THE EFFECT OF LANDSCAPE CHARACTERISTICS ON MESOCARNIVORE OCCUPANCY IN FOREST FRAGMENTS

by

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TABLE OF CONTENTS

LIST OF TABLES v
LIST OF FIGURES vi
ABSTRACT vii

1 INTRODUCTION 1

2 STUDY AREA 4

3 METHODS 7

4 RESULTS 9

5 DISCUSSION 15

LITERATURE CITED 18

MESOCARNIVORE HOME RANGE DATA 21

LIST OF TABLES

Table 1 Landscape parameters for the 21 Delaware forest plots in which I estimated occupancy probabilities for mesocarnivores in 2012. 6

Table 2 The AIC values of PRESENCE models run to predict domestic cat occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where cats were detected and not detected. I considered models with a ΔAIC <2.00 to be best fit for the observed data. 11

Table 3 The AIC values of PRESENCE models run to predict raccoon occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where raccoons were detected and not detected. I considered models with a ΔAIC <2.00 to be best fit for the observed data. 12

Table 4 The AIC values of PRESENCE models run to predict red fox occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where foxes were detected and not detected. I considered models with a ΔAIC <2.00 to be best fit for the observed data. 13

Table 5 The AIC values of PRESENCE models run to predict Virginia opossum occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where opossums were detected and not detected. I considered models with a ΔAIC <2.00 to be best fit for the observed data. 14

LIST OF FIGURES

Figure 1 Map of the 21 forest plots in Newark, DE used to investigate the effect of landscape characteristics on mesocarnivore occupancy in 2012. Plots varied by proportion of multiflora rose cover, average distances to the nearest road and to the nearest stream, total patch size, and bordering proportions of forest, agriculture, and non-forest cover. 5

ABSTRACT

The objective of this study was to identify landscape characteristics which predict the presence of mesocarnivore species in forests fragmented by urban development. I used remote cameras to detect mesocarnivores in 21 forest patches in Newark, Delaware in June and July 2012. Using the program PRESENCE, I determined which of the following seven landscape characteristics were the most likely predictors of occupancy for the four species detected: proportion of multiflora rose (*Rosa multiflora*) cover within the plot; average distance of the plot to the nearest road and to the nearest stream; patch size; and proportions of forest, agriculture, and non-forest cover within a 100-m buffer surrounding the plot. The proportion of multiflora rose cover and proportion of surrounding forest cover were common predictors of occupancy for domestic cats (*Felis catus*), red foxes (*Vulpes vulpes*), and Virginia opossums (*Didelphis virginiana*). For foxes and opossums, occupancy probability increased with forest cover and decreased with rose cover. The reverse was true for cats. No landscape variables could be identified as effective predictors of occupancy for raccoons (*Procyon lotor*), possibly reflecting the species' ability to adapt to a variety of habitat types. While not applicable for all mesocarnivores, the models derived from my research may be useful in predicting the occupancy of select species in forest fragments based solely on landscape characteristics.

Chapter 1

INTRODUCTION

Mesocarnivores are medium-sized mammals classified in the order Carnivora. Most are opportunistic, feeding on a diversity of live prey, carrion, or vegetative matter depending on availability. Mesocarnivore species observed in Delaware forests include the raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), striped skunk (*Mephitis mephitis*), three species of weasel (*Mustela erminea, M. frenata, M. nivalis*), and domestic cat (*Felis catus*). While the Virginia opossum (*Didelphis virginiana*) is not classified in the order Carnivora but rather in Didelphimorphia, the species has a similar trophic niche to those of true mesocarnivores and therefore has been included as a target species (Reid 2006).

Characteristics of a fragmented landscape likely influence the abundance and distribution of mesocarnivores. A study in the urban setting of coastal southern California documented that smaller, more isolated fragments limit occupancy for several mesocarnivores, including badgers (*Taxidea taxus*), long-tailed weasels, and western spotted skunks (*Spilogale gracilis;* Crooks 2002). In contrast, domestic cats, gray foxes, and opossums were more abundant in smaller, more isolated patches (Crooks 2002). These landscape characteristics had little effect on the abundance of raccoons and striped skunks (Crooks 2002). Within the habitat patches, mesocarnivore abundance was greater in areas that had greater exotic plant cover and were closer to the urban edge (Crooks 2002).

