

# Carnivore Interactions at an Urban Den Used by at Least 11 Mammal Species

Caroline E. Savage, Taylor S. Readyhough, Jonathon D.  
Cepek, and Remington J. Moll



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Cover Photograph: Two adult Red Foxes at an urban den in Cleveland, Ohio, USA. Photo by: Cleveland Metroparks.

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## Carnivore Interactions at an Urban Den Used by at Least 11 Mammal Species

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Jonathon D. Cepek<sup>2</sup>, and Remington J. Moll<sup>1\*</sup>

**Abstract** - Dens are important for many mammal species, particularly when raising young. Given the resources required for den excavation, several species might use dens simultaneously. However, den sharing among urban mammals is relatively undocumented. Between March 2021, and June 2023, we monitored a den in Cleveland, Ohio, USA and documented den use by at least 11 mammal species, including *Vulpes vulpes* (Red Fox), *Canis latrans* (Coyote), *Procyon lotor* (Raccoon), *Marmota monax* (Woodchuck), and *Didelphis virginiana* (Virginia Opossum). Coyotes, the apex predator in the system, and Red Foxes both scent-marked at the den. We documented den use by these competitors during a period when Red Foxes had young inside the den. These observations improve our understanding of mammalian urban den use and interspecific interactions at dens located in habitat fragments.

### Introduction

Urbanization alters wildlife community composition and dynamics (McKinney 2006) and can intensify species interactions in fragments of “natural” habitat within the urban matrix (Parsons et al. 2019). Medium-sized (i.e., <15 kg) carnivores can thrive in urban environments (Gompper 2002, Prugh et al. 2009) due to human-provisioned food resources and shelter associated with built structures (Bateman and Fleming 2012). Developed areas also have fewer large predators, which reduces pressure on mesopredator populations, further contributing to their growth (Gompper 2002, Prugh et al. 2009).

*Vulpes vulpes* L. (Red Foxes) and *Canis latrans* Say (Coyotes) are successful urban mesocarnivores that compete for limited resources (Moll et al. 2018, Mueller et al. 2018, Parsons et al. 2019). Coyotes are dominant over Red Foxes and can kill Red Foxes when the species’ space use overlaps (Sargeant and Allen 1989). Consequently, Red Foxes avoid areas of high Coyote activity and may situate their ranges between, or at the edges of, Coyote home ranges (Harrison et al. 1989, Levi and Wilmers 2012). In urban landscapes, Coyotes use undeveloped natural areas and often avoid highly developed areas, while Red Foxes prefer open spaces and smaller habitat fragments (Moll et al. 2018, Mueller et al. 2018). Suitable den sites may be a limiting resource for co-occurring urban Red Foxes and Coyotes (Mori et al. 2015). In the Northern hemisphere, pup-rearing occurs between March and June for Red Foxes (Cypher 2003) and between April and July for Coyotes (Bekoff and Gese 2003). Thus, competition for dens might be particularly intense between April and June. Given that Red Foxes can repeatedly use a den site for generations (Cypher 2003), competition with Coyotes for den space could influence long-term Red Fox population dynamics.

Red Foxes and Coyotes also compete with other sympatric urban mammals for resources and den space. *Procyon lotor* L. (Raccoons) reach high densities in urban environments (Hadidian et al. 2010) and typically have smaller home ranges than in rural settings, indicat-

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ing intense resource and space use (Bozek et al. 2007). They preferentially use woodlands (Bozek et al. 2007, Hill et al. 2023), but also use human structures or den in the ground (Gross et al. 2012). *Didelphis virginiana* Kerr (Virginia Opossums) also share space with the aforementioned mesocarnivores and use *Marmota monax* L. (Woodchuck) dens (Hossler et al. 1994), sometimes benefitting from Woodchuck den expansions by Red Foxes (Gardner and Sunquist 2003). In urban areas, multiple species likely share woodchuck dens (Pustilnik et al. 2021), although we have much to learn about interspecific interactions at such types of features.

Here, we report on the multi-species use of a den in an urban park system (Cleveland Metroparks, Ohio, USA) over 2 years. We used data from camera traps positioned around the den to assess and quantify den cohabitation and used by multiple species. In total, we recorded 11 mammal species that used the den at least once during the study period. Interestingly, Coyote and Red Fox activity overlapped at the urban den site, which we describe with emphasis on periods when the Red Foxes had a pup in the den.

