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**INFLUENCE OF URBANIZATION ON HOME RANGE SIZE AND HABITAT SELECTION OF RACCOONS IN NORTHEASTERN ILLINOIS**

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***Abstract***: With the spread of urban areas, gaining a greater understanding of the effect of human presence on wildlife species is essential for wildlife managers. I determined the influence of urbanization on home range size and habitat selection of raccoons (*Procyon lotor*). I examined habitat selection of 120 raccoons (52 males, 68 females) at 3 sites near Chicago, IL using radiotelemetry data collected from 1996 to 2000 during the summer season (June – August). These 3 sites differed considerably in degree of urbanization; one was rural, one suburban, and one urban. The study sites were partitioned into 5 habitat categories using aerial photographs: human use, aquatic, short grass, tall grass, and woodland. The Animal Movement extension in ArcView was used to generate fixed kernel home range estimates and thus determine home range size of each animal. Home ranges were found to be significantly larger at the rural site relative to the suburban and urban sites. These results suggest that raccoons were able to occupy smaller home ranges at the suburban and urban sites since food and shelter resources may be more concentrated around areas of human activity such as buildings, housing areas, dumpsters, and picnic areas. By analyzing the radiotelemetry data using the Animal Movement extension in ArcView and compositional analysis, habitat selection of raccoons was examined at the second-order home range, the second-order core-area use, and the third-order home range scales. Human use areas received the highest selection at the urban site, intermediate selection at the suburban site, and no significant selection at the rural site. This illustrates the importance of anthropogenic resources to urban and suburban raccoons. By examining the use of human use areas, managers can better understand the needs and behaviors of this urban wildlife species.

**INTRODUCTION**

As urbanization continues to spread, it is increasingly important to understand how human activities affect wildlife species. The 2000 Census of Population and Housing determined that 79% of the U.S. population resided in urban areas (USCB 2006). In Illinois, this percentage was markedly higher at 88% (USCB 2006). Urbanization impacts wildlife species through habitat fragmentation and human presence.

McKinney (2002) described “urban adapters,” such as raccoons and opossums, that utilize both human and natural resources and are habitat and diet generalists. Raccoons have been shown to use sewers and buildings for den areas, and remnants of garbage and non-native food have been found in their feces (Hoffmann and Gottschang 1977), providing distinct evidence that raccoons forage in dumpsters and possibly gardens of suburban residents. Of urban-adapted mesopredators, raccoons are most efficient at exploiting anthropogenic resources (Gehrt 2004, Prange and Gehrt 2004).

Availability of concentrated anthropogenic resources may allow raccoons to maintain smaller home ranges in urban and suburban areas than in rural areas. Smaller home ranges of urban raccoons have been demonstrated in a number of previous studies (Schinner and Cauley 1974, Hoffmann and Gottschang 1977, Slate 1985, Rosatte et al. 1991, Feigley 1992, Prange et al. 2004). Habitat selection is also likely affected by the amount of urbanization at a site. Presumably, raccoons that heavily utilize anthropogenic resources will be less dependent on natural resources.

The summer season is a critical time in the life cycle of the raccoon. Raccoons in North America typically mate from January to March with birth following in April (Gehrt 2003). Thus, litters are reared in summer. Juveniles are completely dependent on milk until about 9 weeks of age, but may continue to nurse until reaching 16 weeks (Montgomery 1969). Obtaining nutrition is vital for the lactating females, and consequently food availability is the primary factor determining home range location and compositions (Sandell 1989). Male distribution is strongly influenced both by female distribution and food availability (Sandell 1989).

My objective was to explore the changes in home range size and habitat selection of raccoons along a rural-urban gradient during the summer season. I hypothesized that raccoons would have the largest home ranges in a rural area, intermediate home ranges in a suburban area, and smallest home ranges in an urban area, and that selection of human use areas would be greatest for urban raccoons, intermediate for suburban raccoons, and lowest for rural raccoons.

## METHODS

### Study Areas

I chose 3 study sites in the Chicago metropolitan area in Cook Country, Illinois, representing positions along the rural-urban gradient. Study areas are often defined arbitrarily, which can lead to inaccuracies when examining habitat selection (Johnson 1980). To avoid such inaccuracies, I constructed a 100% minimum-convex-polygon (MCP; Mohr 1947) using the combined telemetry locations of all raccoons pooled across years for each site. The MCPs represented the minimum effective trapping areas, and I used them to define each study area.

The rural site was Glacial Park and its surrounding area (Figure 1). This 1,052-ha public conservation area was located in McHenry Country, Illinois, roughly 60 km northwest of Chicago. The Glacial Park study area consisted of 26% aquatic habitat, 11% human use areas, 3% short grass, 45% tall grass, and 16% woodland (see habitat type description below; Figure 2). Human use areas included 2 picnic areas and a hunt club located within the Park, and suburban housing areas beyond the Park's boundaries.

The suburban site was the Max McGraw Wildlife Foundation and its surrounding area (Figure 3). The Foundation was a 495-ha natural area and hunting preserve for upland birds, located in Kane County, Illinois, roughly 40 km northwest of Chicago. The study area consisted of 8% aquatic habitat, 22% human use areas, 1% short grass, 21% tall grass, and 48% woodland (Figure 4). The eastern portion of the site also contained a large open gravel area. When examining telemetry locations, this area had very minimal use and was not included as available habitat. Human use areas included 2 amusement parks, a miniature golf area, restaurant, shopping areas, and suburban housing areas.

