Variation in arthropod diversity, guild composition and abundances along an urban-rural gradient: nine years of CAP LTER monitoring

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Abstract

Two assumptions associated with urbanization are that 1) diversity decreases in urban areas and 2) remnant or restored habitats will have or re-gain the same diversity as natural areas. Earlier case studies have shown contradicting results for both assumptions. After nine years of monitoring arthropod communities in the Central Arizona Phoenix (CAP) area, we focused on desert sites, desert remnant sites and two different landscaping categories: xeric yards and mesic yards. We combined data from annual pitfall sampling with data from 2000 and 2005 sweep net samples. The first assumption was not supported, while the second assumption was partially supported. Of particular note is the high variation in diversity between the years, where we were unable to detect a consistent pattern. The differences between the sampling methods are discussed. We provide recommendations for further monitoring and landscape planning.

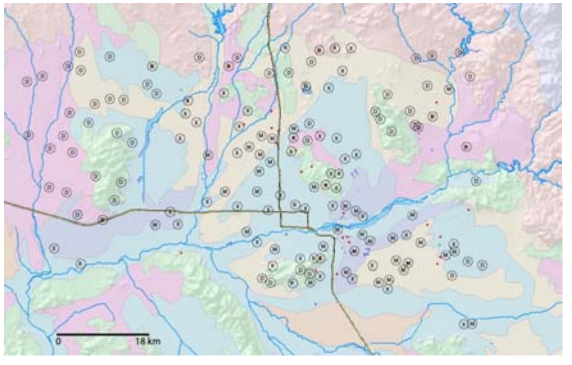

Figure 1: Map of the Central Arizona Phoenix area with the location of sites for sweep net sampling (circles) and pitfall sampling (red dots) used in the analyses. D = desert, R = remnant, X = xeric and M = mesic.

Background

In spite of accounting for only 2.8% of the total land area on Earth, urban areas embrace half of the world's population (McGranahan et al. 2005). When an area is urbanized, most pre-existing ecosystems are likely to be severely disrupted, if not entirely transformed. Fragmentation can isolate once natural habitats, making them less likely to be re-colonized by native species (e.g. Kozlov 1996). However, cities can harbor a great diversity of ecological niches and resources, and as such be havens for biodiversity, in terms of both ecology and species, even in industrial areas (Bradshaw 2002).

The effects of urbanization on species diversity are under much debate. Case studies have documented both decrease and increase in species diversity with urbanization, but the effects seem to be more complex. The lack of a consistent pattern makes it difficult for landscape planners and conservation agencies, resulting in a wide range of means to conserve, restore or ignore once natural habitats within urban areas. One simple strategy is to simply leave the remnant area alone, and assume that native species will return and re-colonize the habitat. This is commonly known as the 'Field of Dreams' hypothesis (Palmer et al. 1997), but has been widely criticized (e.g., Hildebrand et al. 2005).

Phoenix and the surrounding area have been monitored since 1998 by CAP Long Term Ecological Research (CAP LTER) on different spatial and temporal scales (Grimm and Redman 2004). Here we present results from nine years of monitoring, and results from two sampling approaches are compared for the first time. We describe how arthropod assemblages change in land use types with varying degrees of urbanization in terms of abundance, functional groups and taxon diversity over time. We tested the hypothesis that diversity is lower in urban areas, and second, we hypothesized that remnant sites and xeric yards are more similar to desert sites than mesic yards.

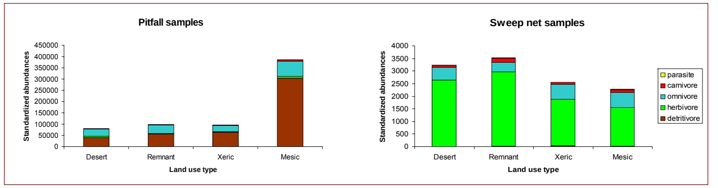

Figure 2: Standardized total abundances of functional groups for nine years of pitfall sampling (left) and two years of sweep net sampling (right). Notice different scale on the second axis.

Results

Standardized total abundances from the pitfall samples were dramatically higher in mesic yards than in all other land use categories, despite being sampled one year less than the others (Fig.2). The pitfalls naturally collected higher proportions of detritivores and omnivores, while the sweep net sampling collected more herbivores. The sweep nets collected higher abundances in desert and remnant areas than in urban areas.

The guild abundances were heavily dependent on land use (contingency table analysis, $\chi^2_{12} = 40919.28$, $P < 0.0001$, pitfall data; $\chi^2_{12} = 375.66$, $P < 0.0001$, sweep net data). The difference between land use was greatest among omnivores, which contributed to 43.2% and 41% of the variation, pitfall and sweep net data, respectively.

