

**Proposal under the URI and NPS Cooperative Agreement
CA 4520-99-008**

**Assessment of Spatial Scale for Mammalian Carnivore Communities in
Northeastern Parks**

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PROBLEM STATEMENT and PURPOSE

Phase I of the National Park Service (NPS) Inventory & Monitoring (I&M) (NPS 2003) program involves conducting inventories to meet three basic objectives:

1. Document through existing, verifiable data and targeted field investigations the occurrence of at least 90% of the species of vertebrates and vascular plants currently estimated to occur in the parks.
2. Describe the distribution and relative abundance of species of special concern, such as Threatened and Endangered species, exotics, and other species of special management interest occurring within park boundaries.
3. Provide the baseline information needed to develop a general monitoring strategy and design that can be implemented by parks once inventories have been completed, tailored to specific park threats and resource issues.

This project is part of a network-wide mammal inventory to be conducted in national parks of the northeast temperate network. As part of that effort, distribution and relative abundance of the mammalian carnivore community will be determined within the major habitat associations located in each park. The work consists of evaluating patch-scale and landscape-scale habitat characteristics on carnivore populations at National Park Service sites in the northeast temperate network. The National Park Service will be provided with a greater understanding of the factors influencing species composition within park boundaries. The information can then be used to develop a valid monitoring program (Objectives 2 & 3 above). Toward that end, this project will focus on evaluating the influence of habitat fragmentation and its impact on the carnivore community located within these parks.

Habitat fragmentation has been postulated as the cause of decline for many wildlife populations and is nowhere more widespread than in the northeastern U.S. As a result, National Park Service properties in this region are greatly influenced by fragmentation and continuing loss of natural habitats adjacent to and surrounding their boundaries. Although generally small in size NPS units in the northeast still offer suitable refuge for many wildlife populations. The issue of fragmentation is further complicated because some species are specialists and have very narrow niche requirements. On the other hand, fragmentation can improve conditions for generalist species thereby increasing population densities and shifting system balance. In either case, management of mammal populations in these areas is difficult because different species respond differently to landscape characteristics at various scales.

Habitat fragmentation occurs when contiguous habitat is divided into one or more smaller areas (Yahner and Mahan 2002). Although natural processes such as forest fires, blow-downs, or insect outbreaks can create gaps in otherwise undisturbed forests, anthropogenic causes are most often the primary factors responsible for habitat fragmentation. Agricultural development, timber harvest, and urbanization are the human-induced factors that account for the greatest increases in habitat fragmentation (Yahner and Mahan 2002). Increases in landscape fragmentation can increase the amount of edge habitat at the same time decrease the suitability of habitat for forest-interior or area-limited species. Increasing amounts of edge improves conditions for omnivorous or generalist carnivores (Andren 1995). In landscapes with high levels of fragmentation, like the northeastern

U.S., these areas may gradually become dominated by edge-adapted species that are not in great need of conservation (Noss and Csuti 1997). In these areas species richness may remain the same even though sensitive native species may be replaced by generalist species. This process of homogenization is one of the most prominent forms of biotic impoverishment worldwide (Noss and Csuti 1997).

At the population level, habitat fragmentation causes increased isolation, reduces habitat connectivity, lowers dispersal success, and increases the likelihood of inbreeding (Sunquist and Sunquist 2002). These factors result in changes in gene frequencies within populations and continent-wide changes in the distribution of species (Noss and Csuti 1997). At the individual level, fragmentation can cause increased isolation, limit movement, alter home-range boundaries, modify habitat selection patterns, limit social interactions, and increase predation rates (Sunquist and Sunquist 2001). The effects of habitat fragmentation are more subtle than from habitat loss because they often affect different populations and species at different rates.

