Effects of Habitat Fragmentation and Landscape Context on Mammalian Predators in Northeastern National Parks

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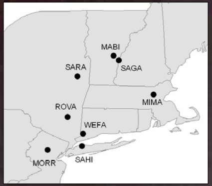
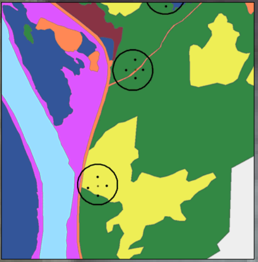
Background - Human disturbance is a significant source of land use change around the world, specifically in the northeastern U.S., where expanding human populations are causing increased landscape development and either habitat loss or fragmentation, thereby exerting pressure on wildlife populations. The effects of fragmentation on some wildlife (i.e., birds) have been well-documented, but for taxa like mammalian predators that are often cryptic and elusive, these effects are difficult to evaluate and not well understood. The effects of fragmentation are important for resources in small protected areas like eastern national parks where the landscape mosaic can limit resource availability for many species. In addition, despite the interest in maintaining biodiversity and monitoring changes in these populations, few programs sample populations in a manner that allow for meaningful changes to be detected. In this study, we attempted to address the influence of fragmentation on several species in national park sites and use sampling techniques that can be used to implement science-based monitoring

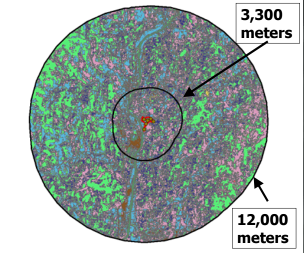


Marsh-Billings-Rockefeller (MABI): 202 ha
Minute Man: (MIMA) 391 ha
Morristown (MORR) 682 ha
Roosevelt-Vanderbilt (ROVA) 276 ha
Sagamore Hill (24 ha)
Saint-Gaudens (61 ha)
Saratoga (1,378 ha)
Weir Farm (24 ha)

All of the NPS sites above are similar in that they all were established for historic/cultural reasons, are small in acreage (60-3400), part of larger ecological systems, and their natural resources are heavily influenced by events and conditions (like fragmentation) beyond park boundaries.

Methods: We collected information on a variety of habitat variables at 3 different scales to evaluate the effects of fragmentation on the target species : Local scale was the same for all species (100 m); 2 landscape scales for each species Home range scale (400 – 3,300 m), Multiple home range scale (6,000 – 12,000 m). We then used models that link detectability and site occupancy (MacKenzie et al. 2003), including habitat data as covariates. We then employed model selection techniques (AIC, Burnham and Andersen 2002) to evaluate the relative importance of these variables.





Target Species

Species	Family Name
Coyote (*Canis latrans*) Red Fox (*Vulpes vulpes*) Gray fox (*Urocyon cinereoargenteus*)	Canidae
Domestic cat (*Felis silvestris*)	Felidae
Ermine (*Mustela erminea*) Fisher (*Martes pennanti*) Long-tailed Weasel (*Mustela frenata*)	Mustelidae
Striped Skunk (*Mephitis mephitis*)	Mephitidae
Raccoon (*Procyon lotor*)	Procyonidae
Virginia Opossum (*Didelphis virginiana*)	Didelphidae

Site Occupancy Models

$$L(\Psi, p) = \left[\Psi^{n.} \prod_{t=1}^{T} p_t^{n_t} (1-p_t)^{n.-n_t}\right] \left[\Psi \prod_{t=1}^{T} (1-p_t) + (1-\Psi)\right]^{N-n.}$$

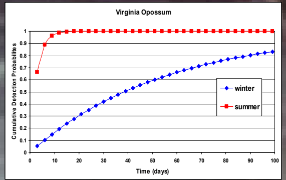
- Use with presence/absence wildlife surveys that have repeat visits to the same sampling sites
- Designed to estimate the 'true' proportion of sampling sites that are occupied after accounting for imperfect detectability of a species
- Useful for detecting changes in wildlife population size
- Model both the probability of Occupancy (ψ) and Detection (p)
- Can include variables in the Maximum-Likelihood Estimates of ψ and p
- Available in Program PRESENCE or Program MARK

Local → Highest Ranked Variables
Home Range → Highest Ranked Variables
Multiple Home Range → Highest Ranked Variables
→ Multi-Scale Model

Results showing relative importance of habitat variables for fisher within and adjacent to NPS sites.