The annual variation in taxon diversity showed remnant sites fluctuating most (coefficient of variance (CV) = 19.1%, Fig.3). The desert habitat was overall relatively high, and did not experience high fluctuations (CV = 10.3%). The xeric areas fluctuated with a CV = 14.3%. An overall trend was that the mesic yards category had a lower diversity, except from three years. Mesic sites had a CV of 15.1%. The exclusion of dominant taxa clarified this picture (Fig.3b).

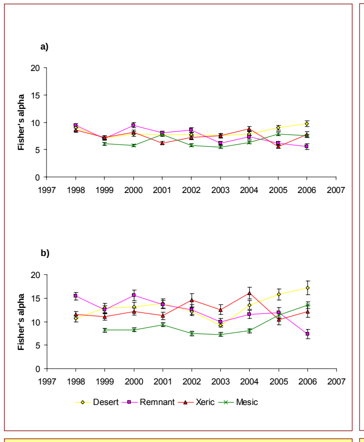

Figure 3: a) Annual variation in taxon diversity in four land use categories from pitfall samples; b) dominant groups excluded (*Collembola*, *Acari* and *Formicidae*). Error bars are standard deviations.

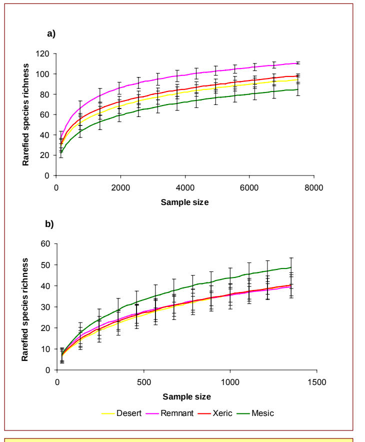

Figure 4: Rarefaction curves showing total taxon diversity in four land use categories from a) pitfall samples (dominant groups excluded) and b) sweep net samples. Error bars show 95% confidence intervals.

Mesic sites had lowest taxon diversity, while remnant sites had significantly higher species diversity than all the other land use types when pitfall data for all the years were combined (Fig.4a). For the sweep net samples we observe a reversed pattern, with mesic sites as more diverse than the other ones, but significantly different from remnant sites only (Fig.4b).

The difference in species composition is illustrated with Nonmetric multidimensional scaling of the annual pitfall data. The first axis separates mesic sites from the other sites, while the second axis clearly separates the urban yards from desert and remnant sites (Fig. 5).

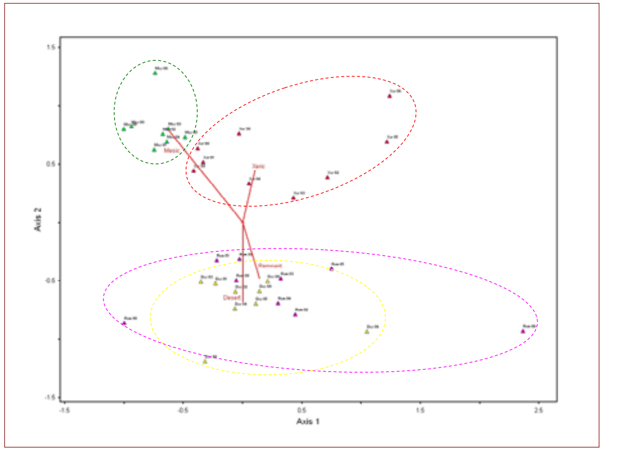

Figure 5: Nonmetric multidimensional scaling of annual pitfall taxon data using Sørensen distance, random starting configuration, 50 runs with real data, and 47 iterations for the final solution. Stress = 10.27184 for the final 2-dimensional configuration, using standard deviations in stress over the last 10 iterations as stability criterion (PC-ORD).

Conclusion

Conclusions about the effect of urbanization on diversity depends on functional group and sampling techniques. We have also demonstrated that taxon diversity changes from year to year independent of land use type. We found no clear evidence that urbanization leads to lower diversity. Ground arthropod diversity is lower in urban areas, while diversity is highest in urban areas for arthropods associated with vegetation. This can be explained by more pollinators attracted to higher plant diversity in mesic yards. Thus, urban areas can support high levels of diversity depending on functional group. Remnant sites and desert sites shared similarities, supporting the 'Field of Dreams' hypothesis at least in terms of community similarity. The separation of xeric sites from desert and remnant sites however, did not support this assumption. This, in addition to the high diversity found in remnant areas stresses the importance of conserving remnant areas within cities.

We recommend continued monitoring of the CAP area, and support using different sampling techniques to capture variation in different functional groups. If possible, a more frequent sweep net sampling will make the two growing databases more comparable.

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