# Examining winter habitat use by bobcats (*Lynx rufus*) in the Hudson Highlands of New York

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## Abstract

Due to the threats caused by habitat loss and fragmentation, understanding the habitat use patterns of mesopredators is vital for developing management and conservation strategies that target these species. The bobcat (*Lynx rufus*) is a mesopredator that occurs at notably low densities in certain locations across the Mid-Atlantic region of the United States. Although previous studies have examined bobcat habitat use in this region, continued land cover changes in the Mid-Atlantic require more updated research on this topic to ensure populations are managed effectively. The purpose of this study is to investigate whether bobcats in the Hudson Highlands of New York use habitat types differently than expected based on availability during winter. This study also examines whether the proportions of habitat types differ between sites where bobcats occur and do not occur. The results suggest a significant difference in the habitat types bobcats used in comparison to what would be expected based on habitat type availability. More specifically, bobcats exhibited a preference for temperate broadleaf deciduous forest and avoided urban and built-up area. The findings also suggest there was no difference in the proportions of habitat types between sites where bobcats occurred and sites where bobcats did not occur.



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## Introduction

Habitat loss and fragmentation due to human activities are considered the greatest threats to wildlife populations globally (Hanski, 2011; Wilson & Primack, 2019). In the last four decades, populations of terrestrial vertebrates have declined in number of individuals by approximately 28% on average (Dirzo et al., 2014). Mammalian carnivore populations are particularly vulnerable to habitat loss and fragmentation (Di Minin et al., 2016), as these species have large territorial requirements, naturally occur at low population densities, and have slow population growth rates (Crooks et al., 2011). Although many mammalian carnivores persist in human-dominated landscapes, these characteristics make adapting to landscape changes more challenging for carnivores than many other animals (Woodroffe & Ginsberg, 1998). Therefore, understanding which habitat types mammalian carnivores use within landscapes is critical for informing wildlife management efforts and for developing conservation strategies that target these species (Carroll et al., 2001; Fox-Rosales & De Oliveira, 2022).

### 1. Impacts of habitat loss and fragmentation on wildlife populations

Habitat loss and fragmentation threaten wildlife populations by causing populations to become more susceptible to stochastic events (Orrock, 2020). Stochastic events refer to unpredictable occurrences that can impact populations and community dynamics (Western, 2001). These events include local environmental changes, diseases, fluctuations in population size, and changes in immigration and emigration rates. Stochastic events can be particularly threatening to populations that have been impacted by human activities, as these populations tend to be smaller in size and are therefore more vulnerable to local extinction (Western, 2001; Kadowaki, 2019). For instance, small cougar (*Puma concolor*) populations in Florida that had

been negatively affected by human activities during the 20th century became more vulnerable to changes in population demographics, which nearly led to their extirpation (Hostetler et al., 2013). Additionally, the black-footed ferret (*Mustela nigripes*), which experienced population declines due to the loss of its preferred prey species (Russell et al., 1994), almost became extinct in the 1980s due to the impacts of canine distemper (Maguire et al., 1988).

Habitat loss and fragmentation can also impact wildlife populations by altering species interactions (Spiesman & Inouye, 2013). Human activities that result in landscape changes can alter species distributions, which can change species interactions such as predator-prey dynamics, mutualisms, and interspecific competition (Tylianakis et al., 2008). For example, human-driven landscape alterations that contributed to the reductions and extirpations of grey wolf (*Canis lupus*) populations across Europe likely caused red deer (*Cervus elaphus*) populations to increase (Dorresteijn et al., 2015). Moreover, habitat loss and fragmentation across the Neotropics have likely altered competitive interactions between jaguars (*Panthera onca*) and cougars, as the former species is less adaptable to human-dominated landscapes than the latter species (Villalva et al., 2024).

## 2. Habitat use by mesopredators

Mesopredators refer to carnivores that have relatively small body sizes and are found at intermediate trophic levels within ecological communities (Prugh et al., 2009). These animals tend to avoid areas with habitat features that could result in encounters with larger carnivores (Torretta et al., 2016; Rodriguez Curras et al., 2021), as entering these areas could result in intraguild predation and antagonistic interactions (Linnell & Strand, 2000). For instance, red foxes (*Vulpes vulpes*) will alter their foraging behaviour and spatial use patterns to avoid areas occupied by grey wolves (Haswell et al., 2018). Mesopredators are also more likely to use areas

with habitat characteristics that enable them to encounter prey species more frequently (Rajaratnam et al., 2007; Wolff et al., 2015), as this allows these animals to have greater access to resources that are essential to their survival. An example is shown in American badgers (*Taxidea taxus*), which have a higher probability of occurring in areas with habitat features that are correlated with higher densities of potential prey species (Holbrook et al., 2016).

