samples will be tested for common diseases (rabies, distemper, heartworm, toxoplasmosis, leptospirosis, parvovirus, echinococcosis, Lyme disease). Test results will enable us to quantify the prevalence of infectious diseases and map locations of diseased animals.

#### ACTIVITY 2 ENRTF BUDGET: \$70,735

Outcome	Completion Date
1. Submit biological samples for disease testing	March 31, 2021
2. Final report and activity results submitted	June 30, 2022

#### First Update March 1, 2020

We collected biological samples from each of the coyotes and foxes we captured and processed. Blood and fecal samples were processed by Katie Worsley-Tonks (PhD student partly funded by the project) and Geoff Miller (following training from Katie). All biological samples were stored pending further analysis.

#### Second Update September 1, 2020

We organized supplies and equipment for the second live-capture season.

#### Third Update March 1, 2021

We collected biological samples from each of the coyotes and foxes we captured and processed. All biological samples were stored pending further analysis.

#### Fourth Update September 1, 2021

We submitted 25 blood serum samples for testing. Preliminary findings suggest high prevalence of some diseases, including canine parvovirus, distemper, and heartworm. Additional literature review will put

our results into context.

#### Fifth Update March 1, 2022

We submitted blood samples for lab analysis. We tested fecal and blood samples for multiple diseases including COVID-19, in collaboration with other University researchers. We also submitted hair samples for analysis and tested a subset of hairs for heavy metals, in collaboration with other University researchers.

#### Final Report between project end (June 30) and August 15, 2022

We detected a total of 8 pathogens in serum of the 17 coyotes, 12 red foxes, and 1 gray fox we sampled (Table 1); indicating previous or current pathogen exposure. All 30 of these study animals had canine parvovirus antigens, while canine distemper antigens were present in 94% of coyotes, 75% of red foxes, and in the one gray fox. We detected Lyme disease, *Leptospira*, and *Toxoplasma gondii* antigens in coyotes and red foxes, while *T. gondii* was the only additional antigen detected in the gray fox. *T. gondii* was detected in 2.8- to 2.9-times more red foxes (50% [IgG] and 83% [IgM] of foxes) than coyotes (18% [IgG] and 29% [IgM] of coyotes). Overall, we detected 3.4 (SD=0.9, n=17) pathogen antigens in coyotes, 2.3 (SD=0.7, n=12) in red foxes, and 3 in the 1 gray fox.

	Coyote	Red fox	Gray fox
Serological pathogens			
N individuals	17	12	1
Heartworm (Dirofilaria immitis) antigen	0	0	0
Erlichia antibody	0	0	0
Lyme disease (Borrelia burgdorferi).antibody	4	7	0
Anaplasmosis (Anaplasma sp.)	0	0	0
Leptospira atumnalis	2	3	0
Leptospira bratislavis	1	2	0
Leptospira canicola	0	0	0
Leptospira grippotyphosa	1	2	0
Leptospira hardjo	0	0	0
Leptospira icterohaemorrhagiae	0	0	0
Leptospira pomona	0	0	0
Toxoplasmosis (Toxoplasma gondii) IgG	5	10	1
Toxoplasmosis (Toxoplasma gondii) IgM	3	6	0
Canine parvovirus	17	12	1
Canine distemper	16	9	1
Serology pathogen richness (mean ± SD)	3.4 ± 0.9	$2.3 \pm 0.7$	3*
Fecal pathogens (sucrose fecal float)			
N individuals	7	1	0
Toxocara canis	3	0	_
Toxocara leonia	1	0	_
Coccidea	5	0	_
Echinococcus sp.	1	0	_
Toxoplasma gondii	1	0	_
Chyptosporidium sp.	1	0	_
Capillaria sp.	0	1	_
Isospora sp.	0	1	_
Tricharis vulpis	0	1	_
Diphyllobothrium latum	0	1	_
Fecal pathogens (zinc sulfate fecal float)			
N individuals	6	1	0
Giardia intestinalis	1	0	_
Strongylidae	1	1	-
Toxoplasma gondii	1	0	_
Coccidea	1	0	-
Isospora sp.	1	1	-
Aclyostoma caninum	0	1	-
Tricharis vulpis	0	1	_
Fecal pathogen richness (mean ± SD)	2.4 ± 1.4	6*	_

\*Richness values without SD result from single observations of a host species.

