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Portland Urban Coyote Project: A Review of Citizen Science's Utility for Researching Urban Canids and the Human Environment

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Portland Urban Coyote Project: A Review of Citizen Science's Utility for Researching Urban Canids and the Human Environment

by

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Abstract

The Portland Urban Coyote Project (PUCP) is a citizen science project that allows community members to upload coyote *(Canis latrans)* sighting data to a database that is used to create a public web map; contributors often add observations as well. I analyzed one year of PUCP comment data in order to assess the utility of the citizen science methods used by PUCP for urban carnivore research. I code and summarize findings from PUCP's data, compare the extracted data to other research studies of urban coyote from other regions, and find that results from this analysis supports conclusions made by other recent studies. PUCP has gathered useful data that contributes to a greater body of work. Observations given by respondents provide information both about coyotes and about the people who observe them, creating a rich resource for further study in Portland as well as the many other communities with resident coyotes.

Acknowledgements:

This project is the result of many hours of work by various participants and managers of the Portland Urban Coyote Project. I am especially grateful to Dr. Barbara Brower, and Zuriel Van Belle (Rasmussen) for both introducing me, and allowing me access to this dataset. Their support during difficulties beyond the scope of this project has additionally been invaluable. I thank Jenny Grant and Zuriel for their roles in creating and expanding the Portland Urban Coyote Project, respectively. I would like to thank my advisors, committee, and former committee members Barbara Brower, Martin Lafrenz, David Banis and Alida Cantor for their flexibility and support.

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Chapter 1: Introduction and Review of the Literature

The Portland Urban Coyote Project (PUCP) is a citizen science-based collaboration between geographers at Portland State University and the Portland Audubon Society, run by graduate students and overseen by professor Barbara Brower. The project gathers both location information and qualitative data on users' experiences with coyotes in Portland. At present (July 2020), PUCP has collected more than 10,000 sightings. A significant number of respondents provide detailed information about the character of their encounters with coyotes. Although preliminary findings have been presented and published (Rasmussen 2015), there has been no comprehensive, digestible interpretation of the PUCP findings, nor an exploration of their relevance to the larger question of urban wildlife research. While PUCP has been sustained by several generations of graduate students, there are plenty of questions that have emerged since PUCP has reached its present format. For this project, I describe and analyze PUCP's data in order to understand both how citizens use citizen science resources, and how researchers can use this information. I also compare the efficacy of PUCP's data for extracting findings to several related coyote studies, in order to further assess the utility of PUCP and citizen science in general for the study of urban carnivores.

While this project is centered around human interactions with coyotes, it aims to be broadly applicable. This work can contribute to a greater body of work that aims to

understand the relationship between humans and wild carnivores at a global scale. Human-wildlife interactions are changing. Habitat loss and fragmentation from expanding human development suggest that humans and surviving animals will be in ever-increasing proximity (Groom, Meffe, and Carroll 2006). This will result in more contact, and in some cases, conflict. Citizen science is a useful method of assessing where and why conflict between humans and wildlife occurs (Larson et al. 2016), and in mediating and reducing conflict. Below, I review what is known about urban coyotes, conflicts between humans and coyotes, and citizen science.

Urban Coyotes

Historically, humans have usually responded to perceived dangers to humans and domestic animal losses caused by large predators with intense and direct persecution. From the beginning of European colonization of North America, colonists killed predators they perceived to be threatening. The US Animal Damage Control Act of 1931 promoted the removal of gray wolves (*Canis lupus)* and other predators perceived to be harmful to ranching, and gray wolves were essentially extirpated from the lower 48 states. As one consequence of the removal of wolves from the scene, coyotes emerged as the primary predator of vast swaths of rural and urban land almost free from competing carnivores (*Figure 1)* (Hody and Kays 2018). Coyotes now thrive within major North

American cities, and meet with varying human responses when they occur in human-dominated urban landscapes (Flores 2016).

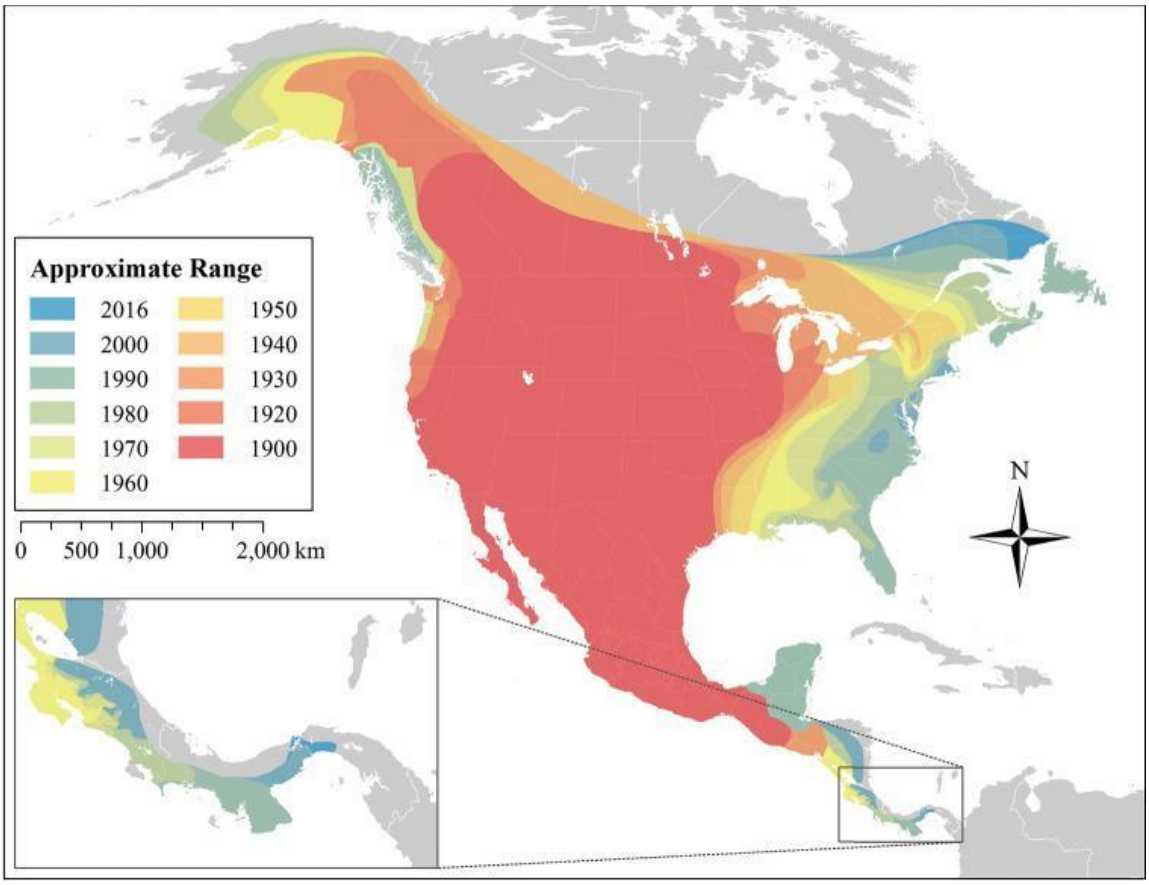


Figure 1: Approximate distribution of coyotes between 1900 and 2016 (Hody and Kays 2018)

The coyote is a medium sized carnivore of 20 to 50 pounds. Urban coyotes frequently prey upon small mammals, including rabbits and rats, and also exploit human refuse, and fruit or vegetable matter (Poessel, Mock, and Breck 2017). Urban coyotes adapt both physically and behaviorally to urban conditions. They may alter their peak

hours of activity, possibly to avoid conflict with humans (Grinder and Krausman 2001). They also traverse smaller average ranges than their rural cousins, and they must make use of natural spaces, strategically denning near likely sources of food and away from dangers (Šálek, Drahníková, and Tkadlec 2015). Despite attempts by both coyotes and humans to avoid one another, conflicts may still occur, and these often result in sensationalized media coverage, which exacerbate human anxieties surrounding predators.

Coyotes share urban environments with a handful of other urban-adapted carnivores. In 2012, Bill Bateman and Trish Flemming published a review comparing the behavioral flexibility of a range of these carnivores, including coyotes, foxes, badgers, raccoons and stone martens, analyzing the morphology, diet, reproductive rates, conflicts, and mortality of each species. According to Bateman and Flemming, coyotes are competitive with, or superior to neighboring species in several key ways. Coyotes are socially flexible, comfortably acting both alone and in groups. Urban coyotes also tolerate higher densities of other coyotes when compared with their rural counterparts. When occupying the same territory as other species such as urban red foxes, coyotes tend to displace these species. While coyotes are not alone in using urban habitat to their advantage, they may significantly increase their survival by doing so. Human hunting of coyotes is a largely rural phenomenon, and it is rarely a threat to coyotes in urban

environments. Finally, coyotes consume a wide variety of food types that are readily available in the urban environment (Bateman and Flemming, 2012).

While some researchers have questioned the extent to which coyotes are suited to urban life, the fact that coyotes have adapted is beyond dispute (Gehrt, Brown, and Anchor 2011). It is, however, less certain how urban coyotes fare in reproduction, survival, and lifestyle when compared with rural coyotes. Certain other species seem almost to have become an extension of human development within cities. Pigeons and raccoons, for example, are sometimes fearless in our shared spaces. From this, we might rightly conclude that these species must benefit from humans and human development to such an extent that the probability of species reproducing successfully is greater than it would be in a "natural" context (Blechman 2007). This conclusion, however, can lead to the misplaced belief that coyotes actively seek association with humans. In 2002, researchers Tigas et al. used trail cameras to assess the presence or absence of coyotes and other species across varying scales of human disturbance. The researchers found a strong negative correlation between the presence of humans, and the presence of most mammal species. The "mere presence" of humans evidently carried profound effects on wildlife, even if the cause was avoidance rather than a reaction to real persecution (Tigas, Van Vuren, and Sauvajot 2002).

In 2011, Stanley Gehrt and his team attempted to classify the urban coyotes of Chicago either with other "synanthropic" species that benefit from human contact or as a

"misanthropic" species that suffers from human intrusion into natural spaces. By analyzing scat contents and radio collar location data, Gehrt et al. concluded that, rather than fitting neatly into one category or the other, urban coyotes exhibit a dichotomous tendency to both avoid close physical contact with humans, and use human dominated landscapes to increase their chances of survival (Gehrt, Brown, and Anchor 2011). While Gehrt's study and others occurred fairly recently, it is likely that increasing human development will continue to increase contact between humans and urban carnivores in the near future. Because there is a shortage of data that can facilitate comparison between rural and urban carnivores, further research in the realm of urban carnivores is vital for our understanding of future human-wildlife relations (Bateman and Fleming 2012).

Urban residents are often concerned that urban coyotes may supplement their diet with pets and small animals. While coyotes have been observed behaving aggressively toward domestic cats and dogs, the source of these conflicts is not well understood. In 2013, researchers Poessel et al. observed that around 76 percent of incidents the researchers analyzed involving pets were attacks on dogs and 22 percent were attacks on cats (Poessel et al. 2013). In a later publication, Poessel et al. analyzed scat contents of urban coyotes and found that, relative to the total number of incidents where coyotes had killed cats or dogs, coyotes rarely consumed the victim animal. Poessel et al. concluded that this was because coyotes perceive pets as competitor animals infringing upon clearly delineated coyote territories, rather than prey species. Coyotes did occasionally consume

pets, which constituted only 2 percent of their diet in this study (Poessel, Mock, and Breck 2017).

Conflict

"Conflicts" between humans and coyotes that occur in cities are rarely unprovoked bites or attacks against humans. The vast majority of physical conflicts that are reported to municipal agencies are attacks against cats and small dogs (Poessel et al. 2013). Although these types of attacks do not threaten human safety, they may evoke significant psychological distress. In many localities, citizens lack basic awareness of risks (or lack thereof) to children and elderly people, eliciting fear and worry. In some studies on conflict with coyotes, many incidents reported by citizens are actually relatively uneventful sightings (Lukasik and Alexander 2011). The degree of distress caused by an interaction between coyotes and urban residents is highly subjective. Some humans may tolerate predation on chickens and other food source animals as an acceptable loss to the local urban ecology. Others may feel that the mere presence of coyotes in an urban environment is unacceptable, warranting their removal.

While academics and carnivore enthusiasts sometimes dismiss the significance of negative coyote encounters, given their low frequency and minimal risk of producing physical harm, some recorded encounters have been serious enough to warrant closer attention. In an early discussion on modern coyote management efforts, researchers Rex

Baker and Robert Timm discussed 53 reported coyote attacks on humans, including 21 bites that occurred in Southern California prior to 1998 (Baker and Timm 1998). While none of the incidents described involved life-threatening injuries or an animal with rabies, some attacks on young children required serious medical attention. Citing several instances in which supplemental food sources appeared to embolden coyotes, the authors urged urban residents and wildlife officials to engage in responsible behavior like removing food sources for both coyotes and coyote prey species (Baker and Timm 1998). This caution continues to be the fundamental message from experts and urban wildlife managers.

Current research clearly shows that habituation, or a decreased aversion response, occurs in individual coyotes that lose a healthy fear of humans (Bateman and Flemming 2012). Traditionally, officials have dealt with habituated animals by simply removing the "problem" animal via shooting or trapping and euthanasia (Baker and Timm 1998). In a supplementary subsection of Is the Urban Coyote a Misanthropic Synanthrope? described above, Gehrt et al described an instance in which a habituated coyote that Gehrt et al. collared was incidentally removed when killed by a vehicle collision. Coincidentally, a public education effort was underway at the same time, urging Chicago residents to avoid accidentally feeding coyotes. Subsequent incidents in the area involving coyote attacks on pets ceased for at least 7 years. Extrapolating, Gehrt et al. concluded that removing habituated animals and educating the public to avoid feeding or otherwise attracting

coyotes was more effective in reducing conflict than attempting to eliminate entire groups of coyotes (Gehrt, Brown, and Anchor 2011, 16-17).

Despite an abundance of evidence for hazing[1] habituated animals, there has been relatively little research on the effectiveness of hazing performed by urban residents. In 2017, Marry Ann Bonnell and Stewart Breck investigated the effects of resident hazing in the Denver, Colorado metropolitan area using a volunteer-based citizen science model. Over approximately one year, the researchers trained 207 citizen scientists to haze coyotes that were behaving in a way they deemed inappropriate, or were intruding upon residential space (Bonnell and Breck 2017). Interestingly, a small number (n=9) of citizen scientists recorded the vast majority of hazing instances. Hazing was generally very effective at causing coyotes to retreat, and most coyotes fled greater than 10 feet from the citizen scientist hazing recruit. The presence of a volunteer's dog significantly reduced the instances of effective hazing, as did the presence of a nearby den. While the study did not collect longitudinal data that might reveal whether hazing reduces the likelihood of future human-coyote conflict, it nevertheless suggests that citizen-based methods are potentially valuable for both disseminating recommendations for human behavior toward wildlife, and collecting information for research purposes (Bonnell and Breck 2017).

[1] The term "hazing" refers to an attempt to cause an animal to leave an area by shouting, clapping, waving, charging, or performing any other intentionally intimidating behavior.

Attitudes

As has been the case with wolves, the extent to which coyotes are visible to urban residents because of highly publicized conflict incidents may strongly influence people's attitudes[2] toward coyotes (Houston, Bruskotter, and Fan 2010). From a broader perspective, these attitudes might reveal larger patterns that suggest where, when, and how conflict will occur. It should be noted, however, that attitudes are a result of complex life histories that are impossible to fully ascertain within the scope of a single study. Current attitudes do not necessarily predict future attitudes. Similarly, all other things being equal, geographic factors may significantly influence the development of attitudes. In a meta-analysis on human attitudes toward wolves in Europe and the United States from 1972 to 2000, researchers found that rural residents and those who were more likely to encounter a wolf were significantly less likely to report positive attitudes regarding the presence of wolves than those whose experience was more abstract (Williams, Ericsson, and Heberlein 2002). While economic reimbursements are often suggested as a remedy for rural wildlife conflicts, evidence for the efficacy of economic incentives is inconclusive and varies geographically. In 2003, Naughton-Treves et al. initiated a survey on participating Wisconsinites' attitudes toward wolves after receiving compensation for wolf-caused livestock losses. The survey results suggested that compensation had no perceptible positive impact on people's attitudes, suggesting that these may more be

[2] "Attitude" is defined as "a settled way of thinking or feeling about something"("Attitude | Definition of Attitude by Oxford Dictionary" n.d.) For the purposes of this project, this includes any emotions, beliefs, and convictions related to the subject in question.

deeply rooted in one's psychology than previously thought (Naughton-Treves, Grossberg, and Treves 2003). When a research team conducted a survey in Portugal, however, in which a selection of livestock owners were asked directly whether an existing compensation program increased their tolerance for wolves, respondents suggested that the program did increase their tolerance somewhat (Milheiras and Hodge 2011).

Attitude-focused work on urban coyotes is currently quite limited. People's attitudes are not always based on simple, rational criteria. Recently, a growing body of conservation psychology literature has begun to explore mechanisms behind the formation of people's attitudes toward wildlife. In a 2014 review of their former work, Ohio researchers Jeremy Bruskotter and Robyn Wilson proposed that an individual's trust in management agencies, control over hazards, perceived risks of species, and perceived benefits of species all interact with one another to influence his/her level of tolerance for a given animal. Importantly, their model of attitude formation suggests that the perceived benefits, including the ecological services a species offers, is more influential in solidifying peoples' final attitudes toward predators than perceived risks (Bruskotter and Wilson 2014).

There is plenty of literature available to support some of the simpler and more intuitive ideas regarding human responses to the presence of carnivores over time. Studies have explored whether general attitudes are changing, and the factors that affect these changes (Treves, Naughton-Treves, and Shelley 2013). In 2011, Shannon Lawrence

and Paul Krausman surveyed Tucson residents' responses to contact with coyotes. Though only 60 total survey recipients responded, an analysis of the results supported the potentially counterintuitive conclusion that respondents with pets were not significantly more likely to view coyotes as a nuisance. The survey also compared data from their 1992 survey, and the researchers found that attitudes toward coyotes appeared to be improving. Lawrence and Krausman speculated that coyotes in Tucson are becoming habituated as a result of resident's indifference toward the coyotes. They also noted that, while improving attitudes toward wildlife can be viewed as a positive, habituation is likely to lead to a higher number of negative encounters (Lawrence and Krausman 2011).

