Small mammal assemblages at different levels of disturbance on the Cloudbrige Reserve, Costa Rica

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Abstract

Costa Rica has experienced a high level of habitat disturbance in recent decades, primarily in the form of deforestation. This has resulted in often catastrophic declines in many populations over the past 30 years. The effect of disturbance on small mammal populations has been poorly studied in Costa Rica. Numerous community studies along disturbance gradients have found that highest diversities are found at sites of intermediate disturbance. However, this initial study found that diversity was inversely correlated with disturbance, whilst abundance was positively correlated. In addition, 6 species of small mammal present at Cloudbridge were identified. The high occurrence of species specific to only a single one site would suggest that sampling at other sites could reveal greater species richness for the Cloudbridge preserve.

Introduction

Costa Rica has suffered catastrophic declines in many animal and plant populations over the past 30 years. Recent publications showing massive declines in species ranging from primates (Boinski et al. 1998), to amphibians and reptiles (Whitfield et al. 2007). Much, although not all of this loss has been attributed to habitat loss, mainly due to conversion of forest to pasture. Estimates of forest loss differ due to factors such as definitions of 'forest', but some idea of the range is given by Rosero-Bixby and Palloni:

> *By 1940, estimates of primary forest cover of Costa Rica range from 68% (Sader and Joyce, 1988) to 78% (Keogh, 1984). The most recent estimates range from 17% forest cover in 1983 (Sader and Joyce, 1988) to 31% in 1990 (FAO).* (1996)

This is precisely the trend that Cloudbridge and reserves like it aim to reverse. Much of the reserve is sited on land previously used for agriculture Cloudbridge features a diverse range of habitats due to its program of acquiring old agricultural land as well as patches of primary and secondary forest. Habitat disturbance is an important and increasingly common factor in species diversity and community structure (Dirzo et al. 2007). Each habitat offers distinctive biotic and abiotic environments which may or may not be suitable for specific species. These interrelated factors include food and water availability, mean and range wind speed, temperature and solar radiation, suitable nesting sites, soil nutrient and pH levels, and a host of other variables.

A review of the literature reveals that diversity does not necessarily decrease with an increased level of disturbance or vise versa (Van den Bergh and Kappelle, 1998). When measured along a disturbance gradient, diversity can often be highest at intermediate disturbances. As well as changes in factors such as species richness, moving from areas of high disturbance to low disturbance will involve a species turnover. That is, species well adapted to areas of high disturbance may be completely absent from areas of low disturbance, and vice versa. Although forest 20 or 50 year after recovery may appear very similar to undisturbed forest many processes and relationships may still be absent.

This study sampled small mammals, specifically those able to be captured by Sherman traps. Despite their low status amongst wildlife enthusiasts, particularly when compared to charismatic mega-fauna and the abundant avifauna found in the tropics, small mammals form and important group in almost every terrestrial ecosystem. Rodents for example, are abundant on every continent except Antarctica and make up 40% of all mammal species (Wilson and Reeder, 2005).

Small mammal diversity in the tropics, as with many groups, suffers from a lack of research. The specific role of small mammals in ecosystem processes are often poorly understood, and although basic information on diet and predators exists, cases focusing on individual predation relationships are limited. Their small size, mobility, secrecy and nocturnal and diurnal activity make studies of this kind in the field practically impossible and are thus limited to laboratory studies. Field research on small mammals tends to focus on community composition, abundances, distributions, reproduction, and mortality rates. It is possible to obtain data on these ecological traits using various capture and release methods. It should be noted that to achieve accurate and reliable pictures of actual community composition, population dynamics and reproductive strategies, trapping must occur over several years at any one site. Data acquired over a short period of time as in this study can only be read as a snapshot.

