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Cover Photograph: A Coyote cautiously examines a baited camera trap station set by wildlife technicians from Northern Illinois University and the Lake County Forest Preserve District. Eighteen percent of coyote camera trap photos are diurnal at this study site in the northern suburbs of Chicago. Photograph © Lake County Forest Preserve District.

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Diel Activity Patterns of Sympatric Mesopredators in a Suburban Preserve Network

John P. Vanek[1,4*], Andrew U. Rutter[2,5], Timothy S. Preuss[2,6], Holly P. Jones[1,3], and Gary A. Glowacki[2]

Abstract - Mammalian mesopredators are among the most recognizable species in urban ecosystems. Subsidized by anthropogenic resources and released from traditional sources of mortality, many mesopredators thrive in urban areas. However, patterns are not universal and surprisingly little is known about the ecology and natural history of mesopredators across different urban landscapes. Here, we describe diel activity patterns and temporal overlap of the terrestrial mesopredator community inhabiting a suburban preserve network in the suburbs of Chicago. Using nearly a decade of systematic camera trapping across 55 suburban preserves and 200+ permanent camera locations, we found strong nocturnal patterns for Northern Raccoons (*Procyon lotor*; 74% of detections), Striped Skunks (*Mephitis mephitis*; 79% of detections), and Virginia Opossums (*Didelphis virginiana*; 82% of detections), with less than 4% of detections for these species occurring during the day. Coyotes (*Canis latrans*) were less nocturnal (58% of detections), with 23% of detections occurring within twilight hours and 18% of detections during the day. In contrast, Red Foxes (*Vulpes vulpes*) and Domestic Cats (*Felis catus*) were more cathemeral. Degree of overlap was highest between Northern Raccoons, Striped Skunks, and Virginia Opossums (>89%). Our results provide quantitative assessments of diel activity periods and temporal overlap for these species in an urban ecosystem.

Introduction

Mesopredators are among the most recognizable species in urban ecosystems (Adams 2016). Some, such as *Canis latrans* Say (Coyote), *Procyon lotor* Linnaeus (Northern Raccoon), *Didelphis virginiana* Kerr (Virginia Opossum) and *Mephitis mephitis* Schreber (Striped Skunk), are well known urban adaptors or exploiters (Adams 2016, Feldhamer et al. 2003, Gehrt et al. 2010). Subsidized by anthropogenic resources and largely released from traditional sources of depredation (e.g., hunting pressure) and competition (e.g., due to human food sources), urban mesopredator populations can have higher survival, fecundity, body mass, and density than non-urban populations (Gehrt et al. 2010, 2011, Graser et al. 2012, Prange and Gehrt 2004, Prugh et al. 2009, Šálek et al. 2015, Wright et al. 2012). As an extreme example, Riley et al. (1998) reported Northern Raccoon densities up to 100 times that of non-urban populations, and Wright et al. (2012) found that urban Virginia Opossums weighed 34% more than non-urban opossums. Given these factors, mesopredators in urban ecosystems are often a source of human-wildlife conflict (e.g., by depredating pets or spreading disease) and can also negatively impact other species of conservation concern, such as nesting turtles (Adams 2016, Gibbons 2000, Urbanek et al. 2016).

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One way that urban mammals are hypothesized to persist in urban ecosystems is by avoiding humans (Bateman and Fleming 2012, Gaynor et al. 2018, Nix et al. 2018, Patten et al. 2019, Ritzel and Gallo 2020, Wang et al. 2015) which in turn may impact biotic interactions (Guiden et al. 2019). This avoidance can occur both spatially (e.g., using greenspaces within the urban matrix), temporally (i.e., being active when humans are not, such as at night), or both. For example, urban Coyotes tend to select natural habitats (e.g., urban woodlands), but may leave the safety of these undeveloped refugia to forage in densely populated neighborhoods at night (Gehrt et al. 2011, Grinder and Krausman 2001). In non-urban areas, Northern Raccoons, Virginia Opossums, and Striped Skunks are highly nocturnal (e.g., Greenwood 1982; Ryser 1995; Neiswenter et al. 2010; Lesmeister et al. 2015) Similarly, non-urban Coyotes and *Vulpes vulpes* Linnaeus (Red Fox) tend to be mostly nocturnal, but also exhibit crepuscular and diurnal activity, particularly in areas with minimal human disturbance (Andelt 1985, Bekoff 1977, Díaz-Ruiz et al. 2016, Kitchen et al. 2000, Travaini et al. 1993). However, while the activity periods of many mesopredator species have been described in rural or wilderness settings, there has been comparatively less work documenting the activity periods of mesopredators in urban settings, such as Striped Skunks and Virginia Opossums (Ritzel and Gallo 2020, but see Mims et al. 2022).

