Cook County Department of
Animal and Rabies Control

ENVIRONMENTAL RESEARCH INITIATIVE GROUP

Annual Report
2017 | 2018

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Cook County Animal and Rabies Control and the Forest Preserves of Cook County received funding 24 years ago to collaborate with the Environmental Impact Research Group (EIRG) of The Ohio State University.

Every resident in Cook County can share pride in this ongoing study which has become an international model. The efforts of EIRG have resulted in analysis of interactions between coyotes, racoons, skunks, deer and feral cats with companion animals and humans. Monitoring these populations serves as an early warning system for emerging diseases which may affect us and our pets.

In 1993, the Zoological Pathology Program was established through a collaboration between the University of Illinois, Chicago Zoological Society's Brookfield Zoo, John G. Shedd Aquarium and the Lincoln Park Zoo. Cook County Animal and Rabies Control and the Forest Preserves of Cook County joined this collaboration along with regional, national and international partners that include zoological institutions, wildlife agencies and conservation organizations.

The work of the Zoological Pathology Program has given us the ability to detect clusters of diseases in animal populations and take measures, including alerting residents, to help prevent the spread of disease to humans and pets.

More than 100 years ago residents of Cook County set up one of the largest green spaces in any county in the United States. Over the last two dozen years, we have established a way to monitor how we and the wildlife in this area can live together with minimal friction and a means to analyze and remedy situations when necessary.

Sincerely,

Thomas J. Wake, DVM
Cook County Animal & Rabies Control

REPORTS

Cook County Department of
Animal and Rabies Control

Environmental Impact Program Annual Report

Cook County Department of Animal and Rabies Control Environmental Impact Program Annual Report

Karen A. Terio, DVM, PhD, Diplomate ACVP, Chief of Staff,
Clinical Professor University of Illinois Zoological Pathology Program

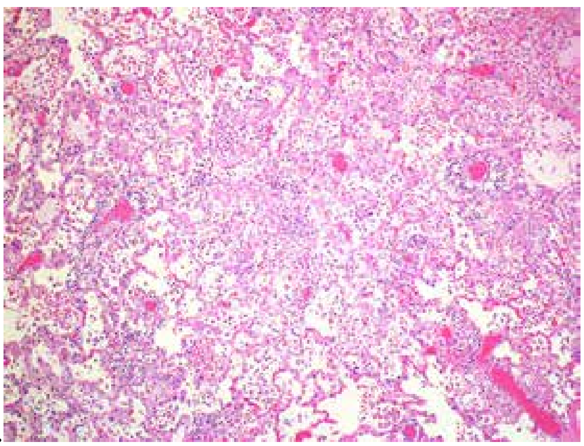
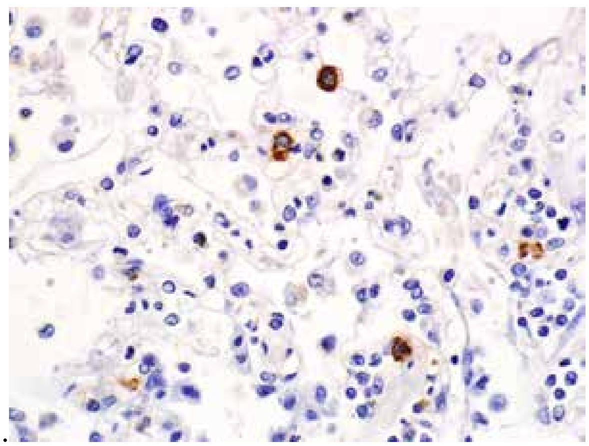
Disease surveillance is a critical component of ongoing and effective wildlife management. Surveillance allows for validation or revision of current assumptions about wildlife disease dynamics, assessment of effects of pass-through migratory species on permanent resident animals, and, probably of utmost importance, monitoring for the emergence/re-emergence of diseases not currently in Cook County but of concern to wildlife, domestic animal, and public health communities. The majority of infectious diseases of concern for public health have wildlife reservoirs. The rising concern over leptospirosis as a wildlife-zoonotic of public health importance and continued colonization of the County by tick vectors capable of transmitting various rickettsial diseases are emblematic of the necessity for continued surveillance. Recent cases of domestic cat rabies in surrounding counties poses a real and serious risk to public and animal health requiring persistent and vigilant surveillance. Continued monitoring for the raccoon-adapted strain of rabies is an indispensable aspect of this mission. The University of Illinois Zoological Pathology Program (ZPP), in cooperation with personnel from the Forest Preserve District of Cook County (FPDCC), has been monitoring wildlife diseases in Cook County since 1993. The multidisciplinary knowledge accumulated through decades of wildlife and habitat study has allowed for major advances in our ability to evaluate ecosystem health.

In 2017, ZPP evaluated carcasses from 158 animals of the following species and groups:

Canids (coyote, fox and dog)	31
Mesocarnivores (raccoon, skunk, otter)	24
Cervids (deer and elk)	5
Fish	87
Avian	3
Other Mammal (opossum, rodent)	6
Feral cat	1
Bat	1

Continued surveillance endeavors are important given the presence and risk of spread of significant diseases affecting humans, domestic animals and wildlife, including most notably rabies, chronic wasting disease (CWD), influenza, leptospirosis, West Nile Virus and tick-borne diseases, in areas with close interaction between wildlife and humans. Surveillance is also important to assess the health of ecosystems utilized for public recreation. The following case examples exemplify the approach and application of results for the betterment of human and animal health in Cook County.

Canine influenza A (H3N2) is an avian-origin influenza virus that came to the United States in February 2015 causing respiratory disease in domestic dogs in the Chicagoland region. The virus spread rapidly through domestic dog populations in the Chicago area and was responsible for sporadic outbreaks nationwide. Affected dogs predominately had mild respiratory disease with a honking cough; some dogs developed pneumonia and there were rare deaths. The virus strain was most similar to one that had been circulating in Southeast Asia. In late 2017 and early 2018, ZPP identified possible cases of influenza in free-ranging coyotes with pneumonia. In these cases, pneumonia was not the cause of death emphasizing the importance of disease surveillance even when the cause of death is known. To date, there are no reported cases of H3N2 infection in free-ranging wildlife in the United States. If confirmed, these findings will be important as wildlife could serve as a reservoir for infection of domestic animals and potentially a source of mutations and new, potentially more virulent, virus strains. Canine influenza strains have been shown experimentally to infect cats but are not thought to be pathogenic to humans. ZPP is continuing to investigate these cases to both confirm infection and identify the specific viral strain.

A.  B. 

Canine Influenza infection in a Coyote: A. Pneumonia in a section of lung from a coyote with epithelial syncytia, interstitial and alveolar inflammation. B. Immunohistochemistry using antibodies against influenza virus demonstrating positive (brown) staining of epithelial cells consistent with the presence of influenza virus in the lung.

Chronic wasting disease is a debilitating neurological disease of free-ranging elk and deer caused by a prion (infectious protein) similar to bovine spongiform encephalopathy ("mad cow" disease). As for previous years, no CWD-positive deer have been detected through the ZPP (or the IDNR) surveillance programs in Cook County. All deer are specifically evaluated for CWD. Statewide there were 75 CWD-positive deer from both hunter killed and intensive culling/surveillance programs in Fiscal Year 2017 (IDNR CWD Annual Report FY 2017). Positive animals have historically been found in Will, Lake, Kane, and DuPage counties and in FY 2017 positive cases were routinely identified in Kane County; thus, spread to areas of Cook County with high deer densities remains a concern.