The urban site was the Ned Brown Forest Preserve and its surrounding area in Cook County, Illinois, roughly 20 km northwest of Chicago (Figure 5). The Preserve consisted of 1,499-ha of oak forests, lakes, wetlands, grasslands, and recreational areas, and the study area consisted of 7% aquatic habitat, 32% human use areas, 3% short grass, 12% tall grass, and 46% woodland (Figure 6). Receiving 1-3 millions visitors annually (Cook Country Forest Preserve District, unpublished data), this site had ample anthropogenic resources for raccoon use. Human use areas included 32 picnic areas and shelters, many dumpsters and garbage cans, recreational roads and trails, and a large suburban housing area and commercial and industrial areas beyond the Preserve's boundaries. For a more detailed description of the study sites, see Prange et al. 2004.

**Radiotelemetry**

Raccoons were captured in box traps, ear tagged, and a subsample of raccoons were radiocollared during spring and autumn 1996-2000. Radiocollared animals were located approximately twice weekly both during day and night for all seasons, except winter when raccoons were largely inactive. Diurnal locations were obtained by walking in on raccoons with a handheld antenna, and nocturnal locations were obtained via triangulation of two or more bearings taken with a truck-mounted antenna. Approximate bearing precision was 2.9° at Glacial Park, 3.2° at Max McGraw Wildlife Foundation, and 3.5° at Ned Brown Forest Preserve. Seasons were defined as summer (June – August), autumn (September – November), winter (December – February), and spring (March – May). Only summer locations were used in these analyses. For a more detailed description of capture and radiotelemetry methods, see Prange et al. 2004.

**Home Range Size and Habitat Selection**

I included raccoons with ≥ 30 locations (Seaman et. al 1999) for the summer season within a single year in home range analyses, and used the Animal Movement Extension (Hooge and Eichenlaub 1997) in ArcView 3.3 to generate a 95% use distribution (home range) and 50% use distribution (core area) for each animal using the fixed-kernel model (Worton 1989). I calculated mean home range size for combined sexes, males, and females at each study site, and compared home ranges using a 2-way fixed ANOVA, with sex and study site as treatments. I used the Tukey-Kramer multiple comparison test to conduct pair-wise comparisons when the ANOVA revealed a significant treatment effect.

I overlaid habitat type polygons on aerial photographs in ArcView to create a habitat map for each study area. I established 5 habitat categories: human use, aquatic, short grass, tall grass, and woodland. Human use areas were those subjected to anthropogenic influence such as buildings, picnic areas, amusement parks, suburban housing areas, and commercial and industrial areas (Prange et al. 2004). At the urban site, I placed a 50-m buffer around main recreational roads and picnic areas and classified it as human use. Similarly, I placed a 50-m buffer around picnic areas at the rural site. The aquatic category included wetlands and a 10-m buffer around open water, but did not include open water as available habitat. Short grass areas included short grass prairie, as well as mowed areas. Tall grass included a wide range of tall grass prairie types and agricultural areas. Woodland contained all forested habitats.

To assess habitat selection, I considered 2 spatial scales based on those given by Johnson (1980). To evaluate second-order habitat selection, I compared composition of 95% home ranges to composition of the effective study area. I also evaluated second-order habitat selection by comparing composition of 50% core areas to composition of the effective study area. Third-order selection examines use of specific areas within the home range (Johnson 1980), and was evaluated by comparing the proportions of individual telemetry points within each habitat type to the composition of the animal's home range.

I determined habitat use using compositional analysis (Aebischer et al. 1993). This method transforms use and availability proportions into log-ratios and allows ranking of habitat types. I took proportions of used and available habitats to the second decimal place, and habitats with use proportions <0.01 were rounded to 0.01. If available habitats were not used, I replaced the zero with a trivial value of 0.003, as suggested by Bingham and Brennan (2004). I examined habitat selection for combined sexes, males, and females for each of the 3 study sites.

## RESULTS

### Home Range Size

I calculated mean home range sizes for a total of 120 raccoons (52 males and 68 females; Table 1). A 2-way fixed ANOVA revealed no significant difference between home ranges sizes of males and females ($F_{1,114} = 1.57$, $P = 0.21$) and no significant interaction between sex and study site ($F_{2,114} = 0.31$, $P = 0.73$). Home range size was significantly larger at the rural site than the suburban and urban sites ($P < 0.05$).

### Habitat Selection

I used home ranges, core areas, and individual telemetry points from 120 raccoons (52 males and 68 females) for habitat selection analyses. At the rural site, habitat use of combined sexes significantly differed from random use based on availability for second-order selection using 95% home ranges ($P < 0.0001$) and 50% core areas ($P < 0.0001$), and third-order selection ($P < 0.05$). Habitat use of males significantly differed from availability for second-order selection using 95% home ranges ($P < 0.001$) and 50% core areas ($P < 0.05$), but not for third-order selection ($P = 0.447$). Habitat use of females significantly differed from availability for second-order selection using 95% home ranges ($P < 0.0001$) and 50% core areas ($P < 0.001$), and third-order selection ($P < 0.001$).