The many unanswered questions that urban coyote and human attitude research have highlighted demand further research. Since questions related to relatively large-scale phenomena require a large amount of data to address, most research options are costly and time-consuming to undertake. Citizen science, in contrast, offers researchers the ability to outsource much of the data collection process and uncover valuable insights hidden in peoples' otherwise private experiences.

Citizen Science

Citizen science is a data collection method that relies on data gathered by nonscientists, often residents of a particular geographic region. The data collected for citizen science projects is uploaded to a central database, usually publicized in some way,

and fulfills an educational function for participants while providing researchers with information. While relatively new, when well designed, these projects have generally been successful in collecting accurate, reliable data (Bonney et al. 2009). Although a practical and comparatively modern method of data collection, the usefulness of citizen science data depends almost entirely on the quality of data that participants provide. It is always important for researchers to ensure that the data requested from citizens can be easily provided by non-professionals.

Citizen science methods have frequently been used for ornithological research, among other subjects. Many efforts. like the South African Bird Atlas Project (SABAP), have succeeded in finding participants, while failing to achieve other stated goals (Tulloch et al. 2013). In 2013, Alesha Tulloch and her team published a review of the features of successful and unsuccessful citizen science programs. Among the features of successful projects, they list “fine scale data collection,” “temporal replication that covers the full range of habitats or land use types,” and “communication of data needs with volunteers.” In other words, research should be collected at a fine enough geographic and temporal scale that data being collected is meaningful, research should be repeated enough, or continue for long enough that an entire range of habitats or land use types is covered by participants, and public interface services (website in the case of PUCP) should clearly communicate what is being requested of participants (Tulloch et al. 2013). Poor data collection that does not follow these guidelines can result in mistakes and

wasted effort or resources. Well designed projects can aid management actions, public awareness, public education, serendipitous discoveries, participant recreation, data on human (participant) behavior, ecological science, and improved citizen science practices (Tulloch et al. 2013).

In 2015, social science researchers Dale Wright et al. surveyed a selection of participants in South Africa's "Second South African Bird Atlas Project" (SABAP2) on their motivations for participating in the project. Prior research on citizen science had largely been focused on the validity of results and content of gathered data, but rarely on the participants of studies themselves. Wright et al.'s study was among the first to target participant motivations. The SABAP2 survey results validated several motivations hypothesized by the researchers, in order of importance; "(1) recreation/nature-based, (2) personal values, (3) personal growth, (4) social interactions, and (5) project organization." While not particularly surprising, these motivations suggest that participation in citizen science projects might be skewed somewhat in favor of those who place importance on these values. Additionally, the desire to participate voluntarily in citizen science research can be diminished somewhat by protocols, such as strict reporting criteria placed on participants. Wright et al. have suggested structuring platforms in such a way that the strictness of reporting protocols do not conflict with volunteers' desire to participate in nature recreation (Wright et al. 2015). While some

error is inevitable in almost any scientific endeavor, simplicity in citizen science limits problematic misidentifications without creating a need for strict protocols.

The Portland Urban Coyote Project is designed to achieve both research and educational goals. When visiting the portlandcoyote.com reporting link, visitors are prompted through an informed consent, then asked to give the time, date, address, and description of coyote sightings, as well as optional contact information *(Table 1)*. I upload this information to a spreadsheet database and public webmap on a weekly basis. Visitors to *portlandcoyote.com* are free to view the public webmap, as well as research information, statistics, presentations, and press provided by PSU graduate students.

Table 1: Types of PUCP data collected

Data	Description	Resolution	Example
Location	Coordinates, Description	Fine resolution, but sightings only accurate to around 50 meters	105 Northeast Beech Street, Portland, 45.472295 -122.735782 *(example only)*
Time+Date	Time, Date, Day/night	Generally +/- 30 mins	6/13/2015, 3:00:00 PM, D *(Day)*
Comments	Primary comments, secondary comments		I saw the coyote running down the sidewalk, heading away from my direction. It was small, less than 20 lbs. At first glance I immediately thought it was a coyote, but then I had my doubts. After doing some research this morning comparing pictures of dogs and foxes, I am fairly certain it was a coyote.

Summary

Coyotes are resilient, adaptable animals that have thrived despite human efforts to control them. After a significant range expansion, coyotes now occupy most of North America, including most major cities (Poessel, Gese, and Young 2017). The presence of coyotes in cities creates tensions among residents because of attitudes and perceptions about the assumed dangers posed by coyotes, as well as because of the actual conflicts generated by their presence in human-dominated environments. Coyotes are not likely to leave urban areas, so strategies for minimizing problems associated with their presence call for better understanding of coyotes in cities and of human reactions to them. Because citizen science is a form of collaborative research that simultaneously provides a vehicle for public education and collects valuable data, it is an ideal format for urban coyote research. PUCP is an existing citizen science project that has collected data on Portland coyotes. Below I further describe PUCP and compare a selection of findings from Portland with related studies in three other cities.

Chapter 2: Portland as a Case Study on Urban Coyotes

The Portland Urban Coyote Project (PUCP) website is accessible at www.portlandcoyote.com. An unfunded collaboration launched and primarily managed by a small cadre of graduate students and faculty at Portland State University, with support from Portland Audubon Society, PUCP currently enjoys ongoing active public participation. Awareness about PUCP and the link to report coyote sightings are spread primarily on social networking websites and by word of mouth. PUCP, in particular its volunteer Director Zuriel Rassmussen VanBelle, further promotes PUCP with direct email responses, pamphlets, flyers, and social media pages, and through public media appearances and professional meetings. Community members directed to the site to log their sightings find educational materials, a tutorial, and links to press and related research and organizations on the website, as well as the frequently updated sightings map depicting sightings since 2011 [https://www.portlandcoyote.com/].

The subjects of this study are Portland residents or visitors who have opted to provide information to PUCP at their discretion. All respondents must agree to an informed consent form, detailing potential risks and benefits of participating in PUCP research. Since the Portland metropolitan area is a fluid environment, and because our form does not request personal demographic information, there are no constraining factors that allow for generalizations on the sampled participants of this study. The

sample of this study consists of those respondents who reported a coyote sighting for one year, between 12/10/2016 and 12/10/2017.

Upon clicking the "report a sighting" link, visitors to www.portlandcoyote.com are given a basic survey requesting the time, date, and location of a sighting. Users are shown an informed consent notice, given the option to provide contact information, provided a space for comments as well as a response field for the question, "what was the coyote doing when you saw it?" The entire response database for PUCP is kept on a spreadsheet, which must be regularly converted and updated to a format usable to PUCP volunteers. Part of this process includes geocoding all location data into latitude-longitude coordinates recognizable to ArcGIS online, through which sightings are made available to the public. Since respondents often include plain language to describe the locations of a coyote, eg."standing by the bush on Fremont by the ice cream shop," it would be inaccurate to claim that any PUCP data is precise to a resolution greater than perhaps 50 meters in ideal cases.

In order to preserve the future utility of this analysis, and to avoid the perils of confirmation bias, I have taken a holistic approach to coding the Portland Urban Coyote Project dataset. This means that I have sorted all potentially applicable data into categories. I only excluded codes made redundant by geographic coordinates that each respondent must also provide, or those without interest to any reasonably foreseeable research. I analyzed the content of 2,893 sightings, accounting for one year of data, from

December 2016 to December 2017. I chose these dates because they allowed for a small amount of overlap with research performed by Zuriel Van Belle (Rasmussen). This enabled me to begin the coding process with some degree of consistency. The dates also represent a period of consistent citizen participation shortly prior to my active participation in the PUCP. Because respondents sometimes report sightings at a time other than the day of their encounter with a coyote, some of the sightings in my sample are outside of the general range of dates I intended to analyze. By the end of my coding process, I had applied 7,680 codes, made up from 282 unique codes, to the 2,893 sightings in the sample period.

I coded PUCP's comment responses using Microsoft Excel as shown in *Table 2*. As I read through each comment, I created codes for any information contained in the comment. If a comment, for example, noted that "there were two coyotes standing in my yard and staring at me and my dog," the resulting codes would be "two coyotes," "in yard," "standing/staring," and "respondent with dog." If a respondent mentioned multiple incidents in a single comment, I simply noted this, rather than adding related codes. This was necessary because, for this project, I assumed that all geographic coordinates and time information given alongside comments were accurate for the content I coded. I omitted some codes provided by respondents, such as "crossing," or "travelling," since, unless the respondent somehow decided to capture the coyote, these could apply to virtually every encounter. I also omitted "in the street," because nearly every comment

that mentioned a coyote in a street described a coyote moving from one terrain type to another. Since our geocoding methodology automatically places coyotes at intersections, I have decided that location data is most valuable when it describes a location other than a street intersection. Lastly, I did not code for micro-behaviors given to describe coyotes such as "open mouth," or for estimated coyote weights, as these were often wildly inaccurate. (It is, however, worth mentioning that respondents seem to overestimate the size of coyotes significantly, often comparing them to large dog breeds). At the end of the coding process, I collated codes using a pivot table function (*Table 3*). The data was then ready to be analyzed, which I did using a variety of Excel-based methods.

> **Respondent 4295**: Good luck with your research! Hope this sighting helps!
> He/She slowly hopped the fence out of my back yard, into some overgrown area between ours and our neighbors yard. Then hung out in that area for a while, long enough for me to grab a camera and take photos/video. Then He/She headed towards 62nd drive, crossed the street, and went up the hill into our others [sic] neighbors yard, seemed to be traveling in a north to south direction. Found it strange to see the coyote in broad daylight, the time stamp on my phones [sic] camera comfirmed [sic]1:29 PM

> **Respondent 4296**: I saw a pair of coyotes in the same location about two months ago right at dusk.It saw me coming up the cart path about fifty feet away and opposite [sic] direction into thick brush.

Table 2: Coding format prior to conversion to pivot table

Respondent	Code	
4295	EXPRESS SUPPORT	1
4295	STANDING/STARING	1
4295	IN YARD	1
4295	JUMPING	1

4295	TAKE/OFFER PHOTOGRAPH/VIDEO	1
4295	SHOULDN'T BE OUT DURING THE DAY	1
4296	MENTIONS MULTIPLE SIGHTINGS	1
4296	STANDING/STARING	1
4296	IN BUSHES	1

Table 3: Pivot table sample containing total counts of selected codes

Code Totals	**Count**
FIVE COYOTES Total	4
FOLLOWED BY CAT Total	1
FOLLOWED BY CROWS Total	13
FOLLOWS/CIRCLES RESPONDENT Total	43
FOUND DEAD SQUIRREL Total	1
FOUND PRINTS Total	1
FOUND SCAT Total	2
FOUR COYOTES Total	14

Results

Respondents generally chose to participate in PUCP in predictable ways. Below, *Figure 2* illustrates the relative frequency of respondent statements as broad categories. Respondents mentioned coyote behaviors more often than any other content in the PUCP dataset, directly answering the prompt "what was the coyote doing when you saw it." There were no overt instances of false reporting or "trolling" in the data. While some individuals chose to use PUCP as a place to vent frustrations, while providing no sighting

data, this was extremely uncommon. A large amount of content described coyote movements e.g. “running” or “trotting.” Unfortunately, due to the complexity of average encounters, I have not been able to find any applications for this type of data. For future work, it should be interesting to note that 352 comments, or 12.2% of comments mentioned a coyote sighting other than the one the respondent provided a location for. For example, many respondents mentioned having seen a specific coyote previously, without listing a location. Others commented that they regularly see coyotes in their neighborhood. Occasionally, respondents described coyotes exhibiting interesting behaviors that could not be captured by coding alone. In these instances, much better qualitative information could be obtained from simply reading respondents’ comments. PUCP’s data format is ideal for aggregating specific types of coyote encounters. Respondents were likely, for example, to mention if they were with a pet at the time of an encounter, as well as the pet’s reactions and behaviors. Since respondents were generally very forthcoming with this information, coding was fairly straightforward. It was possible, for example, to sort a reasonable number of coyote encounters by the size of a respondent’s dog, which could be valuable because coyotes are likely to appraise the risk of approaching a respondent very differently depending on the respondent’s dog size or breed.

While locational data represented 15.5% of all the content I coded, this information was generally mentioned passively. Respondents often provided location data

as vague descriptions such as “in the woods,” or “on the sidewalk.” Together with address data, however, even the vaguest locational information can increase the accuracy of visualized points significantly. Because of the transient nature of coyote encounters, it is much easier to visualize the “storyboard” of certain events by comparing images from open source geographic software with text comments. Some respondents provided information that significantly aided in pinpointing the location of an encounter, such as a specific trailhead in a large park.

Respondents often offered their opinions freely. It can be tempting to view PUCP and other citizen science data through a sort of disconnected, scientific perspective. Sometimes, respondents’ language obscured the intensity of their emotional experiences:

> Respondent 4731: Four coyotes attacked my cat. Scared then off and rushed my cat to the vet, she did not make it.

> Respondent 4056: We are curious about coyote behavior. For example, my cat was very cautious and very fast and we were surprised that the coyotes could catch her. I read that they hunt in teams of two. Could they have tricked/cornered her strategically? Just curious. Obviously, we are more interested in coming to terms with the death of our pet, but also interested in the coyotes and their role in the cycle of life. Also, they took that top half of her body (head and front legs). Is that normal? Should we expect to find the rest of her around our yard or do they take it with them? We plan to get another cat and are wanting to know the chances of another death. Do you have statistics on this? Thank you!

It is clear, however, that many respondents have experienced real emotional distress, and even changes in lifestyle as a result of either anticipated or actual experiences with coyotes:

> Respondent 5428: How can we get rid of them or discourage them from coming around? We are afraid to let our animals or kids out at night!
>
> Respondent 4422: What exactly is being done about this? These attacks are occurring more & more frequently throughout our neighborhoods and just noting random sightings seems a futile approach to addressing the actual problem?
>
> Respondent 5607: how [sic] do we find out if these specific coyotes have been reported to the proper authorities? and if anything is being done about it?
> we are very concerned that the apartment management seemed so flip [sic] about it and most likely done nothing about it.
>
> Respondent 5662:The coyote was stalking me and my 2 small Havanese dogs. We were walking on Blaine Ct. The coyote was perhaps 10 feet away at the closest. As we walked, it ran from place to place to intercept us as we were walking down the curving hill. I yelled at it and it backed off to about 20 ft and sat watching us. I picked up a rock and threw it. It hit where the coyote had been, but the coyote ran off. A neighbor has seen a group of 8 coyotes all together (4 adolescents). Another neighbor had a single coyote attack 2 of her dogs in their own back yard. One dog required multiple stitches. I had hoped that Animal Control would remove these coyotes to the Oregon desert, but apparently everyone is expected to believe your 2008 article that coyotes are harmless because they have only killed one toddler. I bought citronella to spray the dog bitten by the coyote because it ignores its collar and invisible fence to run from its yard across the street to bark, snap, growl and jump within an inch of our dogs now. I also bought pepper spray in case a coyote or a group get within 10 feet so

> that I can defend myself and our dogs. I have no experience with coyotes other than the ones on our hill in our neighborhood, but these are certainly dangerous and aggressive. Some people in the neighborhood often have toddler grandchildren visiting. Unfortunately you may have to update your article in the near future. And are there no statistics on the number of pets attacked and/or killed by coyotes?

It is important to note that the vast majority of PUCP comments mentioned only the details of a coyote encounter. Portlandcoyote.com features information sections clearly explaining that the purpose of PUCP is education, research, and data collection. Still, it would be unrealistic to expect every respondent to read the entirety of Portlandcoyote.com's "research" and "about" pages. The few respondents who mistook PUCP for a type of animal control service are unlikely to have gained much insight from reporting to PUCP. PUCP can, however, direct efforts to minimize the potential for citizens misinterpreting PUCPs citizen science engine. Where users' comment data has been insufficiently descriptive to make sense of users' experiences, including tragic losses, follow up surveys may offer enormous potential for future research. When practical, PUCP sometimes responds to such comments.

The kinds of responses that participants chose to include in their comments could mostly be sorted easily into categories. While many only included relatively simple descriptions of coyote behavior, others were willing to provide more context. This sometimes included details about the participant and his/her pet or transportation method.

Those who added attitudes or beliefs did so knowingly, although some seemed to assume that these attitudes or beliefs were shared by others.