Small mammal species impact an ecosystem structure both up and down its trophic levels. As seed predators small mammals can affect seed fertilization and germination success through pollination, seed dispersal and predation, although their importance for pollination is far less than that of insects. Small mammal abundances are likely to be a factor in plant community composition, as they differentially predate on large and small seeds (up to 30 times more on small than large) which may act to impoverish under story vegetation and effect regeneration (Dirzo et al. 2007). Small mammals predate upon a wide range of prey species other than seeds, including arthropods (Brower et al. 1985), annelids and other soil organism, amphibians

Small mammals are important prey species for many bird, mammal, reptile and amphibian species. The exact feeding relationships are poorly understood for many species but those given for *S. xerampelinus* on the INBio species page:

("zorro pelón" (*Didelphis marsupialis*), "zorro cuatro ojos" (*Philander opossum*), "zorro de balsa" (*Caluromuys derbianus*), "comadreja" (*Mustela frenata*), "tolomuco" (*Eira barbara*), "zorro hediondo" (*Conepatus semistriatus*), "pizote" (*Nasua narica*) etc.), aves ("gavilán" (*Harpagus bidentatus*), "gavilán pollero" (*Buteo platypterus*), "gavilán" (*Buteo jamaicensis*), "lechuzas" (*Lophostrix cristata, Pulsatrix perspicillata, Ciccaba virgata, C. nigrolineata, Aegolius ridgwayi*), "lechuza de campanario" (*Tyto alba*) etc.) y reptiles ("serpientes o culebras" (*Chironius fuscus, Dendrophidion clarki, D. percarinatum, D. vinitor, Drymobius melanotropis, D. rhombifer, Erytrholamprus mimus*), "zopilota" (*Spilotes pullatus*), "terciopelo" (*Bothrops asper*) etc.). (Luis Humberto Elizondo, 2000)

gives some indication of the diversity of predators that are at least partially dependent on small mammal species as a food source.

Methodology

Trapping was carried out at three sites, chosen for their different disturbance levels. Grids were set in primary (the hectare), secondary (approx. 20 years old, adjacent to Gavilan) and disturbed (ex pasture adjacent to primary forest) (figure 1). At each site 10 traps were set in a 5 x 2 grid, with each trap spaced 20m apart. The traps were moved to an adjacent grid mid-way through the study, making a total grid of 5 x 4, or 80 x 30m. Although this method will inevitably result in distortions in the data, it was chosen due to the small number of traps, and considered justified as the same method was used at all three sites, allowing direct comparison. Traps were marked and matched to a grid, allowing the position of each individual catch to be recorded. Where trapping occurred in the canopy the traps were fitted inside wooded boxes which could be tied to branches or trunks in the canopy. in the lower canopy a transect of 5 points 20m apart was marked and the traps attached at the nearest suitable point. in the upper canopy 5 traps were attached in only 1 tree, wherever possible. this was not ideal but the best compromise given the constraints on equipment and demands on other volunteers already limited time was marked and Captured individuals had their species, mass, head and body length, tail length, back "foot" length, ear length and sex recorded.

The sites were at different altitudes, but chosen to give the minimum variation between the three. It was not possible to compare sites at the same altitude due simply to the lack of suitable comparison sites at the same altitude. As small mammals are primarily nocturnal, traps were set at dusk and checked in the morning (Gurnell and Flowerdew, 1990). This method was also selected to minimize the risk of mortalities due to high temperatures during the day. Traps