Some mesocarnivore species seem well adapted to landscapes affected by development and habitat fragmentation. For instance, Crooks and Soulé (1999) found that smaller patches had greater cat abundance due to a larger ratio of edge-to-core habitat area. In a fragmented landscape in southern California, native plants, scrub-breeding birds, and rodents did not disperse across the surrounding matrix of development to other habitat patches, leading to isolation of the populations (Soulé et al. 1992). However, fragment isolation had little effect on human-tolerant mesocarnivores, such as raccoons, striped skunks, opossums, and cats. These species readily moved through the matrix between isolated habitat patches (Crooks 2002). As generalist feeders, mesocarnivores probably take advantage of food resources like vegetable gardens and trash in residential areas (Crooks 2002, Wright et al. 2012).

In addition, fragmentation influences the interspecific interactions of mesocarnivores. Habitat fragmentation poses a threat to larger mammalian predators, such as mountain lions (*Puma concolor*), bobcats (*Lynx rufus*), and coyotes (*Canis latrans*). As habitat patches become smaller and more isolated, these populations move toward extinction (Brown 1986). In the absence of such predators to keep their populations in check, mesocarnivores then become important predators of birds and other prey species (Crooks and Soulé 1999). Crooks and Soulé (1999) observed a negative correlation between the number of native scrub-breeding bird species and the abundance of mesopredators in habitat fragments in southern California. Because they receive food subsidies, feral cats in particular can afford to kill prey species at an unsustainable rate despite low prey numbers (Churcher and Lawton 1987).

While the general effects of fragmentation on mesocarnivores have been described for the scrublands of southern California, these effects may not apply in the Mid-Atlantic region, where the flora and fauna differ considerably. More research is needed to identify specific descriptors that limit occupancy in fragmented, temperate forestland. My objective was to determine which landscape characteristics best predict the presence of mesocarnivore species in Delaware forest patches that are fragmented by urban development.

Chapter 2

STUDY AREA

I conducted my research within a series of 21 forest patches in the urban setting of Newark, Delaware (Figure 1). The vegetation in these habitat fragments consisted predominately of mixed deciduous hardwoods.

The 21 plots of forest ranged in size from 2.1 to 16.3 ha. The shapes of these plots varied, with some plots consisting of contiguous, convex blocks of forest, whereas others were more oblong or concave in shape. In addition, the study sites varied in the type of cover within and surrounding the plots (Table 1). Percent of multiflora rose (*Rosa multiflora*) cover within the plots ranged from 0 to 62%. The average distance of each plot to the nearest road and to the nearest stream ranged from 71 to 429 m and 32 to 881 m, respectively. The patch size for each plot, consisting of the total area of the plot plus all adjacent forest, ranged from 4 to 2,554 ha. The percent of forest cover within a 100-m buffer of each plot varied from 6 to 80%. While several plots had no agriculture or non-forest cover within a 100-m buffer from the perimeter, percent agriculture and non-forest cover ranged up to 33% and 40%, respectively.

From 1981 to 2010, the mean maximum temperatures for the months of June and July on the University of Delaware farm in Newark, Delaware, were 29.5°C and 31.2°C, respectively, with average minimums of 16.3°C and 18.8°C, respectively (ODSC 2013). Mean monthly precipitation levels for June and July were 10.24 cm and 12.19 cm, respectively (ODSC 2013).

Figure 1 Map of the 21 forest plots in Newark, DE used to investigate the effect of landscape characteristics on mesocarnivore occupancy in 2012. Plots varied by proportion of multiflora rose cover, average distances to the nearest road and to the nearest stream, total patch size, and bordering proportions of forest, agriculture, and non-forest cover.