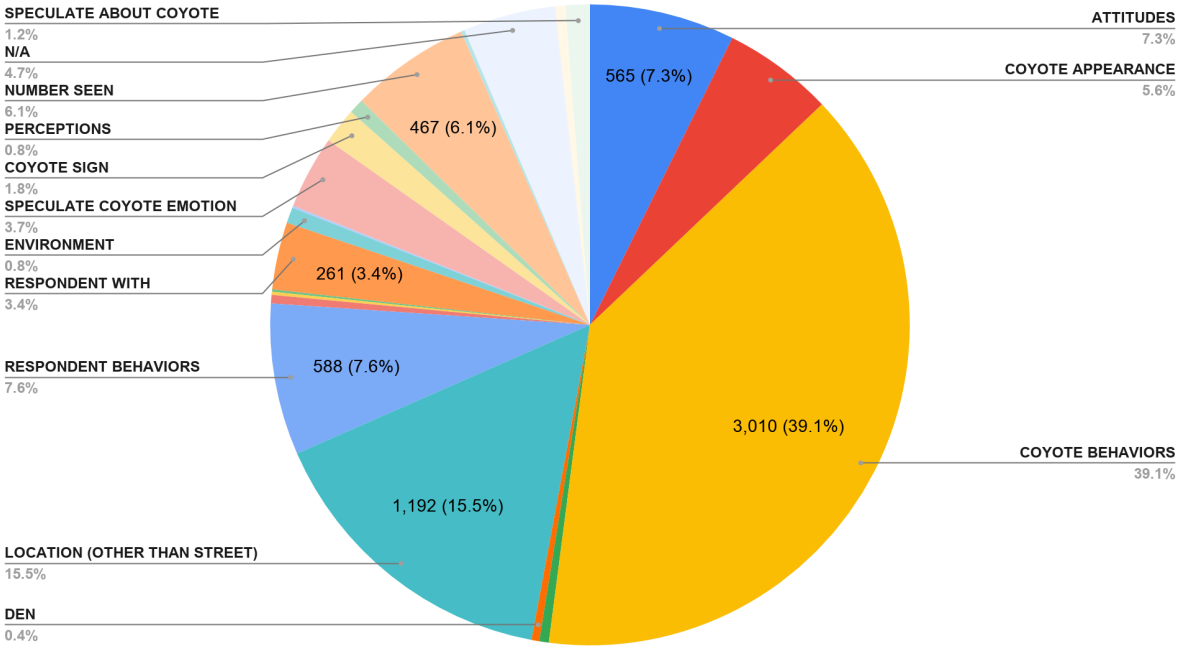


Figure 2: Count and percentage of codes by category

Table 4: Count and percent of comments in which more than one coyote was sighted

Coyotes Seen	Count	Percent of Total Sightings
TWO COYOTES	332	11.48%
THREE COYOTES	65	2.25%
FOUR COYOTES	14	0.48%
FIVE COYOTES	4	0.14%
SIX COYOTES	3	0.10%
SEVEN COYOTES	1	0.03%
MULTIPLE COYOTES UNSPECIFIED	46	1.59%

While the majority of comments described a sighting involving a single coyote, 466, or 16% of sightings involved multiple coyotes, as depicted in *Table 4*. One hundred twenty commenters, or 4% of total sightings described what they considered to be juvenile coyotes or pups. As shown in *Figure 2,* the most frequently mentioned content within PUCP comment data was related to coyote behaviors, which represented about 39% percent of all coded content, and provided 111 unique code types. The next most common information provided was information about terrain that coyotes chose to travel through, or remain in, which represented 15.5% of information, and provided 19 unique codes. Respondent behaviors and details accounted for 7.6 % of all content, and provided 15 unique codes. Approximately 7% of information coded from the data was related to human attitudes and beliefs, and these fit into 49 unique code types. Respondents used comment space differently depending on their personal preference and the character of their encounter. Not all PUCP participants gave comment information, usable location data, or permission for PUCP to use survey information. Often, I could not use provided data because of ambiguous language or location descriptions.

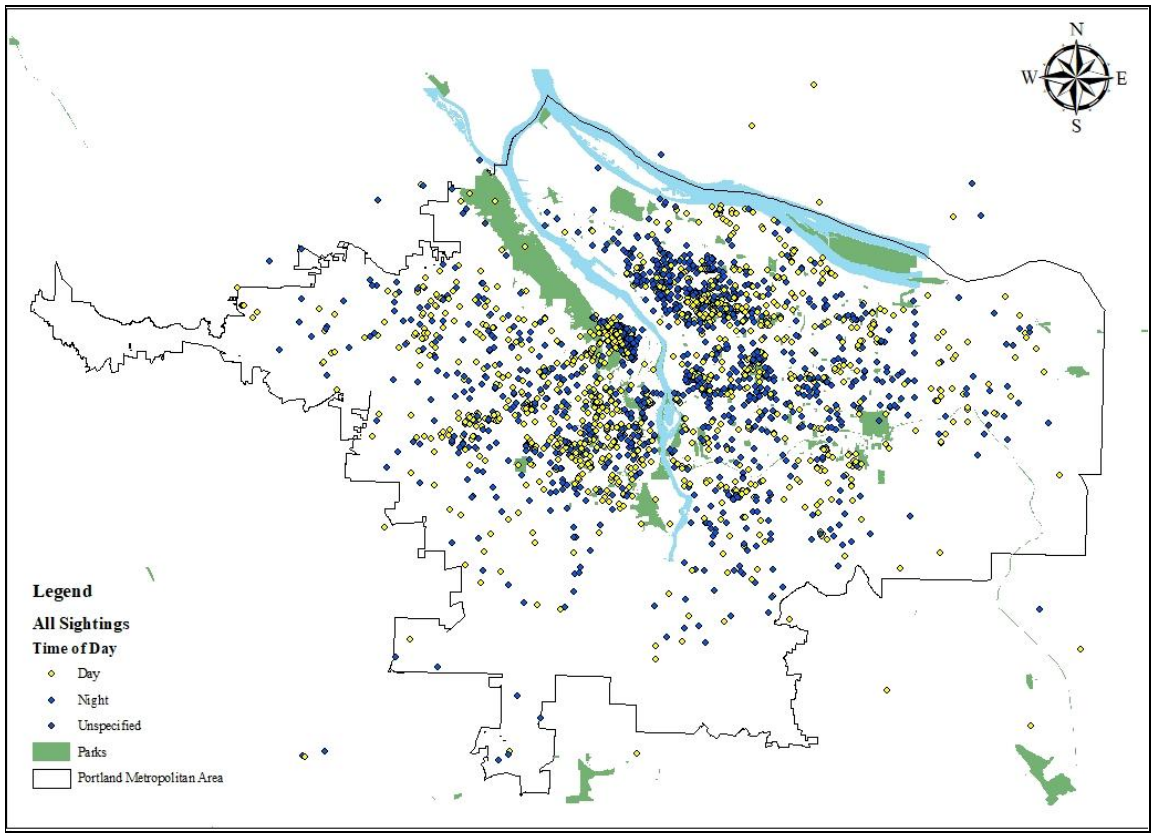


Figure 3: Map of sightings colored by time of day. Approximately 47.6 percent of sightings occurred during daytime hours while 51.6 occurred at night. .8 percent of respondents did not specify the time of a sighting.

Coyote sightings were reported at night (after sunset and prior to sunrise as per www.timeanddate.com) slightly more often than during the day *(Figure 3)*. Because humans are more likely to be active during the day, and PUCP coyote sightings are still reported more often as occurring at night, these data probably support the notion that coyotes are avoiding humans by travelling more frequently at night. Respondents reported coyote sightings occurring in the early morning most often, and at night

somewhat less often (*Figure 4)*. This might suggest that coyotes are most active during crepuscular hours. While increased human activity alone could probably account for early morning sightings, it does not necessarily account for a spike in sightings within the 21:00 (9:00 PM) hour. Sightings increased dramatically during the winter of 2016, and somewhat during the winter of 2017 *(Figure 5)*. I speculate that this is because coyotes have less access to cover during the winter months. In Portland, lush vegetation is available during much of the year, and coyotes may use this vegetation to avoid contact with humans, even within relatively close proximity.

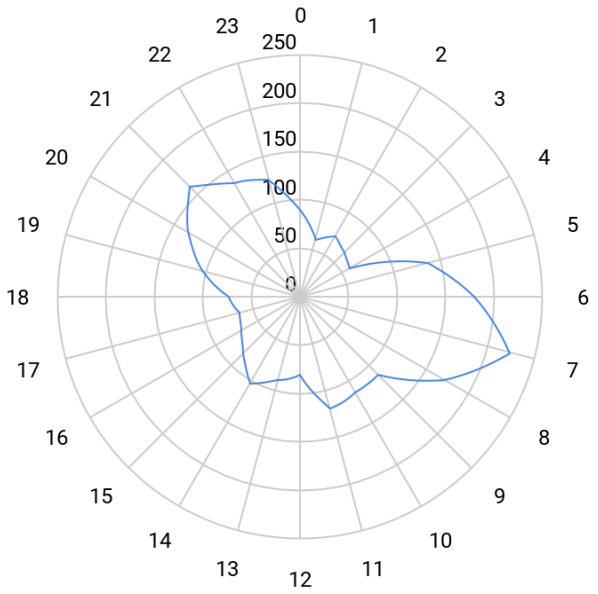


Figure 4: Number of sightings by time (military)

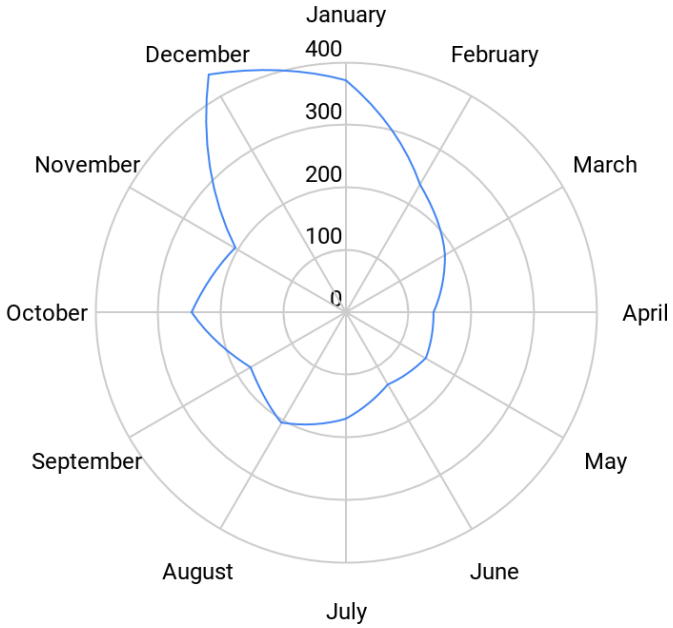


Figure 5: Number of sightings by month

Use of the Portland Metropolitan Area

Portland, OR is a medium sized city of approximately 655,741 inhabitants, with an average population density of 4,375.2 individuals per square mile. The median household income for city residents is 65,740 (U.S. Census Bureau 2019). The densest population and construction in the city is located in the central downtown area to the west of the Willamette River, which divides Portland across a roughly east-west axis. Residents generally refer to the five main sections of the city by their directional orientation. These include North, Northeast, Northwest, Southeast, and Southwest Portland. Portland residents are fortunate to have access to a wide range of public parks. As shown in *Figure 6*, Forest Park, the largest park in the city, is located in the western

hills and encompasses around 20.3 square miles or 52.6 square kilometers of forested area. Other Portland parks are substantially smaller, but many, including Mount Tabor Park, are still large enough to conceal considerable populations of wild animals from public view. Although Portland is largely composed of residential and commercial space, the city can be contrasted with other, especially Northeastern cities like Philadelphia, PA, in that many of its houses feature yard space that hosts significant vegetation. While areas to the east of the Willamette are generally flatter than those to the west, several small volcanic features, including Mount Tabor Park and Powell Butte Nature Park, provide topographic variety as well as refuge for wildlife *(Figure 6)*.

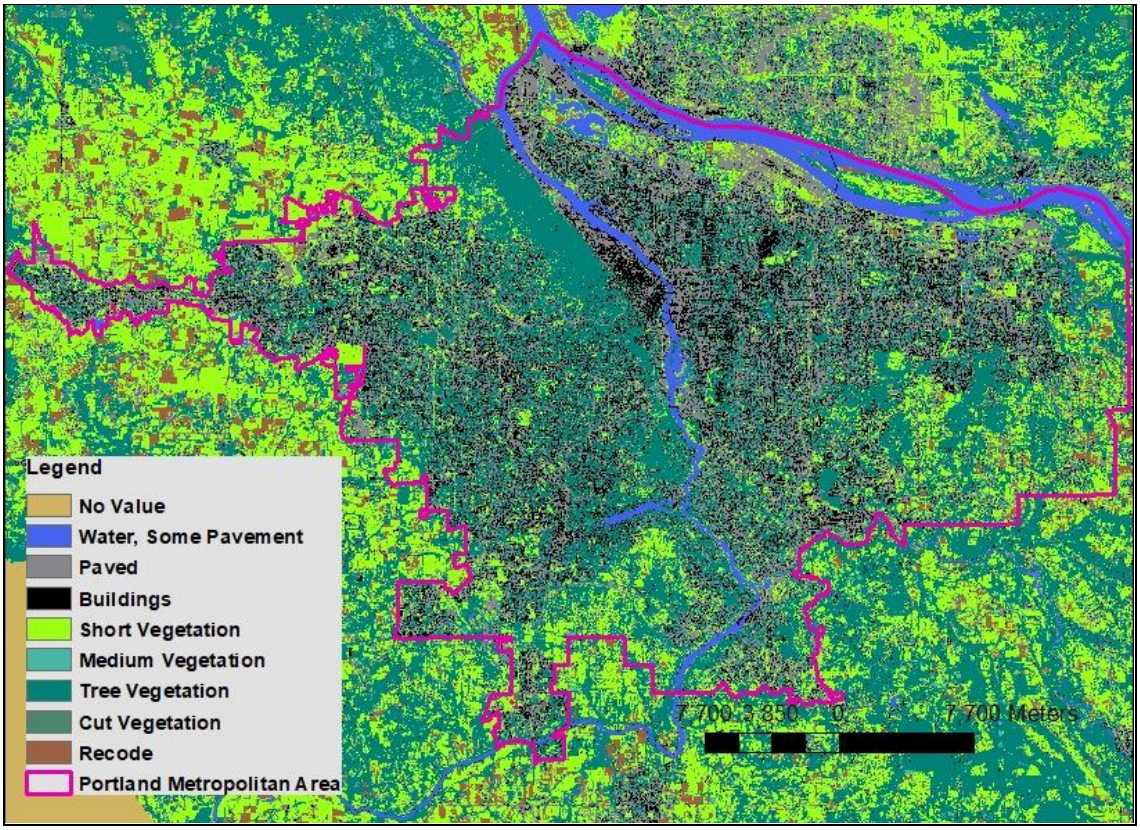


Figure 6: Land cover map of Portland using National Land Cover Database data.

While it is difficult to draw inferences from data presented as point clusters, the kernel density maps I created for daytime and nighttime sightings seem to both validate intuitive expectations and suggest larger patterns of human-coyote interaction in Portland. Sighting clusters are most dense where dense urban areas border with park areas, such as the area where Forest Park meets residential Northwest Portland. As shown in *Figures 7 and 8,* daytime sightings clearly overlap with large parks like Forest Park and Sellwood Park more often than nighttime sightings. We should expect this because these parks are

largely limited to daytime use. Both multiple year and single year analyses seem to suggest that sighting patterns differ somewhat predictably between day and nighttime in the north Portland area, although the significance of this is unclear.

The geographic distribution of sightings seems to manifest somewhat similar patterns between seasons across multiple years *(Figure 9)*. Sightings tend to spike in winter, which we have cautiously attributed to a lack of ground cover during winter months. Seasonal sighting patterns do not occur uniformly across Portland. In spring and fall for example, more sightings appear clustered around Northeast Portland in the direction of Alberta Park. In winter and summer, more sightings are apparent in Northwest Portland at the southern edge of Forest Park *(Figures 9 and 10)*. More research is required to fully explore the spatial dimensions of how humans and coyotes interact and to attempt to discern the role of human patterns of behavior in shaping observations of coyotes.

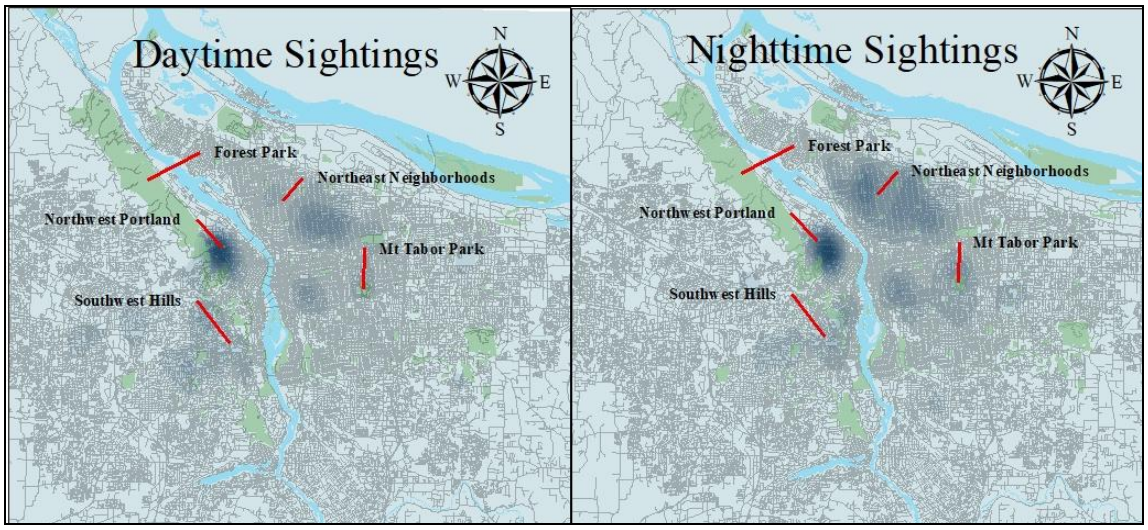


Figure 7: *Kernel density map for sightings from the coding period for this project separated by time of day*

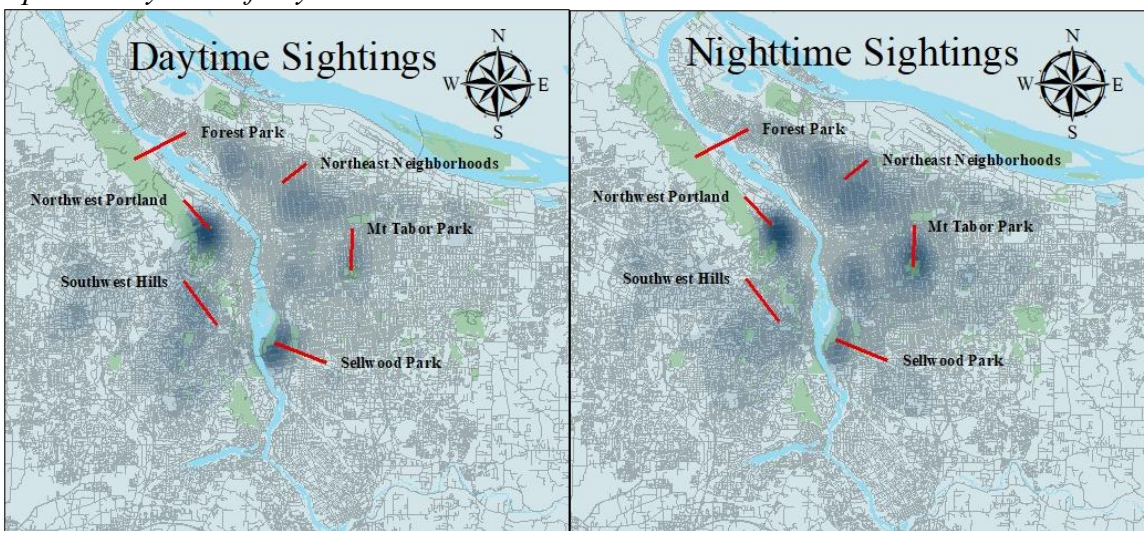


Figure 8: Kernel density map for sightings from the entirety of PUCP's database history separated by time of day

