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Distribution and Habitat Analyses of American Badgers (*Taxidea taxus*) and Plains Pocket Gophers (*Geomys bursarius*) in McLean County, Illinois

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ABSTRACT

Despite the loss of prairie habitat, fossorial species such as the American Badger (*Taxidea taxus*) and the Plains Pocket Gopher (*Geomys bursarius*) still persist in intensive agricultural landscapes in the Midwestern U.S. We determined the distribution of the two species in McLean County, Illinois via roadside automobile surveys in 2017 and 2018. We detected 88 badger burrows (0.09 burrows/km) in 18 of 30 townships, mostly in central, southern and eastern McLean County. Based on home range size from previous studies, we estimated a minimum of 5 and a maximum of 9 badgers inhabited the burrows. Likewise, we recorded 245 pocket gopher mounds in 16 mound clusters (15.31 mounds/cluster; 0.02 clusters/km) in 5 of 30 townships in central and eastern McLean County. There was no significant difference in the amount of hay/pasture within the home ranges of badgers versus in random locations, and for both species there were no significant effects of soil type, distance to railroad rights-of-way, and distance to habitat along streams. Populations and distributions of both species are likely limited by the lack of grassland habitat in the county and could be below minimum viable population size.

Keywords: American Badger, *Taxidea taxus*, Plains Pocket Gopher, *Geomys bursarius*, McLean County, Illinois, distribution

INTRODUCTION

About 60% of Illinois consisted of prairie prior to Euro-American settlement in the early 1800s, but less than 0.01% remained by the early 1900s, the rest of the landscape largely replaced by agriculture (Iverson 1988). Farming practices also changed in Illinois beginning in the 1950s, which greatly reduced the amount of hay land (and pastures) throughout the state (Walk et al. 2010). Today, approximately 82% of McLean County, Illinois is composed of row-crop agriculture, which consists predominantly of corn (*Zea mays*) and soybeans (*Glycine max*) (USDA 2017), while grasslands are mostly narrow strips of non-native grasses between roads and agriculture fields. The loss of prairie has contributed to steep declines in the populations of prairie-dependent species (e.g., Pergams and Nyberg 2001, Bellar and Maccarone 2002). Despite these declines, both American Badgers (*Taxidea taxus*) (Duquette et al. 2014) and Plains Pocket Gophers (*Geomys bursarius*) (Hoffman and Choate 2008) still persist in heavily agricultural landscapes.

American Badgers and Plains Pocket Gophers are fossorial, prairie-dependent mammals that historically occurred in McLean County, Illinois. Kennicott (1858) and Hoffmeister (1989) indicated that badgers were present in central Illinois in the mid-1800s. Ver Steeg and Warner (2000) surveyed records of badger sightings throughout Illinois, and confirmed that badgers were present in McLean County, Illinois prior to 1900, and between 1951 - 1977; however, they indicated that badgers were not reported between 1900 - 1950, which they attributed to inadequate assessment records. Plains Pocket Gophers, which are found in Illinois in a narrow band east and south of the Illinois and Kankakee Rivers (Hoffmeister 1989), were documented in central Illinois in the mid-1800s (Baird 1857, Kennicott 1858), and in McLean County in the early 1930s (Komarek and Spencer 1931, Mohr 1935, Mohr and Mohr 1936). Today, badgers are ubiquitous in Illinois (Ver Steeg and Warner 2000), while pocket gophers are common in regions of glacial outwash plains in the state with sandy soil (Tucker et al. 2014).

We determined the distribution and possible habitat associations of both species via roadside automobile surveys of badger burrows and pocket gopher mounds. Badger burrows and pocket gopher mounds are often seen along roadsides in Illinois (Hoffmiester 1989, Mohr and Mohr 1936), and badgers are attracted to roadside grass strips that provide habitat for their prey (Klafki 2014). No recent studies have been conducted on either species in McLean County, and such data can provide insight as to how these organisms are persisting in major human-altered landscapes within their historic home range.