The rise of high-quality natural history data collection, facilitated by motion-sensitive camera traps, provides a historically unparalleled opportunity to quantify and statistically analyze these traditionally anecdotal and descriptive data (Tosa et al. 2021). Here, we report on the diel activity periods of the terrestrial mesopredator community (i.e., mammalian predators between 1 and 15 kg, sensu Buskirk 1999) inhabiting an extensive preserve network in the northeastern suburbs of Chicago, Illinois (species composition initially described by Cassel 2014 and Greenspan et al. 2018). Based on nearly a decade of long-term camera trap monitoring, our objectives were to 1) describe the diel activity patterns for the terrestrial mesopredator guild and 2) quantify the degree of temporal overlap between species. Given the highly urbanized landscape, we predicted to see strong nocturnal patterns similar to that of rural populations for Northern Raccoons, Virginia Opossums, Striped Skunks, Coyotes, and Red Foxes, with the strongest nocturnality for the former three species (Gaynor et al. 2018, Grinder and Krausman 2001, Lesmeister et al. 2015, Mueller et al. 2018, Wang et al. 2015). Thus, we expected these species would maintain their natural tendencies towards nocturnality as increased diurnal activity would increase potentially negative interactions with humans. Additionally, we contextualize the activity patterns of these native species with comparisons to sympatric *Felis catus* Linnaeus (Domestic Cat), for which activity patterns have already been described (Vanek et al. 2021b).

Material and Methods

Study Area

Our study took place in Lake County, Illinois, a highly suburbanized county in the Chicago Metropolitan Area (Fig. 1). Lake County has a population density ca. 600 persons/km^2 with a total population >700,000 and >7,000 km of paved roads, making it one of the most densely populated counties in the US (United States Census Bureau 2017). Within this urban ecosystem, the Lake County Forest Preserve District (LCFPD) manages 55 preserves for biodiversity and outdoor recreation (e.g., hiking and bird watching but not hunting). These preserves cover ca. 10% (13,000 ha) of the county's land area and range in size from 7 ha to >3,000 ha (= 215.2 ha ± 182.3 SD). Plant communities within the preserve system consist mainly of forest (28%), wetland (17%), and old fields (15%). Historically dominant communities, such as prairie and savanna, are relatively uncommon (8% and 5% respectively) but are the focus of large-scale restoration efforts (Chicago Region Biodiversity Council 1999). Common invasive species include *Rhamnus spp.* L. (Buckthorn), *Lonicera spp.* L. (Honeysuckle) and *Phalaris arundinacea* L. (Reed Canary Grass). See Vanek (2020) for a detailed site description and landscape context.

Field Methods

The LCFPD initiated a long-term wildlife monitoring program in 2009 to inventory and monitor vertebrate diversity across the preserve system. The LCFPD established 232 permanent wildlife monitoring points stratified by preserve within 26 focal preserves and 29 non-focal preserves. Focal preserves were assigned a priori by local managers and were typically larger, contained more diverse plant communities, and were subject to more intense ecological restoration (Vanek 2020). Monitoring points were randomly distributed (min distance between points = 400 m) at a density of 1 point/40.5 ha in focal preserves (n = 159 points) and 1 point/81 ha in non-focal preserves (n = 74 points). Preserves were monitored on a rotating basis, with 16 focal preserves monitored in odd years and 10 focal preserves monitored in even years. Non-focal preserves were monitored every 4 years. Thus, a total of 18-21 preserves (and 82-108 points) were monitored each year. By 2013 all