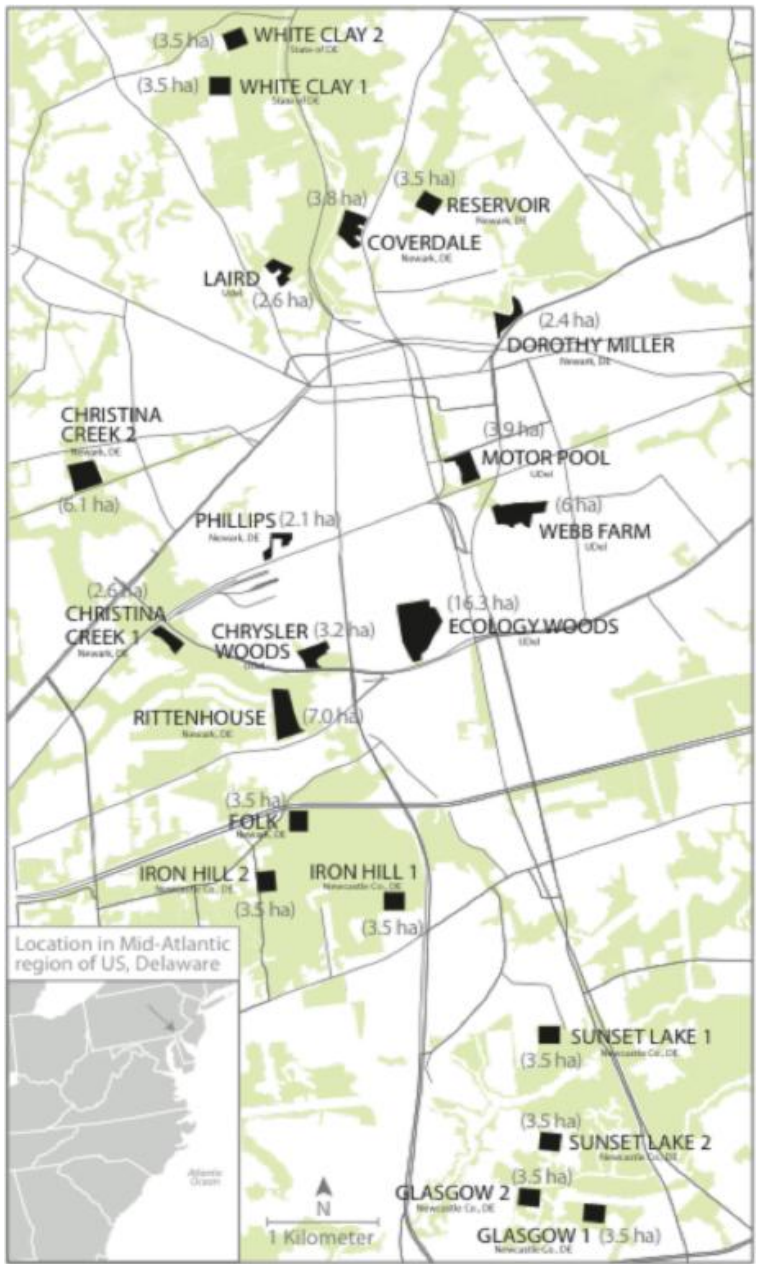

Table 1 Landscape parameters for the 21 Delaware forest plots in which I estimated occupancy probabilities for mesocarnivores in 2012.

