Trophic Dynamics In Urban Communities (Dinámicas tróficas en comunidades urbanas)

Stanley H. Faeth[1] and Wendy A. Marussich[2]

[1]Arizona State University, Tempe, AZ USA, [2]University of Arizona, Tucson, AZ USA

Introduction

Human activities have dramatically changed abundances, diversity, and composition of species. Urbanization, the most intense human activity, has altered biodiversity but little is known about the underlying mechanisms for these changes, such as control of food webs and trophic structure in urban biological communities.

Ecologists embrace three models of food web control. The ***energy*** or ***bottom-up*** model holds that energy supply limits the number of trophic levels and biomass at each trophic level. The ***'world is green'*** or ***top-down*** model states that predators and parasites limit herbivore populations such plant biomass is not limiting and the world remains green. The ***environmental stress*** model is a combination of the the bottom-up and top-down models: the relative effects of predation vary as a function of environmental stress and productivity. Predation is more important at low and intermediate levels of "stress" (e.g., high temperatures).

We are beginning to determine food web structure and unravel the mechanisms underlying changes in trophic structure and control in the CAP LTER via observational and experimental studies. We know that species composition is radically altered and resource subsidies increase and stabilize productivity (Fig 1).

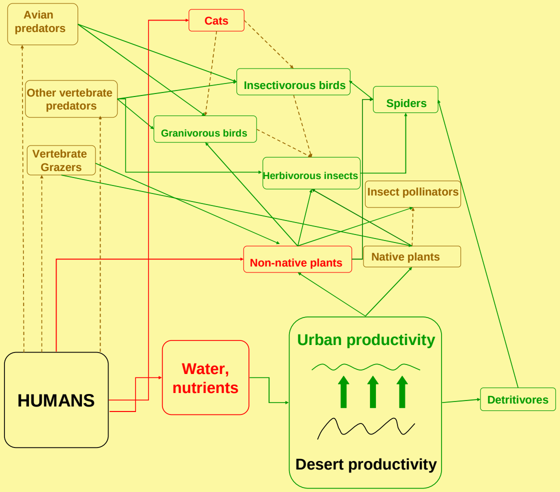

Fig 1. The CAP LTER food web. Human activity has directly increased available resources, particularly water, and non-native plants (red text), which has increased and stabilized productivity. This, coupled with other direct effects (red solid arrows), such as introduction of domestic cats (red text), and indirect effects, such as reduction in vertebrate predators (brown text) have directly (red solid arrows) or indirectly increased (green solid arrows) abundances of some biotic groups while decreasing others (brown dashed arrows).

Stabilization of productivity dampens seasonal and yearly fluctuations in species diversity, elevates abundances and changes behavior of some key species, while other species disappear. Notably, large predators of birds (e.g., raptors) are absent or reduced. What are the consequences of these changes in terms of control of food web structure and function? Ecological theory predicts that high and stable productivity and reduction of predators should shift control of food webs in cities to more ***bottom-up*** control (***the energy model***).

Methods and Results

To test what controls trophic dynamics, we began a long term experiment using a common Sonoran desert plant, brittlebush (*Encelia farinosa*), which is also used in urban landscapes. This experiment consists of 40 plants at each of 3 sites: a mesic, suburban yard, an urban desert remnant, and a desert site outside the city. Treatments included exclusion of avian predators (via netting) and ground dwelling predators (via metal flashing) and supplemented water.

Herbivores significantly increased when birds were excluded in urban areas but not in desert areas, although herbivores were already more abundant due to higher productivity (Fig. 2). These results suggest more top-down control from avian predators in urban areas and greater resource-based control of insect herbivores in outlying deserts. Also, increased resources alters herbivore-invertebrate predator dynamics by reducing stress in resource-rich urban areas.

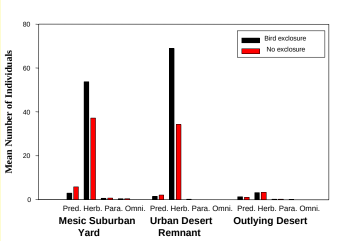

Fig. 2. Results of excluding birds from brittlebush plants at mesic, desert remnant and outlying desert sites on abundances of arthropod predators, herbivores, parasites and omnivores. Exclosure treatments significantly altered herbivores, but not other arthropod groups.

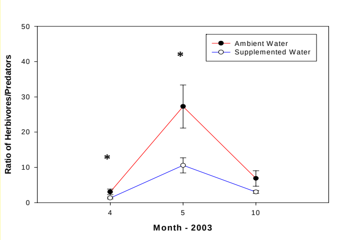

Fig. 3. Ratio of herbivores to predators differed in April (*) and May (*) but not in October on plants with supplemented water (blue) compared to those with ambient water (red). Predators appear more susceptible to water stress than herbivores in April and May, two of the driest and hottest months in Arizona.

Discussion

Counter to conventional ecological expectations, predation by birds and invertebrates (***top-down model***) becomes the primary force controlling arthropods on urban plants in contrast to outlying deserts, where limiting resources dominate (***bottom-up model***). How do we explain this shift in trophic control? Other experiments in CAP LTER (e.g., Shochat et al. 2004) show that urban birds reach high densities and alter foraging activity because of increased and stabilized productivity in the city. Urban birds intensify foraging on arthropods with impunity because their own predators are missing in the city. Likewise, urban environments reduce stress for invertebrate natural enemies (***environmental stress model***).

The urban combination of bottom-up (for birds) and top-down control (for arthropods) and reduced environmental stress contrasts sharply to the less human-dominated habitats into which the Phoenix metropolitan area is rapidly expanding (Fig. 4). Shifts in control of food web dynamics are likely common in urban ecosystems, and are influenced by complex human social processes and feedbacks.

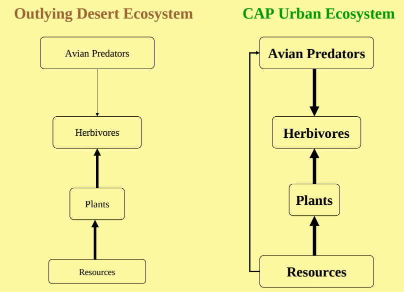

Fig. 4. Hypothesized control of outlying desert and urban food web based upon our experiments. Size of text and thickness of arrows indicates relative biomass and strength of interactions, respectively. Bottom-up forces dominate desert ecosystems whereas top-down and bottom-up forces regulate urban ones.

Acknowledgements

Supported by CAP LTER. Many undergraduate and graduate students contributed to this research. We owe them our thanks.

References

Faeth SH, Warren PS, Shochat E, Marrusich WA. 2005. Trophic dynamics in urban communities. BioScience 55:399-407

Shochat E, Lerman S, Katti M, Lewis D. 2004b. Linking optimal foraging behavior to bird community structure in an urban-desert landscape: Field experiments with artificial food patches. American Naturalist 164: 232-243

CAP LTER
Central Arizona–Phoenix Long-Term Ecological Research