METHODS

Automobile surveys for badger burrows and pocket gopher mounds were conducted from September - November 2017 and from March - November 2018, when both species were active. Automobile surveys, which allow a large area to be surveyed in a short time period, have been used in other studies to determine the distributions of both species (e.g., Berkley and Johnson 1998, Quinn et al. 2010, Proulix and

MacKenzie 2012). Our surveys, which totaled 1030.79 km, were conducted by two teams of two individuals per vehicle, and each member of these teams remained either an observer or a driver for the duration of the study. During the surveys, which were conducted while travelling from 24 - 32 km/hr, the observer scanned both sides of the road for badger burrows and pocket gopher mounds. The surveys were performed in each of the 30 townships within McLean County, Illinois. Only secondary, bituminous roads were selected, such that equal numbers of zonal and meridional roads were surveyed in each township (Figure 1). Primary roads with higher traffic volume and higher speed limits were avoided for safety reasons. Roads along which roadside vegetation may have obscured burrows or mounds were surveyed on a later date after the vegetation died back or had been mowed. We recorded the GPS location when badger burrows or pocket gopher mounds were observed. GPS coordinates were initially determined via cell phones using the app *GPS Status* (MobiWIA), and the accuracy of these GPS coordinates was later verified with a Garmin GPS MAP 64s receiver.

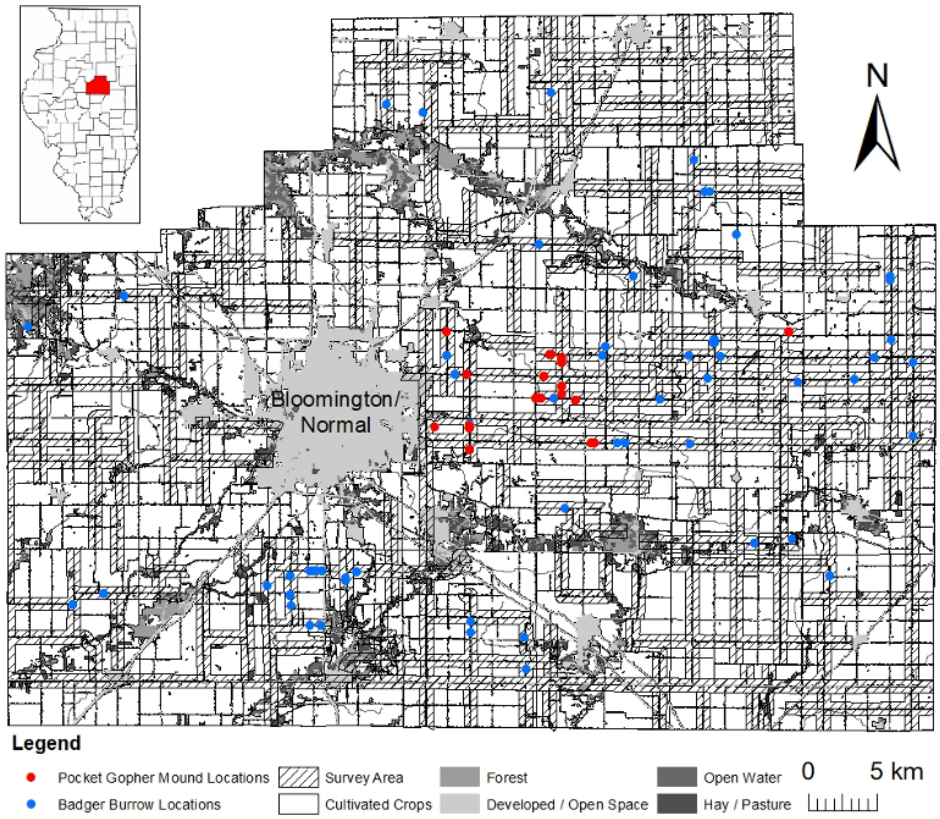

Figure 1. American Badger burrows and Plains Pocket Gopher mounds observed in McLean County, IL from September - November 2017, and March - November 2018.

We identified burrows and mounds of both species based on criteria of previous studies. American Badgers dig burrows that have an entrance wider than high (Hoffmeister 1989), with the topsoil piled around it in a fan-shaped deposit (Eldridge 2004). A burrow was counted only if it was ≥ 50 cm deep because Lay (2008) considered excavations < 50 cm deep to be "diggings." Badger burrows were distinguished from Woodchuck (*Marmota monax*) burrows in that badger burrows are much wider and more fan-shaped (Grizzell 1955). Burrows that were dug straight down or had soil that came out of the hole in a narrow cone were assumed to be excavated by mammals other than badgers and were not counted. In contrast, pocket gopher excavations have a characteristic triangular, or deltaic, shaped mound with a round patch of soil located at the apex (Quinn et al. 2010). Mounds that were not triangular-shaped or were connected by raised tunnels visible above ground were assumed to be created by Eastern Moles (*Scalopus aquaticus*) (Hoffmeister 1989) and were not counted.