Study Site	Proportion of Rose Cover	Avg. distance of plot to nearest road (m)	Avg. distance of plot to nearest stream (m)	Total size of forest patch (ha)	Proportion of forest within 100m of plot	Proportion of agriculture within 100m of plot	Proportion of non-forest within 100m of plot
Christiana Creek 1	0.271	83.822	59.549	92.700	0.504	0	0
Christiana Creek 2	0.623	138.290	36.139	188.730	0.533	0	0.067
Chrysler	0.115	115.504	64.254	4.040	0.079	0	0
Coverdale	0.408	107.041	137.688	2553.840	0.403	0.042	0.028
Dorothy Miller	0.101	70.968	78.649	68.130	0.422	0	0
Ecology Woods	0.086	160.790	408.692	16.330	0.068	0.320	0.044
Folk	0.005	137.383	801.052	855.900	0.577	0	0
Glasgow 1	0.006	276.793	303.474	188.640	0.580	0.008	0.395
Glasgow 2	0	74.266	157.077	188.640	0.650	0.103	0.137
Iron Hill 1	0.015	144.872	200.748	855.900	0.707	0.122	0
Iron Hill 2	0.001	98.378	734.166	855.900	0.786	0	0.077
Laird	0.118	149.872	64.671	2553.840	0.638	0	0
Motor Pool	0.362	131.130	31.639	4.990	0.065	0	0
Phillips	0.163	93.953	881.067	4.500	0.177	0	0
Reservoir	0.040	235.696	84.455	49.230	0.597	0	0
Rittenhouse	0.145	138.444	131.969	92.700	0.772	0	0.006
Sunset Lake 1	0.002	154.950	388.257	188.640	0.575	0.331	0.071
Sunset Lake 2	0	428.536	370.852	188.640	0.803	0.197	0
Webb Farm	0.117	124.957	123.019	9.630	0.251	0.123	0.102
White Clay 1	0.008	234.265	55.967	2553.840	0.764	0.227	0.009
White Clay 2	0.019	220.008	309.899	2553.840	0.798	0	0.143

Chapter 3

METHODS

This study is part of the University of Delaware's Forest Fragments in Managed Ecosystems (FRAME) project. Using ArcGIS software, the FRAME team marked each plot with a grid system of 25 m between adjacent points. An exception was the University of Delaware's Ecology Woods, which had a preexisting grid of 50-meter intervals. For my mesocarnivore study, I selected the most centrally located grid point at each site. From each central point, I then installed a passive infrared camera (HC600 HyperFire, Reconyx, Inc., Holmen, WI, USA) to the nearest suitable tree trunk so that it was parallel to and approximately 15 cm from the ground. To get the clearest view of animals passing within range, I removed any protruding vegetation that may have blocked the camera's field of view. I also baited each station with a handful of dry cat food and a few drops of a generic scent lure (Cronk's Outdoor Supplies, Wiscasset, ME, USA), placed approximately 3 m in front of the camera. I conducted two rounds of surveys at the 21 sites during the months of June and July 2012. I collected data for 10 days in the first survey period and 12 days in the second. During each period, I checked survey equipment every other day excluding weekends. At each check, I replaced the used camera cards with blank ones and replenished bait as needed. I then reviewed the images captured at each site and identified all species photographed.

For each study plot, I measured seven landscape parameters: proportion of multiflora rose cover within the plot; average distance of the plot to the nearest road; average distance of the plot to the nearest stream; patch size; and bordering proportions of forest, agriculture, and non-forest cover (Table 1). Patch size was the total area of the plot plus all adjacent, connected forest. I defined non-forest cover as scrub-shrub, herbaceous vegetation, and emergent wetlands. Because the average home range radius of many cats was <100 m (Barratt 1997, Kays and DeWan 2004, Say and Pontier 2004; Appendix A), I determined the proportions of forest, agriculture, and non-forest cover within a 100-meter buffer from each plot's perimeter. I applied the same buffer for all detected mesocarnivore species to maintain consistency and comparability.

Using the program PRESENCE, I compared these seven landscape characteristics with the probabilities of occupancy for each mesocarnivore species detected (Hines 2013). I ran nine models for each species: one model with occupancy probability held constant, seven models that each varied in occupancy probability by a single site covariate, and a global model with occupancy probability varying by all seven covariates combined (MacKenzie 2006). For all models, the probability of detection was held constant. I then determined all models with a ΔAIC value of $\leq$2.00 to be the most likely predictors of the presence data I observed for each species (Burnham and Anderson 2002).

