**Spatial, Temporal and Contextual Predictors of Conflict with Urban Coyotes from a 10-Year Community Reporting Database**

***499 Final Paper – April 29 2021***

*JJ Farr, MJ Pruden, R Glover, S Sugden, MH Murray, HW Harshaw, CC St. Clair*

**ABSTRACT**

In cities throughout North America sightings of coyotes (*Canis latrans*) have become common, and reports of human-coyote conflict are rising. Also increasing is the public demand for proactive management to prevent conflict, but achieving that requires more information about the spatial, temporal and contextual correlates of conflict and how they are changing over time. An important source of this information is the direct observations of citizens who may report both coyote behaviour and their perceptions of their interactions with coyotes. We used a web-based reporting system to collect *N* = 7,872 reports of coyotes that were voluntarily submitted in the city of Edmonton, Alberta, between January 2011 and December 2020. Each report contained the time and date of the sighting or interaction, the location, and 95.4 % also contained optional comments. We developed a standardized classification method to extract further information from the comments including the coyote response to people, human perception of coyotes, the human activity occurring at the time of the interaction, and the presence or mention of pets or children, which we defined as vulnerable individuals. We used ordinal regression to determine the effect of several spatial, temporal and contextual variables on the likelihood interactions occurring that were suggestive of conflict, as measured by both the boldness of coyote responses to humans and negative human perceptions of coyotes. With both measures of conflict, we found that conflict was more likely in modified open, mowed and residential areas, and during the pup-rearing season. Reports that mentioned pets or children were more likely to describe negative interactions. Over the 10 years of reporting, descriptions of coyote behaviour increased on our boldness scale, while human perceptions became less negative. This combination suggests that humans and coyotes are habituating to one another with increased tolerance of coyotes in Edmonton. Our results provide important information for proactive management actions to prevent conflict, including public education about protecting pets, preventing food-conditioning of urban coyotes, and using aversive conditioning to increase wariness of coyotes in residential areas.

**INTRODUCTION**

Urban landscapes are inhospitable for many animal species, but some survive and thrive in cities and suburbs, intertwining their lives with those of humans (Schell et al. 2020). In North America, well-known examples of such species include Racoons (*Procyon lotor*), House sparrows (*Passer domesticus*) and Norway rats (*Rattus norvegicus*; McKinney 2006; Bateman & Fleming 2012). These synanthropic species are highly adaptable and have undergone population expansions even as the global increase of urbanization diminishes biodiversity and displaces other species (Foley et al. 2005; McKinney 2006). Most large carnivore species have experienced substantial range contractions because they cannot persist alongside high densities of humans (Woodroffe 2000). One exception to this pattern is the coyote (*Canis latrans*), which has emerged as a highly successful carnivore that flourishes in urban environments throughout North America characterized by frequent interactions with humans (Bateman & Fleming 2012; Hody & Kays 2018).

Increasing populations of urban coyotes are associated with an extensive range expansion across North America since the early 1800s following human land-use changes and mesopredator release associated with the widespread extirpation of wolves (*Canis lupus*; Gompper 2002; Prugh et al. 2009; Hody & Kays 2018). Even densely populated cities attract coyotes, which are now well-known as an urban exploiter (McKinney 2006; Bateman & Fleming 2012). Coyote success in urban areas is attributed partly to their behavioural plasticity that allows them to occupy home ranges of highly variable sizes with minimal amounts of naturally vegetated habitat, and to increase their nocturnal activity to avoid periods of high human activity (Grubbs & Krausman 2009; Gese et al. 2012; Poessel et al. 2016). Coyotes are also omnivorous with remarkable breadth of natural diets (Andelt et al. 1987), with the capacity to consume many kinds of anthropogenic food resources including urban compost and garbage (Murray et al. 2015a; Murray et al. 2016), fruit from ornamental trees (Fedriani et al. 2001), and free-roaming pets (Nation & St. Clair 2019). Another contributor to coyote success in urban environments is shifting public perceptions towards a greater acceptance of coyotes and reduced approval of lethal population control (Lawrence & Krausman 2011; Jackman & Rutberg 2015; George et al. 2016).

Interactions between urban coyotes and people are usually benign and the vast majority occur without any conflict (Drake et al. 2021). Urban coyotes also provide several benefits to humans by controlling rodent and smaller mesopredator populations to increase urban biodiversity (Crooks & Soule 1999), scavenging animals that died from other causes (Fox 2006), and providing aesthetic enjoyment (Soulsbury & White 2015). Up to 52% of city-dwellers accept or desire the presence of coyotes in urban areas (Soulsbury & White 2015). However, negative interactions between humans and coyotes attract considerable media attention (Alexander & Quinn 2011), and there has been an apparent increase in human-coyote conflict in cities and suburbs across North America over the past decade or more (Baker & Timm 2017; Poessel et al. 2017a).

Human-coyote conflict occurs when coyotes pose real or perceived threats to the well-being of humans or their pets. In cities, factors related coyotes and other wildlife that affect conflict include behaviour, health, and exploitation of human resources, whereas factors related to humans that affect conflict include attitudes toward wildlife, activities and behaviours (Schell et al. 2020).

Although human-coyote conflict includes the spread of zoonotic diseases (Catalano et al. 2012; Luong et al. 2020) and property damage (Glas et al. 2019), its most common manifestation is the risk that coyotes pose to the safety of humans and their pets (White & Gehrt 2009). Coyote attacks on pets and humans are uncommon, but appear to be increasing (White & Gehrt 2009; Baker & Timm 2017). Coyotes sometimes eat outdoor cats and small dogs (Poessel et al. 2017b; Nation & St. Clair 2019), and may behave territorially towards both cats and dogs, leading to attacks (Gehrt et al. 2013; Poessel et al. 2017b). Attacks on pets can endanger pet owners who may be bitten while intervening (Poessel et al. 2013) and these attacks can lower tolerance of the public towards (Draheim et al. 2013). Direct coyote attacks on humans are extremely rare, but attacks pm children are typically predatory and often cause serious injury (Carbyn 1989; White & Gehrt 2009; Baker & Timm 2017). Attacks on humans are the most severe form of conflict, and can generate substantial media attention and degradation of public tolerance towards urban coyotes (Alexander & Quinn 2011; Draheim et al. 2019).

Human-coyote conflict is often measured retroactively from attacks (White & Gehrt 2009; Baker & Timm 2017; Poessel et al. 2017a), but conflict potential can also be proactively assessed from coyote behaviour or the perceptions of people. Conflict-prone coyote behaviour could include increased boldness or aggression towards humans and their pets (Baker & Timm 2017). In general, urban coyotes exhibit behaviours that increase their odds of conflict relative to rural animals (Breck et al. 2019), likely from repeated interactions with humans (Schell et al. 2018; Young et al. 2019), reduced human persecution (Kitchen et al. 2000), and anthropogenic food conditioning (Murray et al. 2015a). Conflict potential also relates to the risk people perceive of injury to themselves, children, or pets. Although these perceptions may not always align with the actual risk of an attack based on coyote behaviour, they can indicate public tolerance towards coyotes, and, subsequently, acceptance of various forms of wildlife management and policy (Sponarski et al. 2018; Draheim et al. 2019). Human perceptions of risk are affected by past encounters with coyotes, previous knowledge of pet or human attacks, and broader wildlife value orientations (Draheim et al. 2013; Sponarski et al. 2016; Drake et al. 2020). Understanding changes in coyote behaviour towards humans and the human perception of coyotes enables proactive conflict mitigation, instead of limiting management to responsive action after attacks (Baker & Timm 2017).

To proactively mitigate the real and perceived risks of coyotes to humans, knowledge of the spatial, temporal and contextual variables that contribute to its occurrence is also essential. Identifying spatial variables that predict negative interactions between humans and wildlife enables targeted proactive management in high-risk areas (Delsink et al. 2013; van Bommel et al. 2020). Likewise, understanding when negative encounters are most likely to occur at diel, monthly, and inter-annual scales, is imperative for conflict mitigation (Morehouse & Boyce 2017; Soulsbury 2020). Contextual variables that interact with spatial and temporal variables to influence the odds of conflict include the presence of pets or children, the number of coyotes, and the health status of individual animals (Poessel et al. 2013; Olson et al. 2015).