## Den Monitoring

### Study area

We monitored a den in the Mill Stream Run Reservation in the Cleveland Metropolitan Area, Ohio, USA (human population ~2 million). This ~1400 ha, predominately forested reservation is part of the Cleveland Metroparks, which consists of 18 reservations ringing the city (Cleveland Metroparks 2022). The den site was on a slope of 55–70%, and 21 m from the edge of a residential 2-lane road (speed limit: 25 mph) that separated the Reservation from a row of suburban houses. The den consisted of a primary access hole 76 cm across and 51 cm tall and a smaller access hole (5 m upslope) 23 cm across by 20 cm tall. The small hole was located on a steeper slope, ranging from 73% to 90%. The surrounding area was forested, with some understory plants around den entrances (Fig. 1).

### Field methods

We captured photos and videos using 3 camera traps (Bushnell Aggressor Trophy Cam HD, Overland Park, KS, USA; and Reconyx Hyperfire, Holmen, WI, USA) set out by Cleveland Metroparks staff between 25 March 2021 and 13 June 2023. Camera traps took photos in bursts of 3 followed by short (5–20 second) videos. Staff visited the den site every other month and replaced camera batteries and memory cards as needed. There were some gaps in data collection due to logistical constraints and the need to redeploy camera traps for other research projects (Fig. 2). During all other times, at least 1 camera trap recorded wildlife activity at the den’s main entrance.

### Data analysis

We classified images and videos using the Timelapse2 software (Greenberg et al. 2019). We identified animals to species and noted den use: if a photo showed an animal with most of its body in the den entrance, or a video captured it entering or leaving the den, it was “using” the den. Otherwise, we classified animals that did not enter the den as “visiting” the site. We summarized den use by species and month over the study period (Fig. 2).