were set along natural runs such as fallen logs or tree trunks and covered with leaves and other debris. Trap openings were left clear and bait (granola, seeds and oats) placed at the entrance and inside the traps. Individuals were identified using INBio species pages from the website (http://www.inbio.ac.cr) and were marked by hair clipping. Trapping occurred for 2 weeks at each site, and included a period in which the traps were left open and baited to allow individuals to become used to the traps. A short trapping period was also carried out around the Gavilan house, the only human habitation adjacent to any of the study areas.
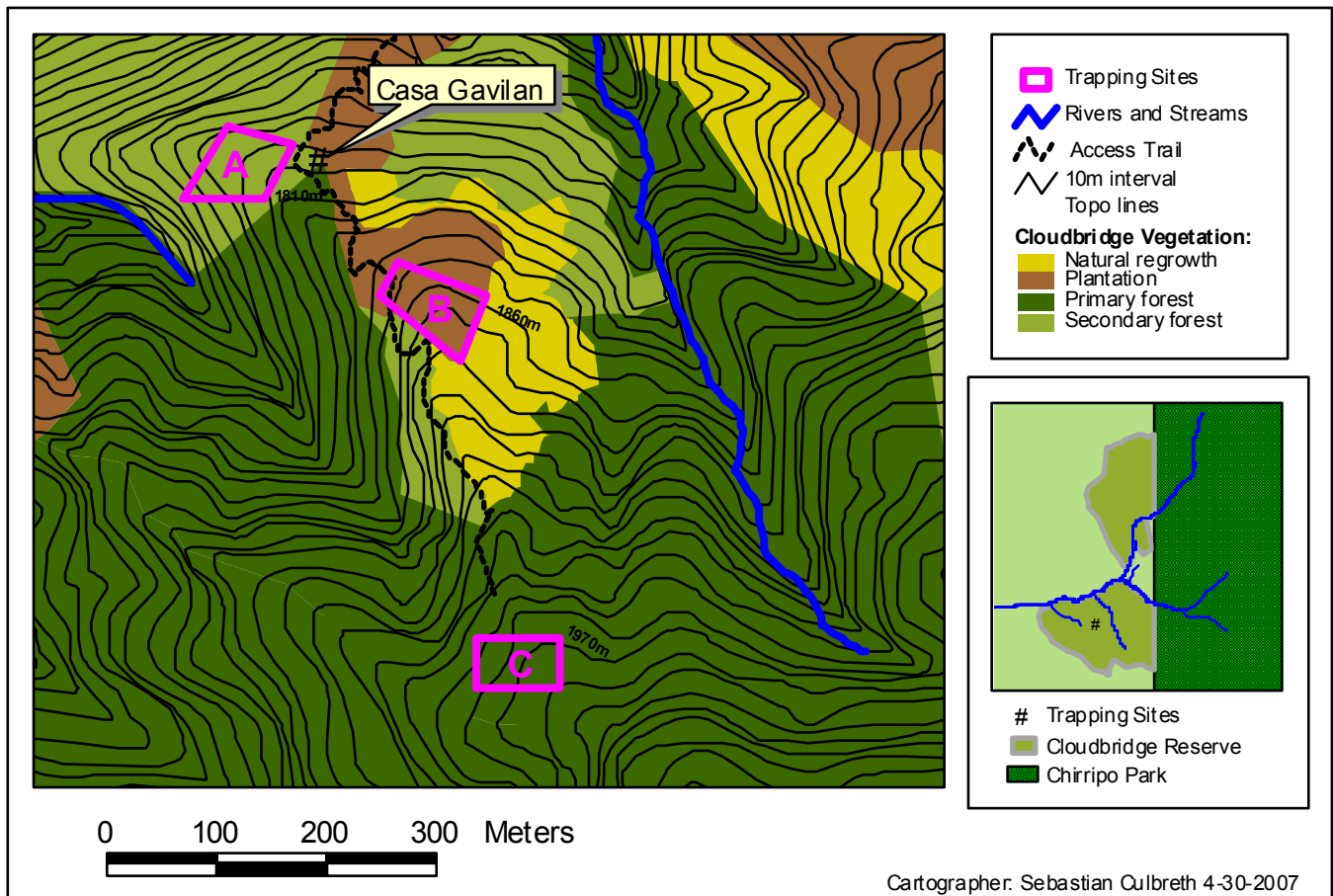

Figure 1. The position of trapping sites on Cloudbridge reserve

Results

Table 1. Captures of each species at 3 main sites

Species	Primary Forest	2nd Forest	Pasture
Scotinomys xerampelinus	1	4	5
Peromyscus mexicanus	2	/	/
Oryzomys albigularis	1	4	/
Cryptotis nigrescens	1	/	/
Oligoryzomys fulvescens	/	/	11
Nyctomis sumichrasti	/	/	/
Total	5	8	16