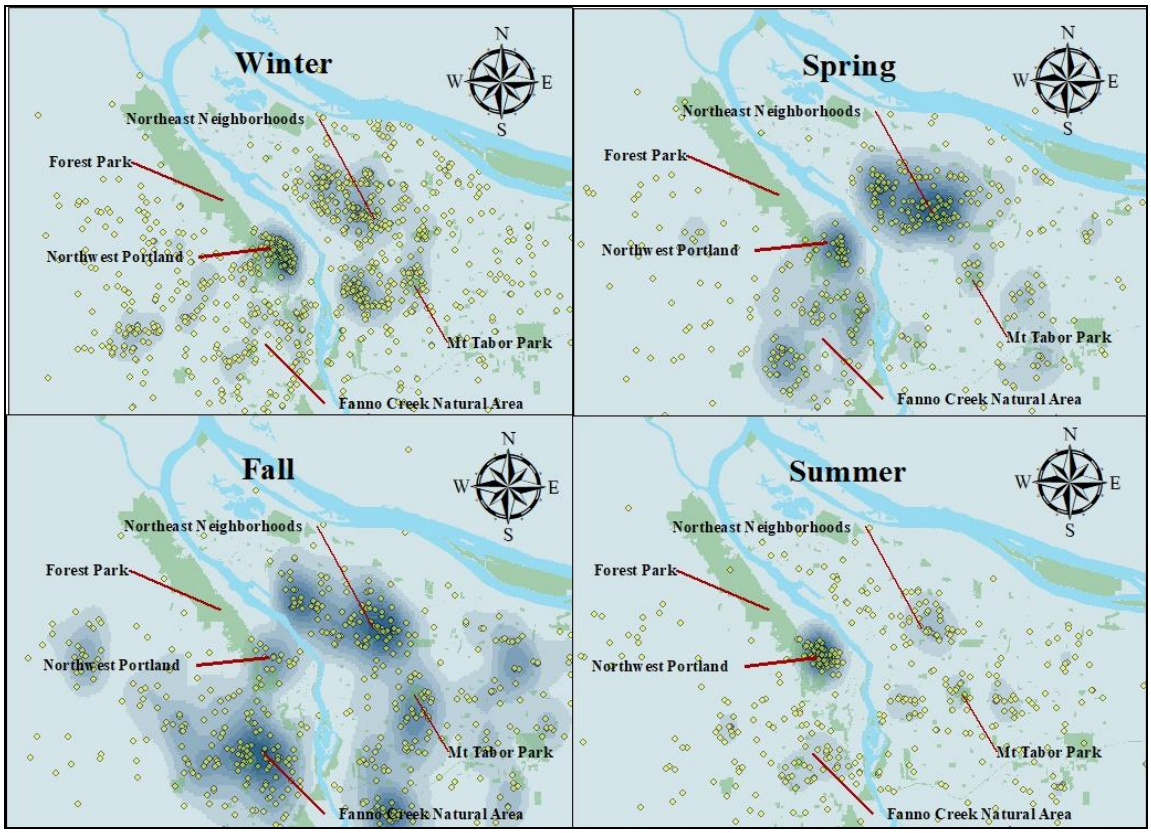


Figure 9: Kernel density map for sightings from the coding period for this project separated by season

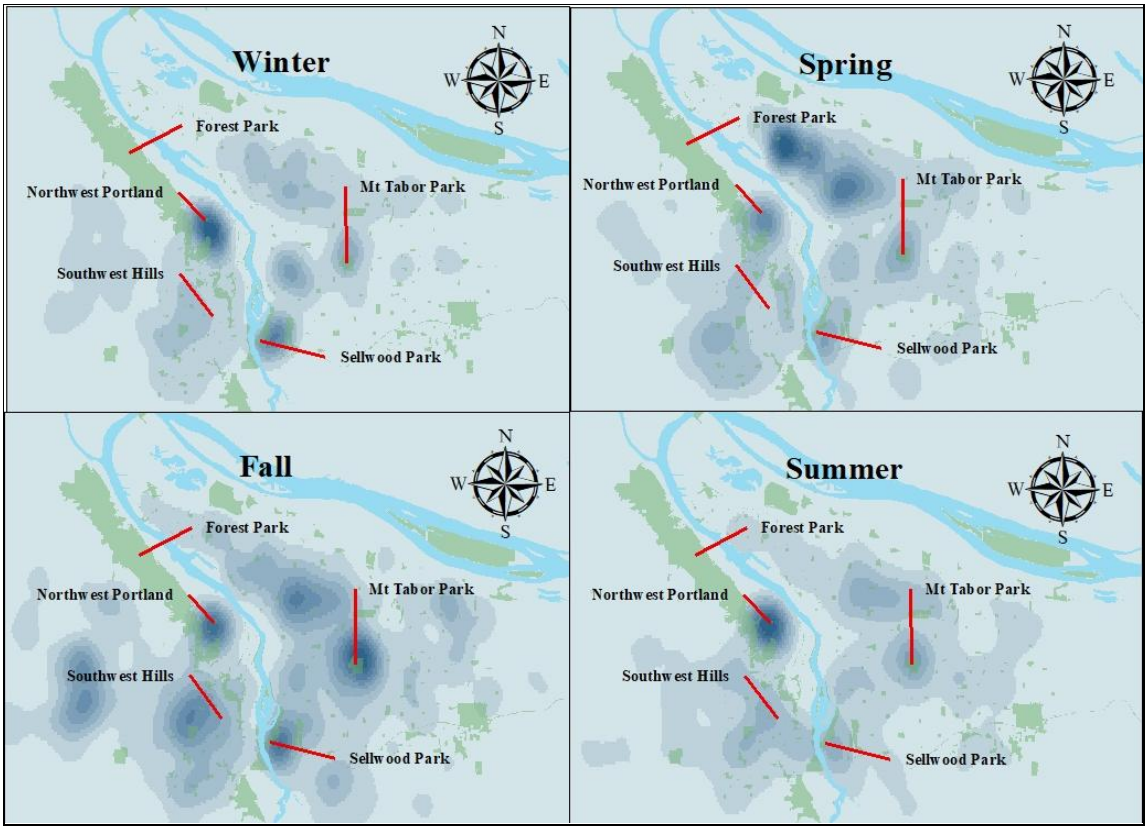


Figure 10: Kernel density map for sightings from the entire history of PUCP's database separated by season

Attitudes

Of 48 respondent attitude and belief code types[3], 23 were negative, 12 were unclear in disposition, and 14 were positive toward coyotes. Two hundred sixty-two (46%) of attitude codes were negative, 200 (35%) were positive, and 103 (18%) were unclear or neutral. Of these responses, the most common (n=61, 10.8%) were instances of the respondents mentioning the deaths of local animals, including pets and livestock,

[3] Attitude statements were often expressed as either simple attitude statements e.g. "I love seeing coyotes," or belief statements that suggested an underlying conviction, such as "coyotes don't belong in big cities."

without being prompted, and without clear relevance to the sighting being reported [MENTIONS ANIMAL KILLINGS NEUTRAL]. The next most common (n=60, 10.6%) were respondents expressing support for PUCP [EXPRESS SUPPORT], and 35 (6%) were complimentary statements about the coyote's appearance [CUTE/BEAUTIFUL COYOTE]. Only 2 (.4%) individuals reported that they hate coyotes, while 25 (4.4%) said that they like or love coyotes or seeing coyotes. Twenty-eight (.97% total) respondents chose to mention that they supported the removal of coyotes, whether by lethal control (n=4, .13% total), nonlethal removal (n=17, .59% total), general removal (n=6, .2% total), or neutering (n=1, .03% total). The most common category of attitudes, beliefs or emotions that respondents expressed were those that reflected anxiety about potential harm to animals or people (n=138, 24.4%) *(Figure 11)*. Positive associations such as [COOL/AMAZING/FASCINATING], or [LIKE/LOVE COYOTES] were the next most common, followed by negative associations such as [HATE COYOTES].

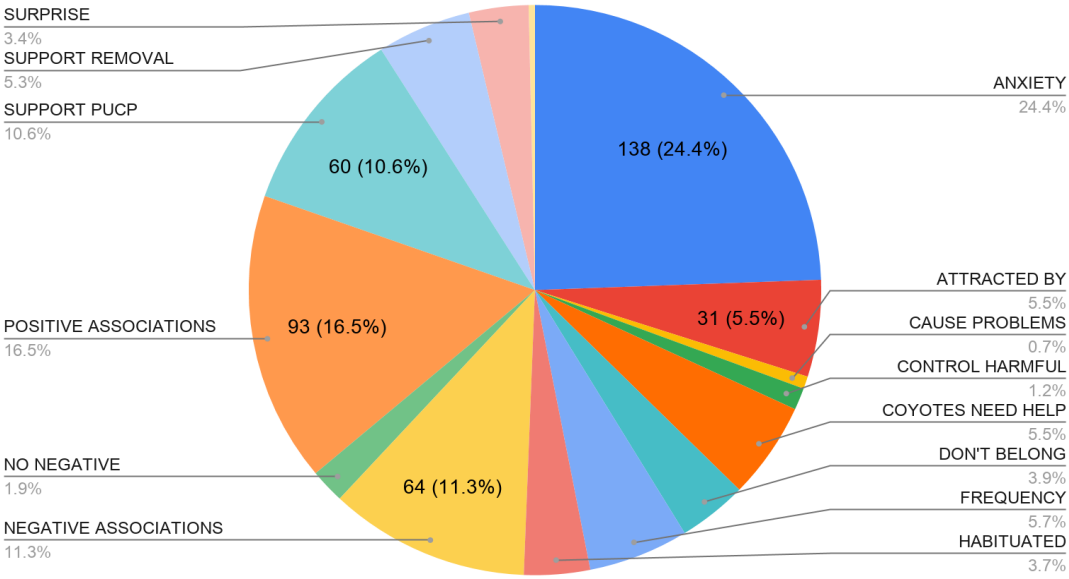


Figure 11: Respondent attitudes, beliefs, and emotions

Beliefs

Of all respondent belief statements, the most common (n=32, 23.2%) were comments about the frequency of coyote sightings *(Figure 12)*, A relatively large number of respondents expressed the belief that either coyotes or sightings had increased lately (n=25, 21.3%), while only one (n=1, .9%) expressed a belief that sightings or coyotes had decreased. 5 respondents (n=5, 4%) speculated that they were seeing the same coyote repeatedly. The next most common category of belief sightings (n=31, 22.5%) were respondents' speculations about why coyotes had moved into an area. Of these, 19 speculated that a local area was good coyote habitat, 5 speculated that coyotes had been

lured by trash, 4 that coyotes were lured by outdoor feeding, 2 by rodents, and 1 by domestic cats.

Of 21 comments that expressed the sentiment that coyotes do not belong where they had been sighted, 17 respondents clearly believed coyotes should not be outside during the day, three felt that coyotes were out of place in cities, and one speculated that coyotes were killing and displacing local wildlife. A number of respondents, however, alluded to the coyote's positive ecological roles, including controlling deer (n=1), controlling outdoor cats (n=2), and controlling rats or mice (n=5).

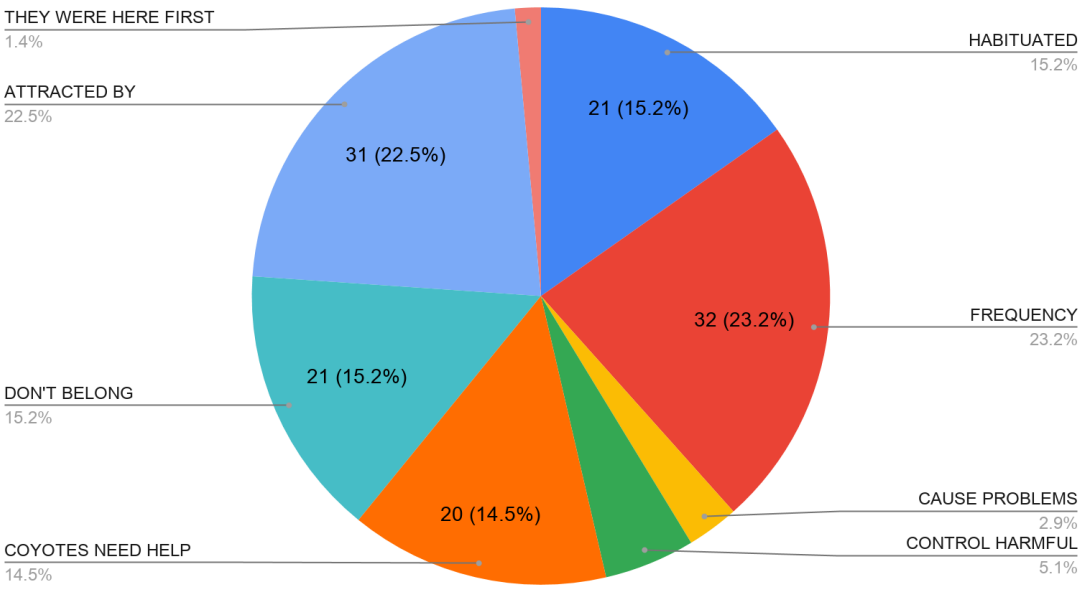


Figure 12: Respondent Beliefs

Respondents sometimes speculated about the internal emotions, motivations or conditions of coyotes based on coyotes' outward demeanor *(Table 5)*. One hundred

thirty-eight comments (4.8% total) described a coyote or group of coyotes as calm, unfazed, relaxed, or other synonyms. Sixty-six comments (2.3% total) described a coyote or group of coyotes as nervous, anxious, frazzled, spooked or other synonyms. Twenty-six (.9% total) respondents referred to coyotes as confident, casual, or brazen. A number (n=20, .69% total) speculated that coyotes were lost or confused. Respondents mistook coyotes for dogs (n=48, 1.69% total) more often than coywolves (n=4, .14% total), wolves (n=2, .07% total), and deer (n=1, .03% total) *(Table 6)*.

Table 5: Participants' speculation about coyote emotion

Code	Count	Percent of Total Sightings
COYOTE CALM/UNFAZED	139	4.80%
FRAZZLED/SPOOKED/ANXIOUS	66	2.28%
CONFIDENT/CASUAL	26	0.90%
SPECULATE CONFUSED/LOST	20	0.69%
SPECULATE CURIOUS	14	0.48%
SPECULATE INTENTFUL/PURPOSEFUL	14	0.48%
SPECULATE HUNGRY/DESPERATE	3	0.10%
SPECULATE AVOIDING HUMANS	1	0.03%
SPECULATE BORED	1	0.03%
SPECULATE HAPPY	1	0.03%

Table 6: Participants' self-reported sensory assumptions

Code	Count	Percent of Total Sightings
FIRST MISTOOK FOR DOG	48	1.69%
SPECULATE COYWOLF	4	0.14%
FIRST MISTOOK FOR WOLF	2	0.07%
FIRST MISTOOK FOR DEER	1	0.03%
HARD TO SPOT	1	0.03%
HEARD PRESUMED GUNSHOT	1	0.03%

When I began to assess respondents' attitudes toward coyotes, it became clear that many respondents offered either their attitudes directly, e.g. [LIKE/LOVE COYOTES], or emotional beliefs, e.g. [COYOTES CONTROL RATS/MICE]. Because beliefs can present a positive or negative overall impression, I have chosen to include them in my discussion of attitudes. The emotional disposition of respondents toward coyotes might best be described as "anxious but humane." While a reasonable number of respondents were hostile towards coyotes, these feelings seemed to stem from anxiety about pets and children, rather than an innate dislike or desire to see coyotes eradicated. While negative statements about coyotes were more common than positive ones, many more respondents (n=25, 4.4%) asserted that they "like" or "love" coyotes than hate coyotes (n=2, .4%). This might reflect some of the demographic characteristics of Portland (left leaning, urban center), which are likely to differ from other locations. It could also reflect the

social desirability bias inherent to survey questioning (Grimm 2010). Some respondents (n=15, .51% total) clearly believed that coyotes were being forced out of habitat by construction; a likely scenario at a local scale, unlikely at a larger scale, or that coyotes "were here first," which is a dubious thesis from most historical perspectives.

Though many respondents expressed support for PUCP, a number appeared to suffer from the misconception that PUCP is an agenda-driven organization either for or against the presence of urban coyotes. Others questioned what the aim of PUCP's research is. The sentiment "what are you doing about the problem?" came across in many responses. While only a few (n=4, .13%) respondents openly suggested lethal control for coyotes, more (n=24, .82%) seemed to believe that removing coyotes from Portland was a practicable option for the city. More respondents are likely to have held these views at the time of reporting, while not choosing to include them in PUCP's comment space.

Attitude statements tended to co-occur predictably with other statements. Negative statements, for example, seem likely from respondents who have previously suffered the loss of a pet to a coyote, or believe that coyotes exacerbate Portland's already dismal traffic situation. Similarly, one might expect that those who write positive statements might also be aware of coyotes' ecosystem benefits. There is, in fact, research to support this connection exactly (Bruskotter and Wilson 2014). Within my analysis of code co-occurrence, however, there were a few unexpected connections. Respondents who saw a cat or stray dog following a coyote, or saw a coyote eating fruit, included a

positive remark, but there were only two instances of each occurring. One respondent mentioned leaving cats outdoors, while also adding a positive comment on the coyote's appearance, despite the perceived danger to the cats:

> Respondent 4504: Two cayotes [sic] were in the garden in front of my house. One was about five feet from the living room window, the second one further away. I'm guessing they jumped up from the sidewalk over the short retaining wall and into the garden because they were interested in my two cats. My cats came through their cat door in such a thunderous run that it woke me up. I was curious to know what had frightened them. When I pulled back the curtain I saw the first cayote run out of the garden and down to the sidewalk. Then the second one followed. They stopped, turned around to look at me, then trotted down the sidewalk East toward NE 7th Avenue. They were a light brown color. One appeared to be smaller than the other. I'm guessing they weigh between 30 and 40 pounds though they a [sic] sleek. Quite beautiful.