Multi-scale Models	AIC_c	ΔAIC_c	AIC_c Weights
Ψ (Overstory Density⁺, Latitude⁺) P (Forest 2600⁺)	209.84	0	0.54
Ψ (Latitude⁺) P (Forest 2600⁺)	212.6	2.75	0.13
Ψ (Overstory Density⁺, DBH⁺, Latitude⁺) P (Forest 2600⁺)	212.74	2.89	0.12
Ψ (Overstory Density⁺, DBH⁺) P (Forest 2600⁺)	214.41	4.56	0.05
Ψ (.) P (.)	229.66	19.81	0

Cumulative Detection Probabilities



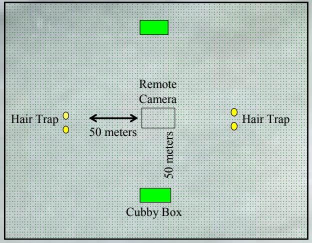
Estimates of the relative importance of covariates from site occupancy models for 5 mammalian predators sampled at 8 National Parks in the northeastern U.S.A. Wi + (j) scores show the relative importance of each covariate in explaining differences in site occupancy probability. Higher values show more support for a covariate. Beta coefficients were obtained from the highest ranked model containing only variable *i* and were fit using the logistic link function.

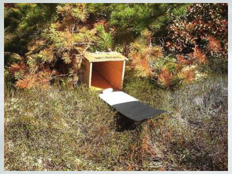
	Virginia opossum	Coyote	Striped Skunk	Raccoon	Red Fox
Variable (i)	Wi + (j)	Wi + (j)	Wi + (j)	Wi + (j)	Wi + (j)
Local Edge	0.523	0.172	0.510	0.121	0.094
Non-native Trees	0.204	0.251	0.051	0.147	0.133
Non-native Shrubs	0.262	0.146	0.047	0.140	0.174
Tree Diversity	0.091	0.123	0.045	0.221	0.108
Shrub Diversity	0.109	0.157	0.053	0.187	0.189

Techniques and Site Layout

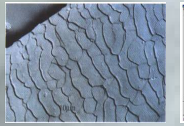
Sites were setup to include:

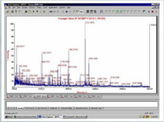
- Remote Camera - Active/Passive Infrared
- 2 Cubby boxes - Sooted aluminum plate housed inside a plywood box
- 2 Hair Traps – Serrated Aluminum attached to stakes
- Equipment was oriented in a configuration similar to the diagram
- Size and shape of the habitat patch occasionally prevented this exact configuration





- Scale patterns and morphological characteristics
  - Enzyme digestion and peptide identification
  - Matrix-Assisted Laser Desorption and Ionization Time-of-Flight Mass Spectrometer (MALDI-TOF)





Species	Site Occupancy (ψ)			Detection (p)			
	Local	HR	MHR	Local	HR	MHR	season
Domestic Cat		x	x			x	
Coyote	x		x			x	
Fisher	x		x		x		
Gray Fox		x					x
Raccoon	x	x	x				x
Red Fox	x	x				x	
Striped Skunk	x	x				x	
Virginia Opossum	x	x	x				x
Weasels	x		x				x

Conclusions

It is possible to build habitat models that incorporate detection probabilities.
Detection rates vary over time and space, which can cause bias in population estimates that use index values.
Detection probabilities suggest that short sampling durations are not appropriate for medium-sized mammal species.
Variables that focused on the amount of human disturbance in the landscape were important at describing site occupancy probabilities as well as detection probabilities.
There were no species that showed a clear negative relationship to habitat fragmentation or landscape development.

Cited

MacKenzie, D.I., J. D. Nichols, G. B. Lachman, S. Droege, R. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: A practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

Which scales were the most important?

	Site Occupancy (ψ)			Detection (p)			
	Local	HR	MHR	Local	HR	MHR	season
domestic cat		x	x			x	
coyote	x		x			x	
fisher	x		x		x		
gray fox		x					x
raccoon	x	x	x				x
red fox	x	x				x	
striped skunk	x	x				x	
Virginia opossum	x	x	x				x
weasels	x		x				x

An 'x' shows whether covariates from the local scale (Local), home range scale (HR), or multiple home range scale (MHR) are present in models with AIC*c* values <2.