Leptospirosis is a disease caused by the bacteria *Leptospira interrogans*. The bacteria can survive within water and soil for weeks and can be shed into the environment by infected wildlife species. People and companion animals can be infected directly from other animals or by ingestion of contaminated water or soil in the environment. In both people and companion animals, infection can result in kidney and liver damage, even failure. ZPP has been conducting a multi-year study into leptospirosis in Cook County to better understand the role of wildlife in disease ecology. Our surveillance has identified squirrels as a new species of concern for monitoring for Leptospirosis and another potential vector for transmission. There were no identified cases of Leptospirosis in submitted wildlife in 2017.

Canine distemper virus (CDV) is a virus that affects carnivores causing pneumonia and encephalitis. The virus is normally present in Cook County carnivores and causes sporadic deaths of raccoons, fox, skunk and coyotes. However, in 2004, there was a large CDV outbreak that spilled over into domestic dogs both in shelters and those that were privately owned. Any disease that causes encephalitis can alter an animal's behavior, which increases the risk of unprovoked bites and attacks making it a public health concern. In late 2015 and early 2016, ZPP identified another large-scale outbreak of CDV in wildlife. Timely reporting and confirmation of the cause to CCDARC allowed them to inform citizens and shelters so that appropriate preventative measures could be taken. Information was disseminated by CCDARC through local TV, print and online media sources. Information was also shared with the public health community through the Program for Monitoring Emerging Diseases (ProMED), an email based public health alert reporting system. In addition to notifying the public of the concern, ZPP began investigations into the virus itself, how it mutates and what strains are shared among coyotes, dogs, raccoons, skunk and fox. This information is critical as CDV strains in China have mutated and infected monkeys suggesting a potential for human infection. Since the 2016 outbreak, we have been closely monitoring the strains of CDV in Cook County wildlife to better understand the factors underlying large scale outbreaks like those in 2004 and 2016. There were 3 cases of CDV in 2017, all in skunks. With the westward geographic progression of raccoon rabies, differentiation between rabies and CDV will be critical. The ZPP laboratory has developed multiple tests for rapid diagnosis of CDV, and our parent lab, the VDL, is now an approved testing site for rabies in Illinois.

In collaboration with EIRG partners, ZPP is monitoring raccoon populations for the parasite ***Baylisascaris procyonis***. The parasite is a normal inhabitant of the raccoon gastrointestinal tract. Eggs are shed in the feces of raccoons and can develop into infective larvae in the environment. These larvae can infect humans. Following ingestion, larvae migrate through the gut wall into various tissues. Most concerning is that the larvae often migrate to the brain where they cause encephalitis and extensive damage despite treatment. Infections can be fatal or cause profound neurologic disabilities. Children are at increased risk of infection when they place potentially contaminated objects and fingers into their mouths. Ongoing research has been studying the distribution and seasonality of infections in raccoons to determine risk factors for human infection.

Other ZPP activities have focused on surveillance for diseases of concern including rabies, West Nile virus, avian influenza (bird flu), CWD & bovine tuberculosis in whitetail deer, leptospirosis, sarcoptic mange, tularemia, yersiniosis, epizootic hemorrhagic disease in deer, systemic isosporosis (avians), and parasitism in skunks.

ANNUAL REPORT 2017

RESEARCH PROJECTS SPONSORED BY THE ENVIRONMENTAL RESEARCH PROGRAM, COOK COUNTY ANIMAL & RABIES CONTROL

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SUBMITTED TO

Cook County Animal and Rabies Control

Environmental Research Program

September 24, 2018

BRIEF INTRODUCTION

Wildlife disease is of great importance to the health and safety of humans and domestic animals with 73% of emerging and reemerging pathogens are known to be zoonotic (transmitted from animals to people). There is increasing evidence suggesting that urbanization and resultant land-use changes contribute to the emergence of wildlife diseases through multiple mechanisms, with consequences for human and pet health. In light of the increasingly close association between wildlife and humans in Cook County, the need for surveillance and proactive research is needed to guide and interlink human health and wildlife management programs with the goal of limiting the risk of human exposure to zoonotic diseases.

The following provides a summary of recent surveillance and research on wildlife species in Cook County that pose important health risks for people and pets. The following work represents collaborations between Cook County Animal and Rabies Control, the Forest Preserve District of Cook County, and the Max McGraw Wildlife Foundation, among other partners. ***Our work consists of 1) Disease monitoring of living or dead wildlife, and 2) research projects designed to address specific questions or problems.***

I. DISEASE MONITORING

To monitor diseases in wildlife populations, we livetrap the animals and collect small blood and fecal samples. These samples are later tested for a variety of diseases. We also collect information on the general health and population characteristics of wildlife that potentially carry (or host) diseases that can be transmitted to pets or people. Among the species we monitor are raccoons, opossums, feral cats, and coyotes.

Disease Monitoring - Raccoons

The raccoon is one of the most common mammalian species in Cook County, and at times reaches overabundant densities. Previous research from this program determined raccoon densities can reach higher than 100 raccoons per km^2 in favorable habitats within the Chicago metropolitan area. Because of their generalist lifestyle, raccoons represent an effective indicator of many diseases and environmental contaminants, many of which can impact people and pets. One of the most alarming diseases is rabies, but raccoons can also host leptospirosis, canine distemper, canine parvovirus, among many other diseases.

We have continued this surveillance to determine if these pathogens are changing in frequency or virulence. We currently (2018) have testing underway for samples collected during 2013-2017.

Frequencies of sero-positive rates for selected pathogens for raccoons in Cook County.

	2005-2006	2008-2009	2010-2012
Pathogen	% Positive	% Positive	% Positive
Canine distemper	39	17	50
Canine Parvovirus	51	50	100
Toxoplasmosis	37	17	50
Leptospirosis sp.	31	69	35

Disease Monitoring - Coyotes

Coyotes are important animals to monitor for diseases, as well as changes in behavior. This is because they range over most of the Chicago area, can host (or carry) a wide range of diseases, and are capable of (occasionally) attacking pets or (rarely) people.

A livetrapped coyote that is being radiocollared and samples collected for diseases

Our monitoring has revealed that coyotes in Cook County are overall quite healthy, but they are important hosts for heartworm, mange, and a variety of parasites and viruses/bacteria. Here, we provide a couple of examples of what we have found so far.

Frequencies of sero-positive rates for selected pathogens for coyotes in Cook County, 2000-2016.

Pathogen	2000-03	2009-10	2011-12	2013-16
Canine Distemper	67%	17%	40%	47%
Canine Parvovirus	99%	58%	98%	99%
Toxoplasmosis	63%	32%	85%	45%
Heartworm	16%	15%	48%	40%
Leptospirosis	27%	40%	38%	34%
Anaplasmosis			2%	5%
Ehrlichia			0%	0%
Lyme			10%	31%
No. Samples	78	41	53	138

Our monitoring has revealed that coyotes are an important host for heartworm, and may increase the risk to dogs in the city. Also, that Lyme disease may be increasing in Cook County.

Case Study - Mange

Mange is a debilitating disease associated with coyotes and their relatives, especially foxes. It is transmitted by a mite that infects an individual and burrows into their skin. Extreme infection often follows, to the detriment of the animal, and the animal typically loses most of their hair and becomes susceptible to other infections or often succumbs to exposure. In urban areas, coyotes likely serve as the host for this pathogen, that can also spread to pets and, rarely, people.

However, in areas where the disease is common, it has contributed to human-coyote conflicts. Our results have revealed that coyotes with extensive mange infections are not aggressive (we have yet to record a pet attack by a mange-infected coyote) but they become more active during the day and often seek food or cover near houses, thereby increasing observations by the public.

Month	Percentage of Mange-related Deaths
January	23.81%
February	4.76%
March	4.76%
April	0.00%
May	9.52%
June	0.00%
July	0.00%
August	0.00%
September	4.76%
October	4.76%
November	0.00%
December	47.62%
Total	100.00%

A radiocollared, mange-infected coyote during the middle of the day. This animal died a few days later as a result of the infection. Table presents the frequency of deaths due to mange across months. Most animals die from mange during the winter.

