Note to Reader: This report focuses on the most complete subsection of my thesis at this time. The goal of the entire thesis is producing evaluation metrics derived from both a conservation value perspective and a ecosystem health perspective. Included here is just the conservation value side, the latter is still very much in the preliminary stages of resolution as there are still a variety of data sources to pull together. So data not included in this report are analysis of site differences, detailed analysis of the different urban insect communities, and soil analysis. Basically what I did was to stop where I was in the research project and submit my most complete results at the time. The more complete work will be forthcoming as data acquisition and analysis is completed.

Using epigaeic insect fauna to evaluate small-scale urban sites for conservation value

Abstract

Epigaeic insect fauna was used to develop site evaluation criteria for urban lots based on conservation value. In order to develop these criteria a series of hypotheses were tested to help predict which species are most vulnerable and what types of sites are most valuable. Are urban insect communities are generally composed of rapid dispersers? Do large natural areas in cities act like refuges and are centers of diversity on the landscape. Is habitat heterogeneity is more important for species richness than habitat area? These hypotheses were tested using epigeic insect data gathered from abandoned lots, community greenspaces, lots in transition from abandoned lot to community greenspaces, forest, and meadows. Insects were collected using a variety of methods. Pitfall traps and hand collecting were used in lots and natural areas, while sticky traps were used along transects from two large parks to the urban center. Comparison of beetle communities between urban areas and non-urban showed a clear pattern that urban areas are dominated by species that are known to fly regularly. In non-urban areas, beetle communities are dominated by flightless species or species that are not commonly observed to fly. Transect data showed the prevalence of flightless insect orders the closer to large natural areas ($r^2(adj) = 0.329$, p-value = 0.002). It was also found that lots near large natural areas produced more unique species than those further away. Ant richness was positively correlated to lot area in community gardens ($r^2(adj) = 0.100$, p-value = 0.007) but negatively correlated with habitat heterogeneity ($r^2(adj) = 0.994$, p-value = 0.036). These results indicate that slow dispersing species are the most vulnerable, and large sites near urban natural are the most valuable.

Introduction

A common method of evaluating sites for restoration is by their conservation value, which is generally measured by the presence of rare or threatened species and communities. Conservation organizations like The Nature Conservancy regularly use rare and threatened species as both a way to monitor restoration projects and prioritize the acquisition of property. The over arching goal in this method of evaluating sites is to try to keep as many species on the landscape as possible (). Native species are focused on specifically because they are thought to be more integrated into the existing ecosystem structure (they have co-evolved predators, mutualists, and competitors and so forth) (). The theoretical idea is that conserving species diversity means conserving functional redundancy in ecosystem processes, which insures the long-term resilience of those processes ().

Assessments on conservation value are overtly based on particular organisms or communities. Certain species are deemed rare or in danger of becoming rare and in need of protection, then the intervention proceeds with this species or community in mind (). Urban areas are usually not subject to this kind of analysis because people don't generally look for rare species in urban flora and fauna. However, this method of site analysis can be used very readily if the focus shifts from globally rare species to simply species or communities that are likely to disappear. Certain species may be quite common in the surrounding landscape, but nearly absent within urban areas (personal observation). This approach also encourages the use of natural history data about sites to make decisions. This kind of information is not only valuable to understand urban ecosystems but also yields surprises every now and then when rare species are found (famous examples include peregrine falcons and American Chestnut in New York City (), snowy owls at the Newark Airport (), and in 1993 a new species of salamander found in a public swimming pool in Austin, Texas ()).

This study focused on epigeaic insect fauna as an assessment tool for a variety of reasons. Previous literature suggests that they are very sensitive to small-scale disturbances (), which is important considering most abandoned lots are less than a hectare in size. Where bird populations may principally respond to scales on the order of hectares, insects respond to scales on the order of meters. In URI greenspaces, insects are generally not managed directly through broad pesticide use, whereas the plant community is managed directly through weeding, mowing, and planting. This provides the opportunity to clearly observe the indirect effects of management. Also there are standard methods of sampling this community that are passive, unobtrusive, and produce enough observations to be statistically useful (). Lastly, local experts are available to aid in identification of ground beetles in ants, which are major members of this community.