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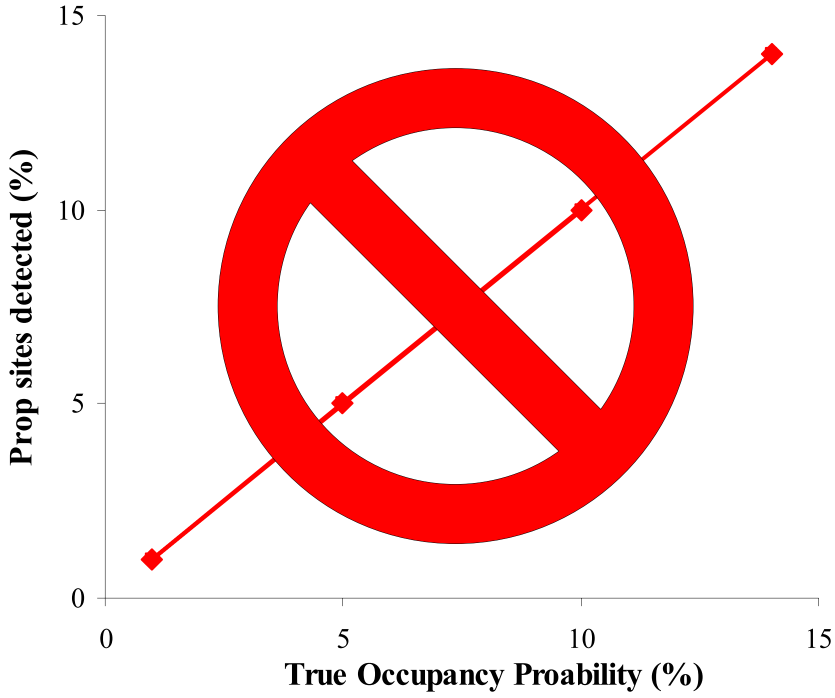

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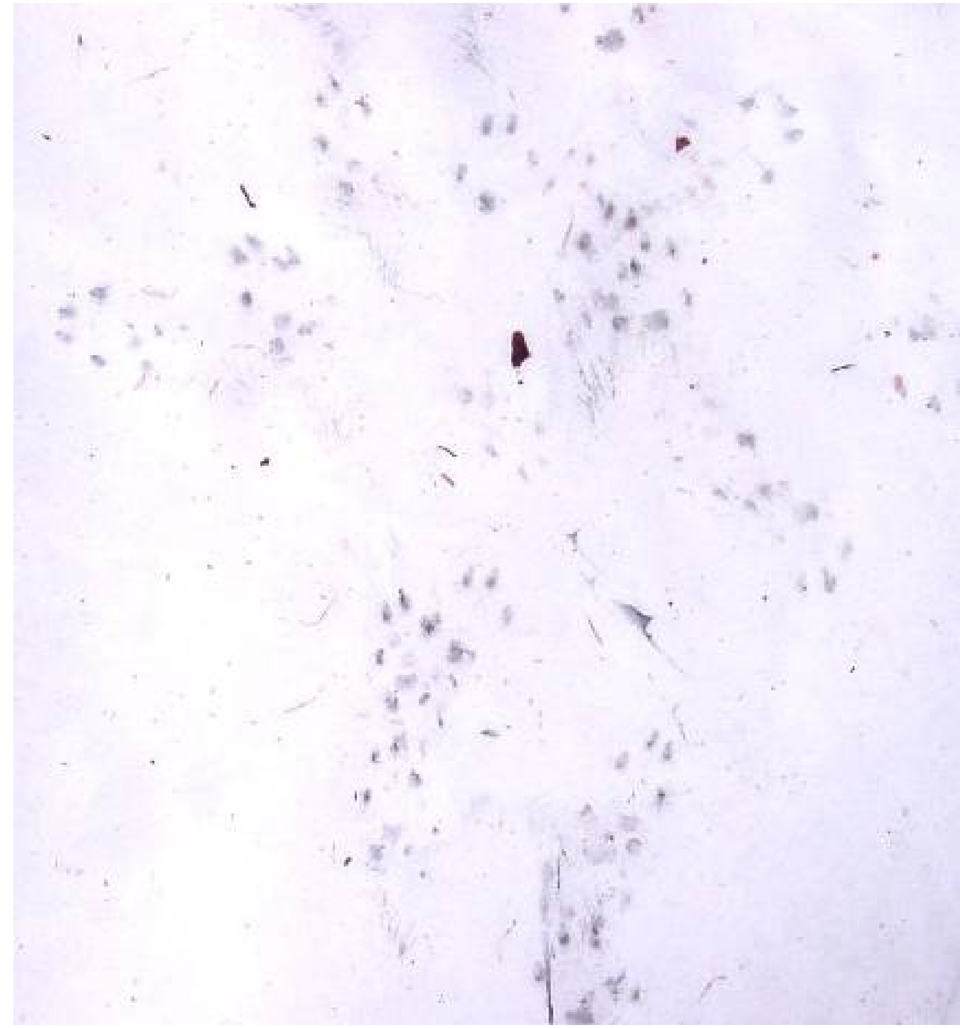
Track Plates

Archived Track Specimens

Virginia Opossum
(*Didelphis virginiana*)



Long-tailed Weasel
(*Mustela frenata*)