Habitat use patterns of mesopredators are also interesting to study in human-dominated landscapes, as these animals are generally more tolerant of human activities than larger predators (Ordeñana et al., 2010; Mohd-Azlan et al., 2023; Vanek et al., 2023). This pattern could be explained by the notion that many mesopredators are habitat generalists (Pasanen-Mortensen & Elmhagen, 2015). Habitat generalists are animals that can survive under various environmental conditions and can therefore persist in many habitat types (Ainsworth & Drake, 2020). The ability of mesopredators to survive in different habitat types is demonstrated with coyotes (*Canis latrans*) and racoons (*Procyon lotor***),** as these mesopredators occur in areas that are not strongly associated with particular habitat characteristics (Zamuda et al., 2022). Another example is shown in leopard cats (*Prionailurus bengalensis*), which are mesopredators that are known to occur in a variety of forest types (Pin et al., 2022).

## 3. Habitat use by bobcats

One mesopredator that occurs in a variety of habitat types is the bobcat (*Lynx rufus*) (Janecka et al., 2016). This medium-sized felid has a distribution that occurs from southern Canada to southern Mexico (Barcenas & Medellin, 2021), and is found in habitat types that include deserts (Draper et al., 2022), montane forests (Witczuk et al., 2015), subtropical wetlands (Buckman et al., 2024), perennial grasslands (Linde et al., 2012), and temperate forests (Monterrubio-Rico et al., 2019). Furthermore, bobcats are known to occur in areas that exhibit

differences in habitat characteristics, such as understory density (Litvaitis et al., 1986), elevation (Draper et al., 2022), and distance to habitat edges (Tigas et al., 2002).

## 4. Importance of studying bobcat habitat use in the Mid-Atlantic region

The Mid-Atlantic region of the United States is comprised of New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Virginia, and North Carolina (Tran et al., 2010). This region has undergone dramatic landscape alterations due to human activities, as approximately 28% of the region experienced land cover changes between 1972 and 2001 due to urbanization and agricultural development (Slonecker et al., 2010). Additionally, many habitat types in the Mid-Atlantic region are predicted to experience notable declines in the future due to climate change, including montane forests, lowland conifer forests, hardwood forests (Butler-Leopold et al., 2018), and temperate wetlands (Vanderhoof et al., 2020). Thus, determining which habitat types different species use in this region will be important for conserving land to protect local wildlife populations.

Although bobcat populations in the Mid-Atlantic region have been studied in relation to habitat use (Fox, 1990; Lovallo, 2000; Matos, 2020; Cerreta et al., 2023), many of these studies were conducted over two decades ago (Fox, 1990; Lovallo, 2000). Due to predicted rates at which land cover changes are expected to occur in many areas of the Mid-Atlantic in the future (Alig et al., 2004; Shade & Kremer, 2019; Ngoy et al., 2021; Yin et al., 2023), more studies that capture current habitat use patterns by this species in this region are needed to implement effective conservation strategies. Certain bobcat populations in the Mid-Atlantic also occur at densities that are concerningly low (Morin et al., 2018; Cerreta et al., 2023; Twining et al., 2024), which could make these populations vulnerable to extirpation (Gray et al., 2014) and emphasizes the importance of understanding the spatial ecology of this species. Furthermore, land cover

changes that have occurred in the Mid-Atlantic over the past two decades (Ngoy et al., 2021; Albright et al., 2023; DiNapoli, 2024) could be altering bobcat habitat use patterns across this region. Lastly, the ability of bobcats to adapt to urban environments (Young et al., 2019) makes this felid a candidate species for predicting how other mesopredators could respond to human-driven landscape modifications. Bobcats should also be classified as mesopredators since these animals are usually not the apex predators of the ecological communities they inhabit (Jachowski et al., 2020).

The purpose of my thesis is to use presence-absence data to investigate the habitat use patterns of bobcats during winter in the Hudson Highlands of New York. More specifically, I aim to determine whether bobcats from this population use certain habitat types more or less often than expected in accordance with habitat type availability. I will also determine if there is a difference in the proportions of habitat types at sites where bobcats occur and at sites where bobcats do not occur. I hypothesize that there will be a difference in the habitat types that bobcats use relative to their availabilities in my study area. I predict that bobcats will use certain forest types more than expected by chance. Furthermore, I predict that bobcats will use urban and built-up area less than expected by chance. I also hypothesize that there will be a difference in the proportions of habitat types at sites where bobcats occur and do not occur. I predict that certain forest types will be more prominent at sites where bobcats occur. Additionally, I predict that non-forest habitat types will be more prominent at sites where this species does not occur.