Small isolated populations are generally more affected by factors associated with the fragmentation of habitat because they have a higher probability of extinction due to demographic, genetic, and environmental stochasticity (Noss and Csuti 1997). Certain life history characteristics can also influence the rate at which species are impacted by habitat fragmentation. Species that are naturally rare, have large home ranges, low fecundity, specialized habitat requirements, and are vulnerable to human exploitation are at greatest risk (Noss and Csuti 1997). Other risk factors, such as small body size, narrow niche breadth, and limited perceptual range, are emerging as important factors as more research on fragmentation is completed (Zollner and Lima 1999, Mech and Zollner 2002, Gehring and Swihart 2003).

Carnivores are attracting a substantial amount of interest with respect to habitat fragmentation and are considered important for determining the appropriate size necessary for conservation areas (Miller et al. 2001). There is a great difference between how species within the carnivore group react to fragmentation, but for many species the available information is limited. Most species are nocturnal and elusive, making detection and data collection difficult. In addition, carnivores can influence prey populations by altering densities and long-term viability.

Landscape effects on mid-sized carnivores have been the focus of at least three studies (Oehler and Litvaitis 1996, Dijak and Thompson 2000, Gehring and Swihart 2003). Studies suggest that some carnivore species have an affinity for specific types of edge (Oehler and Litvaitis 1996, Dijak and Thompson 2000, Gehring and Swihart 2003). The correlation between abundance of species in relation to habitat edges may, in fact, be determined by the habitat composition or habitat fragmentation of the surrounding landscape (Donovan et al. 1997). This may be the reason that studies of edge effect on predation rates have shown confounding results (Stephens et al. 2003). Species willing to traverse matrix habitat will be less impacted by fragmentation effects (Sunquist and Sunquist 2001). Mammalian predators may respond to several landscape features other than matrix alone, including size of habitat patches, habitat diversity, and proximity to habitat edges (Oehler and Litvaitis 1996). The reasons for the increase in generalist predators due to effects of fragmentation are two fold. Firstly, generalist predators respond positively to increases in edge habitat. Secondly, once many top order carnivores that are sensitive to fragmentation are eliminated from landscapes, there is no intraguild competition to control population sizes of mid-sized

generalist predators (Crooks and Soulé 1999). Overabundance of generalist predators in conservation areas places undue predation risk on sympatric prey species.

Much of the work on mid-sized carnivores has been conducted in agricultural areas (Dijak and Thompson 2000, Gehring and Swihart 2003). It is important to collect information from as wide a range of areas as possible because all landscapes are inherently different. For example, documented edge use in agricultural areas could be different than use in grasslands located in National Parks maintained for historical significance. Finally, an important aspect of collecting data on National Park Service lands in the northeast allows for evaluating species composition or species responses to landscape attributes that have been influenced by humans. This is vital information for the park service because of their goal of balancing human use and natural processes.

Specific objectives are as follows:

1. To determine whether predator communities respond to larger landscape patterns over edge habitat which is the result of fragmentation
2. To identify the relationship of relative abundance of carnivore species to local and landscape habitat diversity
3. To predict the effect of human population size and land use on relative abundance of carnivore species.

STUDY AREA and PROPOSED METHODS

Study Sites

After field visits and reconnaissance, six to eight parks will be included in the sampling design based on an elimination of the smallest of the parks that are unlikely to contain viable populations of carnivores. The most likely parks for selection are the largest sites, based on their potential for harboring carnivores. Based on size alone, those parks are:

Acadia National Park (Bar Harbor, ME).
 Marsh-Billings-Rockefeller NHP (Woodstock, VT).
 Minute Man NHP (Concord, MA).
 Morristown NHP (Morristown, NJ).
 Roosevelt-Vanderbilt NHP (Hyde Park NY).
 Saratoga NHP (Stillwater, NY).