At the rural site, woodland ranked highest among habitat types for combined sexes, males, and females for all significant spatial scale comparisons (Tables 2, 3, 4). Human use areas did not receive significantly greater use relative to any other habitat type for combined sexes, males, or females at any spatial scale ($t \leq 1.07$, $P \geq 0.306$).

At the suburban site, habitat use of combined sexes significantly differed from availability for second-order selection using 95% home ranges ($P < 0.0001$) and 50% core areas ($P < 0.0001$), and third-order selection ($P < 0.0001$). For both males and females, habitat use significantly differed from availability for second-order selection using 95% home ranges ($P < 0.0001$) and 50% core areas ($P < 0.0001$), and third-order selection ($P < 0.001$).

At the suburban site, woodland was ranked highest among habitat types for combined sexes, males, and females for second order selection using 95% home ranges and 50% core areas (Tables, 5, 6, 7). However, at the third-order spatial scale, aquatic habitat was ranked highest among habitat types for combined sexes, males, and females, although the ranking for aquatic habitat was statistically interchangeable with woodland for combined sexes and females. Human use areas were selected more relative to tall grass for third-order selection of combined sexes and males ($t \geq 2.16$, $P \leq 0.046$, for both tests).

At the urban site, habitat use of combined sexes significantly differed from availability for second-order selection using 95% home ranges ($P < 0.0001$) and 50% core areas ($P < 0.0001$), and third-order selection ($P < 0.0001$). For both males and females, habitat use significantly differed from availability for second-order selection using 95% home ranges ($P < 0.0001$) and 50% core areas ($P < 0.0001$), and third-order selection ($P < 0.05$).

At the urban site, woodland was significantly ranked highest among habitat types for combined sexes, males, and females for second order selection using 95% home ranges and 50% core areas. However, at the third-order spatial scale, human use areas were ranked highest among habitat types for combined sexes, males, and females, although the ranking for human use areas was statistically interchangeable with woodland for combined sexes and females. For combined sexes, human use areas were selected more frequently than aquatic habitat and tall grass for second-order selection using 95% home ranges and 50% core areas, and more frequently than aquatic habitat, short grass, and tall grass for third-order selection ($t \geq 2.96$, $P \leq 0.005$, for all tests). For males, human use areas were selected more frequently than aquatic habitat for second-order selection using 95% home ranges and 50% core areas, and more frequently than aquatic habitat and short grass for third-order selection ($t \geq 2.57$, $P \leq 0.018$, for all tests). For females, human use areas were selected more frequently than aquatic habitat and tall grass for second-order selection using 95%

home ranges and 50% core areas, and more frequently than short grass and tall grass for third-order selection ($t \geq 2.07$, $P \leq 0.05$, for all tests).

**DISCUSSION**

Home ranges of rural raccoons were significantly larger than those of suburban and urban raccoons. This complements previous research (Schinner and Cauley 1974, Hoffmann and Gottschang 1977, Slate 1985, Rosatte et al. 1991, Feigley 1992, Prange et al. 2004) and partially supports my first hypothesis; however, no significant differences occurred between suburban and urban raccoon home range sizes, and consequently the hypothesized decline in home range size relative to the degree of urbanization (i.e., suburban vs. urban) was not substantiated. While the increased amount and variety of food items in human use areas may play a key role in influencing home range size, other factors such as isolation of habitat within the urban matrix and boundaries created by roads, may also have an effect (Prange et al. 2004).

In examination of habitat selection at the second- and third-order scale, with the single exception of third-order selection of rural male raccoons, use significantly differed from random use based on availability. For second-order selection using 95% home ranges and 50% core areas, woodland ranked highest among all other habitat types for all sex classes at all study sites. This further supports previous research that has suggested the importance of forested habitat in home ranges of raccoons and also in the areas of concentrated use (Chamberlain et al. 2003). Trees are important habitat features because they provide hollow den trees, and these den sites are especially important when rearing young during the summer season (Kaufmann 1982). Woodland also offers a wide variety of food sources, such as berries and nuts, and provides habitat for small mammals and birds taken by raccoons as occasional prey items (Kaufmann 1982). The importance of aquatic habitat, most clearly seen in the third-order selection of suburban raccoons, also supports previous information associating raccoons with water and wetland habitats (Kaufmann 1982, Gehrt 2003).

As omnivorous opportunistic feeders (Kaufmann 1982), raccoons are able to exploit a wide range of food items. The ability of raccoons to retain information about food types (Dalgish and Anderson 1979) aids in learning to use anthropogenic food resources (Gehrt 2004, Prange and Gehrt 2004). Their flexible fingers are also somewhat opposable, providing greater dexterity and ability to manipulate items (Kaufmann 1982), which may allow them to gain access to dumpsters and trash cans (Prange and Gehrt 2004). The high ranking of human use areas for both males and females at the urban site, particularly at the third-order selection scale, supports the hypothesis that urban raccoons most strongly select human use areas. Although both suburban and rural raccoons had fairly low rankings for human use areas, human use areas were selected significantly more often than tall grass at the third-order selection scale for both suburban combined sexes and males, whereas human use areas were not selected more often than any other habitat type for any sex class of rural raccoons. This supports the hypothesis that suburban raccoons exhibit intermediate selection of human use areas, and rural raccoons would exhibit lowest selection.