## Methodology

### 1. Study area

Data for this study were collected from the Hudson Highlands, which is in southeastern New York in the United States. The terrain of the Hudson Highlands is characterized by hills and mountains (Budnik et al., 2010). Deciduous forests dominate this region and contain hardwoods such as red maple (*Acer rubrum*), white oak (*Quercus alba*), chestnut oak (*Quercus montana*), yellow birch (*Betula alleghaniensis*), and northern red oak (*Quercus rubra*) (Lorimer, 1981; Schuster et al., 2008). The total size of my study area was approximately 169.03 $km^2$ and was comprised mostly of temperate broadleaf deciduous forest (55.14%) and urban and built-up area (29.19%) (Table 1). The various habitat types in my study area were based on land cover categories defined by 2020 Landsat satellite imagery provided by the Commission for Environmental Cooperation (Commission for Environmental Cooperation, 2019).

**Table 1.** Various habitat types and the approximate relative percentages they comprised in the study area in the Hudson Highlands of New York in the United States. The habitat types are based on land cover categories used in 2020 Landsat satellite imagery provided by the Commission for Environmental Cooperation.

| Habitat type | Percentage (%) |
|---|---|
| Temperate broadleaf deciduous forest | 55.14% |
| Urban and built-up area | 29.19% |
| Cropland | 5.12% |
| Wetland | 4.46% |
| Water | 3.64% |
| Temperate shrubland | 0.82% |
| Mixed forest | 0.71% |
| Temperate grassland | 0.54% |
| Barren land | 0.25% |
| Temperate needleleaf forest | 0.14% |

## 2. Data collection

Data were collected with camera-traps (Reconyx HyperFire2), which are specialized cameras that are prompted to take photos after movement is detected (McCallum, 2013). The camera-traps were deployed from November to March during the following years: 2018 to 2019, 2019 to 2020, 2020 to 2021, 2021 to 2022, and 2022 to 2023. They were mostly deployed in three protected areas: Schunnemunk Mountain State Park, Storm King State Park, and Black

Rock Forest. The camera-traps were placed at a minimum of approximately 400 m away from each other at sites that corresponded to the availabilities of the various habitat types in the area. Sites were also selected for camera-trap deployment if they maximized the likeliness of capturing photos of mesopredators. The camera-traps were then attached to a tree at the selected sites so that the lens faced north, which reduced the impacts of glare on photo captures. The camera-traps were also deployed approximately 0.5 m above the ground and were then programmed to take bursts of 10 photos per trigger. All camera-traps were placed approximately 30 m to 800 m away from roads to reduce their potential impacts. Each camera-trap was then deployed for approximately 2 months. Most sites were monitored on multiple years, but camera-traps that were tampered with or damaged due to flooding were moved to another location the following year. All photos obtained by the camera-traps were then sorted based on the following variables: camera-trap station, camera-trap deployment, year of study, species that was photographed, number of individuals in photo, age of individuals in photo, and sex of individuals in photo. Multiple photos obtained of the same animal simultaneously were also considered a single photo capture event.

To increase the chances of obtaining high quality mesopredator photo captures, each camera-trap was baited with ~2 kg of white-tailed deer (*Odocoileus virginianus*) carcass. The meat was strapped to a tree about 3 to 5 m away from the camera-trap and was positioned to be approximately 2 m above the ground. A small amount of lure (Cavern's Gusto and Caven's Tree Climber) was applied at the site to attract nearby carnivores.

### 3. Data analysis

Before the GPS coordinates of each camera-trap station were mapped, I averaged the coordinates of stations with multiple deployments in accordance with recommendations provided

by the Black Rock Forest biological field station. Averaging the coordinates of certain stations with multiple deployments helped account for handheld GPS errors and small deviations caused by differences in selected deployment trees between years. Moreover, true distances between the camera-trap stations were considered negligible due to the broad scale of the ecological interactions being investigated in this study. I then recorded whether a bobcat photo was captured by each camera-trap station during each day of the study period and the number of bobcat photos captured at each station per day and per year. I also recorded whether a camera-trap site was surveyed more than once in a single year and if the averaged coordinates I used for certain stations contained coordinates that were used during summer deployments.

To determine the size and habitat composition of my study area, I mapped the GPS coordinates of the camera-trap stations with Esri's ArcGIS Pro 3.4.0 software. I then extracted land cover data from the 2020 Landsat satellite imagery and added these data to my map (Figure 1). I assumed there were minimal changes to land cover in my study area between 2018 and 2023. There were also no changes to land cover at the camera-trap station sites during this period (LaPoint, pers communication). The land cover data also had a spatial resolution of 30 m, which I considered fine enough for the purposes of my study. I added a buffer of 250 m to my study area to accommodate for 250-m buffers that would be added to the coordinates of the camera-trap stations. This buffer size was chosen to reduce spatial overlap between the buffers of different stations and because this buffer size has been used in other camera-trap studies that examined mesopredator spatial ecology (Cove et al., 2012; Furnas et al., 2017). Once the buffer was added to my study area, I used ArcGIS Pro to clip the land cover data to the confines of my study area. I then created a polygon of my study area using the map layers that contained the clipped land cover data and the coordinates of the camera-trap stations. This step transformed the

clipped land cover data, which was initially raster data, to a polygon. The attribute table of the map layer that contained the polygon was then used to measure the size of my study area and the land coverage of each habitat type within my study area. The total area covered by each habitat type was then converted to percentage with Microsoft Excel based on the proportions of land each habitat type occupied within my study area.