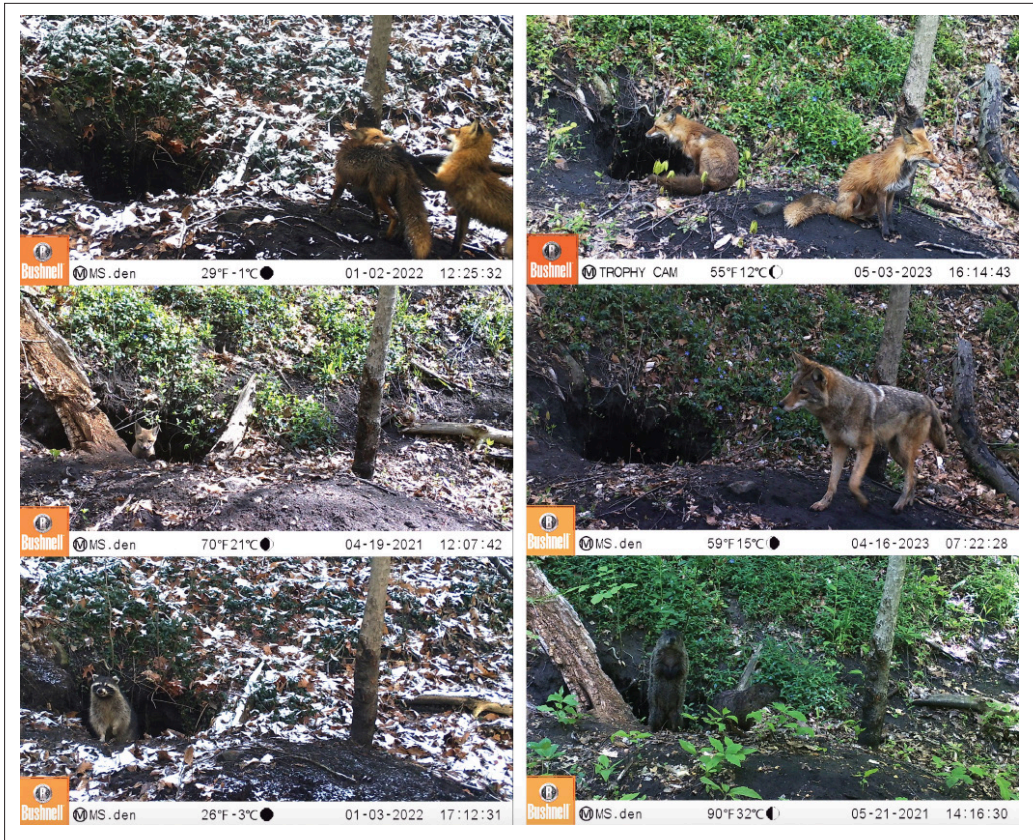


Figure 1. Mammal species that used the urban den site in Cleveland, OH, USA between March 2021 and June 2023 including (top left and top right) adult Red Foxes, (center left) Red Fox pup, (center right) Coyote, (bottom left) Raccoon, and (bottom right) Woodchucks.

## Observations

### Red Fox activity

Red Foxes used the den site every year and had pups in the den during 2021 and 2023 (Fig. 2, Fig. 3). There was 1 Red Fox pup at the den on 19 April 2021 (Fig. 1). On 1 December 2021, a Red Fox dug in the den hole and on 2 January 2022, 2 adult Red Foxes entered the den and exhibited courtship behaviors (Fig. 1). On 24 September 2022, a Red Fox was again digging near the den entrance. A Red Fox raised its leg and urinated on a tree near the den entrance on 20 and 27 October 2022, during the same period that Coyotes frequented the site (described below). Between 8 and 26 April 2023, another Red Fox pup and 3 different adults used the den during this time. On 8 April, 1 of the adults nudged the pup into the den hole 3 min before a Coyote arrived at the site (Supplemental Files 1 and 2 available online at <https://www.eaglehill.us/URNAonline2/suppl-files/urna-248-moll-s1.mp4> and <https://www.eaglehill.us/URNAonline2/suppl-files/urna-248-moll-s2.mp4>). On 9 April, an adult groomed the pup, and that same day, 2 of the adults exhibited intraspecific aggression, 1 with teeth bared and ears flattened back. On 24 April, 1 of the adults brought back a *Glaucomys volans* L. (Flying Squirrel), which the pup took into the den. On 26 April, the pup was eating

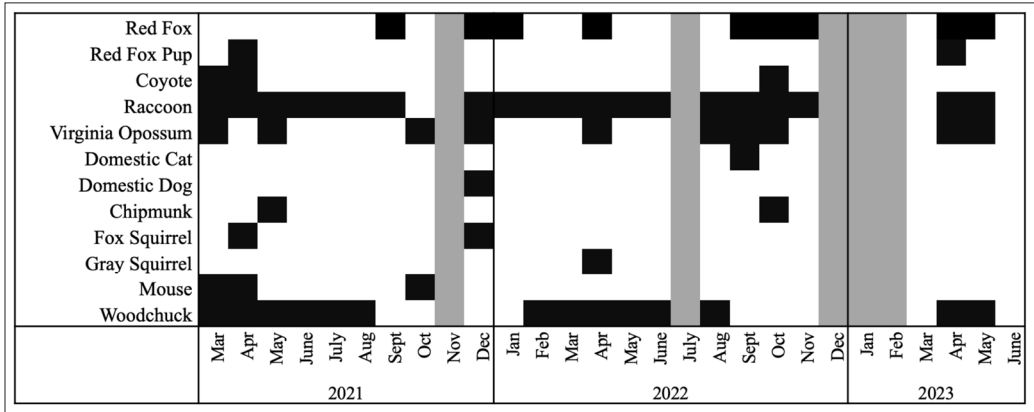


Figure 2. Species that used (entered, exited, or were inside of) an urban den in Cleveland, Ohio, USA from March 2021 to May 2023. Note that Red Fox pup is the same species as Red Fox. Den use occurred when an animal entered or left the main den entrance with its body mostly in the hole. Black squares indicate den use during the month indicated. Gray columns indicate months when cameras were not deployed at the site.

immediately prior to a Coyote arriving at the site (Fig. 3); the pup was not observed thereafter but adult Red Foxes were detected until 31 May 2023.