Table 2. Diversity indices at each site

	Species richness	Number of individuals	Trap success	Simpson index of diversity
Hectare	4	5	18.0%	0.90
2nd forest	2	8	23.6%	0.56
Pasture	2	17	42.0%	0.46

Table 3. Percentage representation by each species at each site

	No. in Primary	% in primary	No. in 2ndary	% in 2ndary	No. in pasture	% in Pasture	No. individuals	% of total
O. fulvescens					11	73.3	11	37.9
S. xerampelinus	1	20.0	4	50.0	4	26.7	10	34.4
O. albigularis	1	20.0	4	50.0			5	17.2
P. mexicanus	2	40.0					2	6.9
C. nigrescens	1	20.0					1	3.4
							29	100.0

Table 4. Captures by species at additional sites

Species	2nd Forest lower canopy	Casa Gavilan
Oligoryzomys fulvescens		2
Nyctomis sumichrasti	3	5

The identification of *Oryzomys albigularis* offered a number of difficulties. The species matched the INBio descriptions other than in colour. The individuals found on Cloudbridge were grey rather than brown. Whether this colour variation is possible, or if it is in fact a different species I cannot determine. No other species of this size were grey according to INBio. The species will be referred to as *Oryzomys albigularis*, as both the most likely identification in my opinion and to simplify the writing of the report.

Discussion

A total of 6 species were caught across all sites. 5 of these were Rodents of the family Muridae. 3 of these species (*Scotinomys xerampelinus* (Elizondo, 2000c), *Oligoryzomys fulvescens* (Elizondo 2000a) and the arboreal *Nyctomis sumichrasti*) were small, weighing 9-14 grams. 2 were larger species (*Oryzomys albigularis* and *Peromyscus mexicanus (*Elizondo, 1999b)) weighing 39-over 100 grams. The remaining species was a shrew, *Cryptotis nigrescens (*Elizondo, 1999a), of the order insectivora and family soricidae, weighing 6 grams. Sampling of the terrestrial habitat at the primary forest, secondary forest, and pasture that formed the bulk of the data collection and are directly comparable will be discussed first. 5 species were caught during these surveys. Species ranged from the generalist S. *xerampelinus* which thrived at all sites, to *O. fulvescens, P. mexicanus* and *C. nigrescens* which were each found at only one site. Individuals of the species O. alb were found at both secondary and primary sites. The communities found were distinctive both in terms of species richness, diversity, abundance and home ranges.

The pasture site had a species richness of 2, the lowest diversity with a Simpson diversity index of 0.46 and by far the highest abundance of any site with a total of 16 individuals captured. Trapping success at this site was high at 42%. 11 of

these were of the species *O. fulvescens*, which dominated this site but was absent from all others. The second species was *S. xerampelinus*, present at all sites. These species are very similar in terms of size (approximately 9 to 14g for grams *S. xerampelinus* compared with 10 to 16 grams *O. fulvescens*), although distinctive due to *O. fulvescens'* conspicuously long tail. Home ranges were indistinct and many overlapped.