To determine the habitat type composition of sites with camera-trap stations that captured bobcat photos, I added the coordinates of camera-trap stations that captured images of bobcats during a certain year to a new map with ArcGIS Pro. I then added buffers with 250-m radii to the coordinates of each station. The steps that I used to determine the habitat type composition of my study area were then repeated for the buffers, although I used the map layer that contained the buffers of the station coordinates for this procedure. I repeated this process for each year included in my study. These steps were also repeated for camera-trap stations that did not capture bobcat photos.

To calculate the latencies of bobcat photo capture events, I subtracted the first day a bobcat photo was captured from the first day of deployment for each camera-trap station during each year. I also determined the number of nights that at least one camera-trap was active by adding the number of days that occurred between the first and last days in which a camera-trap was deployed during each year. I calculated the frequency at which each camera-trap station captured an image of at least one bobcat by dividing the number of bobcat photo capture events by the number of days each station obtained data for each year. Lastly, I estimated camera-trapping effort for each year by multiplying the number of camera-traps that were used by the total number of nights the camera-traps were active. The total number of nights the camera-traps

were active was determined by adding the number of nights that each camera-trap station that was used in the same year operated.

A chi-squared test was used to compare the land cover data present in the buffers of camera-trap stations that captured images of bobcats to the land cover data in my entire study area. If the bobcats exhibit a preference for certain habitat types, the habitat type percentages of these buffers will differ from those of my study area. This observation would also be expected if the bobcats are avoiding certain habitat types. Finally, if the bobcats are using habitat types in accordance with availability, it would be expected that the percentages of the habitat types in these buffers will be similar to those of my study area.

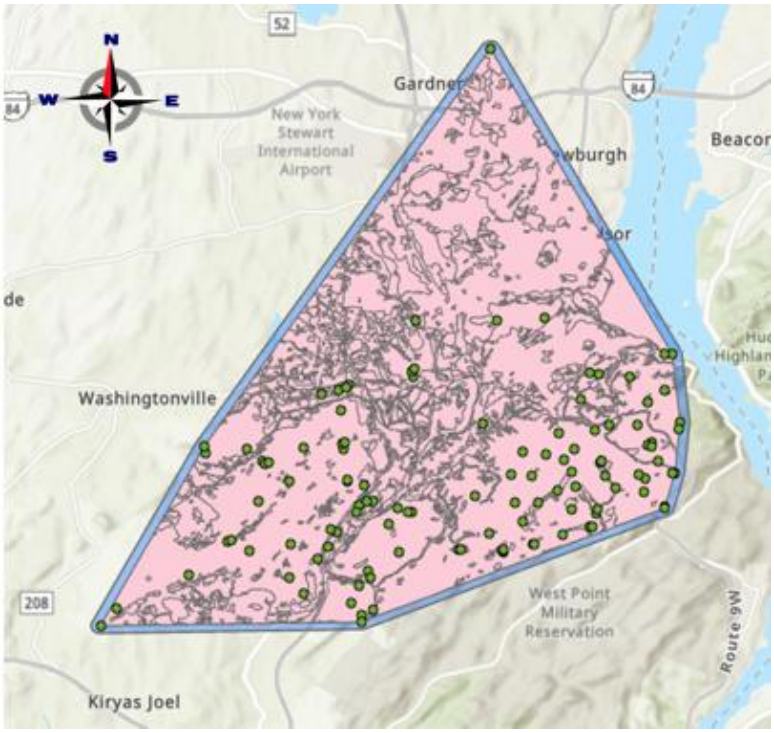



**Figure 1.** Map of the entire study area in the Hudson Highlands of New York. The study area was created based on the placements of various camera-traps and is shown on the map in pink. The green dots represent the locations of camera-trap stations while the blue border represents the 250-m buffer that was applied to the perimeter of the study area.

## Results

### 1. Camera-trapping survey

A total of 144 different camera-trap stations were used to obtain data from my study area. The estimated camera-trapping effort across the duration of the study was 17,586 camera-trapping nights (Table 2). The average camera-trapping effort for each year of the study was approximately 3,517 camera-trapping nights (Table 2). The total number of events that captured a photo that contained at least one bobcat across the study period was 232 (Table 2). The mean number of events that captured an image of at least one bobcat during each year of the study was approximately 46.4 (Table 2). The mean latency of capture events for bobcat photos was approximately 6.8 days across the study period (Table 2).