**Table 1.** Pathogen antigens and parasites detected in coyotes and foxes in the Twin Cities Metro Area.Pathogen richness is the number of pathogens detected per individual.

We identified 14 fecal parasites (Table 2) from rectal fecal samples of seven coyotes and one red fox, but were unable to collect samples from other study animals (fecal matter was absent). We identified *Coccidia* most frequently in coyotes (N = 5 individuals). Coyotes had an average fecal parasite richness of 2.4 (SD=1.4, n = 7 individuals) while the single red fox had 2.5-times greater fecal parasite richness.

Fecal parasite richness, presence of pathogens, and presence of parasites were not correlated with any land-cover variables but serological pathogen richness was positively correlated with the proportion of annual home range covered by non-moving water bodies (e.g., ponds). This positive relationship appears to be partly explained by the interaction between vectors of pathogen transmission and habitat selection, as cat-feces-transmitted *Toxoplasmosis gondii was* one of the most prevalent pathogens we detected in coyotes and foxes. *T. gondii* was especially frequent in red foxes, potentially due to red fox selection of residential areas where free-roaming domestic cats are more common. Additionally, elevated heavy metal content in the hair of coyotes that selected impervious surfaces is likely a result of coyotes using industrial and commercial areas more than foxes, the latter of which selected residential areas that were less affected by heavy metal contamination.

In addition to testing for disease, we collaborated with UMN's Emilie Snell-Rood to examine presence of heavy metals in coyote and fox hair. Our data provide reference levels for coyotes and foxes in the TCMA that improve understanding of how each species interacts with their environment. We found that impervious surface was positively correlated with levels of chromium, cobalt, nickel, arsenic, and cadmium in coyote hair but not in fox hair. Such elevated heavy metal content in TCMA coyotes that selected impervious surfaces is likely to be a result of using industrial areas (more likely to be polluted) more than foxes, which use more residential areas.

#### **IV. DISSEMINATION:**

**Description:** We will present results at state and national scientific conferences (e.g., annual meetings of The Wildlife Society). We will make scientific publications that result from this project available through University of Minnesota websites, Open Access journal websites, and upon a request. Outreach will include speaking engagements at nature centers (e.g., the Eastman Nature Center operated by the Three Rivers Park District) and at meetings held by organizations that are interested in conservation and management of wildlife (e.g., the Minnesota Trappers Association). We expect that this research will draw media attention, which will provide additional opportunities to inform the public about findings from this project.

The Minnesota Environment and Natural Resource Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the <u>ENRTF Acknowledgement Guidelines</u>.

#### First Update March 1, 2020

We created a University website (tccfp.umn.edu), Facebook page (@tccfp), and iNaturalist page (inaturalist.org/projects/tccfp) for the project. The Facebook page has 85 followers and the iNaturalist page has 419 members who have submitted 809 coyote and fox observations. Nick McCann delivered presentations to the city councils for North Oaks and Bloomington before project funding started, and additional presentations to North Oaks and Highland District Council (Saint Paul) after funding began. Nick McCann was also interviewed by MPR and WCCO (CBS; segment to air in early March 2020).

Outreach and training included opportunities for volunteers. We had 29 volunteers out to check, maintain, and set live-traps with us on 33 occasions. This included 12 graduate students from multiple University Departments (Fisheries, Wildlife and Conservation Biology, Veterinary Medicine, and Ecology, Evolution and Behavior) on 16 occasions; 13 FWCB undergraduate students on 13 occasions; 3 post-

doctoral fellows on 3 occasions; and 1 program coordinator from the Vadnais Lake Area Water Management Organization. Additionally, we invited the Bloomington Animal Control Officer, 3 postdoctoral fellows, a private landowner, a railroad manager, and a visiting researcher to attend processing of study animals. Six FWCB Club undergraduate students helped constructed cable restraint anchors after training from Geoff Miller and James Forester. Lastly, 1 FWCB undergraduate and 1 recent FWCB graduate worked as interns on the project following training from Geoff Miller and Nick McCann.

#### Second Update September 1, 2021

We added additional content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist page. Our Facebook page membership has increased to 184 followers. Our iNaturalist page has increased to 506 members who have submitted 1,009 coyote and fox observations. Nick McCann delivered a presentation to a Macalester College ethics class and co-presented with PhD student Geoff Miller to a University of Minnesota class. Nick McCann was interviewed by BioGraphic Magazine. Additional outreach and training included opportunities for University of Minnesota Undergraduates, as we made plans for >30 students from a field course to deploy an array of trail cameras to help locate study animals for this project.