However, in order to make predictions about the likelihood of species becoming rare, a series of hypotheses about the spatial distribution of communities in cities had to be tested. Highly fragmented and unpredictable environments are thought to produce r-selected communities, which persist by rapid dispersal over direct competition. Since cities are highly fragmented and highly dynamic, poor dispersers should be rare in cities, regardless of either competitive ability or abundance in the surrounding landscape. If dispersal is how urban communities are put together, then those native organisms that are poor dispersers deserve special attention. To address this hypothesis, insect communities were compared in terms of their dispersal ability between various urban habitats and more natural habitats such as meadows and forests near these urban areas.

Another related theory about the spatial distribution of diversity on landscapes comes out of biogeography and is based on certain areas becoming refuges in the wake of catastrophic disturbance. Originally, this idea was formulated for glaciers, where the distribution of diversity corresponds to the areas that remained ice-free during the last glaciation. As habitat was destroyed the last population remnants took refuge in these areas, which then become centers of diversity as species recolonized the landscape (). Large natural areas in cities, like East Rock Park, probably serve a similar function in the urban landscape. They are, in a sense, reservoirs of 'old diversity'. The implication is not only vital to the management of these areas, but is also important to the management of parcels near these areas. If it is true that these areas are refuges, then parcels closer to these parks should come up with more unique species than those far away. Furthermore, poor dispersers should be more common closer to these parks. Two methods were used to evaluate this hypothesis, the first was to collect insects along transects from downtown to two parks, East Rock and West River Memorial Park. Also the distance from a large park was also estimated for each lot studied.

There is a generally accepted ecological pattern that the larger the area the more species that area contains (). There have been a variety of hypotheses proposed to explain this pattern. One of these is the habitat heterogeneity hypothesis, which is that larger areas have more kinds of habitat than smaller areas. This implies that the species richness is primarily a function of habitat richness (). This is relevant to urban areas because most urban abandoned lots are rather small and uniform in area, usually less than one hectare. Generally, under these circumstances it is impossible to increase the habitat size, but it is possible to vary the microsite richness within the parcel. Teasing apart this relationship would give some insight on whether the focus of biodiversity management should be on microsite diversity or simply larger sites. If habitat richness is more important than habitat area, then the correlation between some index of heterogeneity and species richness should be stronger than area and species richness. This hypothesis was evaluated by comparing different lots of roughly similar habitat types in terms of species richness of ground beetles and ants, lot size, and habitat heterogeneity within the lot. Also because there is general interest in how community gardens compare to other habitat types. Insect richness was compared across a habitat types.

Materials and Methods

Sites

Nine different urban sites and 4 sites from forests and meadows were studied from mid July until mid November. The urban sites were chosen as representatives of 3 different urban habitats: abandoned lots, transitional greenspaces, and community gardens. Six different URI greenspace projects were chosen to represent 2 different urban habitats. The Nash street, Arch street, and Shepard street greenspace projects were used as representative community gardens. The Hamden Animal Shelter, Blake street greenspace, and the Mechanic street community gardens were chosen as representatives of transitional greenspaces. Transitional means that they are works in progress towards fully resolved greenspaces. Three different abandoned lots were chosen for ease of access and their spatial placement: one on the corner of Prospect street and Division street, one behind a derelict building and Hertz Rental Car off Orange street downtown, and the other next to the Cosi coffeehouse on Park Street. Two different meadow sites and two forested sites within East Rock Park and West River Memorial Park also were sampled as comparisons. Each site was also classified in terms of the management intensity required to maintain the site in its current form (See table 1).

Table 1. Sites sampled by habitat type and estimated management intensity

Sites	Habitat Type	Mgmt Intensity

9th Square Area	Abandoned Lot	Low
Cosi	Abandoned Lot	Low
Prospect and Division	Abandoned Lot	Very Low
Arch Street	Community Garden	High
Nash Street	Community Garden	High
Shepard Street	Community Garden	High
East Rock Park Forest	Forest	Very Low
West River Park Forest	Forest	Very Low
East Rock Park Meadow	Meadow	Low
West River Park Meadow	Meadow	Low
Blake Street	Transitional	Medium
Hamden Animal Shelter	Transitional	Low
Mechanic Street	Transitional	Medium

Insect collecting methods

Within each of these habitats insects were collected through a variety of methods, but only two have been used in this analysis. Hand collection was done by inspecting the ground, turning over rocks and wood, and inspecting vegetation. This was done once in July and once in late August or early September for each habitat. In mid August, pitfall traps were installed in each of these sites. Generally they were placed under rocks or boards away from view, and were collected on average once every 6 weeks. However, only the first set of pitfall trap samples have been sorted and analyzed. From both the hand collected samples and the pitfall trap samples carabidae and formicidae collections were assembled for identification. Greenspace groups were asked for permission to sample their projects prior to hand collecting and installing pitfall traps.