**Table 2.** Summary of camera-trapping effort, bobcat photo capture events, and latency of bobcat photo capture events between the years 2018 to 2019 and 2022 to 2023.

| Year of study | Number of camera-trapping nights | Number of capture events for bobcat photos | Latency of capture events for bobcat photos |
|---|---|---|---|
| 2018 to 2019 | 4239 | 51 | 9 days |
| 2019 to 2020 | 2856 | 63 | 3 days |
| 2020 to 2021 | 2177 | 33 | 3 days |
| 2021 to 2022 | 3971 | 39 | 4 days |
| 2022 to 2023 | 4343 | 46 | 15 days |

### 2. Composition of sites where bobcats occurred

The mean percentages of temperate broadleaf deciduous forest and urban and built-up area in the buffers of the camera-trap stations that obtained bobcat images across the study period were approximately 82.77% and 3.27%, respectively (Table 3).

**Table 3.** Approximate mean relative percentages of various habitat types in buffers of camera-traps that captured bobcat images between the years 2018 to 2019 and 2022 to 2023.

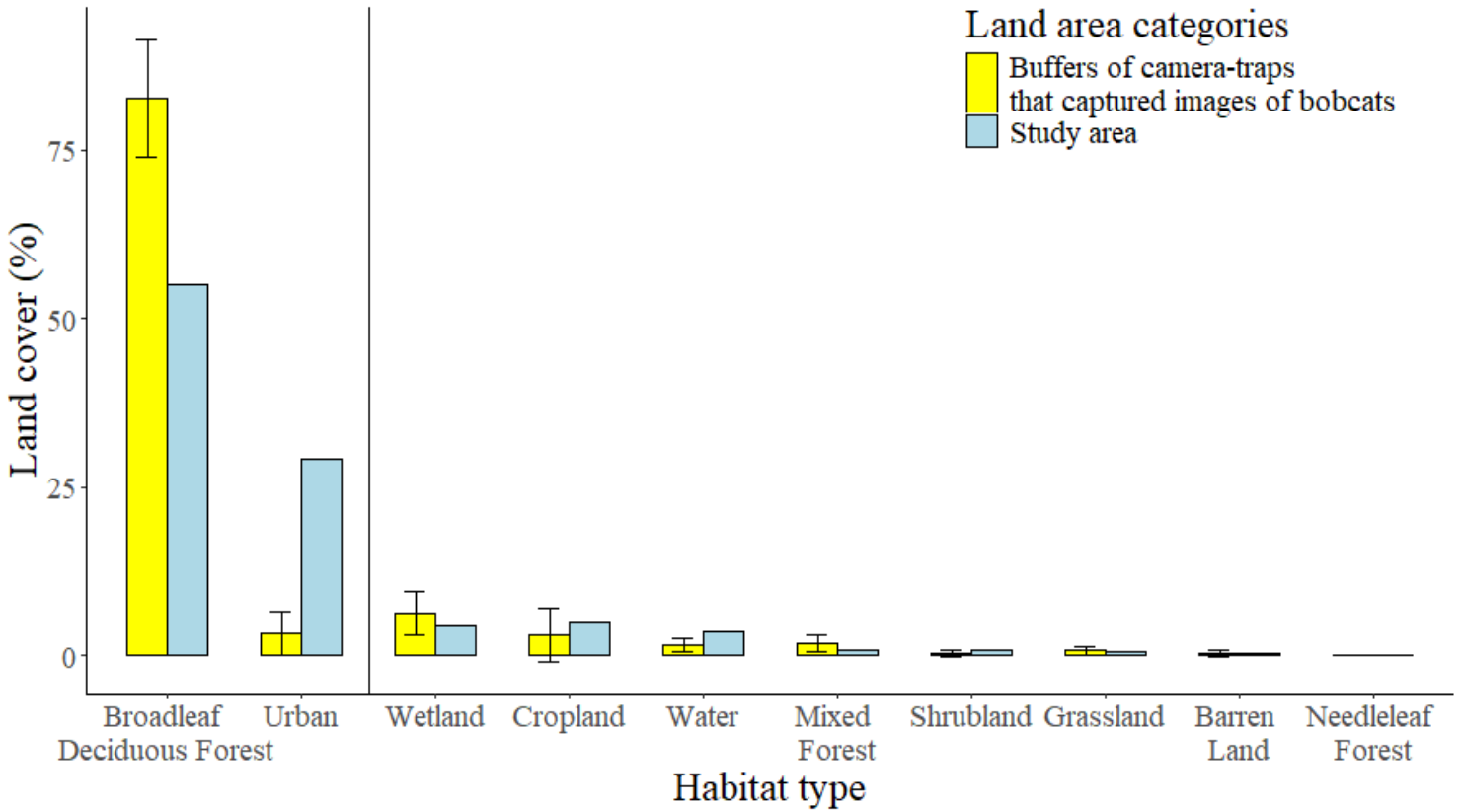
| Habitat type | Percentage (%) |
|---|---|
| Temperate broadleaf deciduous forest | 82.77% |
| Wetland | 6.23% |
| Urban and built-up area | 3.27% |
| Cropland | 3.06% |
| Mixed forest | 1.84% |
| Water | 1.44% |
| Temperate grassland | 0.74% |
| Barren land | 0.37% |
| Temperate shrubland | 0.33% |
| Temperate needleleaf forest | 0.02% |