Over the past decade, public reports of coyote sightings and encounters have emerged as an invaluable source of information for researchers studying the spatial, temporal and contextual variables associated with human-coyote conflict. This information source allows researchers to conduct otherwise difficult long-term studies over large geographic areas while simultaneously engaging and educating members of the public (Weckel et al. 2010; Frigerio et al. 2018). Voluntary reports of coyote activity have been collected through websites (Wine et al. 2015; Mowry et al. 2020), city reporting databases (Lukasik & Alexander 2011; Poessel et al. 2013), public surveys (Weckel et al. 2010), and apps (Mueller et al. 2019; Drake et al. 2021). Studies resulting from analyses of these datasets have focused largely on the broad patterns in reports and have identified temporal trends in reporting as well as socioeconomic and landscape factors associated with their occurrences (Weckel et al. 2010; Wine et al. 2015; Mowry et al. 2020). In Calgary, Alberta, Lukasik and Alexander (2011) found that most negative incidents were associated with high-density neighborhoods and the city’s river valley corridor, and occurred during the pup-rearing season (May – August). In both Calgary and Edmonton, Alberta, anthropogenic food consumption was a key correlate of increased conflict (Lukasik & Alexander 2011; Murray et al. 2015a). In Madison, Wisconsin, Drake, Dubay and Allen (2021) identified road distance, seasonality and time of day as important factors predicting distance between humans and coyotes, which they interpreted as a proxy for conflict (Drake et al. 2021).

In this study, we used reports collected from an online database to ask three questions pertaining to human-coyote interactions in Edmonton, Canada from 2011 to 2021. Based on the information in reports, we categorized two indicators of human-coyote conflict: the boldness of coyote behaviour towards people and the human perception of threat posed by coyotes. First, we asked if coyote boldness and human perceptions were affected by spatial (habitat, distance to roads, building density), temporal (season, time of day) and contextual factors (human activity type, presence or mention of vulnerable activity, number of coyotes, coyote health). Our second question was whether coyote boldness or human perceptions had changed over the ten years of report collection. Finally, we asked which spatial, temporal and contextual variables were associated with any long-term changes in apparent conflict.

**METHODS**

**Study area**

Our study took place in the city of Edmonton, Alberta, Canada (53.54728oN, 113.50068oW), which is large in both area (684 km2) and population (976,223 in 2019 census; City of Edmonton 2019). Edmonton’s climate is characterized by warm summers (Jun-Aug daily average = 16.7°C) and cold winters (Dec-Mar daily average = -9.7°C;

Environment and Climate Change Canada 2018). Edmonton is located within the central parkland natural subregion – an area composed of productive agricultural lands interspersed with wetlands and mixed forests of aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and spruce trees (*Picea spp*; Natural Regions Committee 2006). The city is bisected by the North Saskatchewan River valley and several large ravines, which form a network of minimally developed natural areas (Figure 1).

**Report collection and classification**

We used a web-based platform launched in July 2010 to collect voluntarily submitted reports of coyotes from members of the general public on the Edmonton Urban Coyote Project website (<https://www.edmontonurbancoyotes.ca/reportsighting.php>). We promoted the website during media interviews, public lectures, and social media posts, through word of mouth, on labels attached to wildlife cameras in the city, and via a link to the website on the City of Edmonton website (<https://www.edmonton.ca/residential_neighbourhoods/pets_wildlife/Coyotes.aspx>) that was added in 2019. Fields in the reporting form included the date, time of day, type of report, nearest intersection to the report location, additional comments, and the reporter’s name and contact information. We also included a Google EarthTM interface with a prompt for the reporter to precisely locate the report by placing a pin on the map. The coordinates for 3,366 reports (36.7%) were missing from the map interface and were instead assigned post-hoc using Google MapsTM based on the reported nearest street intersection and information in the comments (i.e. if a specific park or building was named). To encourage participation, no registration or login was required, and we identified and removed 1,562 spam or duplicate reports.

When submitting a report, users were asked to indicate whether the type of report was a sighting defined as an observation at a distance with no interaction, or encounter, defined as an interaction at close range. Most reports (96.8 %, *N* = 8,859) also included optional comments with further details about the human-coyote interaction, so we developed a Google Form to categorize this information. We used the classification form to categorize the two response variables that are indicative of human-coyote conflict: coyote boldness towards people and the human concern of coyotes. We classified coyote boldness into nine coyote response categories that we binned into a four-point ordinal scale ranging from avoidance (e.g., ran away) to aggressive behaviours (e.g., made physical contact, Table 1). For human concern of coyotes, we classified reports on a three-point ordinal scale from positive (e.g., beautiful), to neutral (e.g., curious or not scared), to negative (e.g., scared) emotional responses based on the explicit presence of words from a compiled list that directly relate to human concern (Table 2). We also used the classification form to extract four contextual independent variables: the presence of vulnerable individuals (children, dogs or cats), the human activity occurring at the time of the report (e.g., walking, cycling, driving), the number of coyotes, and coyote health. We assessed the repeatability or report classification between classifiers by randomly selecting and re-classifying five subsets of twenty reports and calculating the percentage of reports that differed between observers.

**Spatial and temporal variables**

To measure spatial variables associated with reports, we first mapped report locations using ArcGIS Pro v2.7 (Figure X). We excluded 256 reports that were located outside of Edmonton city limits or located in recently annexed but undeveloped land outside of the city. We then identified our study area by generating a minimum convex polygon around report locations. We categorized land cover types using geospatial data from the City of Edmonton Urban Planning Land and Vegetation Inventory (uPLVI) database, a high resolution (minimum polygon size = 1 ha) database that uses remotely sensed imagery and Softcopy photogrammetry to identify land cover types for urban land use decisions (City of Edmonton 2018). We categorized six land cover types representing various degrees of human development and coyote habitat quality (Figure S1; Table S1). These land cover types were measured at five scales as the proportional area within a 100, 200, 400, 800 and 1600 m radius circular neighborhood of reports. We measured multiple scales because coyote boldness and human perceptions may be more strongly affected by site-specific conditions (100, 200, 400 and 800m radii; van Bommel et al. 2020) or broader landscape conditions at the approximate scale of urban coyote territories (1600m radius; Murray et al. 2015b; Wine et al. 2015). We applied a centered log-ratio transformation to the compositional land cover variables (Quinn et al. 2019). We also assigned a discrete land cover type to each report as the category with the greatest proportional area within a 100-meter radius. We determined the distance of reports to roads using the City of Edmonton single line street network geospatial database and applied an exponential distance decay function (*e*-*ad*, d = distance to roads, a = 0.002) to transform values exceeding a few hundred meters to zero and confine all values to be between zero (far from road) and one (on road) (Nielsen et al. 2009). Lastly, we determined building density based on the proportional area of building footprints within each of the five scales (Statistics Canada 2019). All spatial variables were measured in raster format with a 10 x 10-meter cell size.

We measured temporal variables at the level of years, months and within a day. Annual trends were assessed based on the year in which report occurred excluding reports from 2010 and 2011 because of minimal reporting. Within years, we used the report date to identify the month and the biological season of coyotes (Morey et al. 2007): breeding (January 1 – April 30), pup rearing (May 1 – August 31), or dispersal (September 1 – December 31). Time of day was submitted by reporters using a drop-down menu with the option to select hourly times between 5 AM and midnight, or one of the following categories: dawn, morning, afternoon, evening or night. We manually categorized time of day into either day (morning, afternoon or any hourly times after sunrise and before sunset) or night (dawn, night, or any times before sunrise or after sunset).

**Statistical methods**

We first assessed spatial, temporal and contextual patterns in reporting based on the distribution of reports across land cover types, years, months, night or day, and contextual variables. For land cover types, we estimated the expected number of reports based on the area of that land cover type within the study area. We then used Pearson’s chi square test to test for differences between the observed and expected number of reports. The limitation of examining overall report distribution is that they are largely driven by the popularity of the reporting website and are strongly influenced by the spatial and temporal biases associated with community reports (CITE). Therefore, we caution against inferring which variables relate to human-coyote conflict based on report distribution.

To assess patterns in coyote boldness and human perceptions while controlling for total reporting frequency, we first calculated the percentage of reports within the ordinal values of each variable across the independent variables of interest. We calculated these percentages from subsets of reports where comments provided sufficient information to classify coyote boldness (N = X) or human perceptions (N = X). We also investigated the relationship between the two response variables, coyote boldness and human perceptions, using Spearman’s ranked correlation test from the *Hmisc* package (CITE) on a subset of reports in which both could be determined (*N* = X) (CITE).

We then used Pearson’s chi square tests to assess relationships between boldness and perceptions and the categorical variables of interest, as well as between categorical independent variables (Weckel et al. 2010). If results were significant, we used the *chisq.posthoc.test* function (Ebbert 2019) to determine the most strongly related categories from Pearson’s Chi-square residuals, and adjusted alpha values with Holm’s correction (Macdonald & Gardner 2000).