The scale at which habitat selection takes place is unknown, and many factors likely influence this selection. Previous research has shown that important microhabitat features are also observed again when examining macrohabitat features (Pedlar et al. 1997). The best example of this phenomenon was the high ranking of woodland habitat at both the finer (third-order selection) and coarser scale (second-order selection) for rural raccoons. Multi-scale examination of habitat selection also revealed the significance of use of human use areas at the third-order selection scale for urban raccoons. The examination of habitat selection at multiple scales is especially important in fragmented areas, such as urbanized areas, because key resources may be limiting and used at more coarse scales (Beasley 2005). In this study, short grass areas were very limited at the urban site. Short grass areas were ranked higher at the coarse scale (second-order selection using 95% home ranges), and ranked considerably lower at the finer scale (third-order selection).

The management of urban wildlife is an important issue facing wildlife managers today, and a greater understanding of how these animals are affected, both positively and negatively, by human influence is needed to understand their needs and behaviors. This issue will likely become even more important as urban areas continue to expand and impact wildlife habitat. This research illustrated the significant use of anthropogenically-influenced areas by suburban and urban raccoons and also indicated that examination of multiple spatial scales is imperative to fully understand habitat selection of raccoons.

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Table 1. Mean home range sizes and standard error (SE) of raccoons for summers (1996 – 2000) at (a) Glacial Park in McHenry County, Illinois; (b) Max McGraw Wildlife Foundation in Kane County, Illinois; and (c) Ned Brown Forest Preserve in Cook County, Illinois.

a) Glacial Park

| | Mean (ha) | SE (ha) | N |
|---|---|---|---|
| Combined Sexes | 227 | 18 | 33 |
| Males | 243 | 28 | 13 |
| Females | 216 | 24 | 20 |

b) Max McGraw Wildlife Foundation

| | Mean (ha) | SE (ha) | N |
|---|---|---|---|
| Combined Sexes | 81 | 7 | 41 |
| Males | 98 | 12 | 18 |
| Females | 68 | 6 | 23 |

c) Ned Brown Forest Preserve

| | Mean (ha) | SE (ha) | N |
|---|---|---|---|
| Combined Sexes | 128 | 13 | 46 |
| Males | 129 | 14 | 21 |
| Females | 127 | 21 | 25 |

Table 2. Simplified ranking matrices (0 = least selected, 4 = most selected) for combined sexes at Glacial Park in McHenry County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | - | - | --- | --- | 0 |
| Human Use | + | | - | --- | --- | 1 |
| Shortgrass | + | + | | --- | --- | 2 |
| Tallgrass | +++ | +++ | +++ | | --- | 3 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | - | --- | 1 |
| Human Use | - | | - | - | --- | 0 |
| Shortgrass | + | + | | - | --- | 2 |
| Tallgrass | + | + | + | | --- | 3 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | + | - | 2 |
| Human Use | - | | - | + | --- | 1 |
| Shortgrass | + | + | | + | - | 3 |
| Tallgrass | - | - | - | | --- | 0 |
| Woodland | + | +++ | + | +++ | | 4 |

Table 3. Simplified ranking matrices (0 = least selected, 4 = most selected) for males at Glacial Park in McHenry County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | - | - | --- | --- | 0 |
| Human Use | + | | + | - | --- | 2 |
| Shortgrass | + | - | | --- | --- | 1 |
| Tallgrass | +++ | + | +++ | | - | 3 |
| Woodland | +++ | +++ | +++ | + | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | - | - | --- | --- | 0 |
| Human Use | + | | - | - | --- | 1 |
| Shortgrass | + | + | | - | --- | 2 |
| Tallgrass | +++ | + | + | | - | 3 |
| Woodland | +++ | +++ | +++ | + | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | - | - | - | - | 0 |
| Human Use | + | | - | - | - | 1 |
| Shortgrass | + | + | | + | + | 4 |
| Tallgrass | + | + | - | | - | 2 |
| Woodland | + | + | - | + | | 3 |

Table 4. Simplified ranking matrices (0 = least selected, 4 = most selected) for females at Glacial Park in McHenry County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | --- | --- | 1 |
| Human Use | - | | - | --- | --- | 0 |
| Shortgrass | + | + | | - | --- | 2 |
| Tallgrass | +++ | +++ | + | | --- | 3 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | + | + | --- | 3 |
| Human Use | - | | - | - | --- | 0 |
| Shortgrass | - | + | | - | --- | 1 |
| Tallgrass | - | + | + | | --- | 2 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | + | + | - | 3 |
| Human Use | - | | - | + | - | 1 |
| Shortgrass | - | + | | + | - | 2 |
| Tallgrass | - | - | - | | --- | 0 |
| Woodland | + | + | + | +++ | | 4 |

Table 5. Simplified ranking matrices (0 = least selected, 4 = most selected) for combined sexes at Max McGraw Wildlife Foundation in Kane County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | + | --- | 2 |
| Human Use | - | | - | + | --- | 1 |
| Shortgrass | + | + | | +++ | --- | 3 |
| Tallgrass | - | - | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | +++ | --- | 2 |
| Human Use | - | | --- | + | --- | 1 |
| Shortgrass | + | +++ | | +++ | --- | 3 |
| Tallgrass | --- | - | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | +++ | +++ | +++ | + | 4 |
| Human Use | --- | | + | +++ | --- | 2 |
| Shortgrass | --- | - | | +++ | --- | 1 |
| Tallgrass | --- | --- | --- | | --- | 0 |
| Woodland | - | +++ | +++ | +++ | | 3 |