II. RESEARCH PROJECTS

We have many projects underway. Here, we highlight a couple as examples.

1) Trap-Neuter-Release Colonies (Cat and Raccoon Monitoring)

Because of their high population numbers, free-ranging domestic cats can be major factors in the ecology of suburban/urban landscapes and can present management or control issues. In addition to locally high densities, free-ranging cats may act as significant predators on wildlife and can be important in the dynamics of wildlife diseases through their interactions with local wildlife.

To better understand the effectiveness of trap-neuter-release colonies of feral cats, we conducted an intensive, long-term study of experimental colonies across Cook County. Fieldwork involved radiocollaring and monitoring cats at colony shelters, and also raccoons, skunks, and opossums that visited those shelters. Fieldwork was conducted from 2009 to 2015, and we are currently analyzing data for manuscripts.

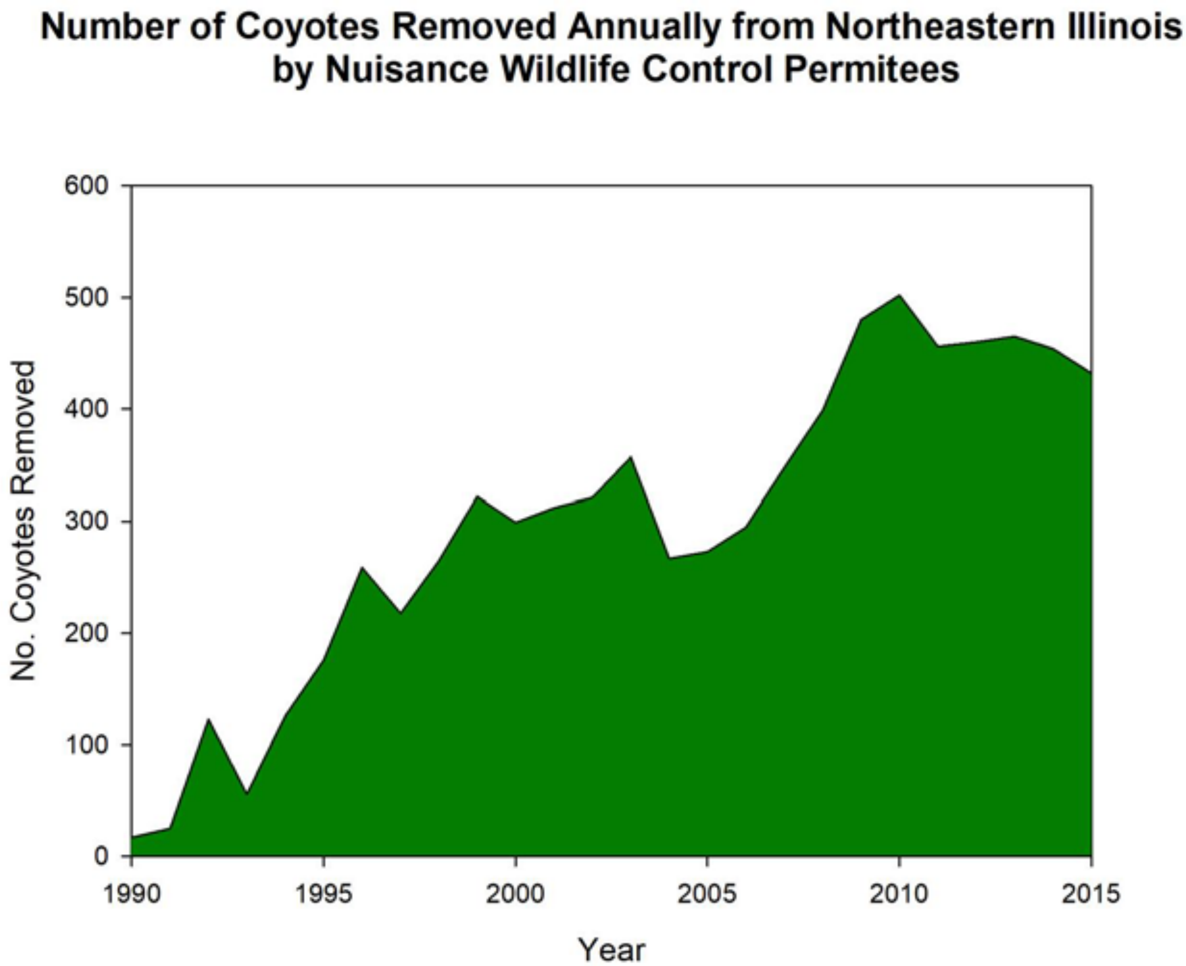
An infrared image from our cat colony monitoring project, with 4 cats and a raccoon feeding in close proximity to each other. We are used camera data to augment radiotelemetry data to measure the frequency of contact between species. The large barrel covers an automated feeding device. Over 1 million images were recorded during the data collection stage.

2) Coyote Research

Coyotes have greatly expanded their geographic range across North America, and have recently become top predators in many metropolitan areas. Their success in urban areas has important ecological implications, and is a potential threat to the health and well-being of people and their pets. Attacks on pets have occurred across the U.S., and attacks on people have become relatively more noticeable in the last 15 years. However, the actual risk posed by coyotes is poorly understood by the general public, and a lack of reliable information typically results in responses borne of emotion in homeowners and decision-makers. Understanding the ecology of coyotes in urban landscapes, and human responses to their presence, is crucial for developing effective responses on the threats coyotes pose to people and pets in metropolitan areas.

Coyote 571 moving through a park during the day with residents watching her.

The number of human-coyote conflicts in the Cook County area increased dramatically during the 1990's, and has remained at a constant level since then, as indicated by the number of coyotes removed as nuisances from the Chicago metropolitan area.



We have been monitoring the coyote population since 2000 to determine population characteristics that may help minimize conflicts and guide management programs, in addition to surveillance for zoonotic diseases. We livetrap coyotes to individually mark and radiocollar them so we can follow their movements and observe their behavior. To date (May, 2018), we have marked over 1,200 coyotes and radiocollared over 600 individuals.

Each spring we enter coyote dens to count and mark the litter. This information allows us to determine if the population is growing and healthy.