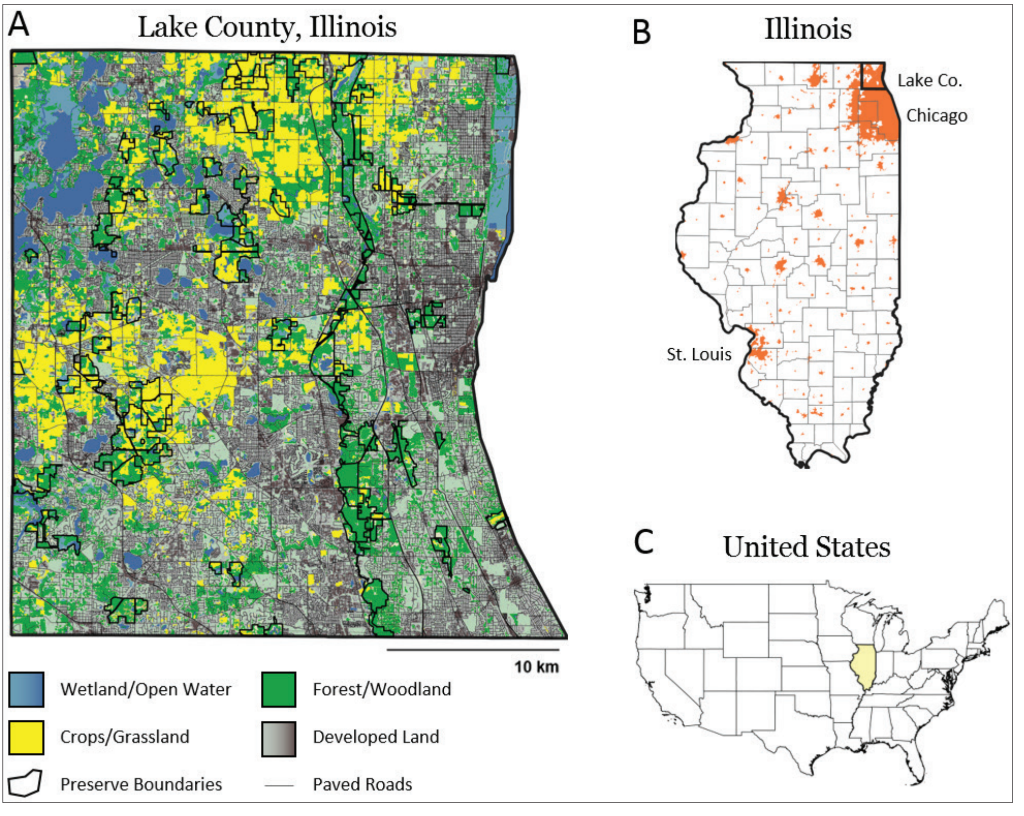

Figure 1. Our study took place in suburban Lake County, Illinois (land area = ca. 1,150 km^2). (a) Within this human-dominated ecosystem are 55 preserves managed by the Lake County Forest Preserve District. Landcover classes (30-m resolution) modified from the National Landcover Database (Yang et al. 2018). (b) Lake County is the northeastern most county in Illinois and is part of the Chicago Metropolitan Area, which is the largest US census designated urban area (orange) in Illinois and the third largest in the United States. (c) The location of Illinois (beige) within the continental United States.

preserves and points had been surveyed at least once.

From 2010–2018, we surveyed for mesopredators during the autumn dispersal period (when activity is typically highest) using remote camera traps at all scheduled preserves (Table 1). At each point, we set one camera (typically a Cuddeback® Ambush™, but occasionally a Bushnell® Trophy Cam™ or Leaf River® IR-3BU™ during early years of the monitoring program) along game trails, habitat edges, or natural bottlenecks (i.e., feature-based placement) to maximize detection probabilities within 100 m (typically within 50 m) of each point's permanent GPS location. Cameras were mounted to a tree or metal t-post at a height of 0.5 m and aimed parallel to the ground or slightly downward (depending on site conditions). Cameras were set on Mondays, checked daily during the day, and removed on Fridays (thus 4 trap nights/camera location; Table 1) for a total of 5 days/4 nights per camera location per assigned year. To increase detection probabilities given our short camera deployments, we emptied 1 can (106 g) of sardines in front of each camera (5 m away) and cleared any vegetation that might block the camera's view of the bait. Sardines have been shown to increase the detection rate of many species of mesopredators (Avrin et al. 2021). Bait was replaced as needed, and we set cameras to record 1 photo per trigger with a delay of 60 seconds. This research was approved the IACUC at Northern Illinois University (ORC# LA14-0002) and followed the ethical guidelines set forth by the American Society of Mammologists (Sikes and the Animal Care and Use Committee of the American Society of Mammalogists 2016).

Activity Periods and Overlap

We classified each detection from the filtered photo dataset as "diurnal", "nocturnal", or "crepuscular" by comparing the time the photo was taken (via each image's metadata) to temporally and spatially explicit sunlight phases calculated with the 'suncalc' package (Thieurmel and Elmarhraoui 2019) in the R Statistical Computing Environment (R Core Team 2018). We classified detections as diurnal if taken during daytime (between sunrise and sunset) and as nocturnal if taken during nighttime (between the commencement of astronomical dusk and the onset of astronomical dawn). Rather than picking an arbitrary cutoff to signify the crepuscular period (e.g., 1 hour pre and post sunrise/sunset), we classified detections as crepuscular if taken during either morning twilight (i.e., between the onset of astronomical dawn and sunrise) or evening twilight (i.e., between sunset and the commencement of astronomical dusk). Sunlight phases varied throughout our sampling period. For example, on 1 Sep 2015, daytime lasted 13 hr 10 min, nighttime lasted 7 hr 01 min, and each twilight period lasted 01 hr 40 min. By the end of the sampling season (e.g., 31 Oct 2015), these time periods had shifted so that daytime lasted 10 hr 23 min, nighttime 10 hr 27 min, and each twilight period

Table 1. Number of preserves and permanent monitoring points used to sample mesopredators in Lake County Forest Preserve District preserves during autumn from 2010–2018. Reported sampling effort does not reflect occasional theft, camera malfunction, or user error (a total loss of <100 trap nights over the entire 9-year period).

Year	Preserves Sampled	Points Sampled	Trap Nights
2010	20	105	420
2011	21	94	376
2012	21	108	432
2013	20	87	348
2014	20	105	420
2015	20	91	364
2016	20	106	424
2017	20	87	348
2018	20	105	420
Total	55	232	3,552

lasted 01 hr 35 min. Accounting for these differences is important in a study spanning several months (Nouvellet et al. 2012).

We quantified the activity periods for each species for which sample size exceeded 50 photos using the date/time metadata from each photo and circular kernel density estimates using the *overlap* package in R (Ridout and Meredith 2020).This package analyzes time using a von Mises kernel density function to accurately represent the circular distribution of time of day (Ridout and Linkie 2009, Rowcliffe et al. 2014). To adjust for changing light levels from late August through the end of November, we used the *sunTime* function so that our activity periods were anchored relative to dawn and dusk rather than artificial clock times (Nouvellet et al. 2012, Vazquez et al. 2019) many animals engage in behaviours known to follow cyclic patterns over days (e.g. singing, diving or foraging behaviours). For example, on 1 Sept 2010, sunrise in Chicago was at 06:16 and sunset was at 13:23 pm. By October 31, sunrise had shifted by more than 1 hour to 07:21, with sunset almost an hour and a half earlier to 17:45. Ignoring these changes would lead to misleading inference. Therefore, to calibrate the *sunTime* function, we converted each photo's clock time (e.g., 7:21 am) to radians (time in radians = time of day on a 0–1 scale × 2 × π), set our anchor point to Chicago's general longitude and latitude in decimal degrees with a WGS84 projection (-88, 42), and set the time zone to "America/Chicago".