We used ordered logistic regression to determine which explanatory variables were associated with each of coyote boldness and human perception using the *clm* function in the R package ordinal (CITE). First, we used a pseudo-optimized multiple scale approach (Mcgarigal et al. 2016) by conducting univariate models to select the best-fit scale for habitat variables and building density based Akaike’s information criterion (AIC; Burnham & Anderson 2004) (Table SX). After assessing correlations with Spearman’s rank correlation coefficient (R > 0.6; Table SX) we removed the correlated variable with the higher AIC value (lower fit). We then created base models that included each of the spatial variables and coyote biological season (categorical variable, breeding season as reference) as additive effects. In these base models we included interaction terms between season and natural, modified open and mowed land cover types (Table SX). We used AIC model selection with the *dredge* function from the package MuMIn (Barton 2020) to identify the variables that were retained in the top models (ΔAIC < 2). We then constructed a global model with the variables from the top models and year as an additive variable to determine if coyote boldness and human perceptions had changed significantly over time. To test if specific variables were related to changes in response variables over time, we included interactions between year and each of the terms in the model. We applied the *dredge* function to the global model to identify our final set of models (ΔAIC < 2). On our final models for each response variable, we tested the key proportional odds assumption using the *scale\_test* function from the package ordinal (CITE). We identified several explanatory variables with non-proportional relationships to the ordinal response variables, and used scale effects to model these variables while relaxing the proportional odds assumption (McCullagh 1980; Cox 1995).

We modelled time of day and contextual variables with univariate ordered logistic regression models because they exhibited numerous significant relationships with other variables (Table X). For time of day, we used night as the reference category and excluding reports where time was unknown (N = X). We compared the contextual variables to the reference category of reports for which there was no mention of the predictor variable. We conducted all statistical analyses in RStudio software (R Core Team, 2019). We considered effects to be significant if 95% confidence intervals did not overlap zero or if P values < 0.05.

**RESULTS**

**Paragraph 1: How many reports & distribution of reports** From January 1, 2011, to December 31, 2020, 7,863 unique reports were submitted to the Edmonton Urban Coyote Project website. Reports were distributed throughout the city (Figure 1), but they were clustered in space based on Ripley’s *K-*function (observed K > upper 95% confidence limit). Within the land cover classes, reports were mostly from residential (45 %) or mowed habitat (22 %), followed by commercial (11 %), natural (10 %), and modified open areas (9.7 %). The distribution of reports across habitat types differed significantly from expected values based on the proportion of each habitat type that was available in the study area (χ52 = 2879, *P* < 0.001; Table 1, Figure 3), with more reports than expected in mowed (χ12 = 543.09, *P* < 0.001) and residential areas area (χ12 = 8.13, *P* = 0.026), and fewer in commercial (χ12 = 330.77, *P* < 0.001), modified open (χ12 = 113.03, *P* < 0.001), natural (χ12 = 19.96, *P* < 0.001), and water areas (χ12 = 36.01, *P* < 0.001). Compared to available locations, report locations were significantly closer to roads, the river valley system and buildings (Table 4). Reports were more common during day (59.1 %) than night (40.9 %). On a monthly basis, reporting was highest from October through March and lowest during spring and summer months (Figure 4), and 37 % of reports were from the breeding season while 21 % and 42 % occurred during the pup rearing and dispersal seasons, respectively. Reporting increased throughout the duration of the website’s availability from 2011 to 2020 (Figure 5).

The mean total repeatability of report classification was 91%, and the mean repeatability of report classification for coyote response to humans or human perception categories were 77% and 96%, respectively. Among all classified reports, 59.6 % were observations with no human-coyote interaction. Within the subset of reports used in the analyses of coyote responses to humans (*N* = 2,585), interactions characterized by avoidance (OSV = 1 or 2; 28.3%) or neutral behaviours (OSV = 3 or 4; 39.8%) were more common than bold (OSV = 5, 6 or 7; 23.1 %) or aggressive reports (OSV = 8 or 9; 8.8 %). The reports that revealed an aspect of human perceptions (*N* = 920), were predominantly negative (67.2%), followed by neutral (18.1%) and positive perceptions (14.7%). Among the reports that permitted classification of both coyote response and human perception, there was a significant positive relationship in ordinal values wherein negative perceptions (OSV = 3) were associated with bolder coyote behaviours (rho = 0.29, *P* < 0.001; Figure 6).

We examined land cover variables to predict the boldness of coyote responses to humans and found six ordinal regression models within 2 AIC of the top model; all models included building density (200 m), and proportion of habitat comprised by modified open (within 200 m), commercial (within 1600 m) and open maintained (within 100 m) as variables (Table SUPPLEMENTARY). The distance decay to roads and water (within 200 m) were present in three of the top models and natural (within 800 m) was in two models. The proportion of modified open habitat and mowed habitat predicted significantly bolder coyote responses to humans, while building density predicted a significant decline in the boldness of coyote responses (Figure 7). In a similar analysis of human perception, twenty-six models of human perceptions had ΔAIC< 2, and this subset included all of the predictor variables, revealing that all variables had some influence on human perceptions. However, only the proportion of residential area (within 800 m) was significant, appearing in all but one of the top models, and predicting more negative perceptions (Table SUPPLEMENTARY; Figure 7).

Analysis of season revealed that coyote responses to people were bolder during the pup-rearing season, relative to the dispersal or breeding seasons (Figure 8). Conversely, the human perception of coyotes was slightly, but not significantly, more likely to be negative during the dispersal season (Figure 8). Analysis of diel patterns showed that coyotes tended to exhibit bolder responses during the day, when human perceptions were more likely to be positive (Figure 8), but 99% confidence intervals for both relationships included zero. The percentage of monthly reports describing bold or aggressive coyote responses was highest during the coyote pup-rearing season, while the percentage of negative human perceptions did not vary among months (Figure 9). From January 2011 to December 2020 the percentage of reports with bold or aggressive coyote responses indicated increased conflict over time, while the percentage of reports with negative human perceptions indicated decreased conflict over time (Figure 10). Poisson model outputs indicated that bold or aggressive reports have increased significantly since 2011, but the number of reports expressing negative human perceptions has decreased over time (Table 5).

Contextual variables were important predictors of both coyote responses to humans and human perceptions (Figure 11). The presence or mention of cats, dogs, children or multiple vulnerable individuals significantly increased the likelihood of bolder coyote responses to humans, which was paralleled by a similarly significant rise in negative perceptions when any of the vulnerable individual groups were mentioned. Of the human activity categories, bolder coyote responses were more likely while walking and less likely while cycling, driving or in the home or yard. Human perceptions were significantly less negative when cycling or driving. For the number of coyotes, both coyote responses and human perceptions were less indicative of conflict when reporters mentioned seeing only one coyote. When coyote health was indicated as either healthy or unhealthy, coyote responses were significantly less indicative of conflict. When coyotes were identified as healthy humans perceived them more positively, but apparent poor health had no effect on human perceptions.

**DISCUSSION**

Human-coyote conflict is increasing in urban areas throughout North America (REFS), creating a need to better understand the correlates of conflict that may result from spatial, temporal, and contextual variables that might be future subjects of mitigation. We approached this goal using almost 8000 reports collected over 10 years on a website based community reporting database (Figure 11). As broad patterns, we found that reports of coyotes were more prevalent than expected in mowed areas and during the fall dispersal period, and increased over time. By classifying report comments to describe each of coyote responses and human perceptions, we found that bolder behaviours by coyotes were associated with negative perceptions of coyotes by people. The boldness of coyote responses increased in modified open and mowed areas and declined with building density, while negative perceptions of coyotes by people increased with the amount of residential area. Seasonally, coyote responses were bolder during the pup-rearing period, but there was little seasonal change in human perceptions. Over years, boldness scores of coyotes have increased while the frequency of negative perceptions by people has declined. Both the boldness of described coyote responses and negative perceptions by people increased when vulnerable individuals, including children and pets, were present or mentioned.

Because coyotes are more likely to have territories and dens in natural or open areas (Gehrt et al. 2009; Dodge & Kashian 2013), we predicted that coyotes in these areas would exhibit bolder responses to people. We found partial support for this prediction; coyote responses were bolder in modified open and mowed areas, but not in natural areas. Our findings are similar to those of Poessel et al. (2013), who also reported increased negative encounters in open areas but not natural areas in Denver, Colorado, and with Wine et al. (2015) who found that coyote encounters were more likely in managed clearings in Mecklenburg County, North Carolina. This pattern may occur because coyotes are visible for longer, this appearing to be bolder, in open areas, or because bolder animals are more likely to occupy areas with less vegetation cover, as has been reported in brown bears (*Ursus arctos*; Bombieri et al. 2021).

Our finding that human perceptions of coyotes were more likely negative in residential areas supports an initial prediction that human tolerance for coyotes would decline in this context. This result supports similar findings by others that people are less tolerant of urban coyotes near their homes compared to tolerance for their broader presence in cities (Bonnell & Breck 2017; Drake et al. 2020). Anecdotally, many reports expressed concern that coyotes may pose a threat to children in their neighborhoods who are playing in parks or walking outside, and this sentiment likely fuels much of this negative perception of coyotes in neighborhoods.