**Coyote activity**

Coyotes visited the den site and occasionally entered the den but did not inhabit it for long periods. Coyotes used the den in March and April 2021 (Fig. 2). On 31 March, a Coyote defecated by a tree at the entrance to the den (Fig. 3). In April, there were up to 3 Coyotes visiting the site at a time. On the morning of 3 April, 1 Coyote was digging in the den, and 1 raised its leg and urinated near the den entrance. This latter individual had an enlarged abdomen, suggesting it was a pregnant female. A Coyote urinated at the den entrance on 3 and 19

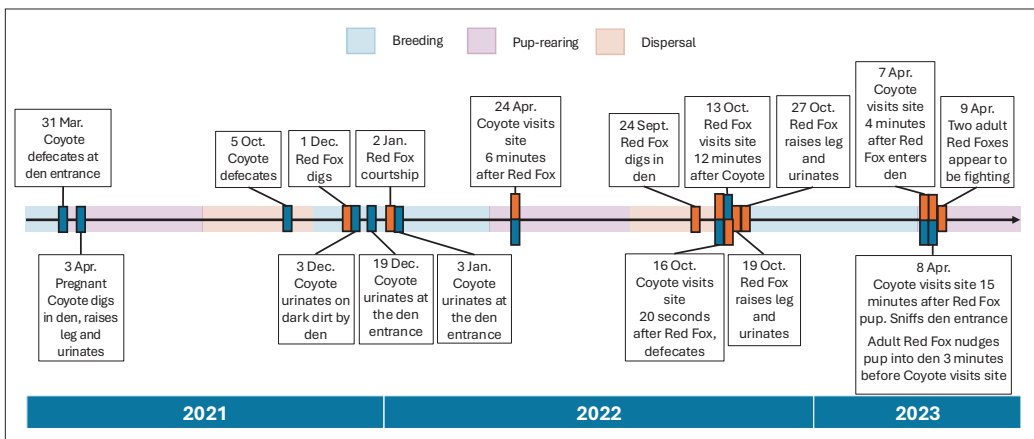


Figure 3. Timeline of notable Coyote and Red Fox activity at an urban den in Cleveland, Ohio, USA from March 2021 to May 2023. Orange bars denote Coyote activity and blue bars denote Red Fox activity. Red Fox reproductive time periods are indicated by colored bars surrounding the main line (light blue: breeding December–March, purple: pup-rearing April–August, light orange: dispersal August–November).

December 2021 and 3 January 2022. On 24 April 2022, a Coyote visited the den site 6 min after a Red Fox. On 16 October 2022, a Coyote arrived and defecated 20 seconds after a Red Fox was detected at the den. On 18 October 2022, a Coyote entered the den. On 7 April 2023, a Coyote came to the den site 4 min after a Red Fox entered the den, and on 8 April, a Coyote sniffed the den entrance 15 min after a Red Fox pup had been there (Fig. 3).

### Other species' activity

Virginia Opossums, Woodchucks, and Raccoons used the den for extended periods. Virginia Opossums used the den each year and during multiple seasons (Fig. 2). Woodchucks similarly inhabited the den for many months during the spring and summer of each year (Fig. 2). On 23 May 2022, a Woodchuck entered and exited the main den hole multiple times, gathering leaves, suggesting that it was actively inhabiting the den, and multiple Woodchucks used the den simultaneously on several occasions (Fig. 1). Raccoons likewise used the den extensively; we documented their use during 20 of the 23 months of monitoring (Fig. 2). Raccoons often visited the site in pairs or trios, and, in September 2022, 4 Raccoons were present at 1 time. Several of these species used the den at the same time. For example, a Red Fox pup and a Raccoon both exited the den on 26 April 2023, and there were numerous months in which Red Fox, Raccoon, Woodchuck, and Virginia Opossum den use overlapped.

Several additional species used the den but did not inhabit it for an extended period. These included 1 visit by *Canis lupus familiaris* L. (Domestic Dog), 1 visit from *Felis catus* L. (Domestic Cat), and multiple visits from small mammals, including *Tamias striatus* L. (Eastern Chipmunks), *Sciurus niger* L. (Fox Squirrels), *Sciurus carolinensis* Gmelin (Gray Squirrels), and *Peromyscus* spp. Gloger (White-footed or Deer Mouse).