To estimate the degree of temporal overlap between species, we calculated the coefficient of overlap (Δ) using the *overlapEst* function in the *overlap* package. This coefficient ranges from 0 (no overlap) to 1 (complete overlap). We used the default bandwidth adjustment (= 1) and the Δ_4 estimator (Ridout and Linkie 2009), which is recommended when sample sizes are > 75 (see Results). As with detection rate, we excluded all detections at the same site if they were within 30 minutes of a previous detection to avoid temporal autocorrelation of the same animal triggering a camera repeatedly. We calculated 95% confidence intervals for all overlap coefficients by generating 1,000 bootstraps in the overlap package's *bootstrap* function and then extracted the confidence intervals using the *bootCI* function. We also analyzed Domestic Cat activity data previously reported in Vanek et al. (2021b) to provide overlap comparisons between this invasive species and native mesopredators.

Results

We detected all five of our target mesopredators on our camera traps: Northern Raccoon, Virginia Opossum, Coyote, Striped Skunk, and Red Fox. We also detected non-native Domestic Cats and *Canis familiarus* Linnaeus (Domestic Dog) (Table 2). Unlike other studies in rural Illinois (e.g., Morin et al. 2018), Domestic Dogs were rarely detected and almost always associated with humans (either leashed or a human was seen in subsequent photo captures). Thus, we did not include domestic dogs in our analyses. We also recorded photographs of 39 other vertebrates, including *Mustela frenata* Lichtenstein (Long-tailed Weasel) and *Neovison vison* Schreber (American Mink), but we excluded these smaller carnivores from our analysis due to small body masses (typically less than 1 kg). We did not detect *Lynx rufus* Schreber (Bobcat), *Urocyon cinereoargenteus* Schreber (Gray Fox), *Pekania pennanti* Erxleben (Fisher), or *Taxidea taxus* Schreber (American Badger), mesopredators which all historically occurred in Lake County but are now exceedingly rare or regionally extirpated in the Chicago metroregion (Hoffmeister 1989, Mohr 1943, Willingham 2008).

Mesopredator Detections

We detected at least one of the five native mesopredators at all 55 preserves and 227 monitoring points (98%) during the 9-year survey period (Table 2). The Virginia Opossum was the most photographed species (n = 11,202 photos), but after filtering photos for temporal autocorrelation, we were left with more photos of the Northern Raccoon (n = 4,238 photos). These two species represented ca. 94% of the unfiltered photo dataset, and ca. 91% of the filtered dataset. Detection rates for Northern Raccoons and Virginia Opossums were similar (119.3 and 100.6 detections/100 trap nights, respectively) and >10 times that of Coyotes and Striped Skunks, >20 times that of Domestic Cats, and >150 times that of Red Fox (Table 2). Correspondingly, Northern Raccoons and Virginia Opossums were widely distributed, and by the end of the study had been detected at nearly all preserves (98% and 96% of all preserves, respectively) and a large proportion of monitoring points (92% and 85%, respectively) (Fig. 2). In contrast to the abundant Northern racoon and Virginia Opossum, we detected Coyotes and Striped Skunks less frequently and at fewer preserves and points (Table 2).

We rarely detected Red Foxes during our study (Table 1). Compared to the other native mesopredators and Domestic Cats, Red Foxes had the lowest number of photos (n = 24), lowest detection rate (0.62 detections/100 trap nights), lowest rate of naïve occupancy for both points (3.4%) and preserves (11%), and no detections in 2016 or 2017 (Table 1). However, while Red Foxes were detected at just 1 or 2 points each year, these were consistently different points, and cumulative Red Fox occupancy continues to increase (approximately) linearly over time (1 point in 2010; 5 points in 2013, 9 points in 2018). Similarly, the number of preserves with detections has increased from 1 in 2010, to 4 in 2013, and 6 in 2018. The low number of Red Fox detections precluded them from formal activity period and overlap analysis.

Activity Periods and Overlap

Given the number of photographs obtained for each species (Table 2), our sample sizes were sufficient to statistically characterize activity periods for Northern Racoons, Virginia Opossums, Coyotes, and Striped Skunks, but not Red Foxes. The former three species were

Table 2. Number of photos, total number of filtered photos (limited to one photo/30 minutes/camera), detection rate/100 trap nights (based on filtered photo number), number of preserves (n_{max} = 55), number of monitoring points (n_{max} = 232), and naïve occupancy for 5 species of native mesopredator (Coyote, *Canis latrans*; Northern Raccoon, *Procyon lotor*, Virginia Opossum, *Didelphis virginiana*; Striped Skunk, *Mephitis mephitis*, and Red Fox, *Vulpes vulpes*) and Domestic Cats (*Felis catus*) detected using baited camera traps (3552 trap nights) in Lake County, IL during 2010–2018.