Table 6. Simplified ranking matrices (0 = least selected, 4 = most selected) for males at Max McGraw Wildlife Foundation in Kane County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at α = 0.05.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | + | - | 2 |
| Human Use | - | | - | + | --- | 1 |
| Shortgrass | + | + | | + | - | 3 |
| Tallgrass | - | - | - | | --- | 0 |
| Woodland | + | +++ | + | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | +++ | --- | 2 |
| Human Use | - | | - | + | --- | 1 |
| Shortgrass | + | + | | +++ | --- | 3 |
| Tallgrass | --- | - | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | +++ | +++ | +++ | +++ | 4 |
| Human Use | --- | | + | +++ | - | 2 |
| Shortgrass | --- | - | | + | - | 1 |
| Tallgrass | --- | --- | - | | --- | 0 |
| Woodland | --- | + | + | +++ | | 3 |

Table 7. Simplified ranking matrices (0 = least selected, 4 = most selected) for females at Max McGraw Wildlife Foundation in Kane County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | - | - | + | --- | 1 |
| Human Use | + | | - | + | --- | 2 |
| Shortgrass | + | + | | + | --- | 3 |
| Tallgrass | - | - | - | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | + | - | +++ | --- | 2 |
| Human Use | - | | --- | + | --- | 1 |
| Shortgrass | + | +++ | | +++ | --- | 3 |
| Tallgrass | --- | - | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | +++ | +++ | +++ | + | 4 |
| Human Use | --- | | + | + | --- | 2 |
| Shortgrass | --- | - | | + | --- | 1 |
| Tallgrass | --- | - | - | | --- | 0 |
| Woodland | - | +++ | +++ | +++ | | 3 |

Table 8. Simplified ranking matrices (0 = least selected, 4 = most selected) for combined sexes at Ned Brown Forest Preserve in Cook County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | --- | - | --- | 0 |
| Human Use | +++ | | - | +++ | --- | 2 |
| Shortgrass | +++ | + | | +++ | --- | 3 |
| Tallgrass | + | --- | --- | | --- | 1 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | --- | + | --- | 1 |
| Human Use | +++ | | + | +++ | --- | 3 |
| Shortgrass | +++ | - | | +++ | --- | 2 |
| Tallgrass | - | --- | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | + | + | --- | 2 |
| Human Use | +++ | | +++ | +++ | + | 4 |
| Shortgrass | - | --- | | - | --- | 0 |
| Tallgrass | - | --- | + | | --- | 1 |
| Woodland | +++ | - | +++ | +++ | | 3 |

Table 9. Simplified ranking matrices (0 = least selected, 4 = most selected) for males at Ned Brown Forest Preserve in Cook County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | --- | - | --- | 0 |
| Human Use | +++ | | --- | + | --- | 2 |
| Shortgrass | +++ | +++ | | +++ | --- | 3 |
| Tallgrass | + | - | --- | | --- | 1 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | --- | - | --- | 0 |
| Human Use | +++ | | - | + | --- | 2 |
| Shortgrass | +++ | + | | +++ | --- | 3 |
| Tallgrass | + | - | --- | | --- | 1 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | + | - | - | 1 |
| Human Use | +++ | | +++ | + | + | 4 |
| Shortgrass | - | --- | | - | - | 0 |
| Tallgrass | + | - | + | | - | 2 |
| Woodland | + | - | + | + | | 3 |

Table 10. Simplified ranking matrices (0 = least selected, 4 = most selected) for females at Ned Brown Forest Preserve in Cook County, Illinois, for summers (1996 – 2000) for (a) second-order selection comparing composition of 95% home ranges to composition of effective study area, (b) second-order selection comparing composition of 50% core areas to composition of effective study area, and (c) third-order selection comparing proportions of individual telemetry points within each habitat type with composition of animal's corresponding home range. The sign of the t-values is shown, and triple signs represent significant deviation from random at $\alpha = 0.05$.

a) Second-order selection using 95% home ranges

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | --- | + | --- | 1 |
| Human Use | +++ | | - | +++ | --- | 2 |
| Shortgrass | +++ | + | | +++ | --- | 3 |
| Tallgrass | - | --- | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

b) Second-order selection using 50% core areas

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | --- | --- | + | --- | 1 |
| Human Use | +++ | | + | +++ | --- | 3 |
| Shortgrass | +++ | - | | +++ | --- | 2 |
| Tallgrass | - | --- | --- | | --- | 0 |
| Woodland | +++ | +++ | +++ | +++ | | 4 |

c) Third-order selection

| | Habitat Type | | | | | |
|---|---|---|---|---|---|---|
| Habitat Type | Aquatic | HumanUse | Shortgrass | Tallgrass | Woodland | Rank |
| Aquatic | | - | + | + | - | 2 |
| Human Use | + | | +++ | +++ | + | 4 |
| Shortgrass | - | --- | | + | --- | 1 |
| Tallgrass | - | --- | - | | --- | 0 |
| Woodland | + | - | +++ | +++ | | 3 |


Figure 1. The rural site of Glacial Park and its surrounding area in McHenry County, Illinois.

