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EFFECT OF HUMAN DISTURBANCE ON SMALL MAMMAL COMMUNITIES IN ITASCA STATE PARK, MINNESOTA†

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ABSTRACT

We determined effects of different levels of human disturbance on small mammal richness and relative abundance from live-trapping data obtained in Itasca State Park in northwestern Minnesota. We developed a quantitative measure of human disturbance based on disturbance units and trapped small mammals on three study sites, each reflecting a different level of disturbance. Our data revealed that small mammal diversity decreased with increasing human disturbance. Amount of ground cover and litter depth also appeared to be important in explaining differences in the demographic patterns of small mammals among sites.

INTRODUCTION

The 1980 U. S. National Survey of Fishing, Hunting and Wildlife-Associated Recreation revealed that nearly 83 million people participated in some form of non-consumptive wildlife recreation (Boyle and Samson 1983). As these numbers continue to increase, concern about human impact on wildlife and wildlife habitat grows. Although many researchers have studied the effect of human activities on vegetation in natural areas, most of our understanding of effects of disturbance on animals is limited to behavioral responses of individual animals, rather than effects on animal communities (Knight and Cole, 1991). It is important to understand how animal populations are affected by human disturbance when making decisions regarding use of natural resources. This study examines how small mammal communities are affected by type and amount of human disturbance, two of the three criteria considered by Cole (1981) to be most important in evaluating human impacts on wilderness sites.

METHODS

Study Area: We conducted the study during July and August, 1993 in Itasca State Park, Clearwater County, Minnesota (T143N, R36W). The park, a 13,000 ha forest reserve near the confluence of prairie, deciduous forest and coniferous forest biomes, contains a variety of forest types at various successional stages.

We chose three study sites to represent three levels of human disturbance. The University of Minnesota Forestry and Biological Station (Sec. 11) represented an area of high human disturbance, the Group Campground at Squaw Lake (Sec. 5) was moderately disturbed, and an undisturbed Control Site (Sec. 15) was located in the Wilderness Sanctuary. We defined the sizes of the disturbed sites as the area encompassing all human structures (buildings, roads and mowed areas) and bounded by roads and/or mowed areas. We believe the Control Site was representative of the vegetation at the Biological Station and the Group Campground prior to human disturbance.

Small Mammal Census

We simultaneously trapped four 100 m traplines at each site for three consecutive days. We selected trapping sites primarily by availability of areas in each site that could accommodate a 100 m transect without interfering with foot traffic or passing through edge habitat. We placed transects at the Biological Station and Campground near the edges of mowed areas adjacent to tall grass and herbaceous cover. Because there were no buildings or mowed areas at the Control Site, we placed transects 10 m apart in parallel rows.

Transect lines consisted of 11 trap stations each containing one Sherman trap (8 x 9 x 23 cm) baited with peanut butter and rolled oats and placed on the ground 10 m apart and a total of 44 traps per site. Each trap also contained cotton bedding and a small piece of raw potato. Nine traps in each transect were placed within a protective cover consisting of a wire mesh dome attached to a wooden board (15 x 2 x 75 cm) to decrease trap disturbance by raccoons; two trap stations on each transect remained unprotected. We checked traps each day at 0600, 1400 and 2100 hours. We identified all animals trapped to species, marked

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them with either an ear tag or by a dot of non-toxic paint applied to the top of the head or body, and released them at the capture site.

Vegetation Analysis

We used the point-quarter sampling method (Cottam and Curtis, 1956) to determine relative density and importance value of each tree genus. Sample points were located every 20 m on trap transect lines. We used an Index of Similarity (Krebs, 1989) to compare tree genera among sites. We measured ground cover at each sample point by estimating the percentage of grass and herbaceous cover (height = 0.5 to 1 m) present in a circle (1.5 m radius) around the sample point. We then ranked each point (0 to 4) according to percent cover and calculated an average rank for each site. We also measured litter depth with a meter stick at each sample point; litter cover less than 0.25 cm was recorded as zero.

Measurement of Human Disturbance

Human disturbance is a difficult concept to define and has been dealt with in various ways in the literature. Many studies have focused on effects of consumptive human activities, such as logging, burning, and strip-mining, rather than recreational use (Blankenship, 1982; Boyle and Samson, 1983; Freedman et al., 1988; Oldemeyer and Allen-Johnson, 1988). Others have examined the response of individual animals to disturbances such as researcher effect and hunting (Paynter, 1951; Livezey, 1980; Parsons and Burger, 1982; Kenney and Knight, 1992). Some studies have considered only presence or absence of human and/or vehicular traffic (Picozzi, 1970; Robert and Ralph, 1975; Vollmer et al., 1976; Strauss and Dane, 1989; Plumpton and Lutz, 1993). Although some research has dealt with effects of campgrounds (Clevenger and Workman, 1977), visitor use in a national park (Garton et al., 1977), and effects of recreational use such as trail construction, hunting, and fishing (Cole and Knight, 1990) on distribution and abundance of small mammals, we found no studies that compared small mammal abundance in areas with different, well-defined levels of human disturbance.