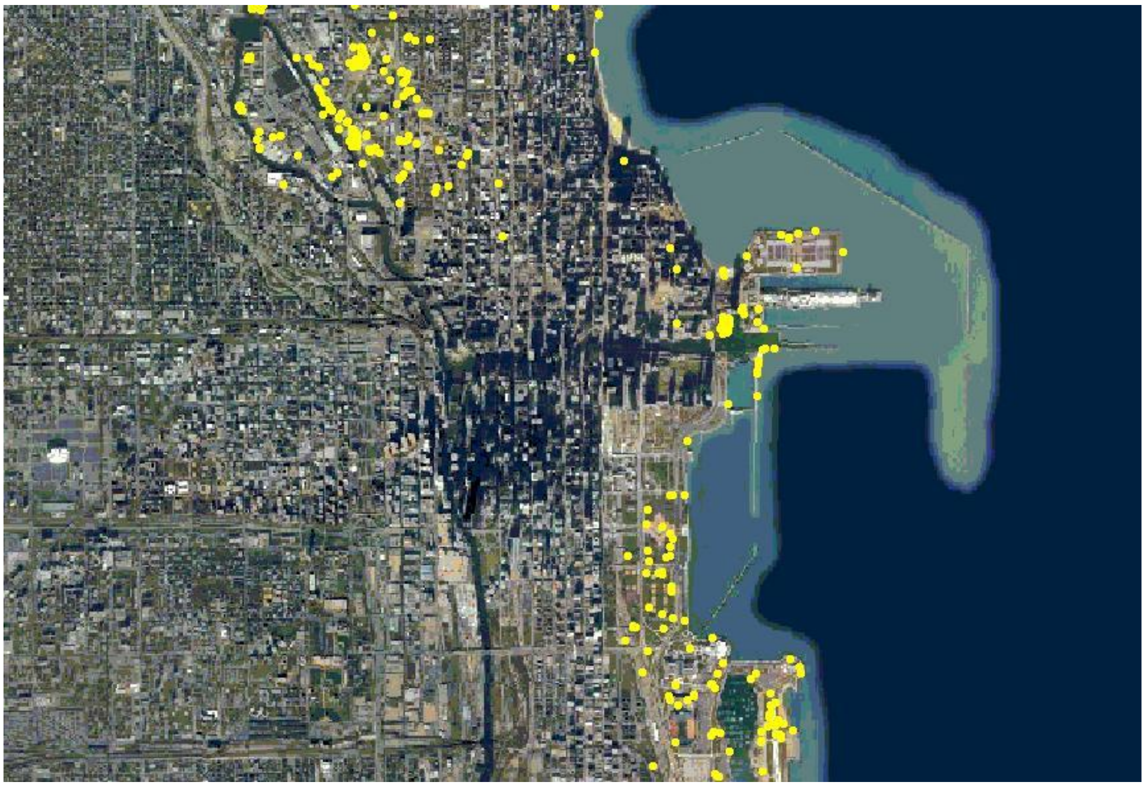
In 2017, we radiotracked over 80 individuals and marked over 60 pups from dens.

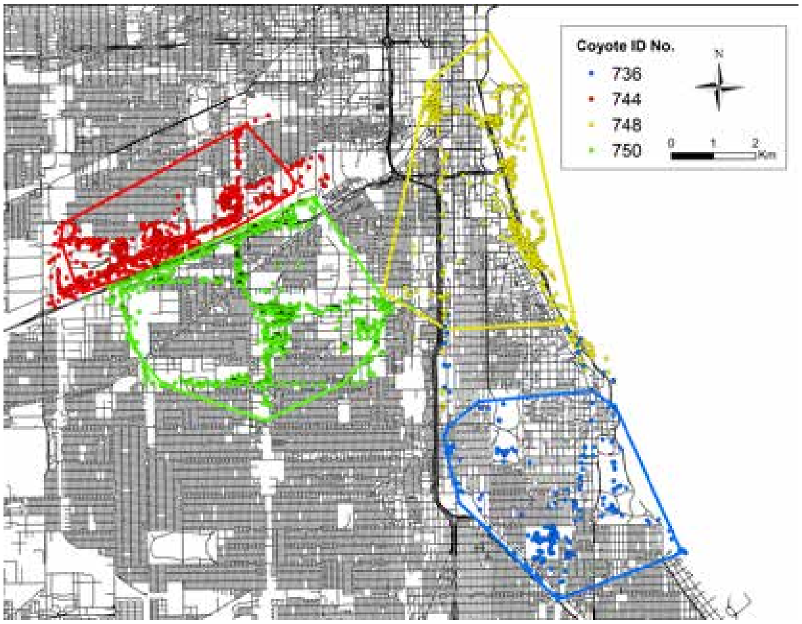
Movement Data

Using data from GPS collars, we have been able to document the ways in which people alter coyote behavior, often leading to conflicts. No other research programs have been able to follow coyotes from birth to their ultimate fate, and we have documented the few cases where coyotes have been fed by people which led to conflicts. Consequently this research has been used by various communities to establish or enforce no feeding ordinances.

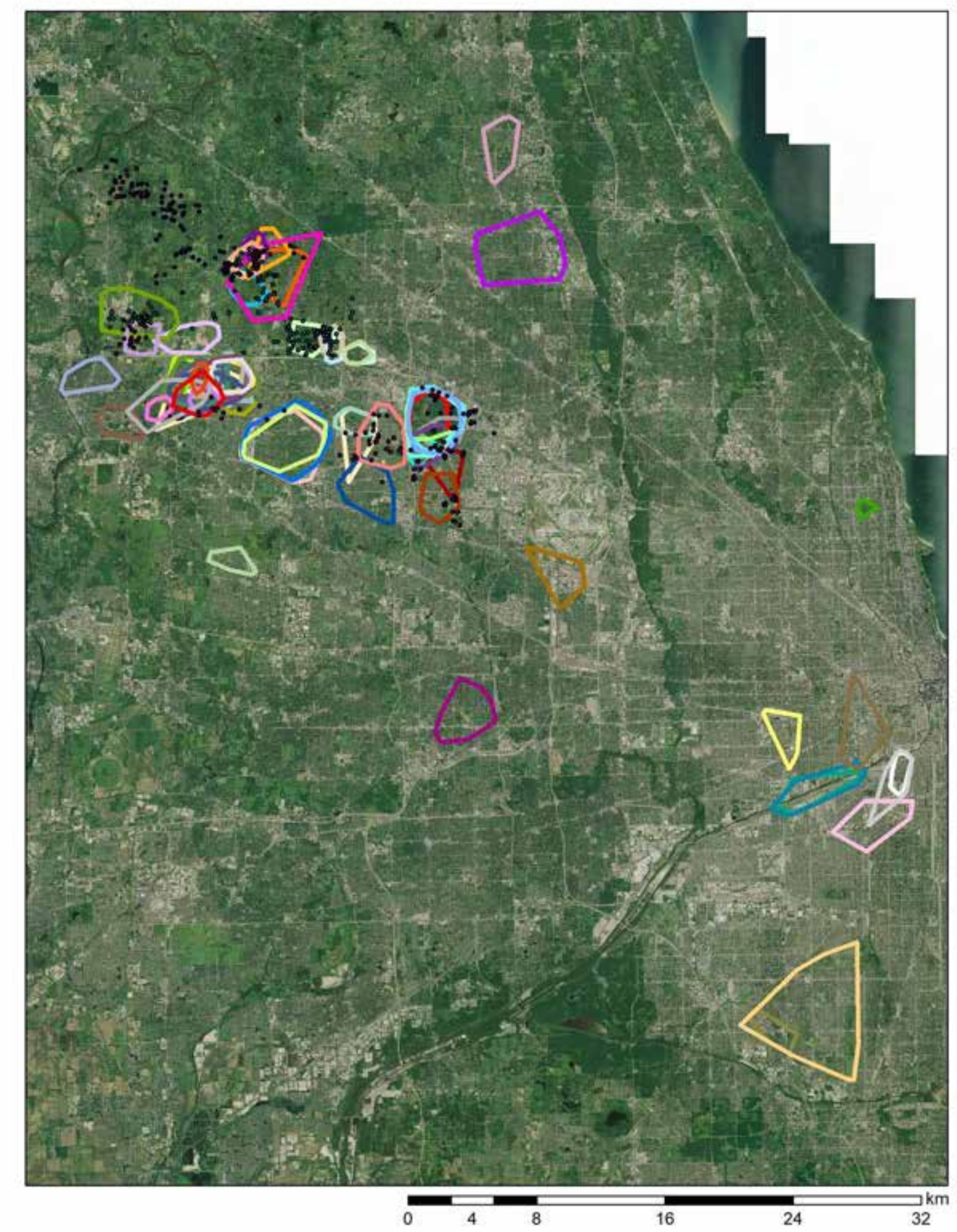
Another important aspect of the GPS technology is it allows us to monitor coyotes inhabiting the most urban parts of the landscape, which is important for us to determine if coyotes behave differently than our suburban study sites. To date, we have not seen an increase in aggressive behaviors exhibited by these coyotes toward people or their pets during the radiotracking, despite the proximity between the coyotes and people. However, the sample size is small, and we do not know if coyotes can continue to live downtown without eventually creating negative encounters with people. More research is needed in this area.