#### Third Update March 1, 2021

We added additional content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist page. Our Facebook page membership has increased to 347 followers. Our iNaturalist page has increased to 588 members who have submitted 1,181 coyote and fox observations. Although COVID-19 reduced presentation opportunities, Nick McCann and Geoff Miller (remotely) co-presented to an Anoka Ramsey Community College class and a University of Minnesota class, and Geoff Miller presented to 2 elementary school groups and a University of Minnesota class. Nick McCann, James Forester, and Geoff Miller were interviewed by the BBC. Nick McCann and James Forester were interviewed by a University of Minnesota English Professor. Nick McCann was interviewed by the Field Regina Northrop Neighborhood Group (South Minneapolis). Additional outreach and training included opportunities for University of Minnesota Undergraduates, as >30 students from a field course deployed an array of trail cameras to help locate coyotes and foxes, and a recent undergraduate volunteered on the project following training from Nick McCann. One regional ecologist attended a coyote processing and Nick McCann twice took along a University of Minnesota English Professor during fieldwork.

#### Fourth Update September 1, 2022

We added additional content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist page. Our Facebook page membership has increased to 405 followers. Our iNaturalist page has increased to 615 members who have submitted 1,285 coyote and fox observations. Nick McCann and PhD student Geoff Miller delivered presentations to Anoka-Ramsey Community College, Macalester College, the City of Shoreview, and to Minnesota Master Naturalists (West Metro Chapter), and Geoff Miller presented to 3 elementary classes. BioGraphic Magazine, the Northeaster, and Prairie Sportsman (PBS) interviewed project staff.

#### Fifth Update March 1, 2022

We added content to our TCCFP University of Minnesota website, Facebook page, and iNaturalist pages, and started engaging the public using Twitter. Our Facebook page membership has increased to 430 followers and Twitter users logged 842 user impressions about project tweets. We also delivered a project presentation to a community college and provided interviews with PBS, Three Rivers Park

District's "Wandering Naturalist" podcast, and MSP Magazine.

#### Final Report between project end (June 30) and August 15, 2022

Overall, we delivered 17 presentations to colleges (e.g., Anoka Ramsey Community College and Macalester College), grade schools, and municipalities (e.g., Cities of Bloomington). We also provided 12 interviews to news outlets and podcasts (e.g., MPR, BBC, and Three Rivers Park District's "Wandering Naturalist" podcast), content for 2 Friends of the Mississippi River newsletters, trained over 60 undergraduate and graduate student volunteers in field activities, and coordinated with 2 UMN courses (60 students total). To further disseminate information, we created a <u>University website</u>, <u>Facebook</u> page, and <u>iNaturalist page</u> for the project, and we have drafted 1 scientific manuscript (set to be published this year).

#### V. ADDITIONAL BUDGET INFORMATION:

Г

#### A. Personnel and Capital Expenditures Explanation of Capital Expenditures Greater Than \$5,000: N/A Explanation of Use of Classified Staff: N/A

#### Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours for entire	Divide total personnel hours by 2,080 hours in 1 year

## Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for	Divide total contract hours by 2,080 hours in 1 year
entire duration of project: 70	= TOTAL FTE: 0.034

#### **VI. PROJECT PARTNERS:**

#### A. Partners outside of project manager's organization receiving ENRTF funding: N/A

Name	Title	Affiliation	Role
John Moriarity	Senior Manager of Wildlife	Three Rivers Park District	Assist with live-trapping efforts on Three Rivers Park District lands
Steven Hogg	Wildlife Specialist	Three Rivers Park District	Assist with live-trapping efforts on Three Rivers Park District lands

#### B. Partners outside of project manager's organization NOT receiving ENRTF funding

#### VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

This project will initiate long-term research opportunities for members of the University of Minnesota's Fisheries, Wildlife, and Conservation Biology Club who will participate in research activities described in this proposal. Students will continue supervised research activities after this project is completed, thereby using this project as a springboard to secure future funding and for developing a long-term data set.