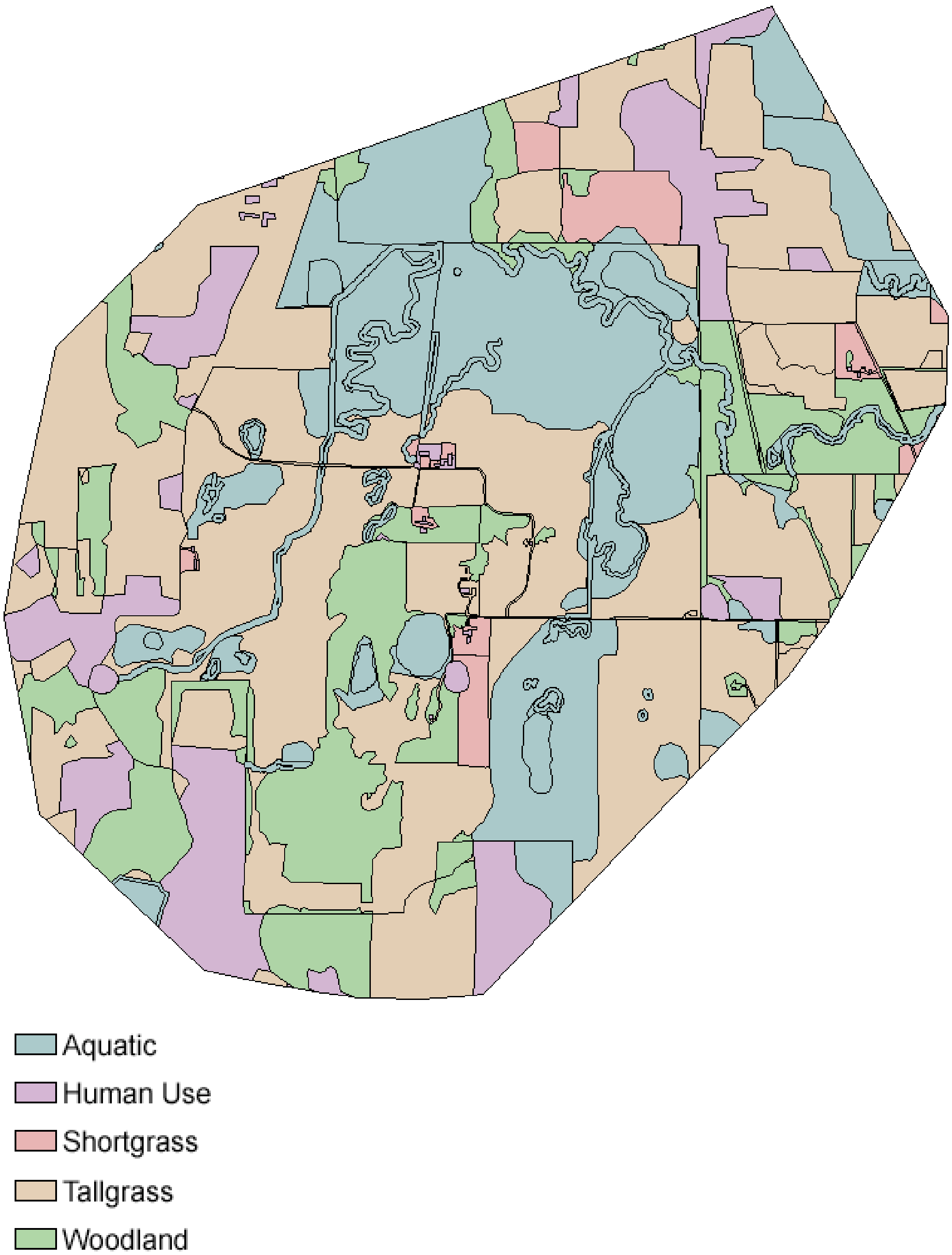


Figure 2. Effective study area for the rural site of Glacial Park and its surrounding area in McHenry County, Illinois.


Figure 3. The suburban site of Max McGraw Wildlife Foundation and its surrounding area in Kane County, Illinois.