GPS locations for a radiocollared coyote using the downtown Chicago area during 2010.





Home ranges and locations of coyotes on the south side of Chicago, 2016-2017



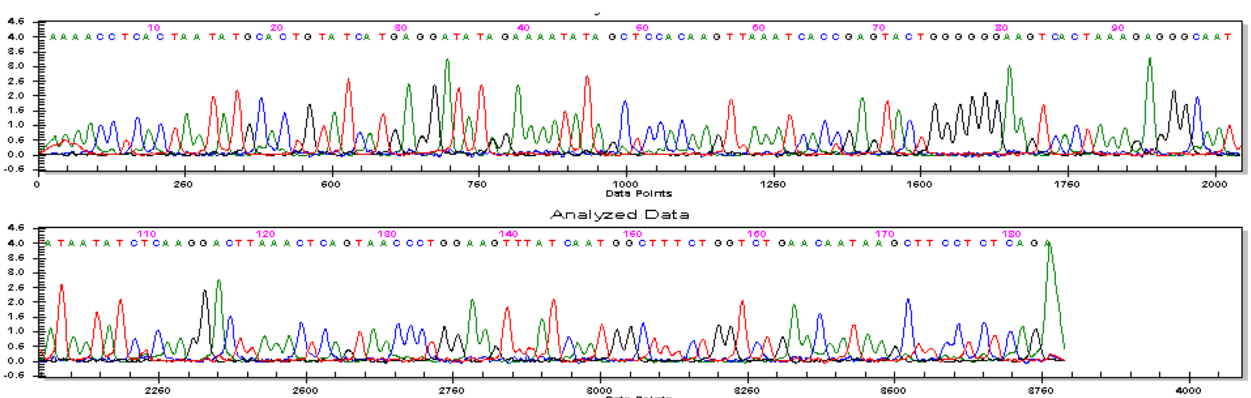
Coyote home ranges across Cook County during 2016-2018.

Coyote 115, at 12 years of age, we radiotracked for over a decade until he died of old age. He is an example of many coyotes that live near people for years without a conflict.

Behavior and Genetic Data

For the past three years, we have been investigating whether coyotes have genes that pre-dispose them to shy or bold behavior. In some cases, they may exhibit aggressive behavior. We have been recording coyote behavior to identify bold or aggressive behavior, and subsequently testing them genetically to identify possible genetic markers. This information will help us determine whether the Cook County coyote population is shifting in behavior, and if so, whether this shift is part of a genetic change or if it is purely a product of living near people. Results from this work may also explain why education/management responses are effective for some coyotes and not others.

Captured coyote in a cage and a fake hand to determine boldness.



Genetic sequencing of a coyote for a behavioral marker, where we are attempting to identify which markers predict coyote behavior.

OUTREACH

A major activity each year is our professional and public outreach. Professional outreach activities include publishing our results in peer-reviewed literature, and presenting our results at scientific meetings. Our public outreach consists of presentations to the general public, to school groups, and interactions with the media. A major effort in 2017 was the revision of our primary website, ***urbancoyoteresearch.com***.

COLLABORATORS

An important aspect of this program is the collaborations and partnerships that form the foundation of much of this work. Partnerships increase our pool of expertise while simultaneously maximizing the financial support, since our partners typically invest their time and resources to individual projects. In addition to our primary agencies (Cook County Animal and Rabies Control, the Forest Preserve District of Cook County, and the Max McGraw Wildlife Foundation), our partners include Loyola University (Dr. Jean Dubach), University of Minnesota (Dr. Meggan Craft), University of New Mexico (Dr. Seth Newsome), University of Calgary (Dr. Ale Massolo), and USDA/APHIS National Wildlife Research Center (Dr. Julie Young).

COOK COUNTY COYOTE PROJECT FACT SHEET

- The project was initiated in 2000 at the request of Cook County Animal and Rabies Control
- Primary support comes from three agencies: Cook County Animal and Rabies Control, Forest Preserves of Cook County and the Max McGraw Wildlife Foundation
- The program monitors the coyote population for abundance, behavior and especially disease surveillance The primary goal of the project is to minimize risk of coyotes to humans and pets. The underlying philosophy is that management is most efficient and effective when there is a clear understanding of the species

Other facts about the project:

- Coyotes are live-captured and marked collecting blood, fecal and tissue samples
- Coyotes are NOT relocated, transported, removed, or introduced to new areas in Cook County
- The project is NOT designed to protect or advocate for coyotes, it is unbiased

Relevant results (coyote population):

- Thousands of coyotes live throughout Cook County
- Most coyotes avoid people and the areas used by people
- Diets of coyotes vary among individuals and seasons, but most avoid human food
- There has been little overall change in coyote behavior over time
- In general, coyotes are healthy, but a few diseases are important to monitor
- Coyotes in Cook County perform ecological functions, consuming rodents, geese and feral cats

Relevant results (management):

- Food determines coyote presence and is at the root of most, but not all, conflicts
- Translocation of nuisance animals in most cases is not effective or humane
- Hazing is a potentially important technique but more research is needed for evaluation
- All removal is temporary; therefore, attempts to reduce population levels through removal are impractical
- For coyotes that pose a risk, specific, targeted removal of the offending animal can be effective, especially if augmented with education efforts

CURRENT OBJECTIVES

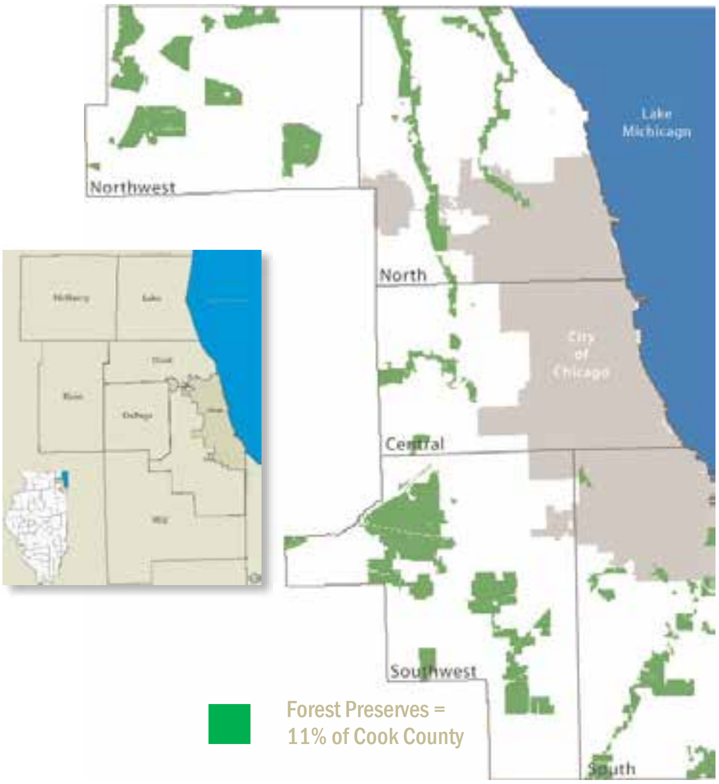
1. Disease monitoring – we continue to collect blood and fecal samples to determine exposure to certain pathogens/parasites, and also collect carcasses for necropsies. Coyotes are an excellent sentinel species, and are hosts to a variety of parasites that can be transmitted to pets or people
2. Population dynamics – to determine if the population is increasing, we estimate reproductive and survival rates
3. Monitor behavior for conflicts, and opportunities to evaluate management responses – we record the behavior of individual coyotes to determine if their behavior toward people and pets is shifting over time
4. Assess the genetic basis for aggressive behavior – We are following the recent research on domestic dogs that links genetic markers to bold/aggressive behavior, to determine if some conflicts are the result of genetic trends
5. Evaluate the possible influence coyotes may have on other species: we have periodically evaluated the influence of coyotes on other species, and we are currently focused on white-tailed deer as this may affect current management strategies for both species
6. Determine the genetic influence on susceptibility to disease, or the ability to host certain diseases with minimum effect on individual survival
7. Investigate the potential transmission of certain pathogens between coyotes, raccoons, and domestic dogs
8. Engage in outreach to the public – an important component of this project is to convey our work and results to agencies and the general public. To that end, we regularly provide public presentations and interviews with the media. When appropriate, we publish our results in peer-reviewed papers as well as lay documents. Lastly, we regularly update and contribute to a website that receives approximately 40,000 visitors annually.