We identified a strong seasonal trend in negative interactions, with bolder responses to people more probable during the pup-rearing season. This trend in coyote behaviour matches our own predictions as well as patterns reported in Calgary, Alberta (Lukasik & Alexander 2011), across North America (White & Gehrt 2009). During the denning period, coyotes may defend their dens from perceived threats posed by dogs or humans (Bombieri et al. 2018). Interestingly, we found that the frequency of reports was greater during the fall and winter months (dispersal and breeding seasons), and lowest in spring and summer (pup-rearing), again consistent with previous studies (Lukasik & Alexander 2011; Poessel et al. 2013; Drake et al. 2021). This result may have occurred because coyotes are less visible due to increased cover from deciduous vegetation or because breeding coyotes avoid visibility to people during the pup-rearing season. Such avoidance of detection by people may contribute to coyote selection for den sites away from edge habitat (Dodge & Kashian 2013). In our study, defence of den sites is likely the reason coyotes exhibited bolder responses during the pup-rearing season.

Over the 10 years of our reporting database, coyote responses to people increased in boldness, supporting conclusions by others that human-coyote conflict is increasing across North America (White & Gehrt 2009; Baker & Timm 2017). We defined boldness as the tendency for coyotes to approach and interact with people, similar to other definitions of risk-taking behaviour (Carter et al. 2013). Recent studies have identified greater boldness in urban coyotes compared to rural conspecifics, suggesting that increasing human-coyote conflict in cities may be linked to rising urban coyote boldness caused by a reduction in human persecution, repeated benign interactions with humans, and an increase in access to anthropogenic food (Breck et al. 2019; Young et al. 2019). There is also evidence that coyote boldness towards humans is passed from parents to offspring, which would further accelerate the increase in boldness-driven conflict (Schell et al. 2018). Increasing density of coyotes in urban areas (REFERENCE) may also select for increasing boldness as a consequence of increasing competition with conspecifics (REFERENCE) . We believe that our study is the first to measure an increase in coyote boldness over time, albeit indirectly through public reports of coyotes.

Despite the increase in the boldness of coyote responses to people we documented over time, the proportion of reports that exhibited negative perceptions of coyotes declined over the same period. Others have predicted that public acceptance of coyote presence in cities will grow over time, even if direct negative interactions continue to occur (Lawrence & Krausman 2011; Jackman & Rutberg 2015). Our study corroborates these findings and suggests that people in Edmonton have become less likely to negatively perceive urban coyotes, despite their growing presence and an apparent increase in antagonistic coyote behaviour towards humans. This relationship may be similar to one described in brown bears where both humans and bears are capable to habituating to the presence of the other, mediated by resource availability and density (Smith et al. 2005).

Of the contextual variables examined in this study, we found that the presence or mention of vulnerable individuals caused an increase in both boldness of the coyote responses and the likelihood of negative human perceptions. Both increases are indicative of conflict. Mention of pets as vulnerable individuals in conflict-indicating reports aligns with the finding by others that the vast majority of reported negative interactions with coyotes stem from pet attacks (Poessel et al. 2013; Baker & Timm 2017), and knowledge of these attacks from media reports can generally reduce public tolerance for urban coyotes (Alexander & Quinn 2011; Draheim et al. 2013). In our reporting database, aggressive encounters most commonly involved dogs (65.6%), and most frequently involved off-leash dogs (19% of reports where further details were given; Table S1) but also included leashed dogs (11.2%) and dogs that were in their owner’s yards (12.2%), suggesting that aggressive coyotes are not always deterred by leashing or containment. Domestic and feral cats are well-known prey for coyotes (Nation & St. Clair 2019), and our reporting database included several reports of cat depredations (16.7% of reports coded as OSV 8 or 9 involved cats, Table S1). Similar to pets, reports mentioning children described bolder coyote behaviour and more negative human perceptions. Attacks on children attract substantial media attention (Alexander & Quinn 2011), are more likely to lead to serious injury (Carbyn 1989), and more likely to be predatory in nature (White & Gehrt 2009). Children were mentioned in only 3.62 % of aggressive encounters (OSV 8 or 9) in our database (Table S1) and none of the 121 reports where coyotes made physical contact involved attacks on humans of any age, together suggesting that the overall risk of attacks on humans was minimal. Nonetheless, a child was attacked by a coyote in our study area during the study period (CITE NEWS REPORT).

Other contextual variables included the human activity at the time of coyote observation, number of coyotes, and health status, but inferences about all of these were limited by small sample sizes (REFERENCE THESE). Coyotes exhibited bolder responses when people were walking and when more coyotes were observed. When coyote health was mentioned, boldness scores declined. Human perceptions were less negative when observers were cycling or driving, when a single coyote was observed, and when coyotes were described as healthy. All of these results are consistent with contexts where people would logically feel more secure. By contrast, people may feel less secure when coyotes appear to be hunting in packs as sometimes occurs (Gese et al. 1996), and coyotes in pairs or packs may be more likely to behave boldly because of intraspecific support (REFERENCE). Although coyotes in poor health may be more conflict-prone (Murray et al. 2015b), coyote responses in our study did not exhibit this trend and we expect that this could be caused by reporting bias as reporters may be more likely to notice and characterise a coyote’s health in encounters where they are not preoccupied with potential risk (i.e. when coyotes were not behaving boldly or aggressively).

Our study had several limitations that are important to note when interpreting our results. First, public reports were non-randomly and non-independently collected, which introduces various forms of bias commonly associated with community reporting databases (Dickinson et al. 2010; Poessel et al. 2013; Sullivan et al. 2014). For example, a single reporter may provide multiple reports that are non-independent in the human perception of coyotes, or a coyote could be reported by multiple individuals in short succession. Previous studies have found that reports are more likely to occur from affluent neighborhoods with higher education levels, to bias reporting locations relative to measured variables (Wine et al. 2015; Mowry et al. 2020). Our post-hoc quantification of coyote responses and human perceptions from a community reporting database does not provide comparable information to empirical behavioural observations of animals (e.g., Breck et al. 2019) or randomized public surveys (e.g., Drake et al. 2020) and should be interpreted cautiously. Importantly, the descriptions of coyote behavioural responses in our reports were not independent of human perceptions of those same behaviours. We recognize the correlated nature of our reports over space and time and attempted to mitigate Type 1 errors that might result by using conservative significance estimates with 99 % confidence intervals. Despite these limitations, we join others in suggesting that community reporting databases provide much relevant information about human-coyote interactions and conflict (Weckel et al. 2010), but that subsequent investigations would benefit from prompting reporters to provide more specific information in reports to support analyses that are anticipated a priori by research teams that include biologists, social scientists, and wildlife managers.

Our findings support several of the management actions that are already being implemented in our study and elsewhere to reduce conflict between humans and coyotes. If coyote boldness is generally higher in open areas presenting greater risk to human and pet safety (Poessel et al. 2013; Wine et al. 2015), management might target these areas for public education (Fox 2006), attractant removal (REFERENCE), and aversive conditioning programs (Bonnell & Breck 2017; Breck et al. 2017). Proactive management should aim to limit coyote use of residential areas (Murray & St. Clair 2017), but if these fail and clusters of highly aggressive coyote behaviour occur, targeted removal of problem individuals may be necessary (Breck et al. 2017). Management efforts might be increased before and during the pup-rearing season, to minimize conflict then that was identified in our study and others (Lukasik & Alexander 2011). Important management messages might include the need to keep dogs on-leash in high risk areas, contain smaller pets with coyote-proof fencing (Draheim et al. 2019), and train citizens to haze coyotes that behave boldly in human-use areas (Bonnell & Breck 2017). These actions are likely to increase opportunities for coexistence by coyotes and people in cities across North America.

**Acknowledgements**

We thank Cassondra Stevenson for assistance with ArcGIS software. Sage Raymond for providing valuable feedback on this manuscript, and Jonathan Wild for assistance classifying reports. We deeply appreciate 23 volunteers who donated their time to help classify coyote reports (Amy Malo, Asma Hamid, Arya Horon, Allison Cain, Caley Campkin, Cleo Randall, Donovan Currie, Danika Wack, Gabrielle Lajeunesse, Sage Raymond, Hailey Dunsire, Jessica Butts, Kelsey Fleming, Khoi Nguyen, Matthew Elphick, Muskaan Tiwari, Osa Campbell, Rachel Godinho, Sydney Enns, Sofia Guest, Stephen Shikaze and Tawnee Dupuis), and thousands of community members who submitted reports of coyotes. We respectfully acknowledge that this work was conducted on Treaty 6 territory, a traditional gathering place for diverse Indigenous peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, Ojibway/ Saulteaux/Anishinaabe, Inuit, and many others.