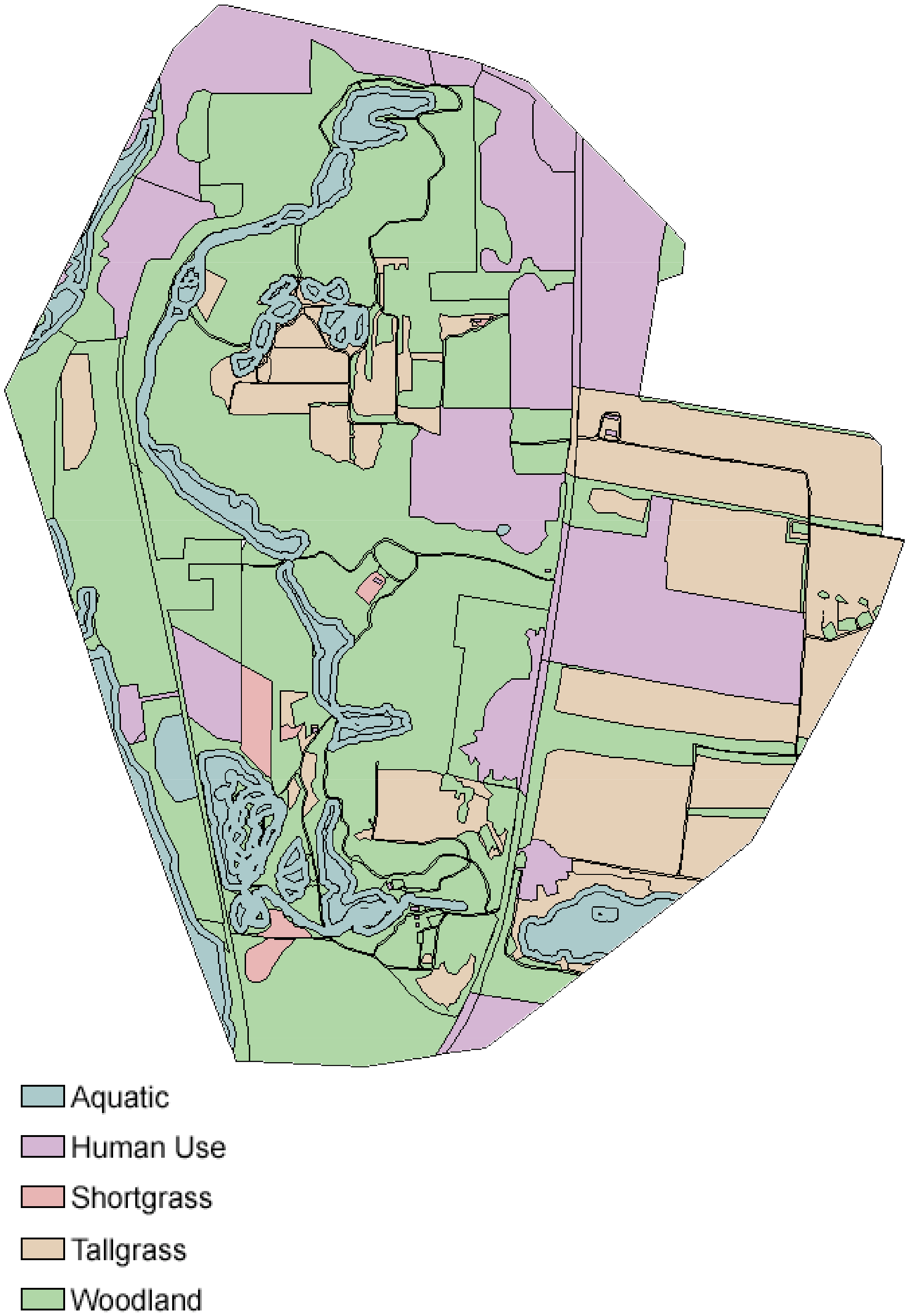


Figure 4. Effective study site for the suburban site of Max McGraw Wildlife Foundation and its surrounding area in Kane County, Illinois.