For more information: urbancoyoteresearch.com

The Forest Preserve District of Cook County

Environmental Task Force Annual Report

Environmental Task Force Annual Report



The Forest Preserve District of Cook County's (FPDCC) role in the Cook County Animal and Rabies Control Environmental Task Force (ETF) is multifold. One role is by providing researchers access to approximately 70,000 acres (*i.e. 11%* of Cook County) of open land area for scientific study. Since the District is adjacent to and integrated within a major metropolitan area — the city of Chicago — its importance as a research tool is unprecedented, in that humans and animals are commonly in contact. Indeed, the confluence of open land, humans, and animals creates a situation in which is unique among major metropolitan areas and available open space.

Scientific Study

Students: Coyote Workup

Partner Universities:

Purdue University

The Ohio State University

University of Illinois at Urbana

University of Wisconsin Stevens Point

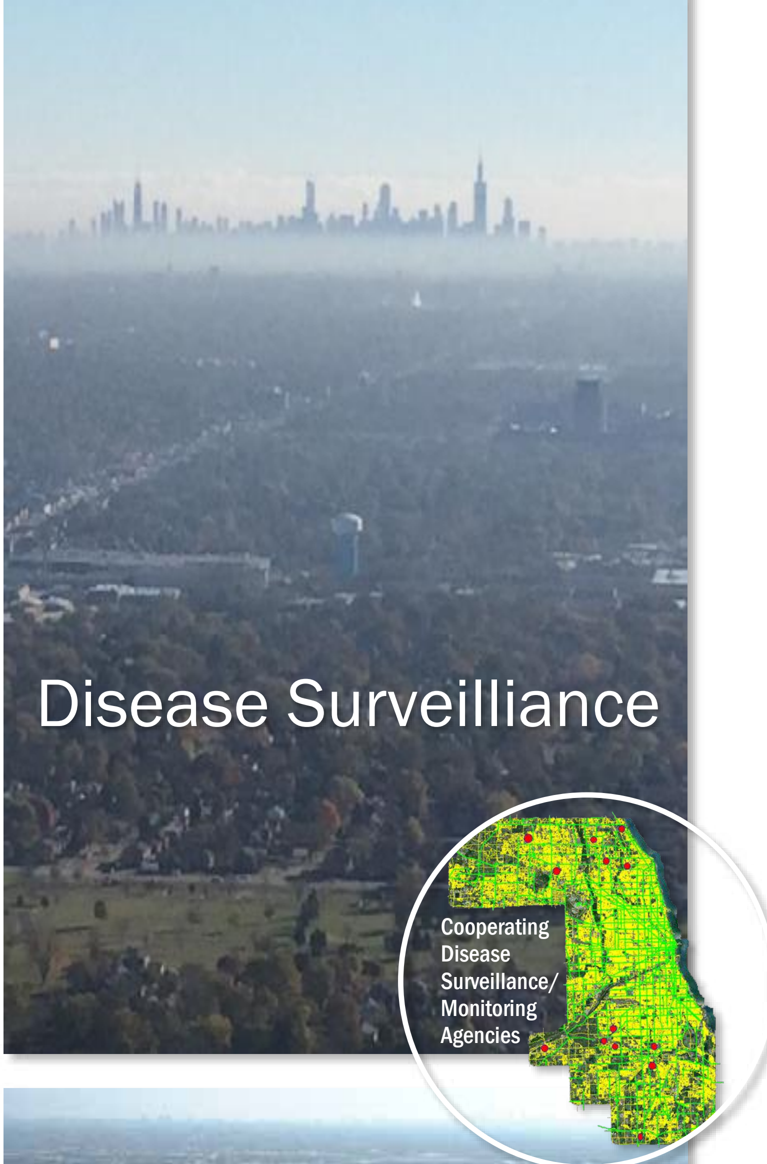
Jusdon

North Park University

Urban Coyote: tooth decay due to human food diet

vhf data Telemetry

Disease Surveilliance



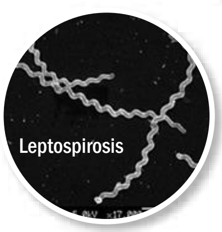
A second role of the FPDCC, as it relates to the ETF, is disease surveillance. For example, the burgeoning human population is commonly in contact with wild animals, such as raccoons, many of which may be carrying a disease transmissible to people (zoonosis). In addition, the tremendous density of humans, wildlife, and people's companion animals produces an optimal situation promoting disease transmission. Because the density of nuisance wildlife (*e.g.* skunk, raccoon, and coyote), as one moves from suburban to urban portions of the county, dramatically increases, so also does the probability of disease transmission.

Blood & Tissue Sample Repository

Raccoons in or near residence: disease transmission potential

Animal Control Officer

Raccoon to pet transmission



Leptospirosis

Baylisascaris procyonis

Conflict

Zoonotic diseases represent greater than **70% of emerging infectious diseases**, according to the World Health Organization. The ETF — comprised of the **Cook County Rabies and Animal Control, FPDCC, Brookfield Zoo, University of Illinois Zoopathology program, and Max McGraw Wildlife Foundation** — shares the task of studying and monitoring zoonotic diseases and wildlife conflict.

Dedicated Wildlife Biologists

On-going wildlife studies, tracking and data collection provide important environmental bio-monitor metrics

Rookery

Carp

Survey Data Collection Painted Turtle

Urban Coyote Project

University Students receive hands on experience

Deer Program

Great Egret

Wildlife

The Wildlife Division of the Resource Management Department of the FPDCC is involved with the following tasks:

- The resolution of human-animal conflicts.
- The obtainment of wildlife blood and tissue samples.
- The study of wildlife via radio telemetry.
- The mentorship/instruction of university students.
- The long-term (*i.e.* decades), baseline surveillance of animal and plant populations.

POSTERS

INFECTIOUS DISEASES IN URBAN COYOTES – DOES LAND USE INFLUENCE PATHOGEN EXPOSURE?

Katherine Worsley-Tonks[1], Stanley Gehrt[2], Meggan Craft[1]
[1]College of Veterinary Medicine, University of Minnesota
[2]School of Environment and Natural Resources, Ohio State University

INTRODUCTION

Although urbanization causes habitat loss and fragmentation, some wildlife populations are able to thrive in urban landscapes. Differences in social interactions and habitat use from living in such heterogeneous environments means that animals might differ in their exposure to various infectious diseases.
We tested this hypothesis in coyotes (*Canis latrans*) in Chicago from 2000-2012. Specifically, we asked whether coyotes utilizing different habitat types varied in their exposure to canine distemper virus (CDV), Leptospira sp., *Toxoplasma gondii*, and canine heartworm, while accounting for differences in host traits (e.g. animal age).

RESEARCH QUESTION

What host and environmental factors influence pathogen exposure in urban coyotes?

Pathogens of interest included:

1) Canine distemper virus (CDV)
2) *Leptospira*
3) *Toxoplasma gondii*
4) Canine heartworm

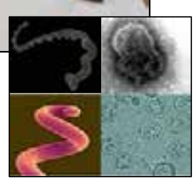
METHODS

109 coyotes were captured and radio-collared in the northwestern portion of the Chicago metropolitan area from 2000-2012.