Respondents generally appeared to be quite capable of holding simultaneous feelings of concern for pets and respect for coyotes without exhibiting signs of cognitive dissonance. Given the complexity of human thought, this might not be surprising, but it is informative. Other urban coyote studies have reached similar conclusions. Shannon Lawrence and Paul Krausman's survey of Tucson residents found that respondents found that cat owners were similarly likely, and dog owners were only slightly more likely to find urban coyotes to be a nuisance than non-pet owners (Lawrence and Krausman 2011).

The ability to map sightings based on response content significantly simplifies the process of conceptualizing people's experiences with urban wildlife. As a part of my

exploration of attitudes, I attempted to map the discrepancy between respondent experiences with coyotes and respondent anxiety toward coyotes. In some instances, respondent anxiety during a sighting appeared closely linked in both time and space to actual injuries or near injuries inflicted on pets. Other instances of respondent anxiety were far from any reported coyote "attack" during the coding period. Forty-six of 111 sightings were 1,000 meters or less from a coyote "attack." Because I have only coded one year of data, there are probably large gaps in my map data that further coding will help to close.

When respondents offered their beliefs about coyotes, these were often phrased as facts. These statements sometimes reflected errors from both pro- and anti-coyote camps. As I have already mentioned, coyotes are not Northwest natives by most measures, having migrated to the Northwest relatively recently (Hody and Kays 2018). Coyotes have likely had contact with human settlements for thousands of years (Swann and Krupat 1987, 342-380). The arguments, therefore, that humans are intruding on coyote habitat, or that coyotes need our help to survive are difficult ones to make. Equally problematic is the claim that coyotes "don't belong" in cities or in human inhabited areas. Coyotes have, of course, adapted astoundingly well to urban life, increasing their densities in urban areas while still avoiding people in most cases (Gehrt et al., 17 2011). It should hardly be surprising that some respondents seem unaware of coyotes' unique tendency to efficiently colonize urban spaces. Many Portland citizens are likely to live

and work in environments that do not foster urban carnivore education. Citizens' insights on dealing with coyotes may draw from irrelevant experiences with other animals. One might logically conclude, after hearing about, for example, an animal control officer removing a den of raccoons, that the same process would apply to "problem" coyotes on a larger scale.

Many more PUCP respondents felt that the number or density of coyotes in their area was increasing rather than decreasing. While it is impossible to say whether coyotes have yet to reach a carrying capacity in Portland, it seems more likely that an increase in one's awareness of the presence of coyotes could "prime" participants to acknowledge aspects of their environment in new ways. Respondents occasionally speculated that coyotes were habituated, or acting abnormally. These claims are probably best verified through coyotes' responses to respondent hazing summarized below. Respondents' speculation about coyotes' inner conditions were mostly based on basic body language cues applicable to most mammals, and usually appeared to be valid. Several respondents first mistook an animal for a wolf or speculated that the animal they saw was a coywolf. Respondents tended to dramatically overestimate coyote size, and sightings of wolves and coywolves are probably an extension of this tendency.

Co-occurrence

During my review of PUCP data, I analyzed the content of all respondent statements by co-occurrence with other statements within a single comment. I have adjusted the spreadsheet in which I collated all comment data so that no codes occur multiple times within a single comment. When displaying co-occurrence, I normalized the number of codes based on their overall representation in the data. This means that higher values did not represent the most common codes in the data e.g. [RUNNING], [WALKING], but rather the percent of times a code co occurs with a given condition or code. Consequently, some codes that were relatively rare co occurred at a high level, since, for example, 100% of the single respondent who saw a coyote being followed by a cat also included a positive comment about coyotes. As shown in *Figure 15,* respondents who included a negative attitude statement about coyotes, such as a fear for domestic cats, were more likely than other respondents to have provided the following additional codes: [COYOTES CAUSE TRAFFIC PROBLEMS], [SUPPORT REMOVAL], [NO COYOTE SIGHTING], [WONDER IF SIGHTING SHOULD BE REPORTED TO ANIMAL CONTROL], [FEAR FOR HUMANS], [PETS KILLED (PREVIOUSLY/NOT WITNESSED)], [COYOTE AGGRESSIVE TOWARD DOG], [DOG FLEES COYOTE]. Respondents who included a positive attitude statement about coyotes provided these additional codes at a higher rate than other respondents; [COYOTES IN TROUBLE/HABITAT DESTRUCTION], [COYOTES CONTROL OUTDOOR CATS], [COYOTES CONTROL RATS/MICE] *(Figure 14)*. Respondents who said that they like

or love coyotes were more likely to provide statements represented by codes [COYOTES IN TROUBLE/HABITAT DESTRUCTION], [COYOTES CONTROL OUTDOOR CATS], [COYOTES CONTROL RATS/MICE] *(Figure 13)*.

When I examined co-occurrence with sightings of a juvenile coyote, codes [COYOTES CHASES COYOTE], [COYOTE ATTACKS RACCOON], [COYOTE KILLS RACCOON] only occurred when a juvenile coyote was present. These co-occurrences probably highlight inexperienced coyotes engaged in experimental play and hunting behavior. More common codes like [RESPONDENT WITH CHICKENS/FOWL], or [LOOKING THROUGH GARBAGE] were slightly less related. The condition [PUP/PUPS] had few consistently related codes. The most frequently co-occurring codes described multiple coyotes or nearby dens.

Figure 13: Co-occurrence of other codes with the code "LIKE/LOVE COYOTES" Values of 1 indicate a +1 correlation between the attitude condition and code. A value of 1 or

greater indicates, for example, that the code appeared every time a respondent mentioned that they like or love coyotes.

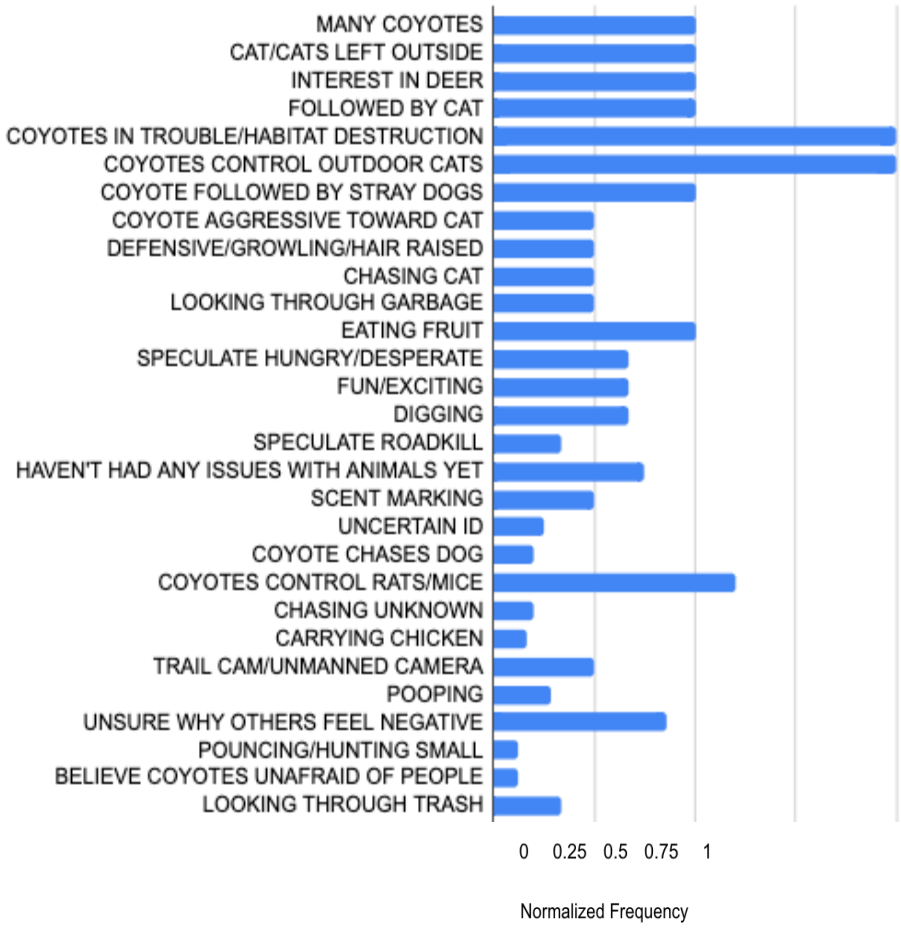


Figure 14: Co-occurrence of other codes with positive statements about coyotes. Values of 1 indicate a +1 correlation between the positive attitude condition and code. Values higher than 1 indicate that multiple attitude statements co-occurred within a given code.

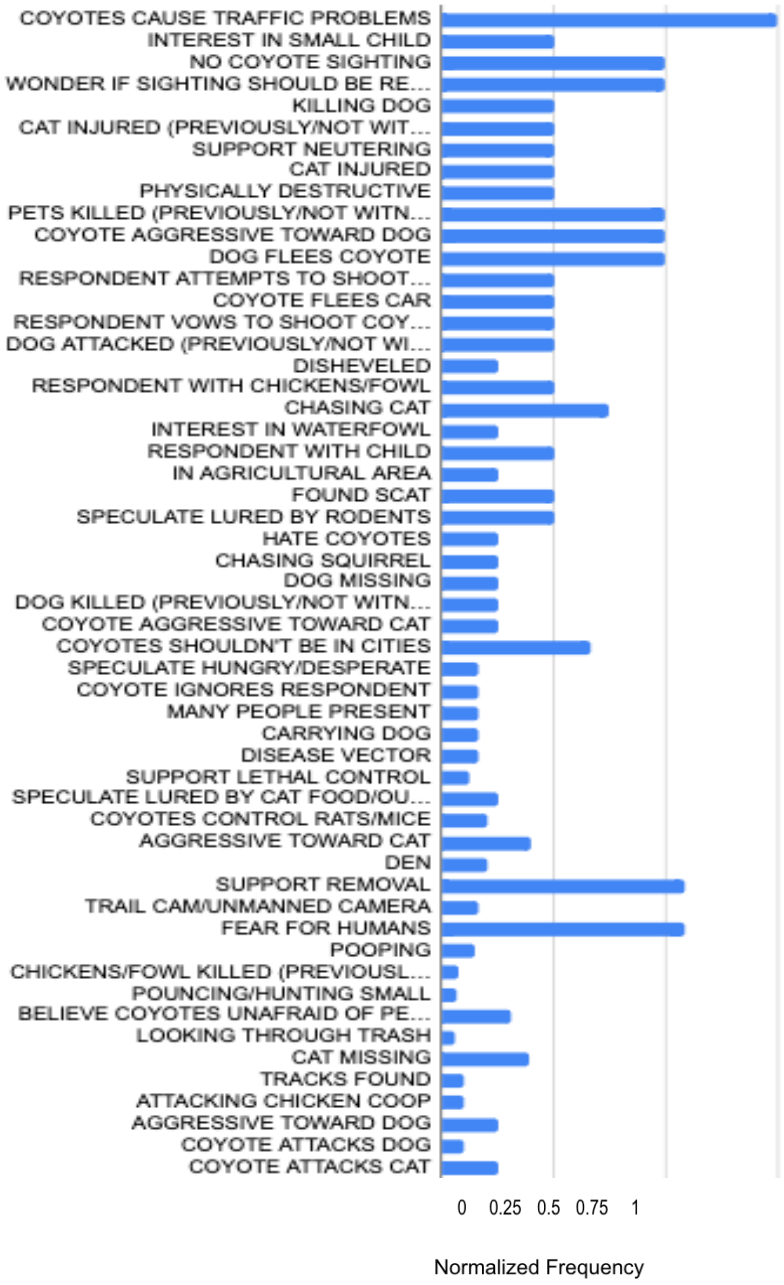


Figure 15: Co-occurrence of other codes with negative statements about coyotes. Values of 1 indicate a +1 correlation between the negative attitude condition and code. Values higher than 1 indicate that multiple attitude statements co-occurred within a given code.

Animal Encounters

Respondents described a wide range of interactions between coyotes and other animals. Dogs, cats, waterfowl, chickens, squirrels, opossums, crows, raccoons, deer, birds, rodents were all mentioned in the year I coded. Sightings involving pets were fairly common. Some 235 (8% total) described an incident in which the respondent was with his/her dog, or a known dog, within access to a coyote (not indoors). Only 22 (0.8% total) respondents reported being with their indoor/outdoor cat at the time of a sighting. Respondents expressed concern most often for cats (n=32, 1.1% total), pets in general (n=28, 1% total), and dogs (n=27, .9% total), slightly less for children (n=24, 8% total), and significantly less for adult humans (n=6, .2% total). It should be noted that some respondents expressed concern for "pets" and cats or dogs in a single comment. The most serious encounters between coyotes and other animals observed by respondents were direct killings *(Figure 16)*. One dog was directly observed being killed (.03% total), while 11 cats (.4% total) were similarly observed. Attacks against animals were occasionally apparent in a single neighborhood over a relatively short span of time, suggesting that a single coyote or group of coyotes might be responsible *(Figure 17)*. Sometimes, respondents reported that their dogs (n=2, .07% total), cats (n=9, .3% total), or chickens (n=2, .07% total) were missing at the time of a sighting, or that a chicken/fowl (n=7, .2% total), dog (n=2, .07% total) or cat (n=25, .9% total) had been killed previously, and a coyote was the presumed culprit.

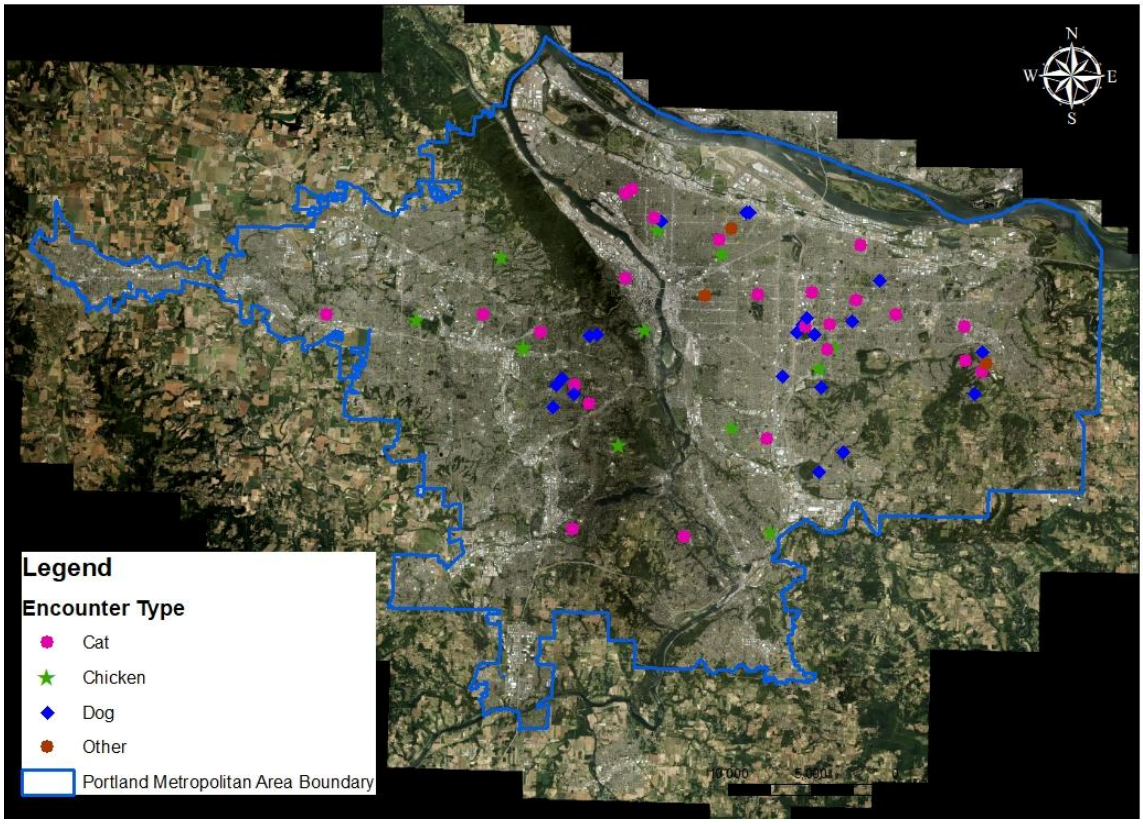


Figure 16: Definitive attack incidents against an animal

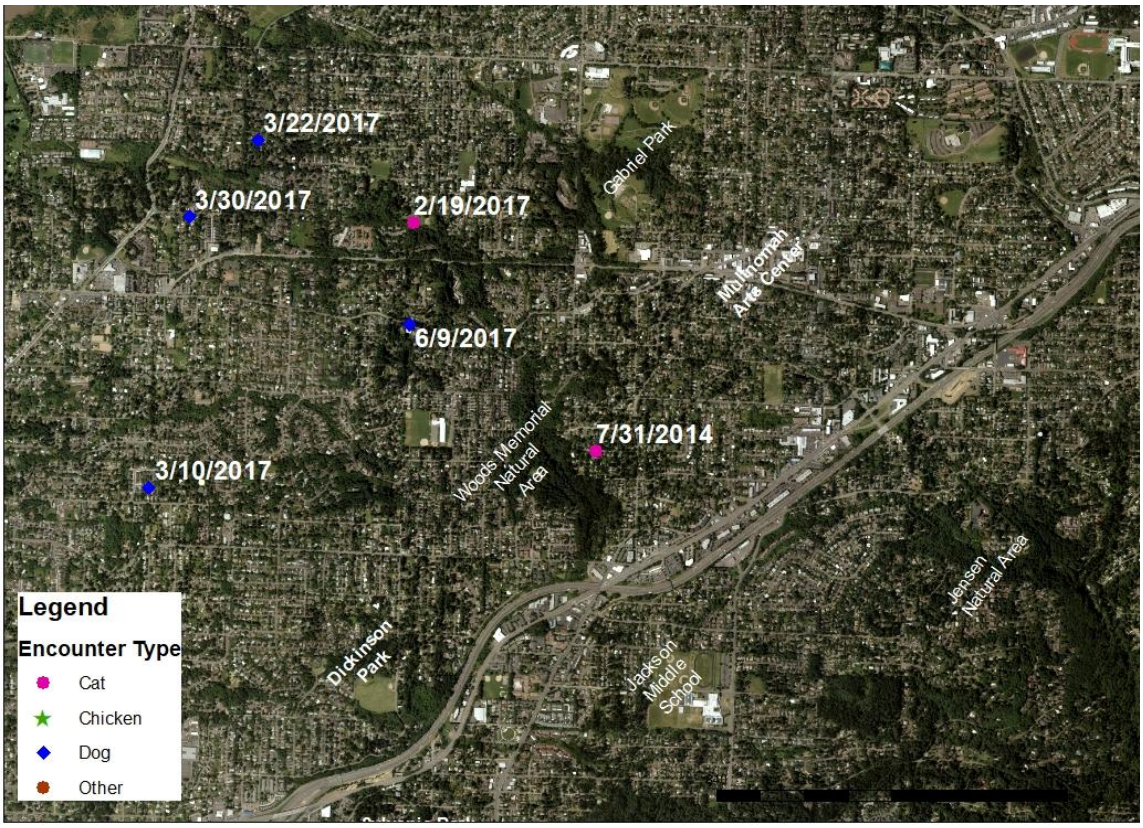


Figure 17: Zoom-in of figure 16 near Gabriel Park with close space-time relationship. 2014 incident point was reported retroactively within the coding period. The four points that occurred in late February and March of 2017 might implicate a single coyote or group of coyotes in the attacks illustrated.