Species	# of Photos	# Filtered Photos	Detection Rate/100 trap nights	# of Preserves (naïve occ)	# of Points (naïve occ)
Northern Raccoon	8,998	4,238	119.31	54 (0.98)	213 (0.92)
Virginia Opossum	11,202	3,574	100.62	53 (0.96)	195 (0.84)
Coyote	577	338	9.52	42 (0.76)	130 (0.56)
Striped Skunk	776	305	8.59	39 (0.71)	107 (0.46)
Domestic Cat	320	165	4.65	25 (0.45)	41 (0.18)
Red Fox	24	21	0.62	7 (0.13)	9 (0.04)
Total	21,897	8,642			

all decidedly nocturnal with some crepuscular activity and with peaks before sunrise or after sunset (Figs. 3 and 4) and were almost never active during daylight hours. Similarly, Coyotes were mostly nocturnal with some crepuscular activity, with peaks of activity just before dawn and after dusk. However, Coyotes also exhibited some daytime activity (18% of filtered photo detections). In contrast, daytime photos represented just 3% of Northern Raccoon and Striped Skunk detections, and just 1.4% of Virginia Opossum detections (Fig. 2). Domestic Cats expressed a cathemeral activity period (i.e., not decidedly nocturnal, diurnal, or crepuscular), with 35% of detections during the day. The small number of Red Fox photos precluded a formal activity analysis, but we classified 19% of the photos as diurnal, 48% nocturnal, and 33.5% crepuscular (Fig. 2).

Overlap in activity periods was highest between Striped Skunk, Northern Raccoon, and Virginia Opossum, with coefficients of overlap ranging from 0.89–0.92 (Fig. 3). Overlap between Coyotes and these three smaller species was lower, but still high, ranging from 0.74 (95% CI = 0.69–0.79) between Coyotes and Virginia Opossums to 0.81 (95% CI = 0.76–0.85) between Coyotes and Northern Raccoons. Overlap between Domestic Cats and the three smaller native mesopredators was relatively low, ranging from 0.52 (95% CI = 0.45–0.59) between cats and Virginia Opossums and to 0.58 (95% CI = 0.50–0.65) between cats and Striped Skunks (Fig. 4). While still lower than overlap with the other native mesopredators, Coyote overlap with Domestic Cats was surprisingly high at nearly 70% (Δ = 0.69, 95% CI = 0.61–0.77) (Fig. 4). Due to the small number of detections, we could not formally assess overlap between Red Fox and the other mesopredators.

Discussion

In this study we used 9 years of rapid camera trap surveys to quantity and assess the autumnal activity periods of terrestrial mesopredators inhabiting preserves in the suburbs of Chicago, Illinois. As expected, we found strong nocturnal patterns for all native mesopredators with a high degree of temporal overlap between Northern Raccoons, Virginia Opossums, and

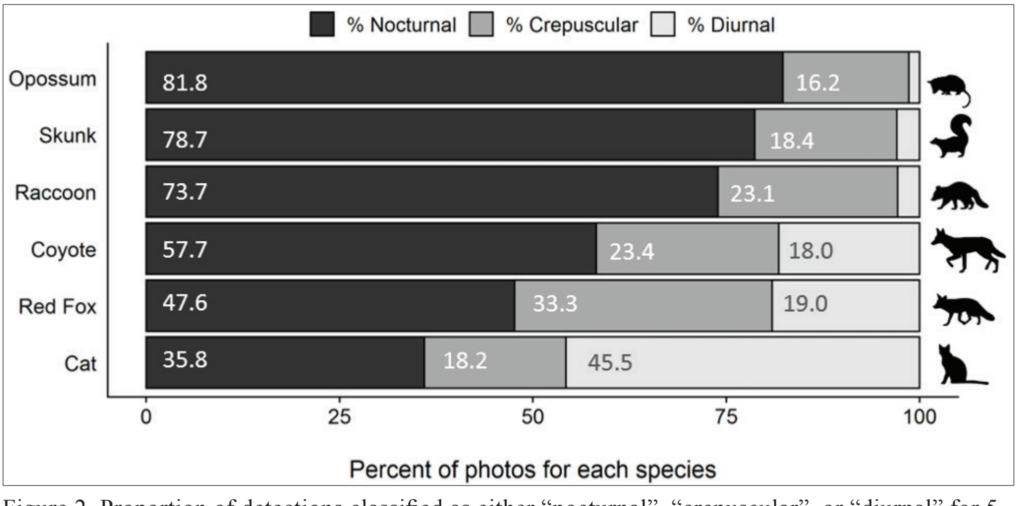

Figure 2. Proportion of detections classified as either "nocturnal", "crepuscular", or "diurnal" for 5 species of native mesopredator (Virginia Opossum, *Didelphis virginiana*; Striped Skunk, *Mephitis mephitis*; Northern Raccoon, *Procyon lotor*; Coyote, *Canis latrans*; and Red Fox, *Vulpes vulpes*) and Domestic Cats (*Felis catus*) detected in Lake County preserves using baited camera traps in autumn from 2010–2018.

Striped Skunks. Coyotes, while also still exhibiting a high degree of nocturnal activity, also showed diurnal and crepuscular activity, consistent with other studies. Our use of camera trap data to elucidate diel activity periods showcases the growing utility of "next-generation natural history" (*sensu* Tosa et al. 2021) to generate important natural history data that can be used by managers to mitigate human-wildlife conflict and aid in the conservation of often overlooked mammalian mesopredators (Marneweck et al. 2021). While similar studies of urban activity periods typically use longer camera deployments across a fewer number of sites, our approach used shorter deployments across a greater number of sites *replicated* over a longer time period, potentially capturing information from a greater number of individuals across space and time. Future studies should examine changes in diel activity period across seasons, years, and by preserve characteristics (e.g., size, shape, degree of surrounding urbanization), as well as the interaction between spatial and temporal overlap of different mesopredator species.