### 3. Habitat use patterns

The data were found to be significantly different than what I would expect if bobcats were distributed across the study site without exhibiting habitat use preferences ($\chi^2 = 253.33$, df = 9, $p < 0.001$). More specifically, bobcats occurred more in temperate broadleaf deciduous

forest than expected by chance. The mean percentage of temperate broadleaf deciduous forest in the buffers of camera-traps that captured bobcat images was approximately 27.63% greater than the availability of this habitat type in my entire study area (Figure 2). Bobcats also occurred less often in urban and built-up area than expected (Figure 2). The mean percentage of urban and built-up area in my study area was approximately 25.92% greater than the percentage of this habitat type in the buffers of camera-traps that captured images of bobcats (Figure 2).

The results also indicate that there are no differences between the habitat types within buffers of camera-traps that captured images of bobcats and those within buffers of camera traps that did not capture images of bobcats (Figure 3).




342

343 **Figure 2.** Average composition of habitat types in buffers of camera-trap stations that captured bobcat images and in the study area
344 between the years 2018 to 2019 and 2022 to 2023. The words temperate and built-up area were removed from habitat type names to
345 provide more space on the x-axis. Standard deviation is shown instead of standard error since habitat type composition in the study
346 area did not vary across the study period and some camera-trap stations were only used to collect data for one year. A chi-squared test
347 found that bobcats used habitat types differently than expected by chance based on the availabilities of habitat types in the study area.