The secondary forest site also had a species richness of 2, an intermediate diversity with a Simpson diversity index of 0.56, an intermediate abundance with a total of 8 individuals captured and intermediate trapping success of 23.6%. There were 4 individuals of both *O. albigularis* and *S. xerampelinus*. *O. albigularis* is the largest species caught at any site with the largest individual weighing over 100 grams) and much greater in size than *S. xerampelinus*. The ranges of the species were distinct, the ranges of individuals within species less so. The species ranges may suggest a lack of uniformity in the habitat, possibly an edge effect or response to gradient. *S. xerampelinus* was found at the grid edge towards the exterior of the forest, whilst *O. albigularis* was found towards the interior (figure 2).
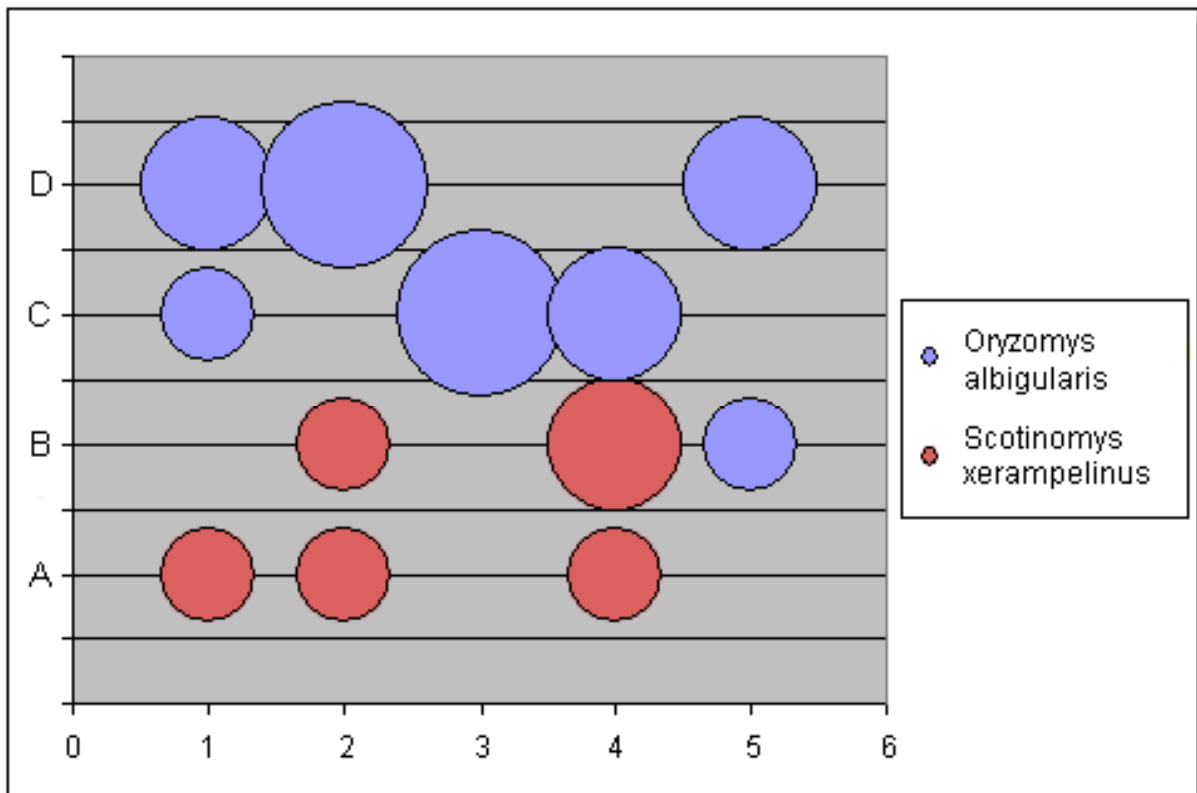

Figure 2 Distributions of species *O. albigularis* and *S. xerampelinus* at the secondary forest site. Axes correspond to trap positions on trapping grid. Size of circle denotes number of captures at each trap (1-3).