We developed a quantitative indicator of disturbance because of the difficulty of directly measuring the amount of human influence in an area. Human structures such as buildings, roads and mowed areas effectively eliminate potential small mammal habitat. Therefore, we used these as one measure of disturbance. We used a method similar to that of Vermeer (1973) to assign disturbance units (DU) to each structure as a function of its size. Buildings received one disturbance unit for each 100 m^2 of total surface area. Additionally, we assumed that roads were the least suitable habitat for small mammals, followed by buildings and mowed areas. Therefore, after calculating the initial DU by the above method, we added an additional DU to each road measurement and subtracted one DU from each mowed area. We calculated a disturbance ratio for each site by dividing the total number of DU by the site acreage.

Human presence may also affect small mammal populations by decreasing the numbers of shy organisms or eliminating them from the community (Wilkes, 1977). Therefore, we used level of use by humans as a second measure of human disturbance. Park records indicated the number of people/day using the Biological Station and the Campground from June through August 1993. We considered usage at the Control Site to be zero because we saw no humans other than ourselves at the site.

Data Analysis

We developed a logistic regression model to examine the relationship of small mammal diversity indices with disturbance ratios, level of human usage, ground cover, and litter depth. We also used Chi-squared goodness-of-fit tests to examine distribution patterns of mammals among sites. We used a significance level of $p = 0.10$ for all statistical tests.

RESULTS

Disturbance ratios indicated that the Biological Station experienced more than twice the level of disturbance with reference to human structures than the Campground (Table 1). Human usage was highest at the Biological Station followed by the Campground. No known human usage or disturbance occurred at the Control Site (Table 2).

Table 1. Disturbance units and ratios for three study sites in Itasca State Park, Minnesota

Study Area	Disturbance Units				Study Area	Disturbance Ratio
	Buildings	Roads	Mowed Areas	Total		
	number				ha	units ha^{-1}
Biological Station	84	53	656	793	11.9	66.6
Campground	8	6	86	100	3.2	31.3
Control Site	0	0	0	0	3.3	0

Table 2. People per day using three study sites from June through August 1993 in Itasca State Park, Minnesota.

Study Area	Monthly Average			Average
	June	July	August	
	people day^{-1}			
Biological Station	62	98	85	81.7
Campground	14	25	13	17.3
Control Site	0	0	0	0

The Index of Similarity (Krebs, 1989) indicated that the Biological Station and Campground were similar in vegetative cover, whereas the Control Site differed from both (Table 3). Trees ha^{-1}, average ground cover and average litter were similar at the Biological Station and Campground. The Control Site had a tree density over tenfold that of the other sites and considerably more ground cover and litter. The importance values of the tree genera indicate that *Pinus* species are very important at all three sites (Table 4). This suggests the existence of a common macrohabitat (e.g. soil type, temperature, rainfall) at these sites. Thus, we assumed that the sites are not of significantly different vegetation type and could presumably support the same species of small mammals.

Species richness of small mammals was greatest in the Control Site (6 species) and equal (4 species) in the Campground and the Biological Station (Table 5). Species diversity varied among sites; the Shannon-Wiener Index of Diversity (Shannon and Wiener, 1949) was greatest at the Control Site (1.75), followed by the Campground (1.41), and the Biological Station (1.18). Regression analysis revealed a significant negative correlation between disturbance ratios and diversity ($p = 0.09$, $R^2 = 0.99$; Figure 1). The data also suggest a negative relationship between human usage and diversity ($p = 0.28$, $R^2 = 0.82$), and positive relationships between litter depth and diversity ($p = 0.23$, $R^2 = 0.87$), and ground cover and diversity ($p = 0.13$, $R^2 = 0.96$).

Only two species occurred in numbers sufficient enough to compare their distribution among sites. Both the woodland deer mouse *(Peromyscus maniculatus gracilis)* and Eastern chipmunk *(Tamius striatus)* had distribution patterns among the sites that differed from expected ($X^2 = 35.45$, $p < 0.01$, df = 2).

Table 3. Vegetative cover at three study sites in Itasca State Park, Minnesota.

Study area	Similarity for tree genera		Trees	Average	
	Campground	Control		Ground Cover	Litter depth
	index		no. ha^{-1}	- rank -	— cm —
Biological Station	0.80	0.50	71	0.3	0.4
Campground	——	0.62	82	0.7	0.6
Control Site	——	——	843	1.9	4.0

Table 4. Importance values of tree genera in three study sites in Itasca State Park, Minnesota.

Tree	Biological Station	Campground	Control Site
— genus —	Importance Value		
Abies	0	3	80
Acer	0	4	0
Betula	15	85	0
Fraxinus	0	0	6
Ostrya	12	3	0
Picea	109	20	6
Pinus	106	107	204
Populus	18	34	0
Quercus	9	44	4
Tilia	31	0	0

Table 5. Small mammals trapped at each of three sites over three consecutive days at Itasca State Park, Minnesota.