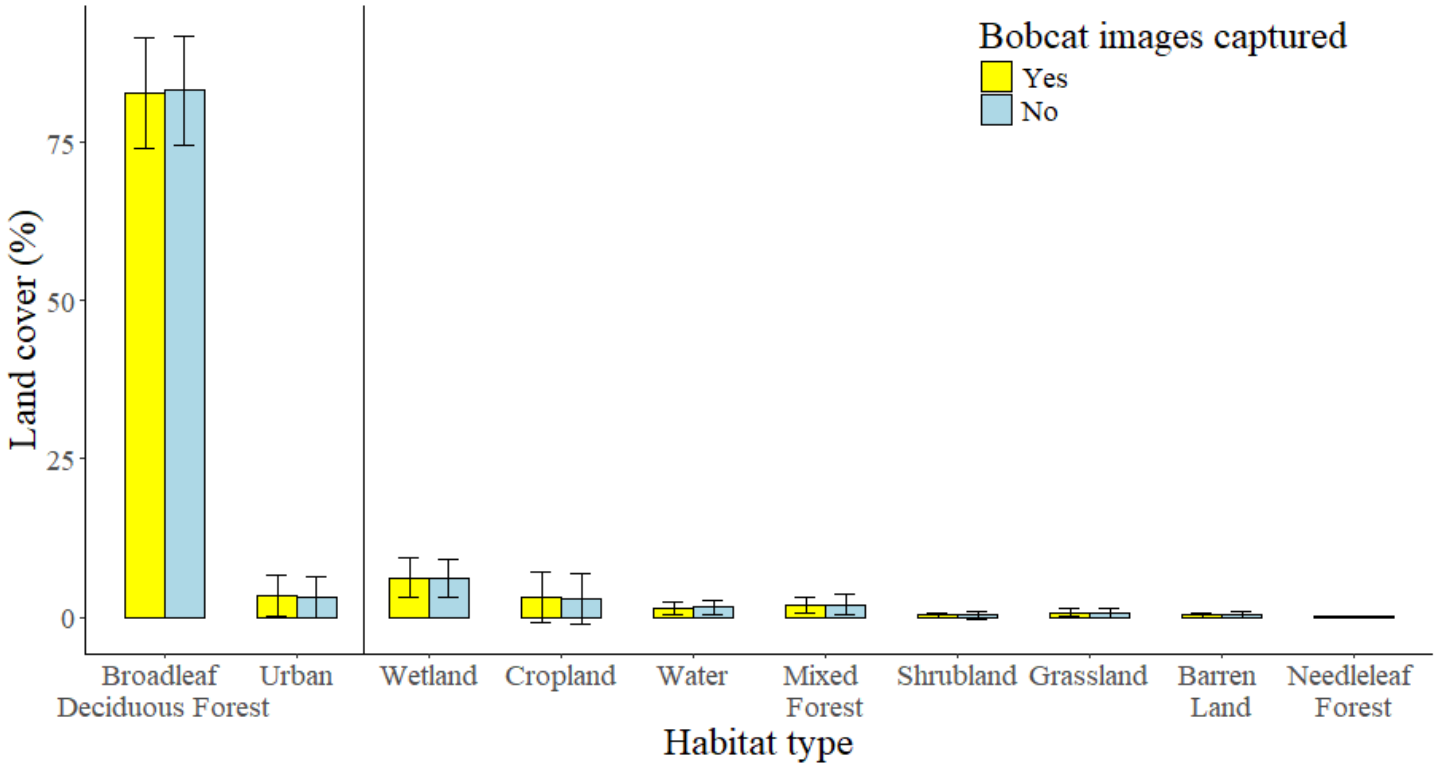



**Figure 3.** Average habitat type composition of buffers of camera-trap stations that did and did not capture bobcat images between the years 2018 to 2019 and 2022 to 2023. The words temperate and built-up area were removed from habitat type names to provide more space on the x-axis. Standard deviation is shown instead of standard error since some camera-trap stations were only used to collect data for one year. There appears to be no difference between the habitat type composition of camera-trap station buffers that did obtain bobcat images and those that did not obtain bobcat images.

## Discussion

### 1. Temperate broadleaf deciduous forest

My study revealed that bobcats in the Hudson Highlands of New York use temperate broadleaf deciduous forest more than expected by chance in comparison to the availability of this forest type in my entire study area. This finding suggests that bobcats from this population prefer to use temperate broadleaf deciduous forest over other available habitat types. Bobcat habitat use patterns have been strongly associated with forests in other populations (Lovallo, 2000; Nielsen & Woolf, 2002; Koehler, 2006; Popescu et al., 2021). A possible explanation for this finding is that some forest types could contain more bobcat prey than other habitat types. Animals often use habitats that contain higher levels of food availability, as greater access to food improves an animal's chances of survival and reproductive success (Boutin, 1990; Hollander et al., 2013). For example, Canada lynxes (*Lynx canadensis*) are more likely to use forest stands that contain higher snowshoe hare (*Lepus americanus*) densities (Fuller et al., 2007). Moreover, leopard (*Panthera pardus*) habitat use in India is positively associated with increased availabilities of various prey species, such as sambar deer (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*) and chital (*Axis axis*) (Chaudhary et al., 2020).

Bobcats in the Hudson Highlands could also prefer temperate broadleaf deciduous forest because this forest type could contain high levels of understory stem density and wood debris. During winter months, bobcats are more likely to use habitats that contain these features, as stems and wood debris provide concealment cover for bobcats in the absence of cover provided by foliage (Kolowski & Woolf, 2002). Felids often use habitats with greater concealment cover to prevent prey detection, which allows these animals to ambush or stalk and chase prey over shorter distances (Murray et al., 1995). Furthermore, areas with increased concealment cover are

more likely to be used by many bobcat prey species (Kolowski & Woolf, 2002) and also provide animals with greater protection from human disturbances (Matos, 2020). Indeed, bobcats in southern Illinois are more likely to use areas with higher understory stem density and wood debris than areas that contain low levels of these features during winter (Kolowski & Woolf, 2002). Moreover, bobcat habitat use in Ohio is positively correlated with high proportions of herbaceous vegetation cover (Popescu et al., 2021). Interestingly, male bobcats are known to use more open areas, such as agricultural landscapes and wetlands, more frequently than females (Matos, 2020). Future research should investigate whether a similar pattern is present in bobcats found in the Hudson Highlands and in other areas in the Mid-Atlantic.

Bobcats in the Hudson Highlands could also be using temperate broadleaf deciduous forest more than other available habitat types because this habitat type could be used less frequently by sympatric mammalian carnivores. Mammalian carnivores often use different areas to avoid encounters with each other, as these encounters can result in injury or intraguild predation (Palomares et al., 2016). Additionally, mammalian carnivores often exhibit spatial avoidance to reduce interspecific competition for limited resources, which decreases the likeliness of resource depletion (Palomares et al., 2016). This pattern is observed in leopards, which spatially avoid areas that are used frequently by tigers (*Panthera tigris*) (Kafley et al., 2019). A similar finding has also been observed in painted dogs (*Lycaon pictus*), which are known to avoid areas that are used by lions (*Panthera leo*) (Darnell et al., 2014). In the forests of New York, bobcats occur sympatrically with many predators, including coyotes, raccoons, black bears (*Ursus americanus*), and fishers (*Pekania pennanti*) (Gompper et al., 2006). However, more research is required to determine the spatial relationships between these predators in the Hudson Highlands and at other locations in the Mid-Atlantic.