Insects were also collected in two transects that were established in order to investigate how insect communities changed in relation to distance from natural areas. One of these transects followed Orange Street from Downtown to East Rock Park. The other followed Columbus Avenue from the Yale Nursing School to West River Memorial Park. From late July until mid October sticky traps were set at 100-meter intervals along these transects. They were deployed for an average of 2 weeks, and were generally placed under vegetation out of plain view. Approximately 80 traps were deployed, but only 35 were recovered.

Sticky traps were used in preference to other methods because they were found to work on nearly any substrate, unlike pitfall traps, which need to be dug in soil. Furthermore, they were inexpensive to manufacture and easy to deploy, which is important considering that 50% of these traps were either lost or destroyed. The traps I used were a modification of the standard sticky trap that is used in entomological study. Normally these traps consist of a piece of paper varnished with non-drying adhesive to capture insects crawling over the ground or on vegetation. However, in this study, trap covers were manufactured made from cardboard and wire. The trap was designed to stick to the cardboard cover if disturbed to avoid pets or people getting caught on the traps. Victor brand cockroach glue traps were used exclusively.

Generally, very little effort was made to extract specimens from glue traps as the process was usually destructive to the specimens. However, when specimens were extracted, the trap was immersed in citric oil solvent for 2 hours to dissolve the glue. Then the specimens were dried with a paper towel to remove the excess solvent and immersed in ethanol. Often specimens have to switched back and forth between citric solvent and ethanol to completely remove the glue. More commonly the recovered traps were just kept frozen to preserve specimens.

Sampling designs for ecological data

Associated ecological data was also gathered for each collecting site and each sticky trap sample. For each recovered sticky trap, ecological data was gathered using nested fixed radius plots to estimate overstory and understory characteristics and recorded in a datasheet (See Point Datasheet in Appendix).

Nest fixed radius plots were also used in the lots (See Lot Datasheet in Appendix), but samples were chosen according to a different design. This design was built around a critical spatial assumption. All possible sample points within the area had to have an equal probability of being sampled. This was attempted through a system using two sets of random numbers. The first set of random numbers was generated from a uniform distribution from 0 to 360. A second set of random numbers was generated from a uniform distribution from 0 to 1. The first set of random numbers was used to pick a compass bearing. The second set was multiplied by the lot's longest dimension in paces to produce a random distance along this bearing. If the computed sample point turned out to be outside the boundaries of the lot, then the sample was taken at the nearest edge. No effort was made to correct biases that may result when fix radius plots sample edge areas (Gregoire 1982) because in most cases this would've resulted in trespassing. Though it probably didn't matter where the observer started, I generally started this "random walk" from the center of the lots.

Dispersal

Primarily, the carabidae collection was used for dispersal analysis, both because ants are known to be relatively better dispersers and because more of the carabidae specimens have been identified to species. Different ground beetle species display a wide variety in their dispersal ability, from species that are often caught in flight to other species whose populations are commonly found without functional wings (Lindroth 1961 - 69). Each species was surveyed in the liturature for indications on their dispersal ability (Lindroth 1961-69, Usis and MacLean 1998, Best et al 1981, Noonan 1990, White 1983, Ribera et al. 2001). If the liturature said that a species had been caught in flight traps or commonly observed to fly, it was designated as a flying species. If the species was commonly known to be short winged, essentially wingless, or rarely ever observed flying the species was designated as a non-flying species. Though none of the members of the tribe Bembidinii have been identified to even genera, they have been designated as flying species because the literature commonly mentions this group as flyers (Thiele 1977, Lindroth 1961-62, Ribera et al 2001). All other cases were left as unknown (See Table 2).