Mammal	Site		
Tree	Biological Station	Campground	Control Site
— species —	number		
Peromyscus maniculatus	3	12	16
Tamias striatus	27	9	0
Clethrionomys gapperi	1	1	8
Zapus hudsonius	0	0	1
Blarina brevicada	0	0	1
Microtus pennsylvanicus	0	1	0
Tamiasciurus hudsonicus	2	0	0
Eutamias minimus	0	0	1
Mustela erminea	0	0	2

Discussion

Our results suggest that human disturbance influences small mammal richness and relative

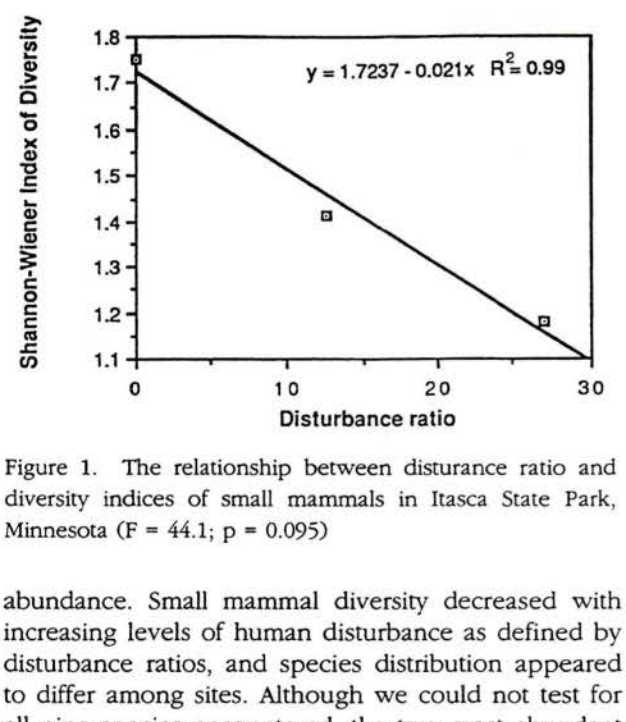

Figure 1. The relationship between disturance ratio and diversity indices of small mammals in Itasca State Park, Minnesota (F = 44.1; p = 0.095)

abundance. Small mammal diversity decreased with increasing levels of human disturbance as defined by disturbance ratios, and species distribution appeared to differ among sites. Although we could not test for all nine species encountered, the two most abundant species, chipmunks and deer mice, were distributed nonrandomly among sites, suggesting that small mammals were choosing certain sites preferentially over others.

Small mammals may be choosing sites based on the likelihood of encountering humans there, perhaps because they perceive humans as potential predators. Thus, more tolerant species would occur in greater abundance at the Biological Station and Campground, whereas shy species would be found in the undisturbed Control Site. Our data, though scant, lend support to this hypothesis. For example, the data suggest a pattern of increasing abundance of chipmunks as levels of human disturbance increase. Hazard (1982) noted that chipmunks were tolerant of human observers. We frequently observed individuals foraging at the Biological Station and Campground, seemingly unaffected by the presence of people. In addition, the chipmunks may have been taking advantage of the food resources provided by human activity.

In contrast, woodland deer mice were most abundant in the Campground and Control Site and the carnivorous short-tailed weasel *(Mustela erminea)* was trapped only at the Control Site, where human disturbance was minimal. Perhaps these species were shy and chose to live in sites with little human activity.

Although some small mammals may prefer sites in which human contact is minimal, the trends we observed may partly be related to habitat differences among sites. Although our study sites contained similar vegetation and tree species, ground cover and litter depth, both likely more important to small mammal ecology, were somewhat higher in the Control Site. The nonsignificant, but fairly strong, positive relationships between diversity indices and both ground cover and litter suggest that these variables also may be important in predicting small mammal distribution and abundance. The smaller numbers of woodland deer mice and red-backed voles *(Clethrionomys gapperi)*, and the complete absence of short-tailed weasel, meadow jumping mice *(Zapus hudsonius)* and short-tailed shrews *(Blarina brevicada)* at the Biological Station and Campground could be related to the relative lack of ground cover and litter in these sites. These species need litter and cover, such as logs, tree roots or other forms of vegetative shelter, as suitable nesting habitat (Hazard, 1982). Thus, human disturbance is also important inasmuch as it removes ground cover and litter from the habitat, thus reducing access to resources such as food or nesting sites.

Although our sample sizes were small, and our tests lacked statistical power, our interesting results warrant similar studies with replicates and larger sample sizes. Our data indicate that small mammal diversity and distribution is affected by a combination of the presence of humans and the absence of ground cover and litter. Thus, we suggest that preserving habitat patches containing ground cover and litter may help maintain small mammal diversity and richness without limiting the numbers of people using an area. When resource managers plan for expansion of camping facilities within parks, we suggest that they consider constructing more rustic campgrounds with few buildings and numerous sites with natural habitat. This would permit persistence of diverse small mammal communities in areas with intense human use.

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