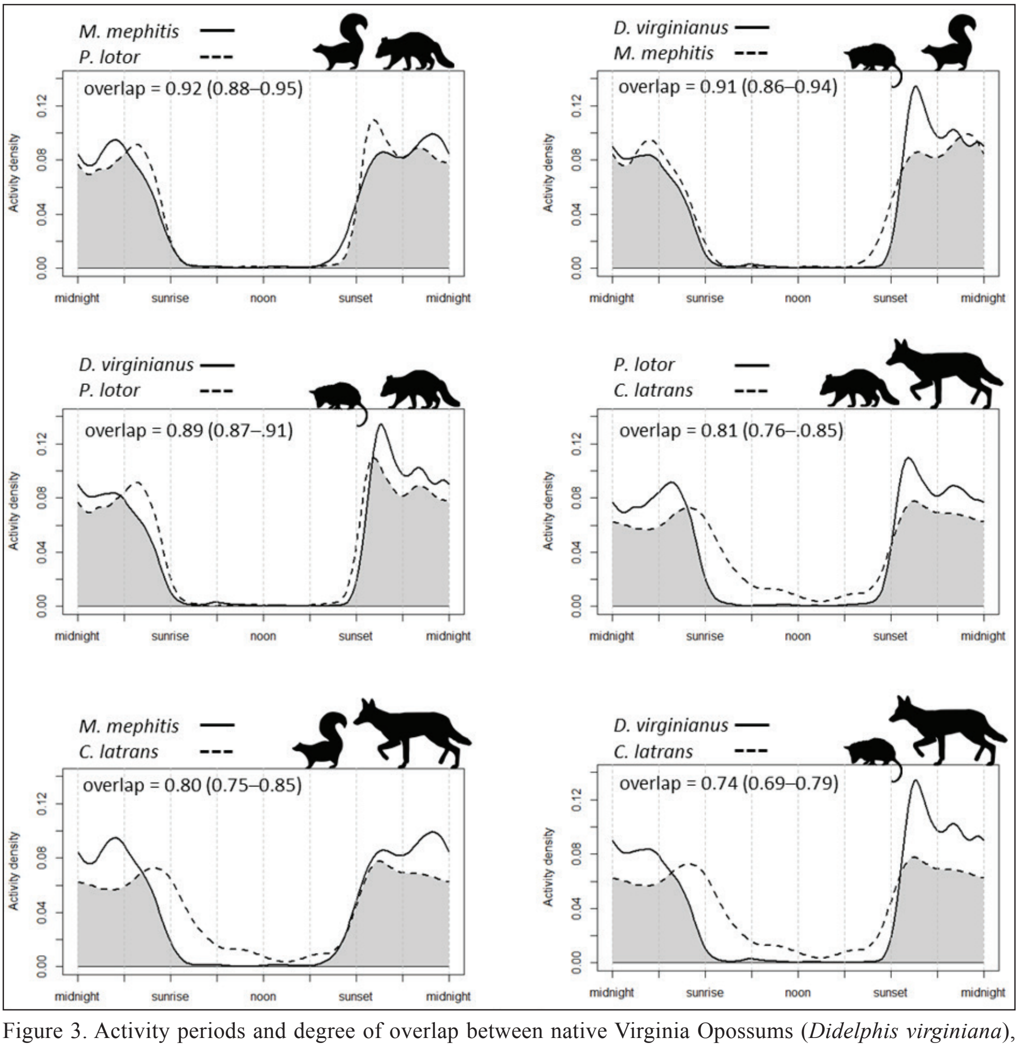

Figure 3. Activity periods and degree of overlap between native Virginia Opossums (*Didelphis virginiana*), Striped Skunks (*Mephitis mephitis*), Northern Raccoons (*Procyon lotor*), and Coyotes (*Canis latrans*) detected in Lake County preserves using baited camera traps during the autumn from 2010–2018. Virginia Opossums, Striped Skunk, and Northern Raccoon were nocturnal, while Coyotes mostly nocturnal. The gray shading represents overlapping activity periods along with coefficient of overlap and 95% confidence intervals based on 1,000 bootstraps.