The primary forest site had a species richness of 4, twice that of the other 2 sites, and the lowest abundance with only 5 individuals captured. the Simpson index of diversity was 0.90, again substantiallly higher than at any other site. trap success was the lowest at 18%. As well as the *S. xerampelinus*, *O. albigularis* was present and 2 species specific to this site, the shrew *C. nigrescens* 6 grams) and the large rodent *P.mexicanus* (39 grams). species ranges were disctinct with no overlap between individuals detected by trapping (figure 3).
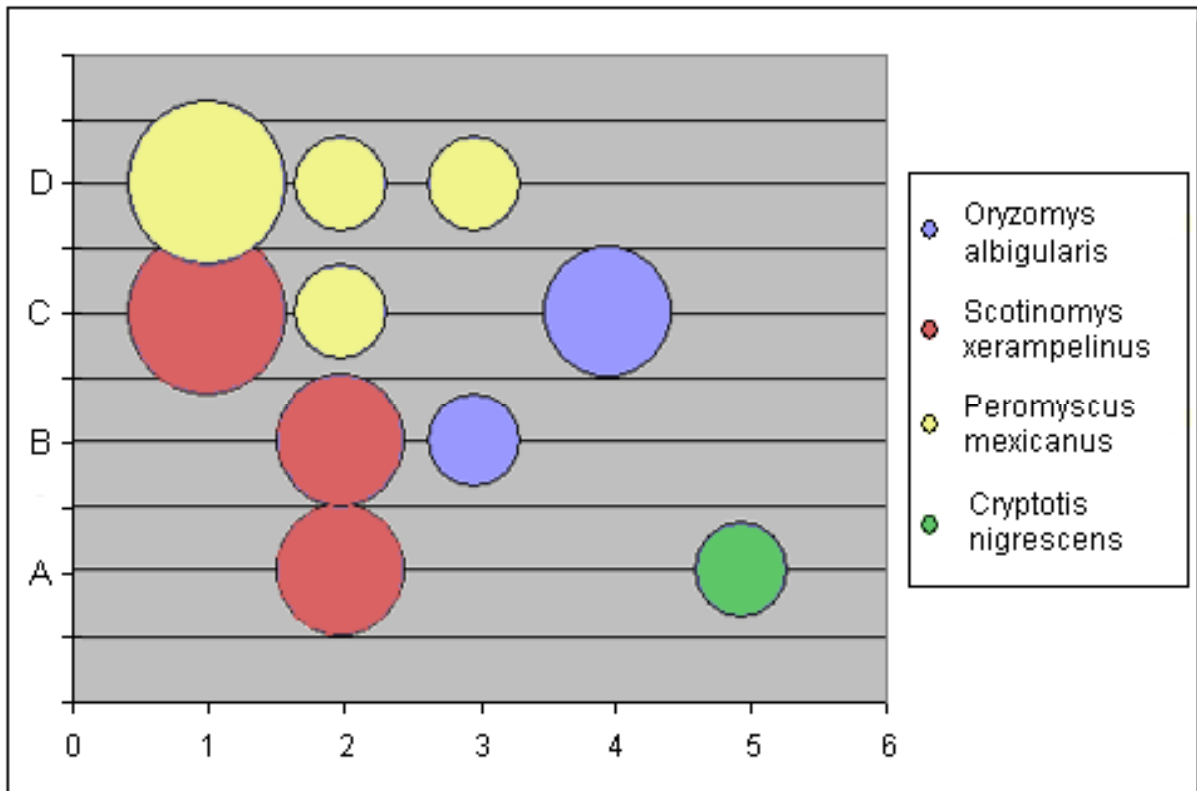

Figure 3 Distributions of species *O. albigularis, S. xerampelinus, C. nigrescens* and *P. mexicanus* at the primary forest site. Axes correspond to trap positions on trapping grid. Size of circle denotes number of captures at each trap (1-3).

The differences in communities is likely to be foremost a response to differences in vegetation, primarily as a food source and secondarily as cover. There were no obvious physical barriers to movement between the 3 main habitats, such as steams, roads or large cleared areas between the primary and secondary site for example. Therefore the absence of species from one area is unlikely to be due to an inability to reach that area, but rather they are unable to establish themselves their due to unfavorable conditions. The plant communities ranged from those dominated by small, short lived early successional (r-selected) species in the pasture, to those dominated by large late successional (k-selected) species in the primary forest. the primary food source for many of the captured species is plant material in the form of seeds. the high fecundity and large volume of seeds produced by r-selected species appears here to support a high abundance

of individuals in the pasture. The smaller seed size produced by these plants is also an important factor as already touched upon, with smaller food items often preferred and larger seeds such simply unavailable to small mammals due to their size. in addition the low, dense cover found at the pasture may well reduce the impact of bird predation compared to the open, relatively sparsely vegetated floor of the primary forest.