Chapter 4

RESULTS

Within the 21 study plots, I detected four mesocarnivore species via remote camera. Out of 40,817 photos captured during the survey, domestic cat appeared in 658 photos, raccoon in 13,049 photos, red fox in 6,469 photos, and Virginia opossum in 2,631 photos.

Cameras detected domestic cats in seven of the 21 plots. The best fit models of occupancy for cats were the global, forest, and rose models (Table 2). The plots where I detected cats on average had a greater proportion of rose cover and a smaller proportion of forest within a 100-m buffer compared to sites with no cats detected (Table 2).

I detected raccoons at 19 of the 21 sites, and all nine PRESENCE models for this species had a ΔAIC value of $\leq$2.00 (Table 3). I could not distinguish a predictive model(s) for raccoon occupancy based on these results.

Out of the models for red fox occupancy, only the global model had a ΔAIC value $\leq$2.00 (Table 4). The 16 plots where I detected foxes had a greater mean proportion of rose cover, distance to the nearest road and nearest stream, and patch size, and smaller mean proportions of forest, agriculture, and non-forest cover within 100 m compared to unoccupied sites (Table 4).

For opossums, the best models of occupancy were the constant, forest, agriculture, rose, and non-forest models (Table 5). The 18 plots where I detected opossums had on average greater proportions of forest and non-forest within a 100-m buffer, as well as a smaller proportion of agriculture within 100 m and a smaller proportion of rose cover than did unoccupied sites (Table 5).

Table 2 The AIC values of PRESENCE models run to predict domestic cat occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where cats were detected and not detected. I considered models with a ΔAIC $\leq$2.00 to be best fit for the observed data.[a]

					Detected		Not Detected	
Model	# of parameters	AIC	ΔAIC	AIC weight	$\bar{x}$	SE	$\bar{x}$	SE
Global	9	124.24	0.00	0.3282				
Forest	3	125.20	0.96	0.2031	0.360	0.110	0.588	0.053
Rose	3	125.87	1.63	0.1453	0.164	0.045	0.104	0.049
Non-forest	3	126.31	2.07	0.1166	0.015	0.015	0.070	0.028
Constant	2	127.24	3.00	0.0732				
Patch size	3	128.40	4.16	0.0410	408.334 ha	358.544 ha	800.733 ha	266.704 ha
Agriculture	3	128.64	4.40	0.0364	0.046	0.031	0.082	0.033
Distance to streams	3	129.09	4.85	0.0290	227.865 m	117.346 m	273.445 m	64.573 m
Distance to roads	3	129.22	4.98	0.0272	161.111 m	45.359 m	156.582 m	16.888 m

[a] For the Constant model, occupancy probability equaled 1. For the Global model, occupancy probability varied by all seven covariates of interest combined. All other models varied in occupancy probability by a single site covariate. Rose = proportion of multiflora rose cover within plot. Distance to roads = distance of plot to the nearest road. Distance to streams = distance of plot to the nearest stream. Patch size = total area of the plot and adjacent, connected forest. Forest = proportion of forest cover within 100 m of plot. Agriculture = proportion of agricultural crops within 100 m of plot. Non-forest = proportion of scrub-shrub, herbaceous vegetation, and emergent wetland cover within 100 m of plot. For all nine models, the probability of detection was held constant.

Table 3 The AIC values of PRESENCE models run to predict raccoon occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where raccoons were detected and not detected. I considered models with a ΔAIC ≤2.00 to be best fit for the observed data. [a]

					Detected		Not detected	
Model	# of parameters	AIC	ΔAIC	AIC weight	$\bar{x}$	SE	$\bar{x}$	SE
Constant	2	594.80	0.00	0.1893				
Non-forest	3	595.23	0.43	0.1527	0.056	0.022	0.005	0.005
Distance to streams	3	595.55	0.75	0.1301	236.118 m	51.549 m	468.517 m	412.550 m
Global	9	595.59	0.79	0.1275				
Patch size	3	596.03	1.23	0.1023	605.803 ha	209.383 ha	1279.170 ha	1274.670 ha
Agriculture	3	596.48	1.68	0.0817	0.066	0.025	0.114	0.114
Rose	3	596.66	1.86	0.0747	0.128	0.039	0.086	0.078
Forest	3	596.74	1.94	0.0718	0.516	0.056	0.470	0.294
Distance to roads	3	596.79	1.99	0.0700	157.458 m	19.383 m	164.109 m	70.156 m