Finally, bobcats in the Hudson Highlands could prefer temperate broadleaf deciduous forest because this forest type could be strongly associated with certain slope and aspect characteristics. Slope refers to the measurement of steepness (Thacker, 2019), while aspect refers to the direction a slope faces (Malaperdas & Panagiotidis, 2018). Slope and aspect influence the density, composition, and structure of plant communities (Sternberg & Shoshany, 2001), as these variables impact the amount of solar radiation an area receives and thus affects soil properties such as moisture content and near-surface temperatures (Bennie et al., 2008). Slope and aspect can also impact prey availability (Lovallo, 2000), as landscape patterns can influence prey spatial distributions and predator-prey interactions (Ferguson, 2004). Indeed, bobcats in northcentral Pennsylvania frequently use areas with slopes that are between seven to eight degrees and are exposed to the east or southeast (Lovallo, 2000). Notably, bobcats from this population also use temperate broadleaf deciduous forest more than other habitat types in both summer and winter (Lovallo, 2000). Although the possible impacts of slope and aspect on bobcat habitat use has been examined in other populations (Lovallo, 2000; Donovan et al., 2011; Reed et al., 2017), whether these factors influence habitat use by bobcats in the Hudson Highlands has not been investigated. Therefore, additional research is needed to investigate whether slope and aspect impact bobcat habitat use in this location and at other locations in the Mid-Atlantic.

**2. Urban and built-up area**

In addition to using temperate broadleaf deciduous forest most frequently, bobcats in my study area also used urban and built-up area less often than expected by chance based on the availability of this habitat type. I expected this observation because many mammalian carnivores actively avoid urban environments due to their high densities of people and associated structures (Bateman & Fleming, 2012). These characteristics cause urban areas to contain disturbances that

increase the probability of predator mortality, as the presence of roads, infrastructure, and development enhances the risk of exploitation, human-wildlife conflict, and transportation-induced mortality (Bateman & Fleming, 2012; Adams et al., 2024). Furthermore, urban areas also contain altered vegetation and food resources that could be challenging for some mammalian carnivores to adapt to (Bateman & Fleming, 2012). Avoidance of urban landscapes is shown in Eurasian lynxes (*Lynx lynx*), which prefer to use areas further away from human settlements (Ripari et al., 2022). Bobcats from other populations have also been known to avoid urban environments, such as in northern California, New Hampshire, and Vermont (Riley, 2006; Litvaitis et al., 2015; Abouelezz et al., 2018). In addition to avoiding urban environments, bobcats are also less likely to use areas near roads (Riley, 2006; Young et al., 2019). Although spatial avoidance of roads has been observed in New York bobcat populations (Fox, 1990), whether these animals respond temporally to roads is not clear. Thus, more research is needed to determine whether bobcat road avoidance in New York and other areas of the Mid-Atlantic is influenced by time of day.

### 3. Camera-trap station sites

Lastly, my study indicates that there was no difference in the proportions of habitat types within buffers of camera-trap stations that captured bobcat images and those that did not. This finding likely reflected the placement of camera-traps at sites that were mostly surrounded by temperate broadleaf deciduous forest, which occurred since this forest type was the most common habitat type in my study area. This result could have also been influenced by the decision to deploy camera-traps at sites that were predicted to be used more frequently by mesopredators. Many wildlife researchers will strategically place camera-traps in locations where photos of target species are more likely to be obtained (Franck et al., 2014). Although this

446 approach is not random, this practice is recommended for researchers that are using camera-traps
447 to improve capture rates of animals that occur at low densities and are elusive (Franck et al.,
448 2014), including felids (Palmero et al., 2023). Nonetheless, future studies conducted in the
449 Hudson Highlands and at other locations in the Mid-Atlantic should place camera-traps at sites
450 where non-forest habitat types are more prominent to confirm their frequency of use by bobcats.

## Conclusions

In conclusion, the results of my research supported my first hypothesis and first set of predictions. During winter, bobcats in the Hudson Highlands use temperate broadleaf deciduous forest more than expected by chance based on the availability of this habitat type in my study area. Bobcats from this population also use urban and built-up area less than expected by chance based on the availability of this habitat type. In contrast, the findings of my study did not support my second hypothesis and second set of predictions. Proportions of habitat types at sites where bobcats occurred did not differ from those at sites where bobcats did not occur. Future studies on bobcat ecology that are conducted in the Hudson Highlands and at other locations in the Mid-Atlantic region should determine if habitat use patterns differ between males and females, if spatial relationships exist between bobcats and other mammalian carnivores, and whether slope and aspect influence bobcat habitat use. Moreover, more research is needed to determine if bobcats in the Mid-Atlantic exhibit temporal avoidance of roads. Finally, future research that examines bobcat habitat ecology in the Hudson Highlands and at other locations in the Mid-Atlantic should investigate bobcat occurrence in non-forest habitat types by placing camera-traps at sites where these habitat types are more prominent.

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