Diet

Coyotes were occasionally observed eating. Often, (n=15), respondents were unsure what the coyote being observed was eating. The next most common reports regarding eating behavior described a coyote eating a cat (n=5), although some of these respondents admitted to being uncertain that the victim animal was indeed a cat.

Infrequently, respondents described coyotes eating chickens (n=1), deer (n=1), fruit (n=2), pet food (n=2), small rodents (n=1), squirrel (n=3), trash (n=1).

Respondents observed coyotes eating an unknown material or animal almost as often (n=15) as they were able to specify the animal or material being consumed (n=16). None of the food coyotes were described eating contradicted any previously held scientific beliefs. Coyotes consumed cats; however, respondents could not specify whether these cats were being scavenged or killed and subsequently consumed. As is the case with every other section of this project, more food consumption data from greater citizen participation and further researcher coding will help to broaden the range of responses to a natural maximum. Because there is probably significant bias in the types of foods that coyotes consume in front of humans, PUCP's data should not be used to estimate the relative percentages of particular food items in coyote diets.

Land Cover Type

By far the most common land cover types that respondents witnessed coyotes traversing were streets, yards, sidewalks, and areas commonly occupied by humans *(Figure 18)*. Respondents were sometimes quite descriptive when recounting how coyotes made use of specific landscape features. Despite the relative infrequency of codes for coyotes' sighted in unmanaged, wooded, and wetland areas, it is likely that coyotes used these areas often to escape human observation. Because these habitats exclude humans very

effectively, citizen science is a poor measure of species' true distribution across urban landscapes. The majority of sightings were located where humans spent the most time. In many cases, respondents used language that clearly indicated a sighting had occurred at the respondent's own residence. In my opinion, this fact offers significant potential for future research as long as an emphasis continues to be placed on the protection of personal data.

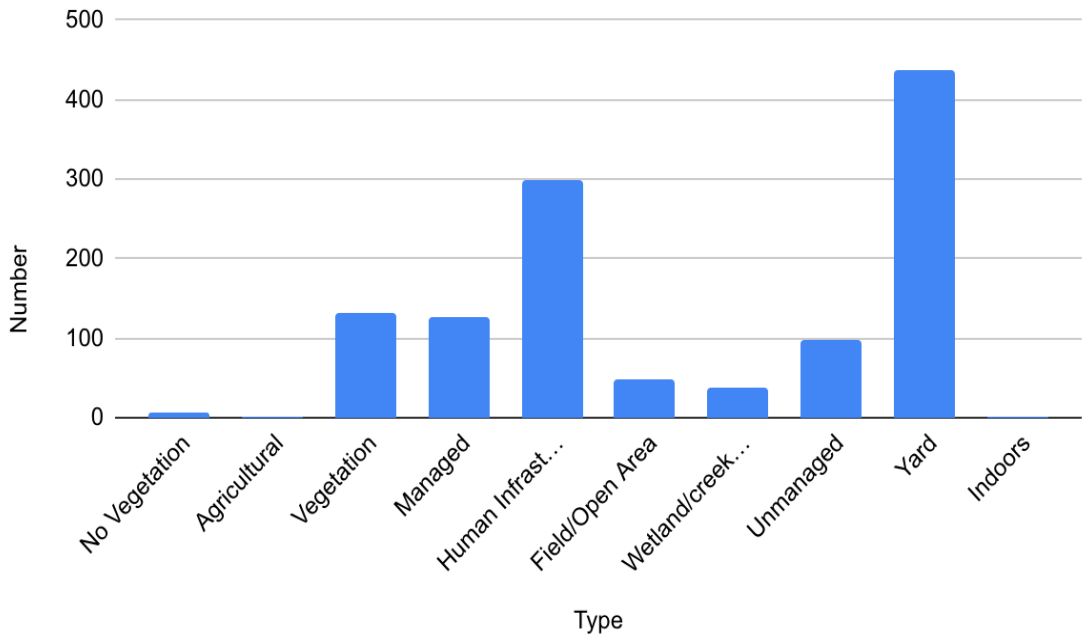


Figure 18: Histogram of land cover types mentioned in PUCP comments

Respondent Behaviors

Respondents reported having varied reactions to coyote encounters. As we have seen, most respondent behaviors, along with the respondents' description of a pet dog's behavior represent a mid-sized fraction (n=543, 18.7%) of respondent statements. Of

these data, 46 (8.4%) statements described a pet dog's behavior, 5 (.9%) described respondent's physical aggression against coyotes, 110 (20.2%) described respondents hazing coyotes, 58 (10.7%) were questions to PUCP or offers to help PUCP, 243 noted that a respondent was in a bike or vehicle, and 146 (26.9%) described a respondent taking or offering PUCP a photograph or video of an encounter. A small number of respondents reported unusual behavior:

Table 7: Selected Respondent Behaviors

Code	Count	Derived From
PEPPER SPRAYS COYOTE	1	One was turning onto [redacted] bound pursuing squirrel, second was just turning onto [redacted] & seemed interested in my dog. I pepper sprayed its direction & it fled East on [redacted]. Five minutes later saw same or different 1 Northbound on[redacted].
SHOOTS AT COYOTES	1	My wife has fired at them w/22 rifle. I've tried to scare them away at night with a 12gauge. They are always hunting around here. We have 2 small dogs, a medium dog, and a large dog. Coyotes got both our cats, and all our chickens. My name is [redacted] and you can get ahold of me most any time.
RESPONDENT FLEES COYOTE	2	
RESPONDENT VOWS TO SHOOT COYOTE	1	I do not remember the date or time that I saw them but two of them were going after one of my cats at The next time I will shoot them because no one is doing anything to get rid of them in the city limits. I have also seen them at [redacted] in the field.

It is abundantly clear from PUCP's responses that Portland's urban coyotes have highly varied temperaments. Respondents have described coyotes behaving quite differently in very similar circumstances. Respondents themselves, however, also respond to events quite differently. This can complicate the process of performing objective analysis significantly. Where one respondent sees a coyote behaving threateningly, another might welcome an opportunity to commune with nature. In one PUCP response that particularly stood out, a respondent recalled that a coyote and the respondent's dog used to play regularly:

> Respondent 3557: I live on 2 1/2 acres; have seen coyotes (up to 3 at a time, but usually 1 or 2) up to 10x/month, but sometimes much less - cross my unfenced property for many years. My (now gone) Australian Shepard used to spend up to 1 hour at a time "playing" with a particular coyote (yes, I have videotape) - who would - for 3 years - show up and sit at the base of a particular tree, look straight into our double doors, waiting for me to let Lucky (dog) out. Lucky chased the (much faster) coyote - they'd run around a trampoline maybe 40x, across the yard, the coyote even came and did a somersault on the lawn, threw L's toys up into the air - very playful behavior. Sometimes they'd rest, positioning themselves 20' apart but looking at each other. Then resume their play. Because I don't have a fence, I was aware it "could" be dangerous, but certainly their interactions took place way before I happened to observe them. Lots more to say, if you're interested. I find the coyotes very interesting.....

Despite a clear potential risk, this respondent allowed their dog to continue direct contact with a coyote over an extended period. In this case, both the coyote and the respondent's

behavior were unusually permissive. Many respondents were instinctively protective of animals. Where coyotes exhibited unusual brashness and respondents exhibited unusual anxiety, conflict was most likely:

> Respondent 5713: I NEED TO KNOW IF THERE IS ANYTHING I CAN PURCHASE THAT WOULD HELP ME DEFEND MYSELF AND MY DOGS IF THEY APPROACH US AGAIN. LIKE A PEPPER SPRAY OR BEAR SPRAY ETC.. THANK YOU SO MUCH.

> THERE WERE TWO MEDIUM SIZE COYOTES. MY LITTLE DOG WAS OUTSIDE AND THEY CAME UP TO ALMOST MY GARAGE DOOR TO TRY AND GET HIM BUT HE RAN UNDER THE CAR. MY DRIVEWAY IS PRETTY LONG AND THEY ONLY RAN OFF BECAUSE I SCREAMED AND WENT TOWARDS THEM WITH MY FLASHLIGHT. WHEN THEY GOT TO THE END OF MY DRIVEWAY ONE OF THEM STOPPED AND TURNED AROUND TO LOOK AT ME APPARENTLY. I DONT KNOW HOW TO PROTECT MY DOGS. I HAVE 2 A CHIUA[sic] AND A DACHSUND. MY ELDERLY NEIGHBOR HAS A CHIUA ALSO AND I AM SO WORRIED ABOUT HER LITTLE DOG.

Summary

Portland coyotes mostly interacted with humans in ways that were consistent with prior research. Coyotes largely appeared to be avoiding humans by using vegetation, green spaces, and nighttime activity. Coyotes and humans seemed to encounter one another in geographic patterns that were sometimes visible across multiple years. Although more respondents included negative attitude statements in comments than

positive ones, many of these statements involved anxiety surrounding pets or children. Respondents offered many interesting theories as to why coyotes appeared to be occupying cities, but many of these seemed to be pure speculation. Individuals who recognized the ecological role of coyotes in controlling rodents or even outdoor cats were likely to state that they liked or loved coyotes. This is consistent with Bruskotter and Wilson's model of human attitudes (2014), and certainly warrants further attention as more sightings are coded in the future. Negative encounters between coyotes and animals were rare, but did occur. These could not be definitively attributed to a handful of habituated coyote attackers using PUCP's data alone, although my map exploration above suggests that this might be the case in at least one cluster of incidents *(Figure 17)*. While respondent's comments about the land cover type traversed by coyotes did not appear to reflect coyotes' actual land use, descriptions of commenters' property hold more promise for future work, since these might allow researchers to better understand who is participating in PUCP. PUCP is clearly a useful resource for understanding the particular state of Portland human-coyote interaction. Below, I expand my analysis to compare PUCP's data with three other noteworthy studies conducted elsewhere.

Chapter 3: An Evaluation of Portland Coyote Data Comparing Coded Results to Findings Accumulated in Other Studies

In order to determine whether data extracted from PUCP is useful for studying specific phenomena, I have compared data taken from PUCP with other studies. Although there have been many studies on urban coyotes, only a small portion of these are appropriate for comparison with PUCP. Studies that use camera traps or other methods to estimate population numbers, for example, rely on rigid sampling methods, so I have not considered examining these. I have chosen three studies from different parts of North America that investigate different phenomena using different methods. Lukasik and Alexander's study in Calgary relies on reported sightings and GIS analysis to examine coyote aggression, Lawrence and Krausman's Tucson study uses a simple survey to highlight human attitudes, and Bonnell and Breck's work in Denver uses a participant-based citizen science method to study hazing.

Calgary, Alberta

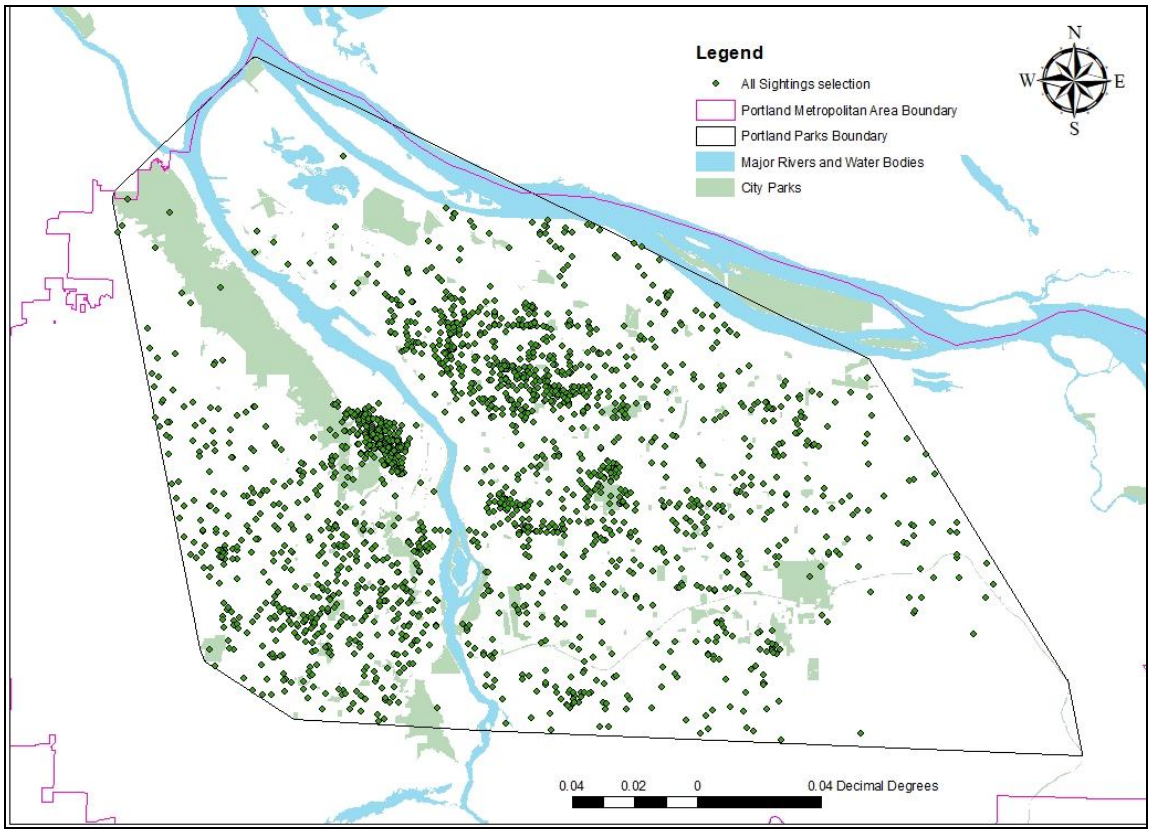
By comparing PUCP's sample year with a study on aggression, I wanted to determine whether Portland coyotes' "aggressive" behavior appeared to match that of coyotes studied elsewhere, and, in doing so, whether PUCP is suitable for this kind of comparison. Categorizing coyote behavior as aggression or by other labels using

voluntary reporting is intrinsically difficult. When behavior is left to the interpretation of respondents, similar behavior is bound to be interpreted differently by different observers. Coyote aggression is a complex subject that must be defined before it can be classified. In Ludwig Carbyn's analysis of coyote-inflicted human injuries in Yellowstone National Park, Carbyn concludes that coyote attacks against humans are "predatory" in nature (Carbyn 1989, 445). These attacks, he says, occur when coyotes lose their natural fear of humans, and this can be compounded by the presence of pups. Other researchers have suggested that "aggressive" coyote behaviors are defensive in nature, and are related to attempts to protect and raise pups. In their Calgary study, Lukasik and Alexander cautiously note that "conflict" was most common during pup raising season. The pair further conclude that conflicts with coyotes occurred more often where greenspaces coincide with areas of high human density. They implemented a simple severity scale for describing coyote incidents based on one introduced previously by Ludwig Carbyn (1989). Lukasik and Alexander's scale includes five categories: "(1) sighting only, (2) coyote seen eating garbage or being fed, (3) coyote following or stalking people and/or pets, (4) aggression (e.g. growl/snap/charge) exhibited toward people or their pets, (5) physical contact with a human or pet" (Lukasik and Alexander 2011,116).

Because my analysis is primarily exploratory, and because many comments I coded were relatively ambiguous, I have only considered instances of charging, close stalking, biting, or killing animals or people (no people were bitten or killed) to constitute

"aggressive" or "negative" incidents[4]. Using the near table tool in ArcMap, I computed the average distance from general sightings and "negative encounters," respectively, to Portland parks *(Figure 19)*. I also measured the proximity of both general sightings and these negative encounters to a buffered (200m) high resolution layer representing the intersection of city parks in high density human areas. Negative encounters were, on average, closer to Portland parks than general sightings. Negative encounters were significantly closer, on average (677.16 meters n=59), to the buffer around city parks in high density areas than general sightings (1553.49 meters, n=2893).

[4] The codes that were considered to constitute aggression were COYOTE ATTACKS CAT, COYOTE ATTACKS DOG, ATTACKING CHICKEN COOP, COYOTE KILLS CAT, CARRYING DOG (live), CARRYING CAT (live) ATTACKING RABBIT COOP, COYOTE ATTACKS RACCOON, COYOTE KILLS CHICKEN, AGGRESSIVE TOWARD CAT, AGGRESSIVE TOWARD DOG. Example of AGGRESSIVE TOWARD CAT: "[t]here were two coyotes three times in December. Each time they followed each other through the side yard onto the bank in back. The first time, one of my cats was out, and they seemed to be cornering him." Example of AGGRESSIVE TOWARD DOG: "two of them were trying to attack my full grown dog while he was using the bathroom in our yard."