[a] For the Constant model, occupancy probability equaled 1. For the Global model, occupancy probability varied by all seven covariates of interest combined. All other models varied in occupancy probability by a single site covariate. Rose = proportion of multiflora rose cover within plot. Distance to roads = distance of plot to the nearest road. Distance to streams = distance of plot to the nearest stream. Patch size = total area of the plot and adjacent, connected forest. Forest = proportion of forest cover within 100 m of plot. Agriculture = proportion of agricultural crops within 100 m of plot. Non-forest = proportion of scrub-shrub, herbaceous vegetation, and emergent wetland cover within 100 m of plot. For all nine models, the probability of detection was held constant.

Table 4 The AIC values of PRESENCE models run to predict red fox occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where foxes were detected and not detected. I considered models with a ΔAIC ≤2.00 to be best fit for the observed data. [a]

Model	# of parameters	AIC	ΔAIC	AIC weight	Detected		Not detected	
					x̄	SE	x̄	SE
Global	9	491.14	0.00	0.7990				
Patch size	3	496.04	4.90	0.0689	860.538 ha	262.964 ha	60.000 ha	36.271 ha
Distance to streams	3	496.89	5.75	0.0451	311.734 m	69.046 m	87.108 m	22.961 m
Distance to roads	3	497.22	6.08	0.0382	174.390 m	22.172 m	105.936 m	11.358 m
Forest	3	497.78	6.46	0.0289	0.575	0.055	0.310	0.116
Constant	2	500.20	9.06	0.0086				
Rose	3	501.64	10.50	0.0042	0.109	0.043	0.173	0.064
Agriculture	3	501.80	10.66	0.0039	0.078	0.030	0.045	0.028
Non-forest	3	502.19	11.05	0.0032	0.052	0.025	0.048	0.030

[a] For the Constant model, occupancy probability equaled 1. For the Global model, occupancy probability varied by all seven covariates of interest combined. All other models varied in occupancy probability by a single site covariate. Rose = proportion of multiflora rose cover within plot. Distance to roads = distance of plot to the nearest road. Distance to streams = distance of plot to the nearest stream. Patch size = total area of the plot and adjacent, connected forest. Forest = proportion of forest cover within 100 m of plot. Agriculture = proportion of agricultural crops within 100 m of plot. Non-forest = proportion of scrub-shrub, herbaceous vegetation, and emergent wetland cover within 100 m of plot. For all nine models, the probability of detection was held constant.

Table 5 The AIC values of PRESENCE models run to predict Virginia opossum occupancy in Delaware forest fragments in 2012, and a comparison of the respective mean parameter values for sites where opossums were detected and not detected. I considered models with a ΔAIC ≤2.00 to be best fit for the observed data. [a]

Model	# of parameters	AIC	ΔAIC	AIC weight	Detected		Not detected	
					x̄	SE	x̄	SE
Constant	2	510.32	0.00	0.3331				
Forest	3	511.42	1.10	0.1922	0.533	0.060	0.385	0.115
Agriculture	3	511.54	1.22	0.1810	0.061	0.023	0.124	0.104
Rose	3	511.79	1.47	0.1597	0.113	0.038	0.191	0.118
Non-forest	3	512.14	1.82	0.1341	0.054	0.023	0.033	0.021
Distance to roads	3	539.40	29.08	0.0000	164.665 m	20.683 m	118.648 m	18.540 m
Distance to streams	3	539.40	29.08	0.0000	223.126 m	54.394 m	469.004 m	218.360 m
Patch size	3	539.40	29.08	0.0000	628.979 ha	219.997 ha	915.660 ha	820.813 ha
Global	9	551.40	41.08	0.0000				