Sample Methodology, Data Collection, and Data Analysis

Selection of sample points will be determined by the larger study that this work is part of. The goal of the larger study is to document the occurrence of 90% of the mammal species in 11 National Park Service sites in the northeast region. The specific focus of the sampling design in relation to these overall goals will be to sample numerous locations with a thorough distribution of sampling sites. A random sample of points will be chosen using a grid cell-based sampling plan to ensure that an

evenly distributed sample is taken. The design will also be stratified based on vegetation to ensure that all habitat types are adequately sampled. The steps that will be taken to construct the sampling design include: 1. a grid (spacing will be 100 meters on a side for all parks except Acadia for which we will employ 200 meter grids [Fancy 2000]) will be placed over the sampling frame; 2. grid cells will be overlaid onto digitized aerial photographs starting with a point of random origin; 3. grid cells will be selected based on a predetermined spacing that will allow for a relatively equal distribution of sampling points; and 4. random points will be placed within each grid cell with the aid of a GIS application.

It is possible that additional locations may have to be sampled to obtain adequate data. In this case, the samples will be obtained using similar methods.

At a minimum, major habitats need to be represented to develop a sample frame representative of the entire park. For each park, GIS data will be obtained and used to develop a complete sampling frame. Depending on the site, it may be possible to conduct all sampling within the grid cell framework, implementing unequal probability sampling to ensure adequate sampling of unique habitats and specific locations. However, it may be more efficient in some cases to sample unique habitats separately for particular species, allowing a simpler sampling design for the grid cell samples (Fancy 2000). This can only be determined after evaluating maps and making site visits.

Once sites are selected they will be set up with one active infrared remote camera and/or one enclosed track plate (cubby box). Although there is some overlap in the utility of each of these types of equipment at documenting visits by target species, each type of equipment has advantages and disadvantages. Remote cameras are very successful at documenting species such as coyote, red fox, raccoon, skunk, and Virginia opossum, however they are expensive to run and are subject to vandalism. Cubby boxes succeed in documenting species such as raccoons, Virginia opossum, striped skunk, weasel and other mustelid species. Cubby boxes are inexpensive to purchase and operate, making them easy to replace if vandalized; unfortunately, they only target the smaller species of the group. Sites will be baited with a small piece of chicken. Baited devices lure animals into specific areas, which they otherwise may not be using. A conservative estimate is that baited devices do not attract animals from a distance farther than 25 meters (based on observations from Cape Cod, MA and work conducted by Dijak and Thompson (2000)). Due to this fact it will be necessary to limit the detail or specificity of the habitat data that are collected.

Data will be collected on a year round basis, although sampling in the winter season may not be as intense as other times. Cubby boxes will be checked weekly to collect track information, replace track plates when necessary, and replenish lures and bait. Cameras will be checked periodically to insure that they are operating properly and to change film when needed. Cameras will be camouflaged and placed only in areas where human use is minimal. Sampling will be conducted at least two weeks each month. Depending on species capture rates, the duration of sampling periods may vary.

ANTICIPATED RESULTS AND IMPLICATIONS

Initially, we will delineate habitats using current aerial photographs. Once in GIS form, patch-scale measurements will be taken from digitized maps. Species information such as relative abundance,

presence/absence, or site occupancy will be compared to habitat patch characteristics such as distance to nearest edge, size and shape of habitat patch (fractal dimension), and habitat diversity (measured by cover type diversity). Distribution, relative abundance, presence/absence, site occupancy rates and other relevant population parameters will be analyzed for different seasons. Species responses to edge habitats in summer may reflect temporal resources that are not available at other times of the year.

This study will concentrate on carnivore species that occur in the northeastern United States. Carnivore species will be targeted because they comprise an assemblage of species that display a variety of life histories and resource requirements. Many of these species likely are affected in different ways by habitat fragmentation, making correlations between species characteristics and levels of fragmentation possible. Carnivores likely to be included in the analysis will be Eastern coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), ermine (*Mustela erminea*), and long-tailed weasel (*Mustela frenata*). The two weasel species may be grouped together because they are not easily distinguished using the proposed techniques. Species less likely to be sampled are gray fox (*Urocyon cinereoargenteus*), fisher (*Martes pennanti*), American marten (*Martes americana*), bobcat (*Lynx rufus*), mink (*Mustela vison*), river otter (*Lutra canadensis*), and black bear (*Ursus americanus*).