**LITERATURE CITED – REVIEW FOR TYPOS**

Alexander SM, Quinn MS. 2011. Coyote (Canis latrans) Interactions With Humans and Pets Reported in the Canadian Print Media (1995–2010). Pages 16:15, 345-359. Human Dimensions of Wildlife.

Andelt WF, Kie JG, Knowlton FF, Cardwell K. 1987. VARIATION IN COYOTE DIETS ASSOCIATED WITH SEASON AND SUCCESSIONAL CHANGES IN VEGETATION. Journal of Wildlife Management **51**:273-277.

Baker RO, Timm RM. 2017. Coyote attacks on humans, 1970-2015: implications for reducing the risks. Human-Wildlife Interactions **11**:120-132.

Barton K. 2020. MuMIn: Model selection and model averaging based on information criteria (AICc and alike), Available from <https://cran.r-project.org/web/packages/MuMIn/MuMIn.pdf>.

Bateman PW, Fleming PA. 2012. Big city life: carnivores in urban environments. Journal of Zoology **287**:1-23.

Bombieri G, Delgado MD, Russo LF, Garrote PJ, Lopez-Bao JV, Fedriani JM, Penteriani V. 2018. Patterns of wild carnivore attacks on humans in urban areas. Scientific Reports **8**:9.

Bombieri G, Penteriani V, Delgado MDM, Groff C, Pedrotti L, Jerina K. 2021. Towards understanding bold behaviour of large carnivores: the case of brown bears in human‐modified landscapes. Animal Conservation.

Bonnell MA, Breck SW. 2017. Using resident-based hazing programs to reduce human-coyote conflicts in urban environments. Human-Wildlife Interactions **11**:146-155.

Breck SW, Poessel SA, Bonnell MA. 2017. Evaluating lethal and nonlethal management options for urban coyotes. Human-Wildlife Interactions **11**:133-145.

Breck SW, Poessel SA, Mahoney P, Young JK. 2019. The intrepid urban coyote: a comparison of bold and exploratory behavior in coyotes from urban and rural environments. Scientific Reports **9**:11.

Burnham KP, Anderson DR. 2004. Multimodel inference - understanding AIC and BIC in model selection. Sociological Methods & Research **33**:261-304.

Carbyn LN. 1989. COYOTE ATTACKS ON CHILDREN IN WESTERN NORTH-AMERICA. Wildlife Society Bulletin **17**:444-446.

Carter AJ, Feeney WE, Marshall HH, Cowlishaw G, Heinsohn R. 2013. Animal personality: what are behavioural ecologists measuring? Biological Reviews **88**:465-475.

Catalano S, Lejeune M, Liccioli S, Verocai GG, Gesy KM, Jenkins EJ, Kutz SJ, Fuentealba C, Duignan PJ, Massolo A. 2012. Echinococcus multilocularis in Urban Coyotes, Alberta, Canada. Emerging Infectious Diseases **18**:1625-1628.

City of Edmonton. 2018. Urban Primary Land and Vegetation Inventory (uPLVI). Spatial Data. Draft 2018 Edition. Prepared for: Urban Analysis, City Planning, the City of Edmonton, Alberta. Prepared by: Greenlink Forestry Inc. Edmonton Alberta.

City of Edmonton. 2019. 2019 Edmonton Municipal Census, Edmonton, Canada. Available from <https://www.edmonton.ca/city_government/municipal-census.aspx> (accessed March 8 2021).

Cox C. 1995. Location—scale cumulative odds models for ordinal data: A generalized non-linear model approach. Statistics in Medicine **14**:1191-1203.

Crooks KR, Soule ME. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature **400**:563-566.

Delsink A, Vanak AT, Ferreira S, Slotow R. 2013. Biologically relevant scales in large mammal management policies. Biological Conservation **167**:116-126.

Dickinson JL, Zuckerberg B, Bonter DN. 2010. Citizen Science as an Ecological Research Tool: Challenges and Benefits. Pages 149-172 in Futuyma DJ, Shafer HB, and Simberloff D, editors. Annual Review of Ecology, Evolution, and Systematics, Vol 41. Annual Reviews, Palo Alto.

Dodge WB, Kashian DM. 2013. Recent Distribution of Coyotes Across an Urban Landscape in Southeastern Michigan. Journal of Fish and Wildlife Management **4**:377-385.

Draheim M, Patterson K, Rockwood L, Guagnano G, Parsons E. 2013. Attitudes of College Undergraduates Towards Coyotes (Canis latrans) in an Urban Landscape: Management and Public Outreach Implications. Animals **3**:1-18.

Draheim MM, Parsons ECM, Crate SA, Rockwood LL. 2019. Public perspectives on the management of urban coyotes. Journal of Urban Ecology **5**.

Drake D, Dubay S, Allen ML. 2021. Evaluating human–coyote encounters in an urban landscape using citizen science. Journal of Urban Ecology **7**.

Drake MD, Peterson MN, Griffith EH, Olfenbuttel C, DePerno CS, Moorman CE. 2020. How Urban Identity, Affect, and Knowledge Predict Perceptions About Coyotes and Their Management. Anthrozoos **33**:5-19.

Ebbert D. 2019. Package 'chisq.posthoc.test', Available from <https://cran.r-project.org/web/packages/chisq.posthoc.test/chisq.posthoc.test.pdf>.

Environment and Climate Change Canada. 2018. Monthly Climate Summary 1981-2010 Edmonton City Center Weather Station, Fredericton, Canada. Available from <https://open.canada.ca/data/en/dataset/746f9469-ab78-5dcc-b165-4b51e8ab8652> (accessed March 8 2021).

Fedriani JM, Fuller TK, Sauvajot RM. 2001. Does availability of anthropogenic food enhance densities of omnivorous mammals? An example with coyotes in southern California. Ecography **24**:325-331.

Foley JA, et al. 2005. Global consequences of land use. Science **309**:570-574.

Fox CH. 2006. Humans and coyotes: can we coexist? Pages 287-293. Proc. 22nd Vertebrate Pest Conference, University of California Davis.

Frigerio D, Pipek P, Kimmig S, Winter S, Melzheimer J, Diblikova L, Wachter B, Richter A. 2018. Citizen science and wildlife biology: Synergies and challenges. Ethology **124**:365-+.

Gehrt SD, Anchor C, White LA. 2009. HOME RANGE AND LANDSCAPE USE OF COYOTES IN A METROPOLITAN LANDSCAPE: CONFLICT OR COEXISTENCE? Journal of Mammalogy **90**:1045-1057.

Gehrt SD, Wilson EC, Brown JL, Anchor C. 2013. Population Ecology of Free-Roaming Cats and Interference Competition by Coyotes in Urban Parks. Plos One **8**:11.

George KA, Slagle KM, Wilson RS, Moeller SJ, Bruskotter JT. 2016. Changes in attitudes toward animals in the United States from 1978 to 2014. Biological Conservation **201**:237-242.

Gese EM, Morey PS, Gehrt SD. 2012. Influence of the urban matrix on space use of coyotes in the Chicago metropolitan area. Journal of Ethology **30**:413-425.

Gese EM, Ruff RL, Crabtree RL. 1996. Foraging ecology of coyotes (Canis latrans): The influence of extrinsic factors and a dominance hierarchy. Canadian Journal of Zoology **74**:769-783.

Glas ZE, Getson JM, Prokopy LS. 2019. Wildlife value orientations and their relationships with mid-size predator management. Human Dimensions of Wildlife **24**:418-432.

Gompper ME. 2002. Top carnivores in the suburbs? Ecological and conservation issues raised by colonization of north-eastern North America by coyotes. Bioscience **52**:185-190.

Grubbs SE, Krausman PR. 2009. USE OF URBAN LANDSCAPE BY COYOTES. Southwestern Naturalist **54**:1-12.

Hody JW, Kays R. 2018. Mapping the expansion of coyotes (Canis latrans) across North and Central America. Zookeys:81-97.

Jackman JL, Rutberg AT. 2015. Shifts in Attitudes Toward Coyotes on the Urbanized East Coast: The Cape Cod Experience, 2005-2012. Human Dimensions of Wildlife **20**:333-348.

Kitchen AM, Gese EM, Schauster ER. 2000. Changes in coyote activity patterns due to reduced exposure to human persecution. Canadian Journal of Zoology-Revue Canadienne De Zoologie **78**:853-857.

Lawrence SE, Krausman PR. 2011. REACTIONS OF THE PUBLIC TO URBAN COYOTES (CANIS LATRANS). Southwestern Naturalist **56**:404-409.

Lukasik VM, Alexander SM. 2011. Human–Coyote Interactions in Calgary, Alberta. Human Dimensions of Wildlife **16**:114-127.