Legend
All Sightings selection
Portland Metropolitan Area Boundary
Portland Parks Boundary
Major Rivers and Water Bodies
City Parks
N
W
E
S
0.04
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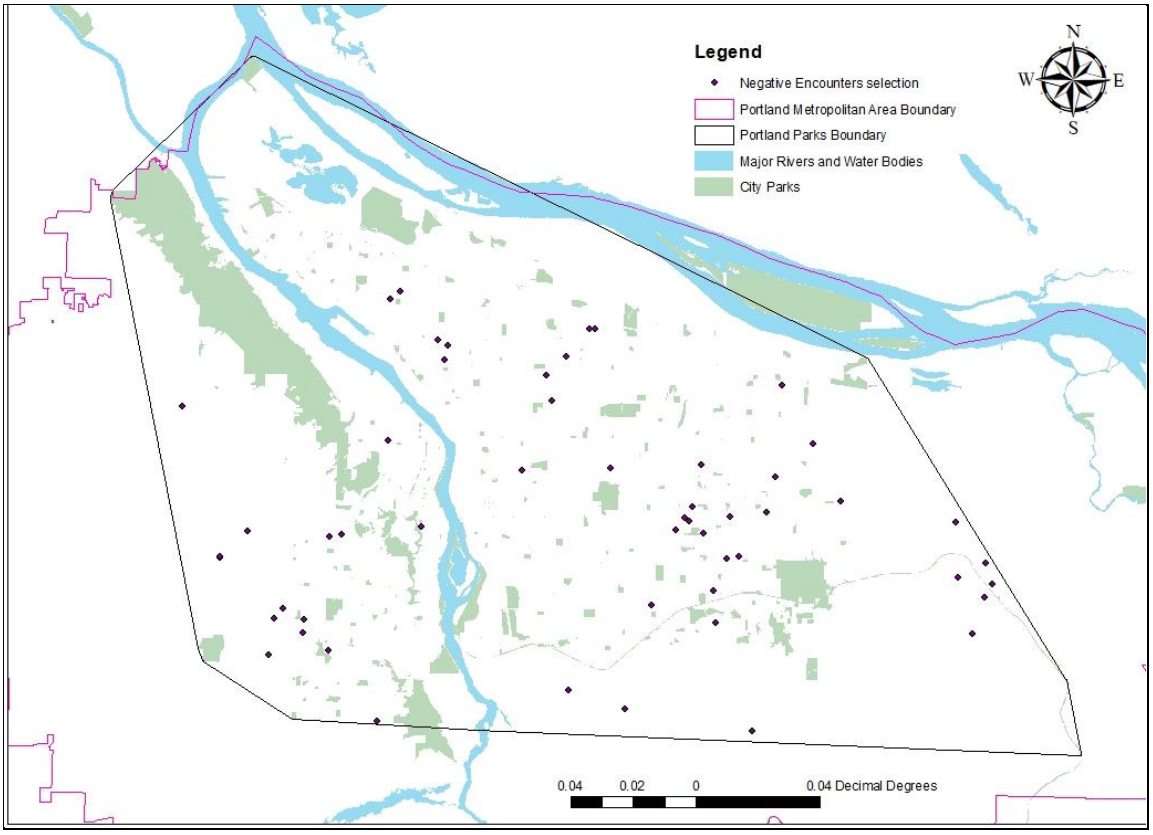
0
0.04 Decimal Degrees



Near Table Average

All Sightings	Negative Encounter
n=2,893	n=59
1472.88 meters	1321.53 meters

Figure 19: Maps include sightings within a boundary area of the Portland city parks layer. This border was created by converting the city parks layer (not including state parks) to a single polygon so that no points were analyzed where no parks data existed. Table represents the average distance from parks between especially negative encounters (n=59), which were characterized by a perceived or real attack on an animal, and all sightings (n=2,893). Negative encounters were slightly more likely than other encounters to occur in or near a park.

Because there were relatively few instances of coyotes stalking, harming, or killing animals, it is questionable whether spikes in this type of activity indicate larger patterns. January, April, and July each contained seven such incidents, the highest number per month present in the data *(Figure 20)*. Since coyotes typically give birth from mid March to mid may, it is possible that the spike in April is related to defensive behavior, but this data is not sufficient to begin speculating on the meaning of any patterns.

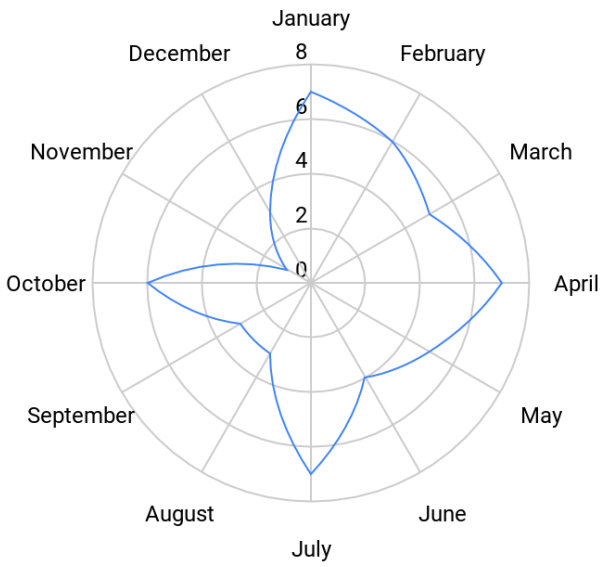


Figure 20: Month during which respondents described a coyote behaving aggressively toward a pet or livestock animal.

These findings support the assertion that "conflict" with coyotes is more likely near parks or places where parks and high-human-density areas coincide. Lukasik and Alexander's assessment that pup-rearing season is responsible, in part, for spikes in conflict appeared plausible in Portland, though spikes in conflict were just as prevalent during other times in the coding period. Since the highest number of instances in PUCP during January, April and July (n=7) were so few, further analysis will increase the statistical certainty of patterns in the data. Since the purpose of this project is to assess the utility of PUCP by examining whether it can produce data that rivals other research in quality, not to replicate other work, it appears that PUCP is more than capable of yielding the sort of analyses described in Human-Coyote Interactions in Calgary, Alberta.

Tucson, Arizona

While PUCP's format does not request that respondents answer specific questions about their attitudes toward coyotes, the comparatively high volume of respondents that participate in PUCP ensure that many of the questions that might be included in a typical survey are answered without anyone having to ask. This has been very convenient, since information about attitudes toward coyotes that respondents voluntarily offer are some of the most meaningful and interesting data to come from PUCP. It is also convenient because surveys distributed for the purpose of research often yield low response rates. Traditional surveys, however, are able to ask specific questions that may address points of

particular concern. Since an important part of this review is an assessment of the utility of PUCP's data, I compare the quality of information provided by PUCP respondents with Lawrence and Krausman's 2011 study *(Table 8)*.

Table 8: Comparing finding statements in Lawrence and Krausman's Tucson study and those derived from PUCP's data. Statements in which PUCP's data had relatively many and semantically comparable codes to main findings in the Tucson study were rated as more equivalent.

Tucson, AZ (Population Size: 60)	**Portland, OR**	
Main Findings	**Best Equivalent**	**Equivalency**
"Overall, 29.3% of respondents in 2007 considered coyotes to be a nuisance"	138 (24.4%) attitude codes described concern over risks posed by coyotes	Medium
"Similar responses were observed among owners of cats (40.0% of respondents) and those that did not own cats (x2 5 0.43, df 5 2, P 5 0.803); 29.2% of owners of cats and 29.4% of those that did not own cats considered coyotes a nuisance."	6 (46%) respondents with a cat at the time of a sighting, who expressed their opinion, added a negative comment about coyotes, while 190 (43%) of respondents without a cat, who chose to add their opinion, added a negative comment about coyotes.	High
"Respondents that owned dogs (55.0%) were only slightly more likely to consider coyotes a nuisance (31.3%), compared to those that did not own dogs (26.9%)."	25 (46%) respondents with a dog at the time of a sighting, who expressed their opinion, added a negative comment about coyotes, while 189 (43%) respondents without a dog who expressed their opinion added a negative comment about coyotes.	High
"Most respondents in 2007 reported that they did not believe that they were threatened by coyotes (85.3% in Colonia Solona and 76% in El Encanto)."	While only 6 (.2% total) respondents expressed concerns that coyotes might harm adult humans, 138 (24.4% attitude responses) expressed concern over potential harm to animals, children, or people.	Medium

"Respondents that did not report believing they were threatened by coyotes were more likely to ignore or remain quiet and watch coyotes (86.6%), compared to 43.8% that believed that they were threatened by coyotes."	**Not possible to make meaningful statistics using NOT criteria**	**None**
"Overall, 33.3% of respondents reported being approached or followed by a coyote."	75 (2.8% total) of respondents recounted a coyote following, circling, or approaching.	Low
"More respondents that reported being followed or approached by a coyote, compared to those that were not, were threatened by coyotes (36.8 versus 10.0%) and reported that coyotes were a nuisance (50.0 versus 18.4%)."	Only 3 (.1% total) respondents reported being followed by a coyote and also mentioned feeling threatened by coyotes in the same comment. 91 (3.4% total) respondents who did not mention being followed reported that they were threatened by coyotes. 3 (.1% total) of 5 (.18% total) respondents that reported being followed by a coyote also included a negative comment about coyotes.	Low
"Residents were asked to identify the activity they were engaged in when approached or followed by coyotes. Most (45.0%) were walking or jogging with a dog, followed by 29% who were walking or jogging without a dog."	27 (1% total) respondents who were walking a dog also reported being followed or circled by a coyote.	Low
"Most respondents in 2007 (45.8%) reported seeing coyotes in their neighborhood 11-50 times/year."	351 (13%total) respondents mentioned seeing at least one other coyote than the one mentioned in the sighting	Low

For each main finding in Lawrence and Krausman's 2011 study, I assessed whether I could create a similar statement using only coded PUCP data, and to what subjective degree (Low/Medium/High) PUCP data rivaled the other study in quality and data volume. One year of PUCP's response database was comparable to 4 of the 9 primary findings from Lawrence and Krausman's survey at a medium or high level. PUCP's respondents were less likely to comment on very specific phenomena, such as

their own walking or running pace, than those who were specifically questioned about this via survey in Lawrence and Krausman's study. While PUCP's database is an excellent platform from which to make statements about phenomena that respondents are likely to comment on, it cannot match standard survey designs for studying situations in which the absence of some condition is a desired finding. A PUCP respondent who does not mention that a coyote followed them home, for example, might have been followed by a coyote nevertheless. When analyzing multiple conditions, a similar, if less problematic, issue can present itself. If a respondent reports, for example, that their hazing behavior was effective at deterring a coyote, researchers would be wrong to assume that the respondent was not with a dog at the time of the sighting, and therefore less likely to trigger aggression.

It is possible to make meaningful statements with citizen science data by sorting coded data into subcategories. Since PUCP aggregates a large amount of data continuously over time, data that is separated into subcategories form what are essentially "mini-surveys." For instance, take 100 respondents who have related their attitudes toward coyotes and are answering the questions "did you see a coyote?" and "if so, how did you feel about the coyote?" If 50 of these respondents give a single, objectively positive attitude statement, and 50 give a single, objectively negative statement, then the conclusion "half of attitude related comments were positive in nature, and half of attitude related comments were negative in nature" is an accurate, valid survey result. In short,

while obtaining specific information regarding the absence of a condition (without asking respondents to provide it) is not an appropriate use of PUCP or citizen science in general, while compiling freely offered data on a broad spectrum of related phenomena is an appropriate use of this technology.

Denver, Colorado

As reviewed in chapter 1, hazing is a frequently recommended treatment for coyote encounters that violate human space. In 2013, Mary Ann Bonnell and Stewart Breck's research in Denver, Colorado assessed the effectiveness of hazing coyotes, using a volunteer based citizen science model, in which, over one year, the researchers trained 207 citizen scientists to haze coyotes that were behaving in a way they deemed inappropriate or intruding upon residential space (Bonnell and Breck 2017). Hazing was generally very effective at causing coyotes to retreat, and most coyotes fled greater than 10 feet from citizen scientist hazing recruits. The presence of a volunteer's dog significantly reduced the instances of effective hazing, as did the presence of a nearby den. Since I coded PUCP's data specifically for hazing behavior, I have decided to examine the effectiveness of hazing based on 110 such instances in the year I reviewed. I defined hazing as any deliberate attempt, using light, sound, motion, or aggressive action, such as throwing something, to cause a coyote to leave an area.

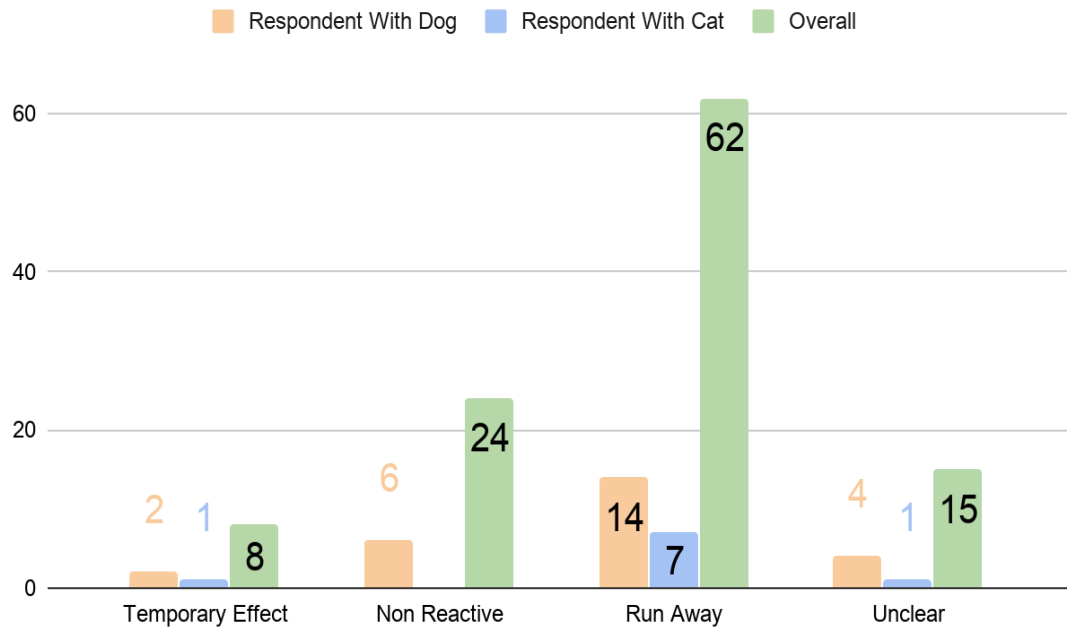


Figure 21: Count of coyote responses to hazing, featuring a relative count of instances in which a pet was present

Over the coding period for this project, hazing Portland coyotes appeared to be effective at causing coyotes to leave an area during most encounters *(Figure 21)*. During 62, or 57% of encounters where a respondent used hazing as a deterrent, the coyote or coyotes apparently fled the immediate area and did not return. This percentage was slightly less (n= 14, 54%) when a respondent described being with a dog at the time, and (n=7, 40%) when a respondent was with a cat. These responses were, however, far less common than descriptions of hazing alone. Coyotes were mostly unreactive in 24, or 21.8% of hazing instances, 6 (5%) of which involved a pet dog, and none of which involved a cat. These results are generally in line with Bonnell and Breck's Denver study.

Hazing was clearly effective in a moderate number of cases in both studies. While the Denver team's data suggested that the presence of a dog was more influential on coyote behavior than in the PUCP data, both showed a slight decrease in the effectiveness of hazing when a dog was present. Where the intent of Bonnell and Breck's work was to educate the public on hazing tactics, PUCP respondents were, as a function of their reporting, already aware of hazing as a tactic (Bonnell and Breck 2017).

Because human and coyote behavior, as well as respondents' levels of descriptiveness varied widely in PUCP responses, it was difficult to assess whether specific actions, such as yelling, or throwing something at coyotes was a more effective deterrent. While hazing generally appeared to cause coyotes to leave an area, plenty of respondents described incidents in which a coyote either returned later or would not leave an area. During only one encounter in which a coyote returned after being shooed away did the respondent attribute this behavior to a coyote eating and subsequently returning to a kill. These incidents are probably legitimate cases of habituation, which should be taken seriously. Although there were too few instances of hazing in the Portland data to determine whether hazing was significantly less or more effective when a pet was present, PUCP's hazing data, and Bonnell and Breck's findings suggest that the presence of a pet might diminish the effectiveness of hazing somewhat.

While many respondents seemed to understand either intuitively or through effective education that hazing is an appropriate response to a coyote encounter, others

were less well informed regarding other actions that influence coyote behavior. For example, both deliberate and accidental feeding may stem from different fallacious assumptions regarding urban wildlife, as noted in these comments made by respondents. Both can exacerbate the process of habituation:

> Respondent 3941: Great site! I keep my cat inside from dusk til [sic] dawn due to the coyote activity in the area. Also, can I feed them?? :) Haha. Not sure if that's a serious question or not, but Maybe help to keep them away from our kitty cats and small dogs??
>
> Respondent 4732: He trotted through our backyard and was in the process of moving up onto our patio sidewalk when I opened the window and yelled at him to scare him off. He seemed to be particularly interested in the wildlife activity happening around our bird feeder. However we have a very small dog and it could have been looking for it. We have no fencing and live in an area with lots of trees and easy access to Woods Creek.

If nothing else, these comments illustrate just how unintuitive many basic concepts in wildlife management can be. While feeding coyotes deliberately is certainly an invitation for trouble, some degree of accidental feeding is inevitable in a city the size of Portland. Research has shown that education campaigns can significantly reduce conflict between humans and coyotes (Gehrt 2010, 16-17). From my selection of PUCP's data, it is clear that PUCP is capable of both uncovering and addressing problematic behaviors. The many individuals who regularly interact with PUCP's webpage are likely to internalize

the information presented there and convey that information to others. Perhaps this fact alone justifies PUCP's continued existence.