Table 2. Ground beetle species identified and dispersal designation

Anisodactylus harisii	Unknown
Anisodactylus harisii	Unknown
Anisodactylus harisii	Unknown
Anisodactylus melanopus	Unknown
Anisodactylus rusticus	Flying
Anisodactylus rusticus	Flying
Bembidiini	Flying
Bembidiini	Flying
Bembidiini	Flying
Carabus nemoralis	Not flying
Colliurus pennsylvanicus	Flying
Harpalus affinis	Flying
Harpalus affinis	Flying
Harpalus compar	Flying
Harpalus compar	Flying
Harpalus erythropus	Flying
Harpalus longicollis	Flying
Harpalus longicollis	Flying
Harpalus pennsylvanicus	Flying
Harpalus rufipes	Flying
Pterostichus adoxus	Not flying
Pterostichus caudicalis	Not flying
Pterostichus lucublandis	Not flying
Pterostichus mutus	Not flying
Scarites substriatus	Unknown
Xestonotus lugubris	Flying

Analysis of city parks as refuges

The formicidae and carabidae collections were also used to analyze whether large natural areas are biological refuges by adding up the unique catches for each site. Unique catches were defined as species known to be especially uncommon like *Harpalus longicollis*, *Xestonotus lugrubis*, and any specimens from the ant genus *Strumigenys*; or species where only one or two specimens were taken over the course of the study. Many of these specimens have not been identified to species so this assessment is primarily based on morphospecies (how many specimens that look different).

The other method of analysis was based on the transect data, which was analyzed for trends in insect richness as a function of distance from parks. Particularly important was the analysis on flightless species. In this case, this information was derived from the insect richness data by simply counting the presence or absence of wingless insect orders to produce an aggregate value representing wingless order richness (See table 3 for list of orders). To estimate distance from natural areas, the numbers in street addresses were used as a proxy. In both cases, the street addresses appeared to regularly increased with increasing proximity to the parks. In the lot data distances were estimated to the nearest large natural area using a map.

Table3. Insect orders observed and dispersal designation

Insect Order	Common Name	Dispersal
Acari	Mites	Wingless
Aranae	Spiders	Wingless
Chilapoda	Centipedes	Wingless
Coleoptera	Beetles	Flying
Collembola	Springtails	Wingless
Diplopoda	Millipedes	Wingless
Diplura		Wingless
Diptera	Flies	Flying
Hemynoptera	Wasps and Ants	Flying
Heteroptera	True Bugs	Flying
Isopoda	Woodlice	Wingless
Microcoryphia	Bristletails	Wingless
Opiliones	Daddy Long Legs	Wingless
Orthoptera	Grasshoppers and Crickets	Flying
Psuedoscorpiones		Wingless

Estimating area and landscape heterogeneity

Size of each lot was simply estimated by pacing. The heterogeneity of each lot was estimated through a more convoluted approach. It quickly became apparent that estimating site heterogeneity depends entirely upon the criteria being observed, which means that there are infinite ways one place can vary from another. In urban areas this is simplified some because people tend to create a mosaic of internally homogenous patches. So estimates of things like patch richness are less biased because it’s easy to tell that a lawn, a flowerbed, and a sidewalk are different patches. However, this is nearly impossible to do for most other habitats.

So my goal was to develop a quantitative method of estimating heterogeneity that can be used to compare urban and natural habitats. The sampling design became critical in this regard, particularly the spatial assumption about all points having an equal probability of being sampled. If that is true, then how samples vary from one to another becomes an estimator of site heterogeneity. To turn this idea into a particular number, two methods were employed. In the first the variance of each variable gathered in the sampling design was assumed to be an estimator of the site heterogeneity. So the variances were normalized by computing the coefficient of variance for each variable, and then summed up to produce an aggregate estimate of site heterogeneity.

The other method was adapted from ordination analysis. In ordination analysis the goal is to cluster samples into meaningful units. In one method of ordination, called indirect ordination, samples are clustered depending upon how similar the observations within them are between samples. For instance in vegetation analysis, each observation of vegetation composition in a sample plot would be compared with all other sample plots to produce clusters. These clusters would be composed of sample plots that had been found to contain similar vegetation. How different all these samples are from each other is called the inertia, which is analogous to sample variance.

Generally this type of analysis is used in ecology with species data to compare how similar sites are to each other and to look for gradients. What I did was plug in the data gathered from the lots to compare how different sample points are from each other. If all points have an equal probability of being sampled, then the inertia of these observations are an estimator of site heterogeneity.