This project will provide foundational information to managers that does not currently exist, resulting in multiple benefits for Minnesota wildlife. Activities 1 and 2 will support development of management strategies for foxes and coyotes. Our project will also serve a model that can be used to develop additional studies for other species (e.g., raccoons) and other urban areas (e.g., Duluth). Activity 1 will inform "greening" initiatives that provide wildlife with habitat. Examples of greening initiatives that could benefit from this research include the LCCMR-supported Great River Greening and Greening the Green Line. Information from Activity 2 will result in a knowledge base of diseases that affect wild canids, pets, and people and act as a first step toward long-term disease monitoring and mitigation programs. Activity 1 will show whether fox and coyote diets influence their health and the risk of conflict with people and pets. Collectively, this project will connect Minnesotans that reside in urban settings to wildlife.

#### VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted March 1 and September 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2022

#### IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

- A. Budget Spreadsheet
- B. Visual Component or Map



- C. Parcel List Spreadsheet N/A
- D. Acquisition, Easements, and Restoration Requirements N/A
- E. Research Addendum

#### Attachment A:

**Environment and Natural Resources Trust Fund** 

M.L. 2019 Final Budget Spreadsheet

Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03g

Project Manager: Dr. Nicholas McCann

Project Title: Mapping habitat use and disease of urban carnivores

Organization: University of Minnesota

Project Budget: \$500,000

Project Length and Completion Date: 3 years; June 30, 2022

Today's Date: August 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND							
BUDGET	Budget		Budget Amount		Ва	Balance	
BUDGET ITEM							
Personnel (Wages and Benefits)	\$	372,846	\$	370,341	\$	2,505	
University of Minnesota Graduate Research Assistant,							
\$44,970 (58% salary, 42% benefits) 50% FTE for 1 year							
University of Minnesota Graduate Research Assistant,							
\$96,108 (56% salary, 44% benefits) 50% FTE for each of 2							
years							
University of Minnesota Undergraduate Intern, \$0 (100%							
salary, 0% benefits) 4% FTE for each of 2 years							
University of Minnesota Postdoctoral Research Assistant,							
\$205,298 (81% salary, 19% benefits) 100% FTE for each of 3							
years							
University of Minnesota Faculty Member, \$12,908 (75%							
salary, 25% benefits) 8% FTE for 1 year							
University of Minnesota Faculty Member, \$12,130 (75%							
salary, 25% benefits) 8% FTE for 1 year							
Professional/Technical/Service Contracts							
Service contract for testing 45 biological samples for 8	\$	3,068	\$	3,068	\$	-	
diseases at University of Minnesota diagnostic laboratories							
(\$13,095)							
Service contract for analysis of diet composition at stable	\$	567	\$	567	\$	-	
isotope laboratory; competitive process will be used to							
identify a laboratory (\$1,350)							
Service contract for GPS collar data downloads; competitive	\$	7,730	\$	7,707	\$	23	
process will be used to identify a provider (\$21,600)							
Professional contract for locating foxes and coyotes and accessing private	\$	5,630	\$	5,630	\$	-	
properties in the Metro area; contract to be with Friends of the Mississippi							
Equipment/Tools/Supplies							
Equipment for fieldwork and managing biological samples,	\$	9,190	\$	9,155	\$	35	
including pharmaceuticals and traps (\$5,490)							
GPS collars for red and gray foxes (30 collars @ \$1,512 per	\$	75,589	\$	75,589	\$	-	
collar = \$45,360); GPS collars for coyotes (15 collars @							
\$1,470 per collar = \$22,050)							
Travel expenses in Minnesota							
Vehicle mileage for locating, capturing, and monitoring study animals,	\$	25,380	\$	24,486	\$	894	
delivering presentations, and meeting with collaborators in Minnesota (14,920							
miles @ \$0.545 per mile = \$8,131)							
Other					\$	-	
	\$	-	\$	-	\$	-	
COLUMN TOTAL	\$	500,000	\$	496,543	\$	3,457	

OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)		Spent		Balance	
Non-State: UMN FWCB Club	Pending	\$ 13,400	\$	-	\$ 13,	,400
Non-state: nonsponsored funds from James Forester		\$ 20,449	\$	20,449	\$	-
In kind:			\$	-	\$	-

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent		Spent				Spent		nce
Current appropriation:									
		\$	300,000	\$	300,000	\$	-		
Past appropriations: M.L. 2016, Chp. 186, Sec. 2, Subd. 03I;									
Restoration of Elk to Northeastern Minnesota; Dr. Nicholas									
McCann was the Postdoctoral Associate for this project									



# Mapping habitat use and disease of urban carnivores







C7

-22 δ<sup>13</sup>C (‰ VPDB)