Luong LT, Chambers JL, Moizis A, Stock TM, St. Clair CC. 2020. Helminth parasites and zoonotic risk associated with urban coyotes (Canis latrans) in Alberta, Canada. Journal of Helminthology **94**:5.

Macdonald PL, Gardner RC. 2000. Type I Error Rate Comparisons of Post Hoc Procedures for I j Chi-Square Tables. Educational and Psychological Measurement **60**:735-754.

McCullagh P. 1980. REGRESSION-MODELS FOR ORDINAL DATA. Journal of the Royal Statistical Society Series B-Methodological **42**:109-142.

Mcgarigal K, Wan HY, Zeller KA, Timm BC, Cushman SA. 2016. Multi-scale habitat selection modeling: a review and outlook. Landscape Ecology **31**:1161-1175.

McKinney ML. 2006. Urbanization as a major cause of biotic homogenization. Biological Conservation **127**:247-260.

Morehouse AT, Boyce MS. 2017. Troublemaking carnivores: conflicts with humans in a diverse assemblage of large carnivores. Ecology and Society **22**:12.

Mowry CB, Lee A, Taylor ZP, Hamid N, Whitney S, Heneghen M, Russell J, Wilson LA. 2020. Using community science data to investigate urban Coyotes (Canis latrans) in Atlanta, Georgia, USA. Human Dimensions of Wildlife:16.

Mueller MA, Drake D, Allen ML. 2019. Using citizen science to inform urban canid management. Landscape and Urban Planning **189**:362-371.

Murray M, Cembrowski A, Latham ADM, Lukasik VM, Pruss S, St. Clair CC. 2015a. Greater consumption of protein-poor anthropogenic food by urban relative to rural coyotes increases diet breadth and potential for human-wildlife conflict. Ecography **38**:1235-1242.

Murray M, Edwards MA, Abercrombie B, St. Clair CC. 2015b. Poor health is associated with use of anthropogenic resources in an urban carnivore. Proceedings of the Royal Society B-Biological Sciences **282**:8.

Murray MH, Hill J, Whyte P, St. Clair CC. 2016. Urban Compost Attracts Coyotes, Contains Toxins, and may Promote Disease in Urban-Adapted Wildlife. Ecohealth **13**:285-292.

Murray MH, St. Clair CC. 2017. Predictable features attract urban coyotes to residential yards. Journal of Wildlife Management **81**:593-600.

Nation PN, St. Clair CC. 2019. A Forensic Pathology Investigation of Dismembered Domestic Cats: Coyotes or Cults? Veterinary Pathology **56**:444-451.

Natural Regions Committee. 2006. Natural Regions and Subregions of Alberta. Compiled by DJ Downing and WW Pettapiece. Government of Alberta. Pub. No. T852.

Nielsen SE, Stenhouse GB, Cranston J. 2009. Identification of priority areas for Grizzly bear conservation and recovery in Alberta, Canada. Pages 38-60. Journal of Conservation Planning.

Olson ER, Van Deelen TR, Wydeven AP, Ventura SJ, MacFarland DM. 2015. Characterizing Wolf-human Conflicts in Wisconsin, USA. Wildlife Society Bulletin **39**:676-688.

Poessel SA, Breck SW, Gese EM. 2016. Spatial ecology of coyotes in the Denver metropolitan area: influence of the urban matrix. Journal of Mammalogy **97**:1414-1427.

Poessel SA, Breck SW, Teel TL, Shwiff S, Crooks KR, Angeloni L. 2013. Patterns of human-coyote conflicts in the Denver Metropolitan Area. Journal of Wildlife Management **77**:297-305.

Poessel SA, Gese EM, Young JK. 2017a. Environmental factors influencing the occurrence of coyotes and conflicts in urban areas. Landscape and Urban Planning **157**:259-269.

Poessel SA, Mock EC, Breck SW. 2017b. Coyote (Canis latrans) diet in an urban environment: variation relative to pet conflicts, housing density, and season. Canadian Journal of Zoology **95**:287-297.

Prugh LR, Stoner CJ, Epps CW, Bean WT, Ripple WJ, Laliberte AS, Brashares JS. 2009. The Rise of the Mesopredator. Bioscience **59**:779-791.

Quinn TP, Erb I, Gloor G, Notredame C, Richardson MF, Crowley TM. 2019. A field guide for the compositional analysis of any-omics data. GigaScience **8**.

Schell CJ, Stanton LA, Young JK, Angeloni LM, Lambert JE, Breck SW, Murray MH. 2020. The evolutionary consequences of human-wildlife conflict in cities. Evolutionary Applications:20.

Schell CJ, Young JK, Lonsdorf EV, Santymire RM, Mateo JM. 2018. Parental habituation to human disturbance over time reduces fear of humans in coyote offspring. Ecology and Evolution **8**:12965-12980.

Smith TS, Herrero S, DeBruyn TD. 2005. Alaskan brown bars, humans, and habituation. Ursus **16**:1-10.

Soulsbury CD. 2020. Temporal patterns of human-fox interactions as revealed from internet searches. Human Dimensions of Wildlife **25**:70-81.

Soulsbury CD, White PCL. 2015. Human-wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. Wildlife Research **42**:541-553.

Sponarski CC, Miller C, Vaske JJ. 2018. Perceived risks and coyote management in an urban setting. Journal of Urban Ecology **4**.

Sponarski CC, Miller CA, Vaske JJ, Spacapan MR. 2016. Modeling Perceived Risk from Coyotes Among Chicago Residents. Human Dimensions of Wildlife **21**:491-505.

Statistics Canada. 2019. The Open Database of Buildings, Available from <https://www.statcan.gc.ca/eng/lode/databases/odb> (accessed March 9 2021).

Sullivan BL, et al. 2014. The eBird enterprise: An integrated approach to development and application of citizen science. Biological Conservation **169**:31-40.

van Bommel JK, Badry M, Ford AT, Golumbia T, Burton AC. 2020. Predicting human-carnivore conflict at the urban-wildland interface. Global Ecology and Conservation **24**:12.

Weckel ME, Mack D, Nagy C, Christie R, Wincorn A. 2010. Using Citizen Science to Map Human-Coyote Interaction in Suburban New York, USA. Journal of Wildlife Management **74**:1163-1171.

White LA, Gehrt SD. 2009. Coyote Attacks on Humans in the United States and Canada. Pages 419-432. Human Dimensions of Wildlife.

Wine S, Gagne SA, Meentemeyer RK. 2015. Understanding Human-Coyote Encounters in Urban Ecosystems Using Citizen Science Data: What Do Socioeconomics Tell Us? Environmental Management **55**:159-170.

Woodroffe R. 2000. Predators and people: using human densities to interpret declines of large carnivores. Animal Conservation **3**:165-173.

Young JK, Hammill E, Breck SW. 2019. Interactions with humans shape coyote responses to hazing. Scientific Reports **9**:9.

**Table 1.** Land cover classes representing different degrees of human development and coyote habitat suitability in Edmonton, Alberta.

|  |  |
| --- | --- |
| **Land Cover Class** | **% Study Area** |
| 1. Natural (forest, wetland and naturally non-wooded areas) | 8.2% |
| 1. Modified open (agricultural and deforested open areas that aren’t frequently maintained) | 16.0% |
| 1. Mowed grass | 7.7% |
| 1. Water (anthropogenic or natural in origin) | 2.7% |
| 1. Residential areas | 42.0% |
| 1. Highly developed commercial areas | 23.4% |

REVIEW TABLES FOR CONTENT AND CONSISTENCY

Table 2. Ordinal coyote boldness scale and associated coyote responses to humans as categorized from community reports (*N* = 2585 reports)

|  |  |  |  |
| --- | --- | --- | --- |
| **Ordinal Coyote Boldness Scale** | **Coyote Response to People** | **# Reports** | **% Reports** |
| (N/A) Sighting | Sightings with no interaction between humans or coyotes | 4451 | 59.6 % |
| (1) Avoidance | Ran away | 579 | 7.8 % |
| Walked away | 316 | 4.2 % |
| (2) Indifferent | Did not appear to notice or care about people | 923 | 12.4 % |
| Watched the reporter | 316 | 4. 2 % |
| Vocalized directly at the reporter | 44 | 0.06 % |
| (3) Bold | Followed or stalked pets or people | 369 | 4.9 % |
| Approached pets or people | 190 | 2.5 % |
| (4) Aggressive | Chased or charged pets or people | 155 | 2.1 % |
| Made physical contact with pet | 121 | 1.6 % |

Table 3. Human perception of coyotes as categorized from community reports and associated ordinal scale values (*N* = 920 reports).