As expected, we observed strong nocturnal patterns for Northern Raccoons, Striped Skunks, and Virginia Opossums. These species are typically reported as being nocturnal (Adams 2016, Lotze and Anderson 1979, McManus 1974, Ryser 1995, Wade-Smith and Verts 1982), but there are surprisingly few studies of quantifying these patterns, especially in urban areas (but see recent studies such as Gallo et al. 2022 and Mims et al. 2022). Rather than seeing a shift to enhanced nocturnality (Nix et al. 2018), our observed proportion of Northern Raccoon, Striped Skunk, and Red Fox photos classified as nocturnal, crepuscular, and diurnal were roughly similar to those observed in a large-scale camera trap study in rural southern Illinois (Lesmeister et al. 2015). However, while the proportion of nocturnal Coyote photos was almost identical in both studies (58% in our study, 55% in Lesmeister et al. 2015), Coyotes in LCFPD preserves were much less crepuscular (23% vs 38%) and twice as diurnal (18% vs 8%) as those in rural Illinois. These results are similar to those found previously in Cook County, Chicago using radio-telemetry (Gehrt et al. 2011). Coyote behavior is quite plastic, and our findings suggest Coyotes using LCFPD preserves may be habituated to human presence (Schell et al. 2018), as hunting is prohibited and Coyotes are unlikely to suffer repercussions for simply being seen by a human in a nature preserve. In contrast, failing to avoid humans in rural areas can be maladaptive. For example, Van Deelen and Gosselink (2006) reported shooting to be the most common cause of mortality for Coyotes in rural Illinois. Our data also supports the notion that urban Coyotes may exhibit bolder behavior relative to rural Coyotes (Breck et al. 2019), and we hope managers can use these findings to better prevent or mitigate human-wildlife conflict. However, confirmation of this hypothesis would require a formal

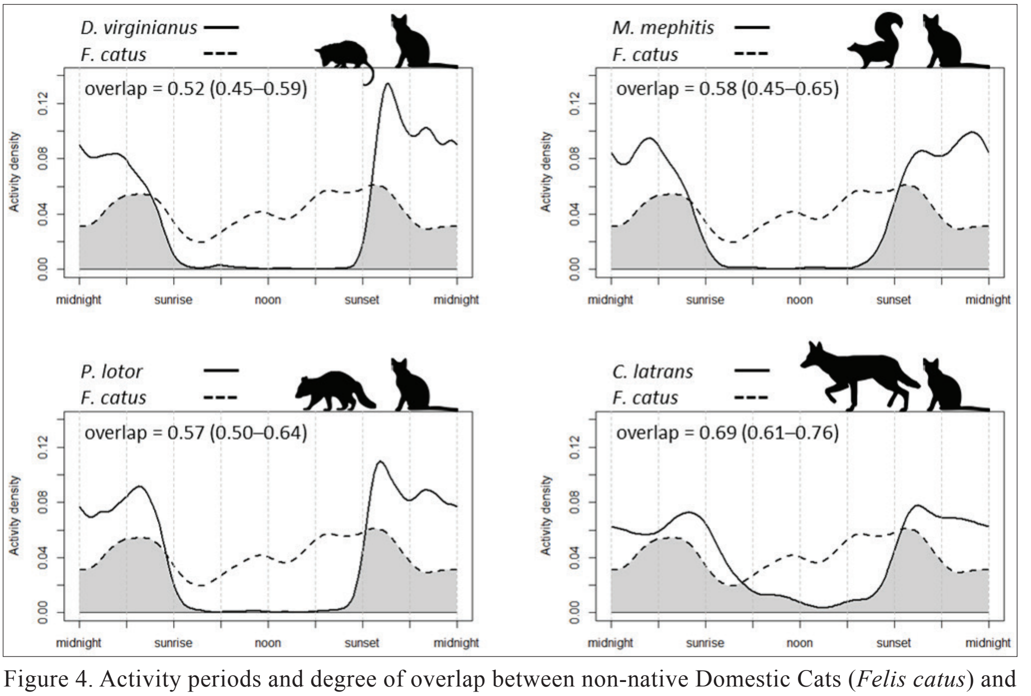

Figure 4. Activity periods and degree of overlap between non-native Domestic Cats (*Felis catus*) and 4 species of native mesopredator (Virginia Opossum, *Didelphis virginiana*; Striped Skunk, *Mephitis mephitis*; Northern Raccoon, *Procyon lotor*; and Coyote, *Canis latrans*) detected in Lake County preserves using baited camera traps during the autumn from 2010–2018. The gray shading represents overlapping activity periods along with coefficient of overlap and 95% confidence intervals based on 1,000 bootstraps.

assessment of activity overlap with that of proximate human activity and should be the subject of future study.

As predicted, we found extremely high rates of activity overlap (ca. 90%) between Northern Raccoons, Virginia Opossums, and Striped Skunks. Though all highly nocturnal, the main differences were in the timing of peak nocturnal activity. For example, Virginia Opossum activity peaked after sunset and then gradually declined to sunrise, while Striped Skunks and Northern Raccoons exhibited pulses of activity throughout the night. These fine-scale differences in activity might facilitate coexistence and minimize competition between these ecologically similar species (Marinho et al. 2020). Overlap between Coyotes and the three smaller mesopredators was somewhat lower (ca. 75–80%) due to the higher rate of diurnal activity for Coyotes. The high rate of overlap between Coyotes and Northern Raccoons is similar to that of forested areas in North Carolina (Chitwood et al. 2020), and supports growing evidence that Coyotes do not suppress populations of native mesopredators (Gehrt and Clark 2003, Jachowski et al. 2020, Prange and Gehrt 2007). Thus, rather than serving as a potential deterrent to turtle and ground-nesting bird predators, Coyotes might be acting as an additional source of mortality for depredation sensitive species, particularly when populations of Coyotes are artificially subsidized at high levels (Fedriani et al. 2001, Lamarre-DeJesus and Griffin 2013, Minckley 1966).