At the landscape-scale, analysis will take place at two different spatial scales. An example of possible scales is 1.5 km and 5 km radii around sampling points. Scales will be chosen based on biological significance to the animal community under investigation, but the spatial distribution of sampling sites will also be a factor. The smaller scale will be chosen to reflect the size of individual home ranges for select species, while the larger scale will encompass multiple home ranges for many of the target species. To derive landscape level information at a coarse scale, landscape cover type maps (ie. National Land Cover Data) will be used (available free from the US EPA or state operated GIS sites such as MassGIS). Important variables that will be calculated for the two landscapes scales will be cover type diversity, landscape composition (percentage of landscape in each habitat), human use or population around sampling points, and level of landscape fragmentation (calculated from landscape indices such as mean patch size, mean nearest neighbor distance, contagion, and adjacency). The final indices used in the analysis may vary, due to predicted colinearity between measurements.

COMMUNICATION OF RESEARCH RESULTS

Results from this project will be communicated to the scientific and resource management community through progress reports, lectures at National Park Service facilities, presentations at scientific conferences, and most important, publications in peer-reviewed journals. Presentations and publications (reports and/or peer-reviewed articles) will be made available for posting on the URI Cooperative Ecosystem Study Unit website.

Deliverables

Species data in database template, ANCS+ and NPSpecies

Copies of capture and habitat data as recorded on field data sheets will be provided to the NPS I&M Program as part of the archives for the project.

Data will be submitted electronically and on CD-ROM in Microsoft Access using the NPS I&M database template or one specifically developed for this particular project by an I&M Data Manager. A data dictionary describing field names and values must accompany each database. All data will be entered by the Research Associate hired for this project and verified by the principal investigators. The investigator is responsible for implementing and documenting quality assurance/quality control (QA/QC) measures used to assure the accuracy of their data. QA/QC documentation will be provided to the NPS with all databases in MS-Word format.

Metadata for all biological data sets will be provided following the Federal Geographic Data Committee (FGDC) Metadata Biological Data Profile. All metadata will be parsed following the NPS GIS guidelines and provided in the following three file formats ASCII text, HTML and SGML on CD-ROM.

GIS data

Differentially corrected GPS coordinates (UTM NAD83) for all sampling locations will be provided as an ArcInfo coverage. The investigators will provide GPS coordinates of all captures. GIS coverages will include all sampling locations overlaid with habitat communities. Each location will have an associated data table containing a list of species captured. At a minimum, all spatial data are to be supplied as an ArcInfo coverage and ArcInfo interchange file, e00, compatible with the current version of ArcInfo (currently 8.3) for the MS Windows operating system, both electronically and on CD-ROM.

Federal Geographic Data Committee (FGDC) compliant metadata for all spatial data sets will be created. All metadata will be parsed following the NPS GIS guidelines and provided in the following three file formats ASCII text, HTML and SGML on CD-ROM.

Reports

A Progress report will be submitted on October 1 of each year to be included in the Annual Administrative Report for the NPS I&M program. Additionally, progress reports will be submitted quarterly in MS-Word format to both the I&M program and Network Coordinator.

Final reports will be written and reviewed by the NPS and peer reviewed by experts selected by the NPS to insure compliance. Drafts of these reports will be submitted digitally, in MS-Word format, on CD-ROM to the Northeast Region I&M Program Coordinator.

The graduate student thesis generated from this project will be submitted in hard copy to the NPS (2 copies).

Investigator's Annual Reports will be completed on or before December 31 of each calendar year that this Agreement is in effect, including the year of completion.

BUDGET JUSTIFICATION AND PERSONNEL

Funds requested in this proposal include support for graduate student at the University of Rhode Island. The student will work with investigators and biologists as part of a team conducting the overall mammal inventory. The student will focus on data collection and analyses that extends the inventory dataset, thereby allowing the NPS to examine information on mammalian species for which little local information is available (e.g. weasels). Ultimately, more informed decisions on monitoring programs can be made. The analyses described above are most effectively conducted in an academic environment that draws upon University resources.