|  |  |  |
| --- | --- | --- |
| **Human Perception of Coyotes** | **Ordinal Scale Value** | **% Reports** |
| No human perception could be determined from report | NA | 87.0 % |
| Positive (reports containing words like love, happy, exciting, cool or beautiful) | 1. | 1.7 % |
| Neutral (reports containing words like surprised or curious, or denying negative reaction) | 2. | 2.1 % |
| Negative (reports containing words like scared, nervous, disturbed, concerned, uncomfortable or alarmed) | 3. | 7.9 % |

Table 4. Logistic regression model output comparing the probability of a report to a non-report location based on proximity to the ravine system, roads, and buildings.

|  |  |  |  |
| --- | --- | --- | --- |
| Predictor Variable | Estimate ± Std. Error | *z* | *P* |
| (Intercept) | - 0.055 ± 0.017 | - 3.28 | 0.001 |
| Ravine Distance | - 0.27 ± 0.017 | - 15.9 | < 2 x 10-16 \* |
| Road Distance | - 0.53 ± 0.027 | - 19.4 | < 2 x 10-16 \* |
| Building Distance | - 0.19 ± 0.023 | - 8.11 | 5.11 x 10-16 \* |

\* asterisk indicates significant effect

Table 5. Output from Poisson models with the number of annual reports with coyote responses to humans ≥ 6 (indicating bold or aggressive encounters) and with negative human perceptions of coyotes as a function of the total number of annual reports and time.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Response Variable** | **Predictor Variable** | **Estimate ± Std. Error** | ***z*** | ***P*** |
| **Coyote Response to Humans** | (Intercept) | -0.879 ± 0.865 | - 1.02 | 0.309 |
| Time (Years) | 2.38 x 10-4 ± 5.78 x 10-5 | 4.12 | 3.76 x 10-5 \* |
| Total Number of Reports | 1.40 x 10-3 ± 1.77 x 10-4 | 7.90 | 2.91 x 10-15 \* |
| **Human Perception of Coyotes** | (Intercept) | 5.05 ± 0.91 | 5.54 | 3.06 x 10-8 |
| Time (Years) | - 1.39 x 10-4 ± 6.16 x 10-5 | - 2.25 | 0.024 \* |
| Total Number of Reports | 1.60 x 10-3 ± 1.89 x 10-4 | 8.48 | < 2 x 10-16 \* |

\* asterisk indicates significant effect

Map

Description automatically generated

Figure 1. Land cover classifications representing various types of coyote habitat; re-classified from the City of Edmonton uPLVI 2018 Land Cover Layer (City of Edmonton 2018).

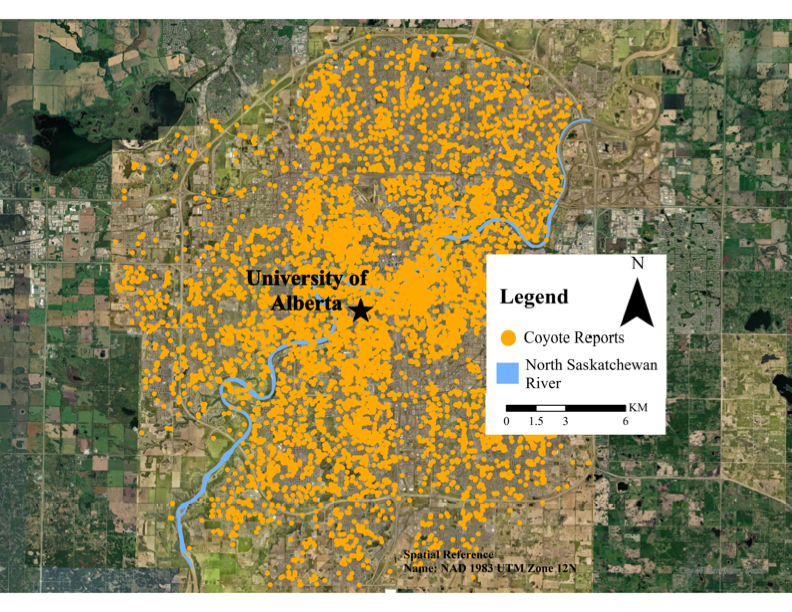


Figure 2. Location of coyote reports submitted to the Edmonton Urban Coyote Project Website from January 1 2011 to December 31 2020.

Chart, bar chart

Description automatically generated

Figure 3. Observed and expected counts of coyote reports within each land cover class. Reports were collected from the Edmonton Urban Coyote Project website between January 1 2011 and December 31 2020, and land cover classifications were determined from the City of Edmonton uPLVI 2018 Land Cover Layer (City of Edmonton 2018).

Chart, histogram

Description automatically generated

Figure 4. Average number of annual coyote reports from each month. Reports were collected from the Edmonton Urban Coyote Project website between January 1 2011 and December 31 2020.

Chart, bar chart

Description automatically generated

Figure 5. Number of reports submitted to the Edmonton Urban Coyote Project website from January 1 2011 to December 31 2020. Reports are represented in four-month intervals to show their relationship with biological coyote seasons.

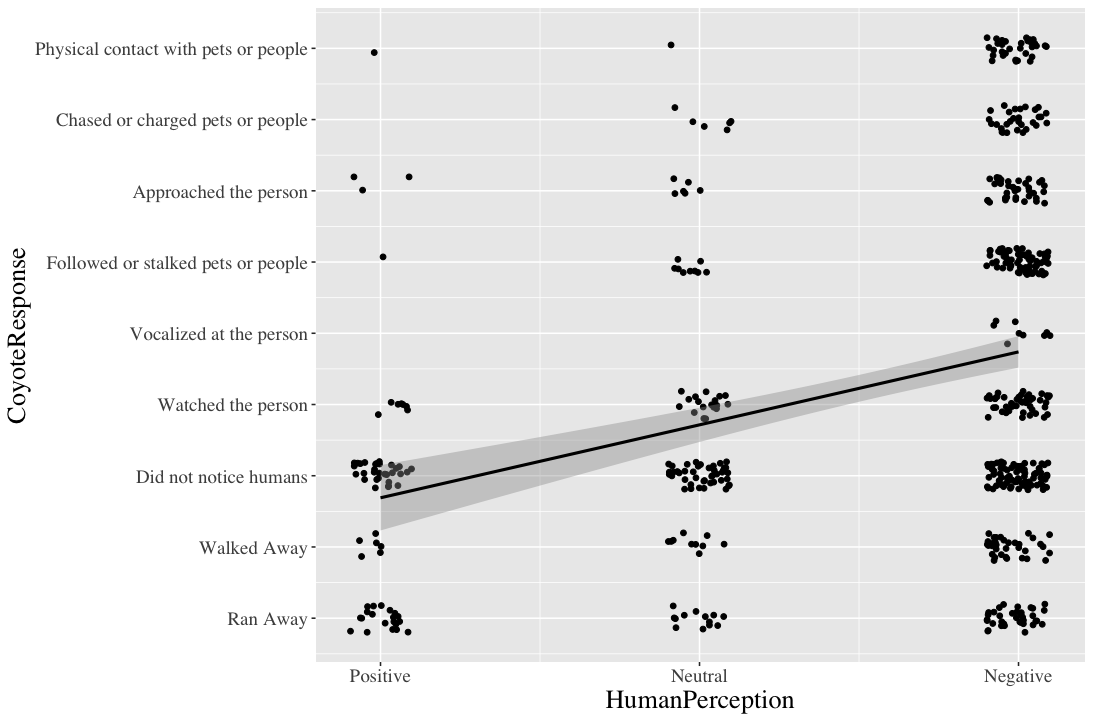


Figure 6. The relationship between coyote response to humans and human perception of coyotes.

Chart

Description automatically generated

Figure 7. Ordinal regression model output of the spatial predictors of coyote response to humans and human perception as indicators of human-coyote conflict. Model-weighted coefficients shown by points were calculated by averaging the weighted coefficients of the top models selected based on AIC < 2 from the top model. Error bars show 99% confidence intervals of the model fixed effect coefficients.

Chart, box and whisker chart

Description automatically generated

Figure 8. Outputs from four ordinal regression models of the temporal predictors of coyote response to humans and human perceptions as indicators of human-coyote conflict. Variables for each univariate model are shown on the x axis with colors indicating the categories within the variable. Error bars show 99% confidence intervals of the model fixed effect coefficients.

Chart, bar chart

Description automatically generated

Figure 9. Monthly trends in the percentage of reports indicating higher levels of human-coyote conflict based on the reports with bold or aggressive coyote responses to humans or negative human perceptions of coyotes.

Chart, bar chart

Description automatically generated

Figure 10. Ten-year trends in human-coyote conflict as indicated by the percentage of reports calculated at four month intervals with either bold or aggressive coyote responses to humans (OSV ≥ 6) or negative human perceptions of coyotes.