Coyote exposure to CDV, *Leptospira,T. gondii*, and canine heartworm was determined by serological analysis.

Annual home ranges were calculated for each coyote and used to evaluate individual habitat selection.

We estimated annual home ranges using 95 % minimum convex polygons.

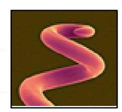


Logistic regression analyses were used to determine factors that predict disease exposure.

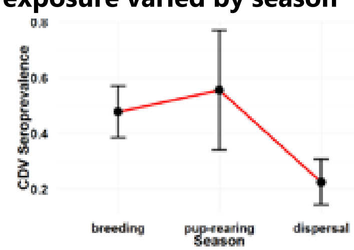
PRELIMINARY RESULTS

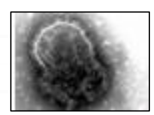
Response variable	Predictor variable	Group	Estimate	OR (95% CI)	Chi-square P-value
Leptospira 	Age	-	-	-	0.09
	Sex	-	-	-	0.63
	Season	-	-	-	0.21
	Home range in residential areas	-	2.48	11.9 (1.4-122.7)	0.02*
	Home range in developed urban areas	-	-	-	0.48
Heartworm 	Age	Pup	-	1.0 (-)	0.04*
		Juvenile	-2.68	0.07 (0.0-0.7)	-
		Yearling	0.06	1.06 (0.2-5.4)	-
		Adult	-0.25	0.8 (0.2-4.0)	-
	Sex	-	-	-	0.4
	Season	-	-	-	0.05
	Home range in residential areas	-	-	-	0.8
	Home range in open developed areas		-		0.2
CDV 	Age	-	-	-	0.7
	Sex	-	-	-	0.5
	Season	Breeding	-	1.0 (-)	0.04*
		Pup-rearing	-0.04	1.0 (0.2-5.6)	-
		Dispersal	-1.4	0.2 (0.07-0.8)	-
	Home range in residential areas	-	-	-	0.6
	Home range in open developed areas	-	-	-	0.2
T. Gondii 	Age	-	-	-	0.7
	Sex	-	-	-	0.5
	Season	-	-	-	0.4
	Home range in residential areas	-	-	-	0.1
	Home range in open developed areas	-	-	-	0.9

Canine heartworm infection varied with coyote age



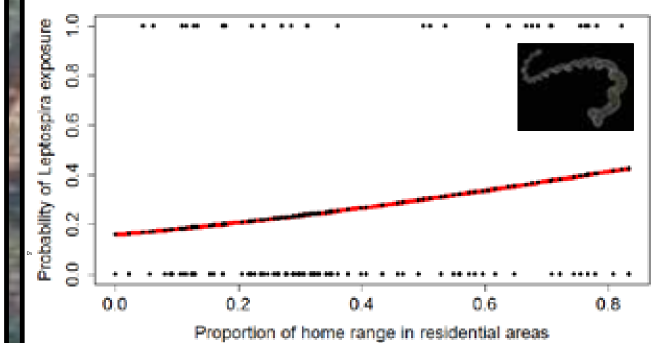
CDV exposure varied by season





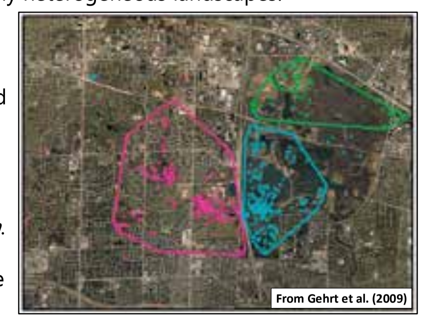
PRELIMINARY RESULTS

Leptospira exposure varied by habitat type



CONCLUSIONS

Understanding whether animals residing in different urban areas differ in their exposure to various pathogens is a critical step towards revealing how wildlife infectious diseases might circulate in these highly heterogeneous landscapes.



Our preliminary work suggests that the different habitats used by coyotes in urban environments may influence exposure to certain pathogens, specifically *Leptospira*. For other infectious agents, such as canine heartworm and CDV, individual life-history characteristics remain the most important predictors of exposure.

ACKNOWLEDGEMENTS

Funding was provided by Dr. Donna Alexander from the Cook County Animal and Rabies Control, as well as the Max McGraw Wildlife Foundation, and the Forest Preserve District of Cook County. We extend many thanks to technicians and graduate students in the Gehrt lab for field and technical assistances. Finally, many thanks to the Craft lab for all the help and support

UNIVERSITY OF MINNESOTA

Antimicrobial Resistance in Urban Mesocarnivores

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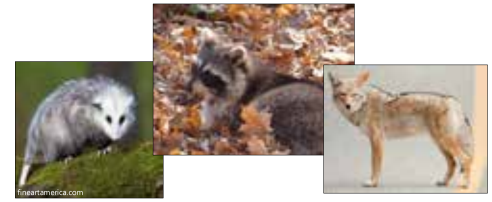


Introduction

Wildlife exposure to antimicrobial resistant (AMR) bacteria has been extensively reported, especially in human dominated landscapes. However, it is unclear whether exposure is solely driven by environmental context or whether wildlife species characteristics are also important. Disentangling these relationships is crucial for understanding how AMR bacteria are disseminated in the environment, and what the consequences might be for public and animal health.

Objective

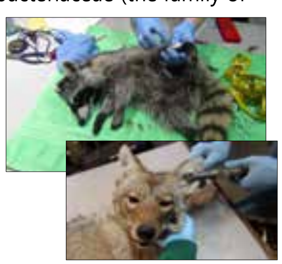
Investigate whether wildlife exposure to cefotaxime-resistant bacteria, from the family Enterobacteriaceae, is a function of spatial overlap with people and domestic dogs, or whether differences can also be explained by the type of host species sampled.

Methods

- In January-March 2017, 31 raccoons, 23 opossums, and 23 coyotes were captured in the north-western portion of the Chicago metropolitan area.

Figure 1: Sampling sites in suburban Chicago (modified from Newsome et al. (2015). Three sites were not accessible to people and domestic dogs (Crabtree, Max McGraw, and Highland Woods, highlighted as red rectangles), and two sites were accessible to people and domestic dogs (Poplar Creek and Busse Woods, highlighted as yellow rectangles). Note: Black polygons are examples of coyote home ranges (from the study conducted by Newsome et al. (2015)), and are not of relevance here.

- Rectal swab and fecal samples were collected and plated onto MacConkey agar containing 2µg/mL of cefotaxime to test for the presence of third-generation cephalosporin-resistant Enterobacteriaceae (the family of bacteria that includes *E. coli*).
- Cefotaxime-resistant bacteria were subsequently identified at the species level using mass spectrometry approaches.
- Logistic regression was used to identify predictors of shedding cefotaxime-resistant bacteria.



Preliminary results

1. Females are more likely to shed at least one cefotaxime-resistant isolate, regardless of the wildlife species sampled.