Hair Traps

Hair Sample Identification

–Scale patterns and morphological characteristics

–Enzyme digestion and peptide identification

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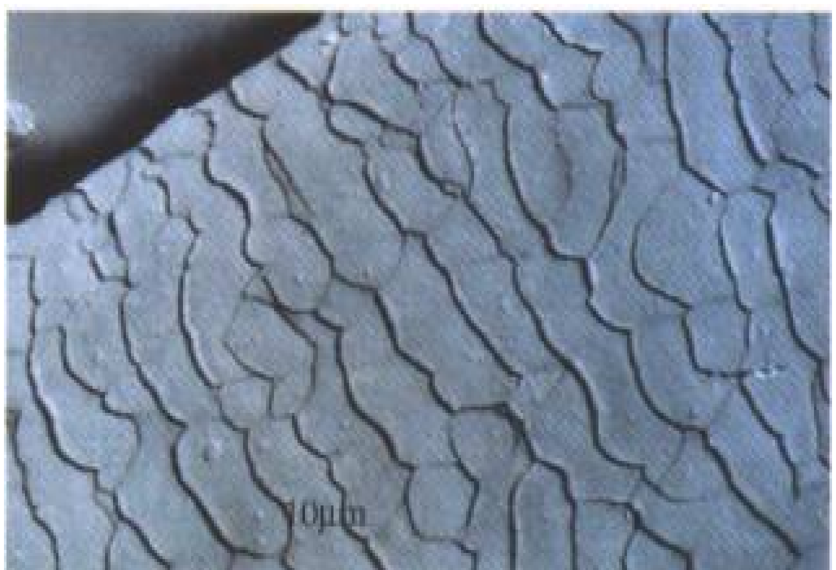

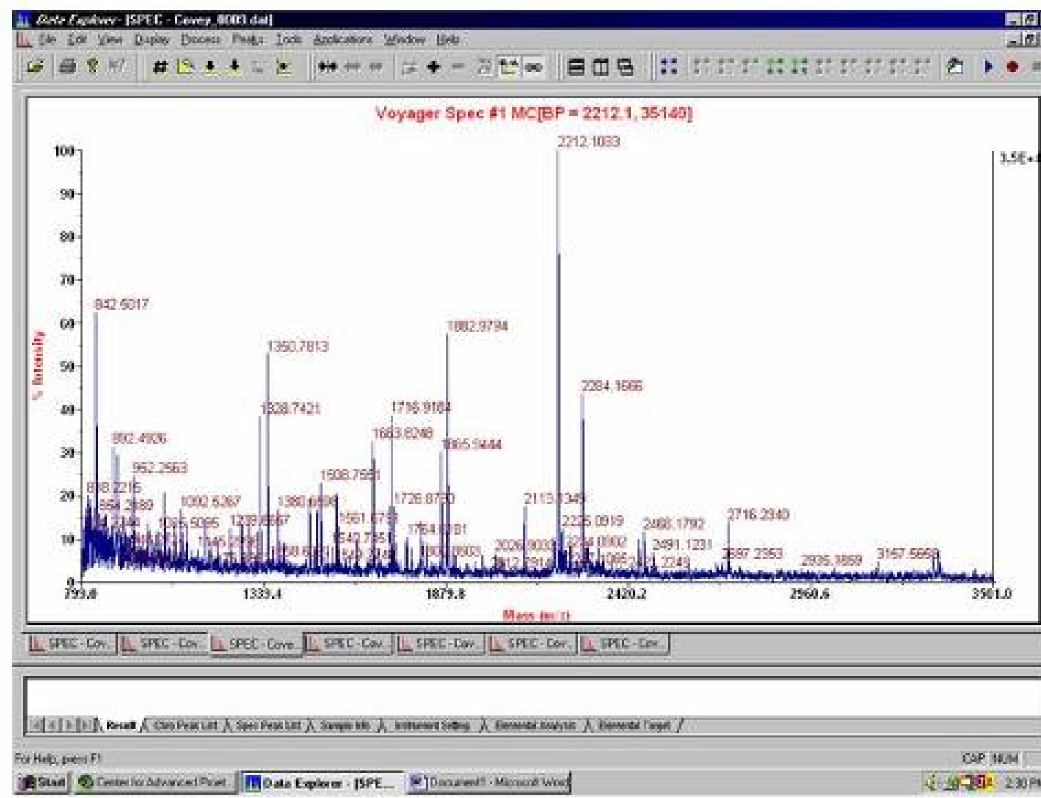

Local Scale Fragmentation

Purpose: To determine how habitat fragmentation may influence the distribution of mammals within parks

	Virginia opossum	**Coyote**	**Striped Skunk**	**Raccoon**	**Red Fox**
Variable (i)	Wi + (j)	Wi + (j)	Wi + (j)	Wi + (j)	Wi + (j)
Local Edge	0.523	0.172	0.510	0.121	0.094
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Results – Fisher

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