Data Analysis

Analysis principally relied on analysis of variance (ANOVA) and linear regression using the Minitab statistical software. ANOVA's are used to test whether sample means are significantly different or not. Linear regression is used to explore how two or more variables are related to each other. In linear regression particular attention was paid to the t-tests on the beta coefficients, as well as r squared values to evaluate the correlations between variables. Graphical methods were also used for qualitative analysis.

Results

Managed versus unmanaged lots

Significant difference were found in ant richness when sample sites were classified according to qualitative estimates of management intensity (See figure 1). No other significant differences were found in insect richness by habitat or management intensity. Neither were significant differences found when anthropogenic patches were compared to unmanaged patches in the transect samples.

Figure 1. Mean ant richness by management intensity by ANOVA (p-value = 0.022)

```
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
            N       Mean    StDev --------+---------+---------+--------
High        3      6.333    1.528       (-------*--------)
Low         5      4.800    1.095 (------*------)
Medium      2      9.000    2.828               (----------*----------)
Very low    3      9.000    2.000                 (--------*--------)
                                  --------+---------+---------+--------
                                         5.0       7.5      10.0
```

Insect community composition and dispersal

Very strong patterns were found between urban and not urban habitat in regard to their ground beetle fauna. Urban sites were predominately populated by species that are known to fly, while non-urban habitats were dominated by species that either are not commonly observed to fly or cannot fly (See figure 2).

Figure 2. Percent abundance of flying and not flying ground beetle species in urban and not urban sites.

City parks as refuges

Transect data showed signficant correlations between house addresses (House address numbers increse with increasing proximity to parks) and insect richness, ordinal richness, and richness of flightless species richness for both transects, particularly in the Orange Street transect (See figure3 and 4).

Figure 3. Correlations between address number and insect richness in the Orange Street and Columbus Street Transects.

	Orange Transect (n=28)			Columbus Transect (n=11)		
	Coefficient	p-value	r^2 (adj)	coefficient	p-value	r^2 (adj)
Total Insect Richness	0.006	0.052*	11.8	0.015	0.006**	54.8
Ordinal Richness	0.004	0.005**	26.9	0.003	0.213	7.3
Wingless Order Richness	0.003	0.002**	32.9	0.002	0.179	10.1

* = significant at the 90% confidence level
** = significant at the 95% confidence level

Figure 4. Scatter plot of wingless order richness by house address number on the Orange Street transect (p-value = 0.002, r^2 = 32.9).

No significant correlations were found between total insect richness, ordinal richness, or wingless insect richness and distance from the nearest natural area in the lot data. However, frequency of unique sightings in the ant and beetle collections and distance from nearest natural area produced a striking pattern. The lots that are closer to large natural areas produced the most unique sightings. Linear regression was not used to analyze this correlation because it is probably not a linear function (See figure 5).

Figure 5. Scatter plot of count of unique ground beetle and ant species found in sites by the site's distance to the nearest natural area.

H: Species – Area

1) Lot Data – landscape heterogeneity, area, and richness
2) Transect Data – landscape heterogeneity, area, and richness

Significant correlations were found between ant species richness and both lot area and lot heterogeneity in community gardens (See figure 6 and 7), but ground beetle richness and total insect richness were not found to be significantly correlated to either area or heterogeneity (See figure 8). No other significant correlations between insect richness and area or heterogeneity were found in the other habitats. The transect data also showed no other significant correlations between patch size or patch richness and insect richness.

Figure 6. Scatter plot of community garden ant richness and lot area in meters (p-value = 0.007, r^2 = 100.0).

Figure 7. Scatter plot of community garden ant richness and lot sample inertia (p-value = 0.036, r^2 = 99.4).

Figure 8. Scatter plot of community garden ground beetle richness and lot area in meters (p-value = 0.66, r^sq (adj) = 0.0)

Discussion

It’s fairly surprising that no differences were found in insect richness among either the different habitat, or in the transect data where each patch was categorized as natural or anthropogenic (Anthropogenic patches mean patches where plant regeneration is primarily human controlled, while in natural patches regeneration is not human controlled). I think much of this has to do with the variability of the observations. All anthropogenic landscapes in a city are by no means the same. Stewardship of landscaping varies dramatically from one house to the next depending on the species planted and the zeal of the landowner.