In analyzing the data, the following information was used in determining the home ranges of both species. Both male and female badgers excavate multiple burrows in a year (Hoffmeister 1989). Because multiple burrows in an area were likely made by the same badger, in our analysis of the amount of hay/pasture surrounding a badger burrow, we only considered burrow locations that represented the central-most burrow within a home range of a 5 km^2 circle (radius = 1.26 km) of multiple burrows (n = 5 burrows for all spatial analyses). We based our estimates of home range on a study in an intensive agricultural landscape in Ohio, where Duquette et al. (2014) reported that male and female badgers had yearly mean home ranges of 2.40 km^2 and 9.61 km^2, respectively. To estimate the maximum number of badgers inhabiting the burrows, we considered all burrows within a radius of 1.26 km (5 km^2) as made by the same individual. Conversely, to estimate the minimum number of badgers inhabiting the burrows, we considered all burrows that had overlapping 5 km^2 home ranges as made by the same individual. In analyzing data for pocket gophers, a pocket gopher mound cluster was defined as a group of mounds within an area equal to a pocket gopher's home range of 66 m^2 (Zinnel 1992). A single pocket gopher typically occupies a burrow system with multiple mounds (Hoffmeister 1989).

Spatial analyses were performed using Arcmap 10.5, with land cover data from 2011. The following spatial analyses were conducted for each species: the amount of hay/pasture within a home range (for badgers only); the soil type (Type A = silt loam and Type B = silty-

clay loam) in which burrows/mounds were located; distances to railroad rights-of-way; distances to streams. We considered railroad rights-of-way as they may contain remnant prairie and grassland habitat (Bacone and Harty 1981), whereas streams are often bordered by grass or forested habitat. To provide comparisons, we collected similar data for each species from randomly selected locations chosen via ArcMap. No badger burrows or pocket gopher mounds were identified within the simulated home ranges around these randomly-selected locations.

Statistical analyses were conducted using SPSS 25 (IBM SPSS Statistics 2018). We used t-tests to compare the mean number of hectares of hay/pasture within 5 km^2 circles around badger burrow locations compared to within 5 km^2 circles around randomly selected locations. We also used t-tests to compare the mean distance of badger burrows versus random locations to railroad rights-of-way and streams, and a chi-square test to compare soil types of badger burrow locations versus random locations. The same statistical tests were also used for the pocket gopher mound cluster analyses, with the exception of the analysis for hay/pasture. Some of the data for both species did not meet the assumption of a normal distribution; however, the outcomes of all parametric tests did not differ from those via nonparametric statistical analyses (analyses not shown).

RESULTS

We found 88 badger burrows (0.09 burrows/km) in 18 of 30 townships, mostly in central, southern and eastern McLean County (Figure 1). No living badgers were observed during any of the surveys. Based on home range size, we estimated a minimum of 5 and a maximum of 9 badgers inhabited the burrows. There was no significant difference in the mean number of hectares of hay/pasture within 5 km^2 circles around badger den locations (339.40 $\pm$ 208.29 ha; $\bar{x}$ + SD; n = 5) compared to hay/pasture within 5 km^2 circles around randomly selected locations (265.90 $\pm$ 307.10 ha; n = 10; $t_{13} = 0.26$, P = 0.64). Likewise, there were no significant differences in the mean distances of badger burrows versus randomly selected locations to railroad rights-of-way ($t_{27.77} = -0.06$, n = 25, P = 0.95) or streams ($t_{28} = 0.82$, n = 25, P = 0.42). There was no significant difference in the frequencies of soil type where badger burrows were located versus at randomly selected locations ($\chi^2_1 = 0.26$, P = 0.61).

We recorded 245 pocket gopher mounds in 16 mound clusters (15.31 mounds/cluster; 0.02 clusters/km) in 5 of 30 townships in central and eastern McLean County (Figure 1). There were no significant differences in the mean distances of mound clusters (n = 16 for all analyses) versus randomly selected locations (n = 25 for all analyses) to railroad rights-of-way ($t_{38.80} = -0.56$, P = 0.58) or streams ($t_{39} = -0.59$, P = 0.56). In addition, there was no significant difference in the frequencies of soil type where mound clusters were located versus the soil type at randomly selected locations ($\chi_1^2 = 2.17$, P = 0.14).

DISCUSSION

There was a very low density of badger burrows in all county townships, likely due to the paucity of grassland habitat present in the county. In 2017, hay/pasture comprised only 0.5% of McLean County (USDA 2017). Our results are similar to those found by Proulix and MacKenzie (2012) in southwest Saskatchewan (mean density of 0.11 badgers/km of road), and by Berkley and Johnson (1998), who found that badgers were uncommon in most regions of Indiana, which also is dominated by intensive row-crop agriculture. The lack of statistical significance for badgers in relation to all habitat characteristics that we measured is likely due to the low density of badger burrows that we observed. Duquette et al. (2014) found that badgers in west-central Illinois and Ohio had larger home ranges compared to those in the western U.S., which they attributed to greater habitat fragmentation that required badgers to move longer distances to find mates and acquire food. They also indicated that agricultural development limits the population growth of badgers, which has likely occurred in McLean County. Badgers also suffer mortality when crossing roads (Hoodicoff et al. 2009, Sunga et al. 2017), and we documented one road-killed badger on 6 July 2018 in Dry Grove Township. However, no badger burrows were observed in that immediate area.