[a] For the Constant model, occupancy probability equaled 1. For the Global model, occupancy probability varied by all seven covariates of interest combined. All other models varied in occupancy probability by a single site covariate. Rose = proportion of multiflora rose cover within plot. Distance to roads = distance of plot to the nearest road. Distance to streams = distance of plot to the nearest stream. Patch size = total area of the plot and adjacent, connected forest. Forest = proportion of forest cover within 100 m of plot. Agriculture = proportion of agricultural crops within 100 m of plot. Non-forest = proportion of scrub-shrub, herbaceous vegetation, and emergent wetland cover within 100 m of plot. For all nine models, the probability of detection was held constant.

Chapter 5

DISCUSSION

I detected domestic cats in sites with relatively higher proportions of multiflora rose cover. This observation is comparable to Crooks's (2002) findings that mesocarnivores were more abundant in habitat patches with a greater density of exotic plant cover. In addition, plots occupied by cats had smaller mean proportions of forest cover within a 100-m buffer. In areas with less forest, human development likely covered much of the remaining area. This inverse relationship could make surrounding forest and non-forest cover indirect predictors of cat occupancy in forest fragments, since cats often rely on human establishment for food subsidies (Churcher and Lawton 1987). Also, less forest cover surrounding the fragments may allow cats to access forest patches more easily.

I could not distinguish any model(s) as being best fit for the observed presence data for raccoons. The landscape variables of interest are not effective predictors of raccoon occupancy. My results seem to reflect the raccoon's ability to adapt to a variety of habitat types by taking advantage of the available resources (Crooks 2002). Similarly, Crooks (2002) found that site variables, such as area, age, and isolation of habitat fragments, had little effect on raccoon abundance in southern California.

Red fox occupancy seemed to vary with all seven landscape characteristics in combination. On average, plots where foxes were detected had a smaller proportion of multiflora rose cover versus unoccupied plots, contrary to Crooks's (2002) observation of greater mesocarnivore abundance in areas with more exotic plant cover. Occupied plots also had a greater total patch size, surrounding proportion of forest, and distance to roads, possibly indicating that foxes prefer more contiguous tracts of forest. This trend corresponds with Adkins and Stott's (1998) findings that foxes used vegetation cover more than expected based on availability compared to open areas and residential settings. When the animals did use residential areas and roads, they often passed through quickly to get from one foraging area to another (Adkins and Stott 1998).

Likely predictors of forest fragment occupancy by Virginia opossums include greater proportions of surrounding forest and non-forest cover, as well as a smaller proportion of multiflora rose cover and surrounding proportion of agriculture. These characteristics seem to correspond with habitat that is affected less by human disturbance. In contrast, Crooks (2002) observed a greater abundance of opossums in fragmented habitat close to the urban edge. Opossums often take advantage of available food resources in residential areas and use buildings for denning sites (Crooks 2002, Wright et al. 2012). However, the studies by both Crooks (2002) and Wright et al. (2012) took place in locations containing coyotes, which are predators of the opossum. Since coyote abundance is typically greater in larger, more contiguous tracts of habitat (Crooks and Soulé 1999, Crooks 2002), opossums may also resort to using more fragmented, urban habitat to escape predation (Wright et al. 2012). Coyotes did not inhabit the study area in Delaware, so opossums did not experience such pressures from predation there. My results suggest that opossums select forest habitat with less exotic vegetation and more natural landscape cover in the surrounding areas in the absence of predators.

My research provides several models which may be useful in predicting mesocarnivore occupancy of forest patches based on landscape characteristics. While models varied in fitness by species, descriptors like proportion of multiflora rose cover and proportions of forest and non-forest cover within a 100-m buffer were common predictors of occupancy. Fox and opossum occupancy probabilities increased with forest and non-forest cover and decreased with rose cover. The reverse was true for cats. One explanation for this trend might be that species which humans typically do not feed directly require more natural vegetative cover to meet their foraging needs compared to cats. Other landscape variables, particularly patch size and distances to the nearest road and nearest stream, do not seem to be useful predictors of occupancy for any of the detected species.