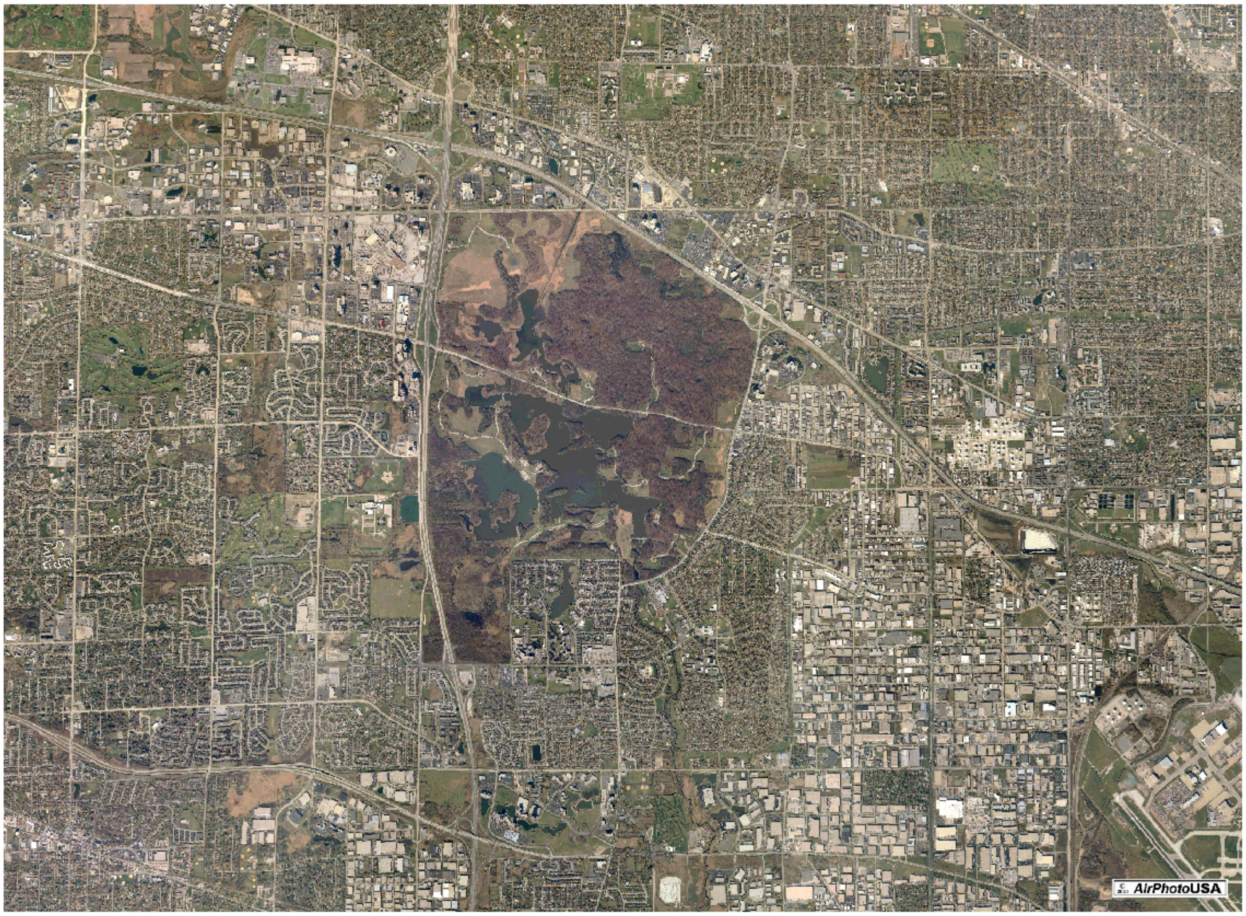


Figure 5. The urban site of Ned Brown Forest Preserve and its surrounding area in Cook County, Illinois.

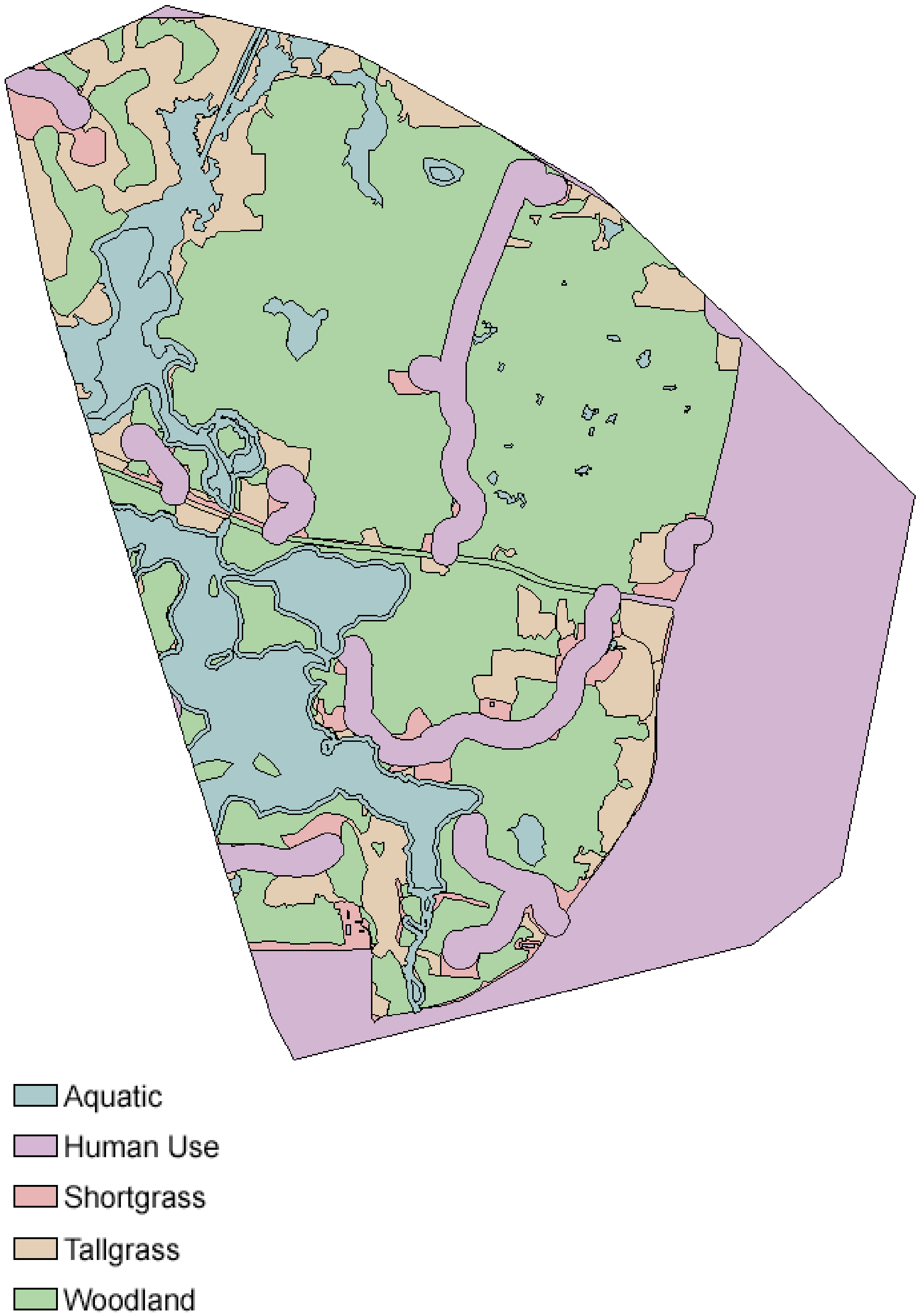


Figure 6. Effective study area for the urban site of Ned Brown Forest Preserve and its surrounding area in Cook County, Illinois.