Table 1: Predictors of shedding cefotaxime-resistant bacteria

Predictor	N (apparent prevalence)	OR (95% CI)	p-value
Species			
Coyote	23 (21.7)		
Raccoon	31 (25.8)	0.68 (0.3-1.47)	0.33
Opossum	23 (13.04)		
Site visited by dogs			
Yes	37 (16.2)		
No	40 (25)	0.65 (0.18-2.27)	0.5
Age			
Pup	8 (12.5)		
Juvenile	19 (15.8)	2.62 (0.95-9.37)	0.06
Adult	50 (24)		
Sex			
Female	29 (37.9)		
Male	48 (10.4)	7.74 (2.18-32.47)	0.001**

2. Multiple bacterial species display phenotypic resistance to cefotaxime.

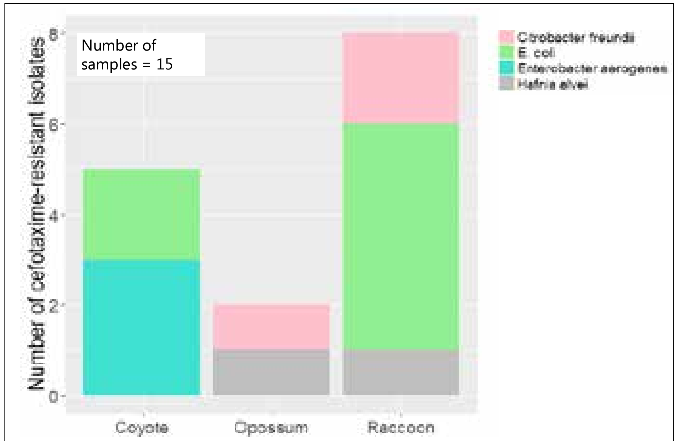


Figure 2: Number of cefotaxime-resistant isolates identified as *Citrobacter freundii*, *E. coli*, *Enterobacter aerogenes*, or *Hafnia alvei* in coyote, opossum, and raccoon samples.

Conclusions so far…

- Sex is an important predictor of wildlife shedding third-generation cephalosporin-resistant bacteria.
- The lack of difference detected between areas visited, and areas not visited by dogs may, in part, be due to the fact that wild animal populations in these suburban areas are well mixed, and differences are more likely to be observed across a larger scale (e.g. urban vs. suburban sites).
- The range of bacterial species displaying resistance to cefotaxime suggests that multiple cefotaxime-resistant bacterial species are disseminated in the environment, and that resistance genes may be transferred between bacterial species in wildlife.

Next steps

For the pilot study:

- Investigate the presence of resistance genes in cefotaxime-resistant isolates, and whether the types of resistance genes present differs for different bacterial species.

Figure 3: Schematic diagram illustrating a hypothetical scenario in which dogs share more similar resistant bacteria with coyotes than with raccoons

For the larger study:

- Collect fecal samples from the local domestic dog population, and investigate the prevalence and phylogenetic relatedness of resistant bacteria with those detected in wildlife.
- Investigate how patterns vary across the urban-rural gradient.

Figure 4: Sampling sites for the larger study (4 suburban and 3 urban sites)

Acknowledgements

Funding was provided by the University of Minnesota, specifically the Office of the Vice President for Research, Academic Health Center Seed Grant, and the Cooperative State Research Service, USDA (MIN-62-098). Funds were also provided by Dr. Donna Alexander from the Cook County Animal and Rabies Control, as well as the Max McGraw Wildlife Foundation, and the Forest Preserve District of Cook County. We extend many thanks to technicians and graduate students in the Gehrt lab for field and technical assistances. Finally, many thanks to the Craft and Johnson lab groups for all the help and support.

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Potential genetic markers for bold or aggressive behaviors in the coyote

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Introduction

The coyote (*Canis latrans*) is a generalist species that continues to expand its range and exploit varying environments. Different environments cause unique stressors and conditions, which may lead to population changes in behavior. Individuals also have unique behaviors and preferences. While some aggressive actions are linked to feeding, other causes are still unknown. Both individuals and populations exhibit behavioral variation. Behavior and genetic analyses can be used to determine how coyotes are adapting to various landscapes. Potential connections between boldness, habituation, and aggression can be detected.

Multiple single nucleotide polymorphisms (SNPs) and microsatellites for boldness and aggressiveness have been found in dogs. In this study, some of these markers will be tested to determine if environments and genes are selecting for certain behaviors.

Figure 1: Coyote in day in neighborhood

Predictions

We predicted that coyotes:
- Are polymorphic at tested SNPs
- Will exhibit behavioral differences
- Genetic variability will causes differences in behavior

Data Collection

- Captured __ coyotes Cook County, Illinois since September 2014
- Trapping mainly during the months of September-March
- Behavior monitored using standardized form during several stages of capture and handling
- Record biometrics and collect blood samples
- Fit VHF or GPS collars
- Released at site of capture

Genetic Methods

DNA was extracted from collected blood samples. All coyotes were then genotyped at each behavioral marker. Sequencing was done through a Beckman Coulter CEQ ……... Genes containing SNPs that were sequenced or are to be sequenced include **PCDH1**, **DRD1, SLC6A1, HTR1D, DRD4,** and **Androgen Receptor (AR)** along with regions on chromosomes **1 and 17**.

Behavioral Methods

Stages behavior was recorded:

In the field:
- while in the trap but with people at a distance
- As a person enters the fight circle
- After a coyote is noosed

At processing facility:
- in a cage after 15 minutes of quiet
- during extended arm test
    - fake hand dropped slowly into the cage
    - motionless for 15 seconds
    - Slowly moved back and forth for another 15 seconds

Figure 2 a and b: Extended arm tests

Behavioral categories recorded:
- Eye contact
- Movement and body language
- Ear, tail, and body position
- Vocalization
- Mouth and teeth display

All coyotes are also given 2 classifications by each observer: shy/bold with aggression level (1-7) and curiosity level (1-5)

1	**2**	**3**	**4**	**5**	**6**	**7**
Terrified	**scared**	**defensive aggression**	**neutral**	**bold**	**aggression/ bold mix**	**pure aggression**

Current Progress and Results

Four markers (A,B,C, and D) have been analyzed in all sampled coyotes. Preliminary analysis suggests that ______ markers are not correlated with basic behavior classifications. However analysis on marker B suggests a correlation with behavior with scared aggressive individuals exhibiting a genotype of TT or TC.

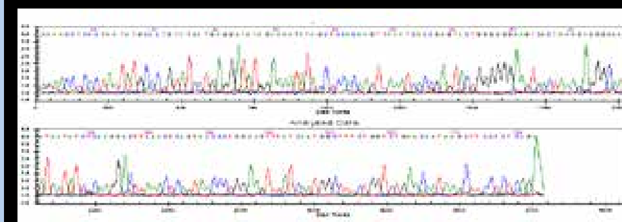

Figure 3: Sequencing for behavioral marker C
OR table of marker results…

Further Research and Discussion

Several SNPs on the DRD1, SLC6A1, and HTR1D are currently being genotyped to include in the candidate set of bold and aggression markers. Once all markers have been sequenced, we can determine which, if any, makers are correlated with bold/shy or aggressive/not aggressive behaviors. This research will determine if gene or SNP sequences that are correlated with behavior in dogs are present in coyotes. As animals captured in this study are followed until death or collar failure, we also have information on habitat use that will be used to determine if urbanization or habitat type influences behavior or behavioral genotype. Results of this study will provide insight into whether bold or aggressive behaviors may have a genetic or environmental basis.

This study will determine if specific genetic markers correlate with coyote behavior, while also providing insight into anthropogenic influences on both behavior and genetics. Findings could highlight reasons why different populations exhibit varying degrees of boldness and aggression. Finally, once behavior has been identified and genetics have been quantified, further studies can examine their influences on life history strategies such as dispersal, mate choice, reproduction, or survival.

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Terrestrial Wildlife Ecology Laboratory

The following reports are awaiting publication and will be distributed when finalized:

- Seasonal Condition and Space Use of Urban Raccoons,

- Katie E. Robertson, Christopher M. Tonra, Stanley D. Gehrt, School of Environment and Natural Resources, The Ohio State University
- Shane C. McKenzie, Max McGraw Wildlife Foundation

- Urban Land Use Influences Heartworm Infection in Coyotes

- Worsley-Tonks, K., Anchor, C., Gehrt, S., Craft, M.

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