Although data on the diet of small mammal species, it is likely that the greater species richness supported in the primary forest is due to an increase in diversity and complexity of the habitat, and a greater range of available niches. Unfortunately, beyond their size and presence or absence we have little idea of the kinds of niches these species occupy. The presence of *P. mexicanus* and *C. nigrescens* only in the primary forest would suggest a dependence on a set of conditions (food source, level of competition or range or constancy of abiotic factors such as sunlight and temperature for instance) that only occur there. Despite appearing similar in many ways to pristine forest, many ecological processes and relationships take many years to develop or recover (Van den Bergh and Kappelle, 1998). The secondary forest is estimated to be around 20 years old, with a number of older trees that remained standing whilst the forest around them was cleared. After these 20 years of recovery the existing small mammal community is still very different from that in the primary forest.

Further sampling uncovered one additional species, *N. sumichrasti*. This was the only arboreal species found, although an additional individual was captured in the upper canopy of the primary forest which escaped before identification. *N. sumichrasti* was found in the lower canopy of the secondary forest, and also somewhat surprisingly as the dominant species at Casa Gavilan. *O. fulvescens* was also found around the casa. Casa Gavilan is located some distance from a forest edge and has little tree cover. Availability of suitable nest sites may be a limiting factor for this species, rather than requiring a specific food source offered by the canopy and not a recovering pasture for example. Additional trapping in the lower canopy of the primary forest, as well as the upper canopy of both the primary and secondary forest is needed and it is likely that N. sum is present at the primary site. It seems relatively abundant in the lower canopy at the secondary site, with 3 individuals caught on a 5 trap transect.

Conclusion

This data can be treated as an initial assay and exploration of the differences between various habitat types found at Cloudbridge. The trapping survey found 6 species of small mammal, a group previously unstudied at this site. Species richness and diversity indices rose with time since disturbance, while number of individuals (a rough measure of density) fell. The disturbed communities (assuming stage of vegetation succession is the primary determinate of small

mammal community structure) appears to move from low diversity (species, evenness and morphology), dominated by *O. fulvescens* to a slightly more diverse community (higher morphological diversity and indices of evenness) dominated by *O. albigularis* and *S. xerampelinus* and finally to a more diverse community (species, morphology and evenness).

Although further trapping is required, the presence of species such as *P. mexicanus* and *C. nigrescens* may be an indicator of a forest at an advanced stage of succession in this area. The high number of species specific to one or two sites indicates the importance of well developed cloud forest to each of these species. Conversely, the restriction of *O. fulvescens* to newly recovering forest highlights the dependence many species have on a level of disturbance for their habitats.

Several recommendations for subsequent research became apparent:

1) Trapping within different habitats at Cloudbridge. The distinctive communities found at each site and high number of species unique to 1 or 2 sites makes the sampling of further sites, such as riparian zones, a priority and would hopefully reveal more species and different communities.

2) A greater number of traps. In order to increase the area and trap nights to a level directly comparable to the literature on small mammal populations in the tropics and Central America a greater number of traps is required. 50 for a test site would seem a good figure, but should be compared with other methodologies being used at sites particularly relevant to Cloudbridge. The hectare revealed a mosaic of species with discrete ranges and it is possible trapping over a larger area would reveal further species. Trapping effort in the upper and lower canopies at the primary site is likely to add arboreal species to its total species complement.

3) Trapping during other times of the year. all trapping here occurred during the dry season and any data can only be viewed as a snapshot of a dynamic system. trapping throughout the year, and across numerous years would give many insights into temporal changes in populations, activity, sexual reproduction and other aspects of life history.

4) Possible use of alternative marking method. This could include ear tagging. Hair clipping is difficult for the inexperienced and grows out quickly. Tagging allows the tracking of individuals over a longer time span.

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