Chart

Description automatically generated

Figure 11. Output from 8 univariate ordinal regression models examining the effect of contextual predictor variables on the likelihood of coyote response to humans and human perceptions as indicators of human-coyote conflict. The reference category for each model is the reports where the contextual predictor could not be classified (unknown reports). Error bars show 99% confidence intervals.

Diagram

Description automatically generated

Figure 12. Process model outlining how this study investigates the spatial, temporal, and contextual variables associated with human-coyote conflict, as indicated by the coyote response to humans and human perceptions.

Table S1. Percentage of reports within each conflict level that occur across categories of each spatial, temporal and contextual predictor variable.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Predictor Variables** | | **Coyote Response to Humans (% excluding unknowns)** | | | | | **Human Perception (% excluding unknowns)** | | |
| Variable | Categories | No Interaction  OSV NA  (59.6 %) | Avoidance  OSV 1, 2  (12.0 %) | Neutral  OSV 3, 4  (16.6 %) | Bold  OSV 5,6,7  (8.1 %) | Aggressive\*  OSV 8,9  (3.7 %) | Positive  OSV 1)  (14.7 %) | Neutral  OSV 2  (18.1 %) | Negative  OSV 3  (67.2 %) |
| Land Cover Type | Natural | 8.4 (372) | 13.0 (117) | 10.4 (129) | 16.9 (102) | 23.0 (53) | 13.3 (18) | 15.0 (25) | 10.8 (67) |
| Modified Open | 9.6 (426) | 8.6 (77) | 8.3 (103) | 12.9 (78) | 20.9 (48) | 8.1 (11) | 8.4 (14) | 10.5 (65) |
| Mowed | 21.4 (953) | 18.9 (169) | 24.8 (307) | 28.0 (169) | 21.3 (49) | 17.8 (24) | 25.1 (42) | 23.6 (146) |
| Residential | 47.2 (2100) | 48.0 (430) | 42.8 (530) | 32.7 (197) | 28.7 (66) | 42.2 (57) | 38.9 (65) | 45.6 (282) |
| Commercial | 12.2 (542) | 9.9 (89) | 12.9 (160) | 7.6 (46) | 3.9 (9) | 15.6 (21) | 10.8 (18) | 8.3 (51) |
| Water | 1.3 (58) | 1.5 (13) | 0.8 (10) | 1.9 (11) | 2.2 (5) | 3.0 (4) | 1.8 (3) | 1.1 (7) |
| Season | Breeding | 40 (1780) | 34.1 (305) | 37.4 (464) | 25.9 (156) | 29.6 (68) | 40.7 (55) | 39.5 (57) | 35.1 (217) |
| Pup Rearing | 19 (847) | 19.2 (172) | 18.6 (231) | 29.7 (179) | 37 (85) | 21.5 (29) | 26.3 (44) | 22.2 (137) |
| Dispersal | 41 (1824) | 46.7 (418) | 43.9 (544) | 44.4 (268) | 33.5 (77) | 37.8 (51) | 34.1 (57) | 42.7 (264) |
| Diel | Night | 37.2 (1654) | 42.5 (380) | 33.3 (413) | 33.5 (202) | 57 (131) | 33.3 (45) | 35.3 (59) | 39.2 (242) |
| Day | 43.8 (1950) | 43 (385) | 51.4 (637) | 46.4 (280) | 23.5 (54) | 51.1 (69) | 51.5 (86) | 41.1 (254) |
| Unknown | 19 (847) | 14.5 (130) | 15.3 (189) | 20.1 (121) | 19.6 (45) | 15.6 (21) | 13.2 (22) | 19.7 (122) |
| Number of Coyotes | One | 54.3 (2419) | 79 (707) | 72.4 (897) | 63.3 (382) | 58.7 (135) | 78.5 (106) | 74.9 (125) | 56.8 (351) |
| Two | 14.5 (647) | 12.5 (112) | 15.7 (195) | 19.2 (116) | 19.6 (45) | 8.9 (12) | 12.6 (12) | 18.0 (111) |
| Three | 4.81 (214) | 3.24 (29) | 3.71 (46) | 7.3 (44) | 4.78 (11) | 6.7 (9) | 4.8 (8) | 8.9 (55) |
| More | 3.91 (174) | 2.12 (19) | 2.58 (32) | 5.31 (32) | 8.26 (19) | 2.2 (3) | 3.6 (6) | 6.1 (38) |
| Unknown | 22.4 (997) | 3.13 (28) | 5.57 (69) | 4.81 (29) | 8.7 (20) | 3.7 (5) | 4.2 (7) | 10.2 (63) |
| Human Activity Mentioned | Walking | 4.38 (195) | 27.4 (245) | 32.5 (403) | 70.3 (424) | 53 (122) | 21.5 (29) | 37.1 (62) | 32.8 (203) |
| Cycling | 0.337 (15) | 3.02 (27) | 1.45 (18) | 0.332 (2) | 2.17 (5) | 2.2 (3) | 4.8 8) | 0.3 (2) |
| Outdoor Activity | 0.539 (24) | 3.8 (34) | 3.39 (42) | 4.15 (25) | 5.65 (13) | 2.2 (3) | 1.8 (3) | 2.8 (17) |
| Home/Yard | 18.6 (830) | 23 (206) | 15.2 (188) | 8.13 (49) | 13.9 (32) | 25.9 (35) | 19.8 (33) | 29.8 (184) |
| Driving | 6.04 (830) | 18.2 (163) | 17 (211) | 0.829 (5) | 1.3 (3) | 20 (27) | 12.6 (21) | 6.6 (41) |
| None | 70.1 (3118) | 24.6 (220) | 30.4 (377) | 16.3 (98) | 23.9 (55) | 28.1 (38) | 23.9 (40) | 27.7 (171) |
| Vulnerable Individual Mentioned | Dog | 6.81 (303) | 26.3 (235) | 30.9 (383) | 73.1 (441) | 65.6 (181) | 17.8 (24) | 32.3 (54) | 42.7 (264) |
| Cat | 0.786 (35) | 2.23 (20) | 1.45 (18) | 1.66 (10) | 16.7 (46) | 5.2 (7) | 0.6 (1) | 4.85 (30) |
| Children | 4.88 (217) | 3.69 (33) | 4.92 (61) | 3.48 (21) | 3.62 (10) | 2.2 (3) | 5.4 (9) | 12.9 (80) |
| Multiple | 1.86 (83) | 3.80 (34) | 4.04 (50) | 5.8 (35) | 7.97 (22) | 2.2 (3) | 3.6 (6) | 18.1 (112) |
| None | 85.7 (3813) | 64 (573) | 58.7 (727) | 15.9 (96) | 6.16 (17) | 72.6 (98) | 58.1 (97) | 21.4 (132) |
| Dog leashed? | On leash | 0.247 (11) | 2.79 (25) | 3.87 (48) | 11.4 (69) | 11.3 (26) | 2.2 (3) | 4.8 (8) | 6.1 (38) |
| Off leash | 0.38 (17) | 3.58 (32) | 2.26 (28) | 5.64 (34) | 19.6 (45) | 2.2 (3) | 2.4 (4) | 6.0 (37) |
| Home/Yard | 1.48 (66) | 3.8 (34) | 3.39 (42) | 3.98 (24) | 12.2 (28) | 3.0 (4) | 1.8 (3) | 9.4 (58) |
| Unknown | 97.9 (4357) | 89.8 (804) | 90.5 (1121) | 78.9 (476) | 57 (131) | 92.6 (125) | 91.0 (152) | 78.6 (485) |
| Hazing | Yes | 0.65 (29) | 29.3 (262) | 14.6 (181) | 42.1 (254) | 44.3 (102) | 9.6 (13) | 12.0 (20) | 27.7 (171) |
| No | 39.8 (1770) | 53.5 (479) | 62.1 (769) | 29.2 (176) | 16.5 (38) | 74.8 (101) | 75.4 (126) | 40.3 (249) |
| Unknown | 59.6 (2652) | 17.2 (154) | 23.3 (289) | 28.7 (173) | 39.1 (90) | 15.6 (21) | 12.6 (21) | 32.0 (198) |
| Coyote Health | Healthy | 12.2 (544) | 22.3 (200) | 20.6 (255) | 9.62 (58) | 9.13 (21) | 56.3 (76) | 27.5 (46) | 12.0 (74) |
| Unhealthy | 6.87 (306) | 6.7 (60) | 6.3 (78) | 3.48 (21) | 2.61 (6) | 3.0 (4) | 4.2 (7) | 5.2 (32) |
| Unknown | 80.9 (3601) | 70.9 (635) | 73.1 (906) | 86.9 (524) | 88.3 (203) | 40.7 (55) | 68.3 (114) | 82.8 (512) |