### Implications

Our observations highlight interesting interspecific interactions between Coyotes and Red Foxes at a multi-species urban den site. Notably, Coyotes visited the den site when Red Fox pups were using the den (Fig. 3). At least 1 Coyote entered the den complex while there were Red Fox pups present, and at least 1 pup survived this interspecific interaction. Red Foxes and Coyotes sometimes visited the den site on the same day, and occasionally within the same hour, suggesting interactions took place (Fig. 3). Both species also exhibited territorial behavior (e.g., defecation) at the den site (Gese and Ruff 1997). These observations suggest that competition was high at this den site, and that the presence of Coyotes contributed to the “landscape of fear” (Laundré et al. 2001) for Red Foxes by elevating the risk of interspecific aggression. Red Foxes, therefore, likely took a calculated risk by continuing to use this den site, presumably with the cost of increased vigilance.

More broadly, the limited availability of natural den sites in urban areas may lead to increased den occupation by multiple species. The den site we observed was in a wooded area, which secluded it somewhat from an adjacent neighborhood. Simultaneous use of the den site by multiple species suggests that there were tolerable levels of interspecific competition between co-occurring species, or that the benefits of the den (e.g., predator avoidance, shelter from harsh conditions) outweighed the costs of competition. Similar den cohabitation has been documented in New Hampshire, USA by *Urocyon cinereoargenteus* von Schreber (Gray Foxes), *Mephitis mephitis* Schreber (Striped Skunks), Virginia Opossums, and Woodchucks (Allen and Kritzer 2023); in New York, USA, by *Sylvilagus floridanus* Allen (Eastern Cottontails), White-footed or Deer Mice, Domestic Cats, Eastern Chipmunks, Striped Skunks and Virginia Opossums (Pustilnik et al. 2021); and in Britain by Red Foxes and

*Meles meles* L. (European Badgers; Soulsbury et al. 2010). Red Fox and European Badger co-occurrence can be explained, for example, by the perception of low risk of aggressive interactions (Macdonald et al. 2004). Alternatively, interspecific den sharing, such as between Red Foxes and European Badgers, may simply be more likely when there is low dietary overlap (Mori and Menchetti 2019). Red Foxes are more carnivorous than Raccoons and Opossums, and Woodchucks are herbivorous. Thus, minimal overlap in dietary niche likely facilitated den sharing in our system.

Den co-occupation by more than 1 mammal species has been documented in a variety of systems globally. In Mongolia, *Vulpes corsac* L. (Corsac Foxes) used *Marmota sibirica* Radde (Siberian Marmot) burrows more frequently than any other type, even when Marmots also occupied them (Murdoch et al. 2009). Similarly, a study in California documented 4 instances of simultaneous den occupation by *Vulpes macrotis mutica* Merriam (San Joaquin Kit Foxes) and Striped Skunks (Harrison et al. 2011). In Illinois, Virginia Opossums, Woodchucks, Eastern Cottontails, Raccoons, Eastern Chipmunks and *Dasypus novemcinctus* L. (Nine-banded Armadillos) were documented inside the winter dens of Striped Skunks (Amspacher et al. 2023). In Namibia, *Xerus inauris* Zimmermann (Cape Ground Squirrels), *Suricata suricatta* Schreber (Suricates), and *Cynictis pencilatus* Cuvier (Yellow Mongooses) have been known to share burrows (Waterman and Roth 2007). A possible explanation for the co-occupation of these and other den sites is that it requires less energy for mammals to dwell within or expand an existing den than it does to excavate a new one (Revilla et al. 2001, Zelová et al. 2010). Regardless of the specific mechanisms, our observations of multiple species occupying a single den site are consistent with other studies of shared dens and suggest that the benefits of den sharing outweigh the costs of interspecific competition in a variety of contexts.

In line with existing research, our observations indicate that a species assembly from different trophic levels can successfully share a den. Additionally, while visits to active suburban Red Fox dens by Coyotes have been recorded (Mueller et al. 2018), the scenario we documented was unique, particularly as Coyotes first appeared to be use the den during their pup-rearing season, but Red Foxes used it later for raising their own offspring. Given that Coyotes can kill adult Red Foxes or their pups (Sargeant and Allen 1989), it is notable that even though both species entered this den during the same reproductive season, the adult Red Foxes did not relocate their offspring. This observation, and the simultaneous den use by multiple mammal species, emphasize the role of den sites in structuring interactions among urban-dwelling species and potentially facilitating coexistence in developed areas marked by limited natural habitat.

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