Chapter 4: Portland in the Context of Citizen Science

Limitations and Suggestions

Citizen science is not always a perfect solution for aggregating scientific data. The geographic component of PUCP adds a level of complexity to accurate citizen reporting. As I have described in more detail previously, the geographic accuracy of PUCP sightings is dependent on two factors: first, the respondent must successfully encode into memory and recall the location of a sighting. Second, the geocoding service in question must successfully recognize and locate the respondent's language as a real location. There are almost certainly sightings in this dataset that have been geocoded incorrectly, perhaps some unacceptably so. While Google Maps and other services are becoming increasingly reliable for this sort of work, PUCP relies on textual descriptions of locations, so this will always add some degree of geographic inaccuracy. The same can be said for the semantic content of text submitted by respondents in response to the questions "what was the coyote doing when you saw it?," and "questions, comments?" Emotionally descriptive text is largely open to interpretation. Some remarks were almost certainly sarcastic or tongue-in-cheek, but this was hardly safe to assume in every case. The PUCP model is fortunate in that it does not rely extensively on a user's ability to identify species, as other citizen science efforts often do. Coyotes are generally distinct from other species, and, as we have seen, it appears that self-reported misidentifications were extremely uncommon in the sample year.

Obviously, coyotes do not occur as points in space and time. Respondents occasionally provided details of encounters with coyotes that spanned wide distances of both time and space. Often multiple sightings described a single coyote or incident. This can be confusing to members of the public new to citizen science mapping projects. It might, therefore, be useful for future citizen science and coyote projects to experiment with heat maps, which may represent the frequency of wildlife encounters better than the point data that is currently standard.

It is important for both researchers and the general public to understand that spikes in sightings that are apparent during various periods do not necessarily indicate an increase in coyote populations, coyote activity, conflict, or any other biological patterns. At several points during this project, I even found myself forgetting this. Participation in PUCP is, first and foremost, a human phenomenon. The subjects of PUCP are PUCP respondents, not coyotes. In order to remain effective, citizen science projects like PUCP must maintain a relatively consistent rate of participation, or risk data becoming geographically or otherwise biased beyond an acceptable level. PUCP is not a random sample of a selection of citizens, nor is it a biogeographical mapping service for Northwest coyotes. PUCP is a citizen science project that Portland citizens willingly participate in, providing valuable details about coyote encounters that would otherwise be obscured by the fog of human separation.

Citizen science has previously been used to study air quality, watersheds, avian diversity, and innumerable other subjects. Several notable researchers, including Cathy Conrad and Krista Hilchey (2011), have pointed out that there is a lack of awareness in the scientific community as to the characteristics of successful versus ineffective citizen science or community-based monitoring (CBM) projects. Often, they caution, both decision making and academic bodies mistrust citizen-based data collection. The data used in projects like PUCP should be able to withstand the criticism that it is likely to be subjected to both in and out of academia. As others have already concluded, "monitoring for the sake of monitoring" is not an automatically worthwhile venture, since it is most important to first ensure that citizens are collecting the "correct" data (Conrad and Hilchey 2011, 281). While PUCP largely sidesteps these risks by asking very little of respondents, it is still critical that the limitations of citizen science be understood by readers of this project.

Utility

PUCP is a spotlight into the previously little-known world of humans' relationship with an intelligent species of urban carnivore in Portland. Thus far, evidently, citizens have been more than happy to participate, and clearly feel that they are doing some good by doing so. The relationship between citizen users and researchers is reciprocal. As Zuriel Van Belle (Rasmussen) periodically updates the PUCP webpage

with new data and information, citizens are able to observe the fruits of their contributions. The potential utility of PUCP for continued human-coyote research is impressive. While certainly credible, other research studies on urban coyotes have been performed using a fraction of the data of PUCP. Coyotes are an important species for studying the human-wildlife interface because their extirpation is virtually impossible. Humans who must deal with their existence will inevitably develop beliefs and perform behaviors in response to coyotes that reflect the particular circumstances of the individual in question, as well as larger physical and social patterns. There is, however, no reason that this brand of citizen science should not be exported to study other fascinating and dynamic urban species, such as urban foxes in Northern Europe, or golden jackals in Southern Europe (Krofel et al. 2017).

Portland

Portland's coyotes, while still coyotes, behave in a way that reflects the particulars of the environment of Portland, Oregon. Some of these behaviors have been surprising, and some seem to fit well with preexisting knowledge about coyotes. Portland coyotes moved throughout the city during times that suggested an overall pattern of avoiding humans. Coyotes did interact with and occasionally attack pets, but these instances were relatively uncommon. While coyotes travelled alone frequently, they were spotted

occasionally in groups of varying sizes. Coyotes ate a variety of foods and traversed a variety of land cover types, while relying on extensive Portland vegetation for cover.

Portland's citizens were quite supportive of both PUCP and the presence of coyotes in nature. Some citizens did seem to consider coyotes as non-urban, believing that coyotes should be "relocated" to a more appropriate environment. Respondents engaged with PUCP in a way that seemed to reflect mostly enjoyment and appreciation for having a resource to submit sightings to. Those who chose to vent their frustration through PUCP were often reacting to a personal loss, rather than simply criticizing PUCP's design. Citizens appeared to be more than capable of holding two simultaneous feelings of annoyance and appreciation for coyotes. While many seemed to carry an exaggerated sense of the risks posed by coyotes, exercising some degree of caution when deciding whether to leave pets and small children unattended is probably wise.

There are presently at least 7,000 sightings that have not been coded in PUCP's database. As more citizens participate, this number will continue to increase. This smaller sample review that I conducted has been sufficient to give an understanding of how Portland residents use PUCP, and how future research using PUCP's data can best be directed. The data I have compiled mostly supports other research. The comparisons I have made between this dataset and the Tucson, AZ study was not able to show directly that peoples' reactions to coyotes are consistent between both locales; however, similarities between the two suggest this may be the case. Some of the conclusions from

Lukasik's work in Calgary were consistent with my brief analysis in Portland. Perhaps more rigorous GIS analysis, or continued coding will provide more insight into whether this is the result of actual differences in human-coyote interactions. Hazing coyotes as a deterrent seems to be similarly effective in Portland as it has been in Denver, CO. While Portland residents were less likely to be with a dog at the time of an encounter, both studies on hazing suggest that the presence of a domestic animal may have an influence on the boldness of urban coyotes. There are sure to be certain unknowable influences that affect the overall character of coyote encounters in Portland. Weather, social leanings, city layout, unnatural lighting and many other factors are likely to influence how people and coyotes interact. Despite a few shortcomings, PUCP is poised to uncover many more truths regarding the human-wildlife interface in urban Portland.

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Appendix A: Coding
Response codes reported to PUCP, December 2016 to December 2017

Coyote Behaviors:

Behaviors, including respondent's interpretation of coyote(s)' intent

AGGRESSIVE TOWARD CAT
AGGRESSIVE TOWARD DOG
CARRYING CAT
CARRYING DOG
CARRYING RABBIT
CARRYING RAT
CARRYING SQUIRREL
CAT INJURED
CAT INJURED (PREVIOUSLY/NOT WITNESSED)
CAT/CATS LEFT OUTSIDE
CHASING CAT
CHASING COYOTE
CHASING SQUIRREL
CHASING UNKNOWN
COYOTE AGGRESSIVE TOWARD CAT
COYOTE AGGRESSIVE TOWARD DOG
COYOTE AND MY DOG PLAY REGULARLY
COYOTE ATTACKS CAR
COYOTE ATTACKS CAT
COYOTE ATTACKS DOG
COYOTE ATTACKS RACCOON
COYOTE CHASES CAT
COYOTE CHASES CHICKEN
COYOTE CHASES COYOTE
COYOTE CHASES DOG
COYOTE CHASES OPOSSUM
COYOTE CHASES SQUIRREL
COYOTE DROPS DOG
COYOTE FLEES CAR
COYOTE FLEES CHILDREN
COYOTE FLEES CROWS
COYOTE FLEES DOG
COYOTE FLEES HUMAN
COYOTE FLEES RESPONDENT

COYOTE FOLLOWED BY STRAY DOGS
COYOTE IGNORES CAT
COYOTE IGNORES DOG
COYOTE IGNORES RESPONDENT
COYOTE KILLS CAT
COYOTE KILLS CHICKEN
COYOTE KILLS DOG
COYOTE KILLS RACCOON
DEFENSIVE/GROWLING/HAIR RAISED
DOG ATTACKED (PREVIOUSLY/NOT WITNESSED)
DOG INJURED
DOG KILLED (PREVIOUSLY/NOT WITNESSED)
EATING BIRD
EATING CAT
EATING CHICKEN
EATING DEER
EATING FRUIT
EATING PET FOOD
EATING RODENT
EATING SQUIRREL
EATING TRASH
EATING UNKNOWN
HUNTING BIRDS
INTERACTING WITH/INTERFERING WITH TRAFFIC
INTEREST IN CAT
INTEREST IN CHICKEN COOP
INTEREST IN DEER
INTEREST IN DOG
INTEREST IN SMALL CHILD
INTEREST IN WATERFOWL
INTERFERING WITH TRAFFIC
KILLING DOG
PETS KILLED (PREVIOUSLY/NOT WITNESSED)
RACCOONS CHASE COYOTE
VOCALIZING NON HOWLING
WAITING FOR CARS/NOT INTERFERING WITH TRAFFIC
AGGRESSIVE TOWARD CHICKENS/FOWL
ATTACKING CHICKEN COOP
ATTACKING RABBIT COOP
CARRYING CHICKEN
CARRYING NON ORGANIC

CARRYING UNKNOWN
COYOTE CAUGHT IN LEGHOLD TRAP
CRAWLING UNDER OBJECT
DIGGING
DRINKING
EATING
FOLLOWS/CIRCLES RESPONDENT
HUNTING/STALKING
JUMPING
LICKING SELF
LIMPING/INJURED
LOOKING THROUGH GARBAGE
LOOKING THROUGH TRASH
LURKING/SNOOPING
LYING/LOUNGING/LAZY
PEEING
PHYSICALLY DESTRUCTIVE
PLAYFUL/PLAYING
POOPING
POUNCING/HUNTING SMALL
ROLLING
RUNNING
SCENT MARKING
SCRATCHING
SITTING
SNIFFING
STANDING/STARING
STRETCHING
TROTTING
WALKING
WANDERING/AIMLESS

Attitudes:

Respondent attitudes, opinions, beliefs, emotions

BELIEVE COYOTES UNAFRAID OF PEOPLE
BELIEVE FEWER COYOTES/FEWER SIGHTINGS LATELY
BELIEVE MORE COYOTES/MORE SIGHTINGS LATELY
BELIEVE SAME COYOTE AS BEFORE

CONTACTS ANIMAL CONTROL
COOL/AMAZING/FASCINATING
COYOTES CAUSE TRAFFIC PROBLEMS
COYOTES CONTROL DEER
COYOTES CONTROL OUTDOOR CATS
COYOTES CONTROL RATS/MICE
COYOTES IN TROUBLE/HABITAT DESTRUCTION
COYOTES IN TROUBLE/STARVING/HABITAT LOSS/THEY WERE HERE FIRST
COYOTES SHOULDN'T BE IN CITIES
CREEPY/SCARY
CUTE/BEAUTIFUL COYOTE
DISEASE VECTOR
FEAR FOR CATS
FEAR FOR CHILDREN
FEAR FOR DOGS
FEAR FOR HUMANS
FEAR FOR PETS
FUN/EXCITING
HATE COYOTES
HAVEN'T HAD ANY ISSUES WITH ANIMALS YET
LIKE/LOVE COYOTES
MENTION ANIMAL KILLINGS NEUTRAL
SHOULDN'T BE OUT DURING THE DAY
SPECULATE DISEASE VECTOR
SPECULATE DISPLACED BY CONSTRUCTION
SPECULATE FEEDING ON CATS
SPECULATE HABITUATED/MORE AGGRESSIVE
SPECULATE LURED BY CAT FOOD/OUTDOOR FEEDING
SPECULATE LURED BY RODENTS
SPECULATE LURED BY TRASH
THEY WERE HERE FIRST
UNSURE WHY OTHERS FEEL NEGATIVE
WONDER IF SIGHTING SHOULD BE REPORTED TO CITY
WORRIED ABOUT COYOTE
CONCERN GENERAL
EXPRESS FRUSTRATION
EXPRESS SUPPORT
SEE MORE COYOTES DURING SPRING
SPECULATE GOOD HABITAT
SPECULATE KILLING/DISPLACING OTHER WILDLIFE

SUPPORT LETHAL CONTROL
SUPPORT NEUTERING
SUPPORT NONLETHAL REMOVAL
SUPPORT REMOVAL
SURPRISING

Coyote Appearance:

SPECULATE MANGE
DISHEVELED
HEALTHY COYOTE
JUVENILE COYOTE
LARGE COYOTE
MEDIUM COYOTE
PUP/PUPS
SCRAWNY/UNHEALTHY
SKINNY COYOTE
SMALL COYOTE
SPECULATE GENDER
SPECULATE MANGE/SICK/SOMETHING WRONG
SPECULATE MATED PAIR
SPECULATE PREGNANT
TAIL MISSING/SHORT

Speculate About Coyote:

ADULT COYOTE
FOLLOWED BY CAT
FOLLOWED BY CROWS
SPECULATE LOOKING FOR FOOD
SPECULATE ROADKILL
SPECULATE SAME COYOTE AS BEFORE
SPECULATE TRAPPED
UNCERTAIN ID

Location:

Non-mutually exclusive categories of terrain traversed by coyote

AT GAS STATION
IN AGRICULTURAL AREA

IN BUSHES
IN CEMETARY
IN DRIVEWAY
IN FIELD/OPEN AREA
IN HIGHWAY/SHOULDER
IN INDUSTRIAL AREA NON VEGETATED
IN PARK
IN PARK/GOLF COURSE/GREEN SPACE
IN PARKING LOT
IN SIDEWALK
IN WETLAND AREA/CREEK/RIVER
IN WOODED/WILD/UNMANAGED AREA
IN YARD
INSIDE BUILDING
ON HIGHWAY/SHOULDER
ON SIDEWALK
ON TRAIN/TRANSIT TRACKS

Den:

DEN
DEN ON PROPERTY
SPECULATE DEN
SPECULATE DEN/LIVING SPACE

Respondent Behaviors:

Behaviors, including communication by a respondent or a member of the respondent's immediate network

DOG AGGRESSIVE TOWARD COYOTE
DOG APPROACHES COYOTE
DOG BARKS AT COYOTE
DOG CHASES COYOTE
DOG FLEES COYOTE
PEPPER SPRAYS COYOTE
SHOOTS AT COYOTES
RESPONDENT FLEES COYOTE
RESPONDENT HAZES COYOTE
RESPONDENT VOWS TO SHOOT COYOTES
OFFER SERVICES

REQUEST MORE INFORMATION ON COYOTES/ASK QUESTION
RESPONDENT IN VEHICLE
RESPONDENT ON BIKE
TAKE/OFFER PHOTOGRAPH/VIDEO

Respondent Suspects Coyote:

CAT KILLED (PREVIOUSLY/NOT WITNESSED)
CAT MISSING
CHICKENS MISSING
CHICKENS/FOWL KILLED (PREVIOUSLY/NOT WITNESSED)
DOG MISSING

Respondent With:

At the time of a sighting, an animal or child was outdoors

RESPONDENT WITH CAT
RESPONDENT WITH CHICKENS/FOWL
RESPONDENT WITH CHILD
RESPONDENT WITH DOG

Speculate Coyote Emotion

CONFIDENT/CASUAL
CONFUSED
COYOTE CALM/UNFAZED
CURIOUS COYOTE
FRAZZLED/SPOOKED/ANXIOUS
SPECULATE AVOIDING HUMANS
SPECULATE BORED
SPECULATE CONFUSED/LOST
SPECULATE HAPPY
SPECULATE HUNGRY/DESPERATE
SPECULATE INTENTFUL

Coyote Sign:

Any instance in which a respondent noted that they had not seen a live coyote directly, but found evidence that one had been at the location of sighting

DEAD COYOTE FOUND
FOUND DEAD SQUIRREL
FOUND PRINTS
FOUND SCAT
HEARD APPARENT FIGHT
HEARD HOWLING/YIPPING
SCAT
TRACKS FOUND
TRAIL CAM/UNMANNED CAMERA

Perceptions:

Subjective sensory experiences noted by respondents

FIRST MISTOOK FOR DEER
FIRST MISTOOK FOR DOG
FIRST MISTOOK FOR DOG
FIRST MISTOOK FOR WOLF
HARD TO SPOT
HEARD PRESUMED GUNSHOT
SPECULATE COYWOLF

Respondent Details:

LARGE DOG
MEDIUM DOG
SMALL DOG
AVID NATURE WATCHER

Environment:

IN SNOW

Other:

GIVES COORDINATES
INSUFFICIENT INFORMATION
MENTIONS MULTIPLE SIGHTINGS
SECOND HAND SIGHTING

Proximity:

CLOSE TO MANY PEOPLE
MANY PEOPLE PRESENT

Appendix B: Word Frequency

Approximate frequency of 50 most common words (non article or number) within the review period of December 2016 to December 2017

Word	Frequency	Word	Frequency
Coyote	2372	**Trot**	372
Street	1196	**Side**	369
Walk	1163	**Stop**	362
Down	882	**Cat**	344
Look	785	**Front**	342
Dog	706	**Away**	340
Yard	705	**Seen**	336
Run	641	**Sight**	313
Up	621	**Turn**	312
One	606	**Sidewalk**	309
Saw	565	**Area**	307
Around	506	**Middle**	298
Out	502	**Through**	296
Back	496	**South**	294
Toward	480	**North**	294
Ran	455	**Seem**	285
Two	425	**Very**	284
Car	417	**West**	265
Cross	405	**East**	265
House	397	**Neighborhood**	257
Park	393	**Went**	244
See	387	**Neighbor**	242
Time	373	**Stand**	239
Head	373	**Go**	226
Road	373	**Watch**	220