The roadside, grassy strips that were adjacent to agricultural fields and grass swales along waterways likely provided habitat for small rodents that are the primary prey of badgers. Spanel and Geluso (2018) found that voles and mice were prevalent in roadside ditches in Nebraska. In addition, small amphibians may breed in pools of water along roadsides (Thurow 1999), and badgers may also prey upon them (Tumlison and Surf 2016). However, because the grass strips adjacent to roads in our study area were narrow (6.48 $\pm$ 2.10 m width; n = 98 strips), and grass swales along waterways were not abundant, it is unlikely that badgers could find sufficient prey in these habitats alone to meet their dietary needs. Agricultural fields may also provide habitat for rodents, but tillage practices have a major impact on rodent abundance (Duquette et al. 2014). In 2017, 64% of agricultural fields in central Illinois were tilled via intensive or reduced tilling practices (USDA 2017). Berl et al. (2017) found an average density of 14.1 individuals/ha of prairie deer mice (*Peromyscus maniculatus bairdii*) in Indiana in reduced tillage row-crop agricultural areas with no post-harvest tillage. It is also likely that tilling practices disrupt badger burrowing sites (Duquette et al. 2014), and the disruption of natal burrows could negatively impact badger populations.

Likewise, we found very low densities of Plains Pocket Gophers, and all of the mounds were found in the central and eastern portions of the county. Because a single pocket gopher typically occupies a burrow system with multiple mounds (Hoffmeister 1989), the mound clusters we observed likely represent only 16 individuals, which represent a relictual population in the county. Unlike badgers that can uti-

lize and disperse over intensive agricultural landscapes, pocket gophers cannot easily do so, as there is likely little available food and their burrows would be disrupted by tilling practices. Hoffman et al. (2007) found that Plains Pocket Gophers in Kansas were unable to inhabit areas that were harvested and tilled annually, because such land-use practices destabilize habitats and eliminate both refugia and dispersal corridors. It is also likely that roads and major highways may impede pocket gopher dispersal (Forman and Alexander 1998, Quinn et al. 2010). Our findings are similar to those of Quinn et al. (2010), who found a declining geographic distribution and abundance of this species in Indiana. The abundance of pocket gophers in McLean County is lower than that observed by Mohr (1935), who indicated they were "common" in central Illinois based on surveys conducted from 1930-1934. Mohr and Mohr (1936) documented five individual pocket gophers on 0.06 ha of a 4-meter wide roadside non-native grass strip in Woodford County, Illinois in 1935. Whereas small populations of pocket gophers can persist and maintain genetic diversity (Bohlin and Zimmerman 1982), the low number of individuals documented in our surveys suggest the population is below a minimum viable size in McLean County due to the lack of habitat and the significant barriers to dispersal.

There were a number of possible limits to our study. For both species, the lack of a statistical relationship to all habitat characteristics was likely due to small sample sizes based on their low abundance. The numbers presented for each species do not represent populations for the entire county, as not all roads in McLean County were surveyed, and no walking surveys were conducted in areas on privately owned land away from roads. While it is likely that both species inhabit areas away from roads in McLean County, extensive row-crop agriculture along with tilling practices may restrict their distribution. We may also have missed badger burrows or pocket gopher mounds in our surveys, as vegetation height may have hindered our ability to observe them. However, we believe this is unlikely, as when areas with taller vegetation were noted, they were surveyed at later dates when the vegetation had either been mowed or had died back. Finally, during our surveys we did not differentiate recent from older badger burrows.

The results of our study suggest that both badgers and pocket gophers have small populations in McLean County. Similar findings for both species in intensive agricultural landscapes have been reported in other studies (e.g., Berkley and Johnson 1998, Crooks 2002, Quinn et al. 2010, Duquette 2014). The paucity of grassland habitat and increased habitat fragmentation from agriculture and roads likely hinders the population expansion of both species in the county. A portion of eastern McLean County is listed by the Illinois Department of Natural Resources as a priority area to expand grassland habitat (Illinois Department of Natural Resources 2016), which would likely benefit populations of both species.

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