This is also true of natural patches where there are vast differences in soil quality from one place to the next. The implication is that in order to better compare urban habitats, more stringent definitions are needed. There are no clear explanations why ant richness would be lower in sites where management intensity is low. Management intensity was based on my general impression of how much work people did to maintain a site in its current state, which is biased by a number of factors. Therefore, this is probably not a very reliable result.

Rapidly dispersing species are known to dominate highly disturbed habitats. Furthermore, early studies on the flora and fauna of European cities were quick to point out the prevalence of ruderal species in urban habitats (Book: The Natural History of London). Therefore, it’s not surprising to find the same pattern among ground beetles.

What is significant are the clear observations concerning the effect of urban natural areas on urban biological communities. The transect data from Orange Street clearly showed higher frequency of poorly dispersing species in proximity to these areas. The reason why this pattern wasn't as strong in the Columbus street transect could have to do with a variety of factors. Probably the most important is the lower sample size. This transect is much shorter than the Orange street transect, which means less traps were deployed. Additionally, most of the traps were lost or destroyed, which further reduced the sample size.

Another factor has to do with the spatial distribution of the recovered traps. The 500 to 600 addresses yielded the most recovered traps, which is also one of the more residential areas on the transect. A similar pattern was evident in the Orange Street transect where fewer traps were recovered downtown than in the residential areas. The urban core provides less places to hide traps because of the lack of vegetation, which means most traps get destroyed. Possibly another factor is that between Columbus Avenue and West River Memorial Park there is a large, very busy intersection where Columbus Avenue and Ella T. Grasso Boulevard meet. This probably results in a significantly stronger dispersal barrier than the smaller streets near East Rock Park.

The previous discussion on insect richness and urban habitat also explains why insect richness and distance from natural areas was not significantly correlated in the lot data. There very stark differences among lots that were put into the same habitat type. For instance, the abandoned lots went from small and mostly bare soil to large and almost entirely forested. The transitional lots were just as varied. This may have masked any relationship between distance and insect richness.

Considering the heterogeneity among the study sites, the unique species with distance pattern is very remarkable. Since most of these species havn't been identified it's not clear whether these particular species are attracted to these nearby urban areas because of particular site attributes, or just simply because they are nearby. The assumption is the latter, but more analysis will have to be performed.

Species richness and area

The species richness and lot area results immediately suggest two things. This relationship is sensitive to the quality of the habitat. In other words, it's important to compare sites that are functionally similar to each other. It's also important to think about the species that are being used to compare these sites. Different results came out for beetles than for ants (See figure 8). Ground beetles seem to be much more sensitive to neighboring habitat. The middle value on the graph belongs to Nash Street, which is very close to East Rock Park (See figures 6 and 8). When both these factors were controlled by using only community gardens and only ants, which disperse readily, the expected relationship emerges that bigger sites produce more species.

At first the insect richness and heterogeneity result seems counterintuitive. However, when the relationship between heterogeneity and site area were examined it was found that heterogeneity decreased with increasing size (See figure 9). This probably has to do with the fact that smaller sites are more influenced by their edges, whereas bigger sites are not. So there's a higher probability of hitting an edge in a smaller site than a bigger site, which is reflected in the variance. This result very nicely illustrated that heterogeneity is not as important as area for ant richness in community gardens.

Figure 9. Scatter plot of site heterogeneity and site area in the community gardens (p-value = 0.03, r^2 (adj) = 99.6)

Conclusion and Recommendations

With these results carry some clear recommendations. Poorly dispersing species are more or less doomed in urban areas. The dynamic nature of the landscape isn't conducive to their survival, while species that may actually be poor competitors but good dispersers will thrive. This brings to the forefront certain organisms – amphibians, reptiles, large beetles, nut bearing trees – and certain resources like pockets of less disturbed soil. Therefore, if these species or resources are found in urban areas they should be regarded as precious, even if they happen to be common in the neighboring forests. The point is that in our backyards they will not persist without deliberate intervention.

Natural areas such as in city parks are vital to landscape diversity. Even if highly disturbed they still contain species that would've otherwise been extirpated. So sites near to these areas offer the most promise in terms of conservation value. Furthermore dispersal corridors that directly connect natural areas to city habitats probably are equally as important. The shorter these corridors are the more effective they probably will be as many of these species literally move at a snail's pace. Lastly, large sites appear to be the most promising in terms of their conservation value.

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