Overlap between Domestic Cats and the mostly nocturnal native mesopredators was lower (ca. 50–70%), due to the cathemeral activity pattern of Domestic Cats. Feral cats typically show a crepuscular or nocturnal activity pattern, more similar to that of native mesopredators (Konecny 1987, Lavery et al. 2020, Wang and Fisher 2012). However, most cats in LCFPD preserves are presumed to be indoor-outdoor house cats or at least subsidized by humans, rather than truly feral populations as seen in Australia and some island ecosystems (Vanek et al. 2021b). Given encounter rates between predator and prey are partially dependent on temporal overlap (Allen et al. 2021), Coyotes could be potentially limiting populations of feral cats, whereas pet cats which remain closer to the safety of buildings can persist. However, the relatively high degree of overlap between Coyotes and Domestic Cats suggests that cats are not actively avoiding Coyotes, at least temporally (but see Gehrt et al. 2013). Nevertheless, the relatively *lower* temporal overlap between Domestic Cats and native mesopredators suggests Domestic Cats in LCFPD preserves occupy a different niche than native mesopredators, and therefore could be competing with diurnal predators (e.g., raptors) more so than otherwise ecologically similar mammalian mesopredators (as hypothesized by Vanek et al. 2021b).

We used a rapid camera trap survey design that was designed as part of a long-term inventory and monitoring plan. This program incorporates not just camera trapping, but small mammal trapping, reptile and amphibian sampling, and bird surveys (Cassel 2014, Cassel et al. 2019, 2020, Vanek et al. 2021a) across numerous preserves and randomly distributed monitoring points. Using multiple survey methods can improve the number of species, individuals, and life stages detected during monitoring programs (Nichols et al. 2008), but there are often trade-offs between sampling depth and breadth based on logistical constraints. Due to the rapid nature of our camera deployments (4 nights per site), cameras were baited to increase detection probabilities. While it is possible daily camera visits to check and replace bait may have influenced activity patterns, we still captured a high degree of diurnal Coyote detections, suggesting this effect was minimal. Additionally, if bait was attracting Coyotes, this may have been responsible for the low detections of Red Foxes and complete lack of detections of Gray Foxes. However, Magle et al. (2019) found low occupancy of Red Fox in the Chicago metroregion, and Avrin et al. (2021), found bait to greatly increase detections of Gray Fox, despite high Coyote occupancy. Our results reveal that rapid, baited camera trap surveys are sufficient to detect the presence of Raccoons and Opossums, species that are important nest predators of ground-nesting birds and imperiled turtles. However, additional trap nights (via more cameras per site or leaving cameras out longer) may be necessary for formal occupancy modeling of less commonly detected species, such as stiped skunks or Domestic Cats (Kays et al. 2020, Pease et al. 2016, Vanek et al. 2021b).

A Depauperate Predator Community

Despite an extensive array of preserved and restored habitat, we found a depauperate mesopredator community dominated by synanthropic generalists. We failed to detect Bobcats, American Badgers, Fishers, or Gray Foxes, mesopredators that, with the exception of American Badger, persist in or are colonizing urban areas elsewhere in the country (Cove et al. 2021, Crooks 2002, LaPoint 2013, Lombardi et al. 2017, Magle et al. 2019, Young et al. 2019). Notably, though present, we rarely detected the Red Fox, a species often associated with urban areas, but may be forced out of urban greenspaces when Coyotes are present (Mueller et al. 2018). These missing species compromise 50% of the historic mesopredator community, representing a significant loss of functional diversity (e.g., the ambush-hunting and crepuscular Bobcat, semi-fossorial American Badger, and semi-arboreal Fisher). While our sampling was not exhaustive, and regular checking of bait may have deterred detection of some species (e.g., foxes), it seems likely these missing species are at least functionally if not fully extirpated in Lake County, consistent with other regional assessments (Hoffmeister 1989, Magle et al. 2019, Mohr 1943, Willingham 2008). These absences, coupled with the historic losses of large carnivores, such as *C. lupus* Linnaeus (Gray Wolf), *Puma concolor* Linnaeus (Cougar), and *Ursus americanus* Linnaeus (American Black Bear), suggest that ongoing restoration work in the "Chicago Wilderness" must be coupled with innovative habitat connectivity and human-dimensions work in order to restore carnivore populations in the rapidly urbanizing midwestern United States (Chicago Region Biodiversity Council 1999; Dreher 2009; Smith et al. 2014, 2016; Watkins et al. 2015).

Finally, as the field of urban ecology advances, there have been calls to move beyond describing patterns and attempt to disentangle processes (Shochat et al. 2006). Understanding the processes and mechanisms dictating how and why wildlife populations thrive, perish, or merely persist in urban ecosystems is undoubtably important and will lead to better conservation and urban planning outcomes. However, documenting and describing natural history and baseline population data is also important, particularly for a rapidly developing and dynamic field such as urban ecology (Ramalho and Hobbs 2012), where species-specific effects may depend on the spatial context and overall configuration of individual cities For example, in a multi-city study, Fidino et al. (2021) found Northern Raccoon and Virginia Opossum occupancy varied as a function of housing density, but this effect could be either positive or negative depending on the housing density of each city. Thus, while advancing our understanding of ecological processes in cities is important, the description of local patterns is still imperative to plan the experimental studies needed to understand those processes, as well as to develop testable hypotheses and make effective management and conservation decisions (Bury 2006, Greene 2005).

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