Thomas Husband is a wildlife biologist and the Chair of the Department of Natural Resources Science at the University of Rhode Island. He conducts both basic and applied ecological research on a wide variety of topics including: faunal inventories in South America; wildlife use of wetland buffers and forest edges; effects of mute swan herbivory; population ecology, behavior, and genetics of the endangered Cretan wild goat; conservation genetics of cottontail rabbits; population ecology of dragonflies; habitat use of deer as determined by GPS tracking; and faunal inventories of the Brazilian Atlantic forest.

Allan O'Connell is a research wildlife biologist for the US Geological Survey, Patuxent Wildlife Research Center in Laurel, Maryland. He has extensive experience working in northeastern national parks on ecological and management issues for a variety of wildlife species including white-tailed deer, coyotes, red foxes, and flying squirrels. Most recently he has developed sampling protocols for detection of medium-sized mammals.

BUDGET

Due to budgetary agreements and term limits between the National Park Service and the University of Rhode Island, only the first year of funding in this proposal is requested for transfer to the University in federal fiscal year 2003. The second year of funding will be requested as a modification to this agreement between the NPS and URI under terms negotiated for the Cooperative Ecosystem Study Unit with an overhead rate of 17.5% (refer to Table below)

	Year 1	Year 2
Husband	URI	URI
O'Connell (3mo/yr)	USGS	USGS
MS Student stipend (full time)	\$21,494 (full calendar year)	\$22,248
MS Student Tuition	\$12,071	\$12,672
Supplies	USGS	USGS
Total Direct Costs	\$33, 565	\$34, 920
Indirect Costs (25% first year ; 17.5% second year)	\$8, 391.25	\$6, 111
TOTAL COSTS	\$41, 956	\$41, 031

Grand Total Costs = \$ 82, 987

SCHEDULE

The work to be conducted under the terms of this agreement consists of two field seasons commencing in the fall of 2004 and running through 2005. Thesis preparation will commence once collection of field data are complete.

LITERATURE CITED

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BUDGET INFORMATION - Non-Construction Programs

OMB Approval No. 0348-0044

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1.		\$	\$	\$ 41,956.00	\$	\$ 41,956.00
2.						0.00
3.						0.00
4.						0.00
5. Totals		\$ 0.00	\$ 0.00	\$ 41,956.00	\$ 0.00	\$ 41,956.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1)	(2)	(3)	(4)	(5)
a. Personnel	\$	\$	\$ 33,565.00	\$	\$ 33,565.00
b. Fringe Benefits					0.00
c. Travel					0.00
d. Equipment					0.00
e. Supplies					0.00
f. Contractual					0.00
g. Construction					0.00
h. Other					0.00
i. Total Direct Charges (sum of 6a-6h)			33,565.00	0.00	33,565.00
j. Indirect Charges			8,391.25		8,391.25
k. TOTALS (sum of 6i and 6j)	\$	\$	\$ 41,956.25	\$ 0.00	\$ 41,956.25
7. Program Income	\$	\$	\$	\$	\$ 0.00

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Standard Form 424A (Rev. 7-97)
Prescribed by OMB Circular A-102

Previous Edition Usable

SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8.	\$	\$	\$	\$
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	\$ 0.00	\$ 0.00	\$ 0.00	\$ 0.00

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	\$ 0.00	\$	\$	\$	\$
14. Non-Federal	0.00				
15. TOTAL (sum of lines 13 and 14)	\$ 0.00	\$ 0.00	\$ 0.00	\$ 0.00	\$ 0.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (Years)			
	(b) First	(c) Second	(d) Third	(e) Fourth
16.	\$ 41,956.00	\$	\$	\$
17.				
18.				
19.				
20. TOTAL (sum of lines 16-19)	\$ 41,956.00	\$ 0.00	\$ 0.00	\$ 0.00

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges:	22. Indirect Charges:
23. Remarks:	