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Appendix

MESOCARNIVORE HOME RANGE DATA

This table shows a collection of average home range estimates observed for four mesocarnivore species in various locations and landscape types. Under methods used to estimate home ranges, ADP = adaptive polygon, FK = fixed kernel, and MCP = minimum convex polygon. Because the average home range radius of many cats was <100 m (Barratt 1997, Kays and DeWan 2004, Say and Pontier 2004), I defined the proportions of forest, agriculture, and non-forest cover within a 100-m buffer from the plot perimeter. I applied the same buffer for all detected mesocarnivore species to maintain consistency and comparability.

Species	Citation	Location	Landscape of study area	Sex of study population	Home range method	Avg. home range value (ha)	Avg. home range radius (m)
Domestic cat	Barratt 1997	Canberra, Australia	suburban area	male & female	MCP	2.54	89.9
			agriculture	male & female	MCP	7.89	158.5
	Horn et al. 2011	Champaign-Urbana, IL	agriculture	male (non-feral)	MCP	0.04	11.3
				male (feral)	MCP	87.7	528.4
				female (non-feral)	MCP	0.6	43.7
				female (feral)	MCP	32.5	321.6
	Kays & DeWan 2004	Albany, NY	forest fragments, neighborhoods	male & female	MCP	1.08	58.6
				male & female (non-feral only)	MCP	0.65	45.5
	Say & Pontier 2004	Lyon, France	isolated city park	male	MCP	0.8	50.5
				female	MCP	0.19	24.6
	Turner & Mertens 1986	Zurich, Switzerland	fields, pastures	male & female	MCP	0.8 to 17.2	50.5 to 234
	Warner 1985	Ford County, IL	agriculture	male	MCP	228	851.9
				female	MCP	112	597.1
Raccoon	Barding & Nelson 2008	Northern Illinois	mixed landscape	male	FK	68.6	476.3

				female	FK	47.5	388.8
	Beasley et al. 2010	Northern Indiana	agriculture	male	FK	92	541.2
				female	FK	58	429.7
	Frey & Conover 2006	Utah	wildlife refuge	male & female	MCP	0.36	33.9
	Gross et al. 2011	Baltimore, MD	urban area (Linthicum)	male	FK	103.3	573.4
				female	FK	24.7	280.4
			urban area (Riviera Beach)	male	FK	94.1	547.3
				female	FK	13.3	205.8
	Prange et al. 2004	NE Illinois	urban area	female	FK	48.7	393.7
			suburban area	female	FK	36.5	340.9
	Slate 1985	New Brunswick, NJ	suburban area	male	MCP	61.6	442.8
				female	MCP	93.5	545.5
	Wehtje & Gompper 2011	Missouri	mixed landscape	male	FK	23.6	274.1
				female	FK	18.3	241.4
Red fox	Adkins & Stott 1998	Toronto, Canada	suburban area	female	MCP	24 to 143	276.4 to 674.7
	Frey & Conover 2006	Utah	wildlife refuge	male & female	MCP	0.35	33.4
	Trewhella et al. 1988	Several locations in U.S.	mixed habitat types	male & female	MCP	10.2 to 96	180.2 to 552.8
	White et al. 1996	Bristol, England	urban area	male	MCP	30.1	309.5
				female	MCP	25.1	282.7
Virginia opossum	Gillette 1980	Wisconsin	woods, agriculture	male	MCP	108	586.3
				female	MCP	51	402.9
	Gipson & Kamler 2001	NE Kansas	tallgrass prairie	male	MCP	114	602.5
				female	MCP	57	426
	Wright et al. 2012	Missouri	urban area	male	MCP	37.3	344.6
					ADP	57.8	428.9
				female	MCP	18.8	244.6
					ADP	32.5	321.6