Urban Trophic Dynamics

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Introduction

Human activities dramatically change abundances, diversity, and composition of species. However, little is known about how the most intense human activity, urbanization, alters control of food webs and trophic structure in 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).

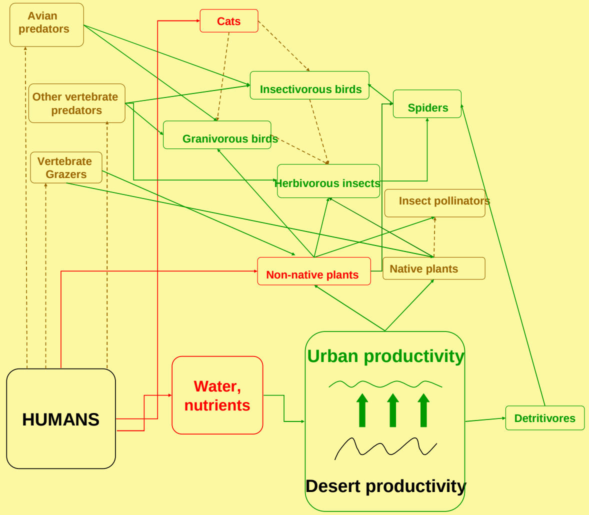

Figure 2. The CAP LTER food web. Human activity has directly increased available resources, particularly water (red text), which has increased and stabilized productivity. This, coupled with other direct (red solid arrows), such as introduction of domestic cats (red text), and indirect effects, such as reduction in vertebrate predators (brown text) have directly increased (red solid arrows) or indirectly (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

To test what controls trophic dynamics in CAP, we began a long term experiment) using a common Sonoran desert plant, brittlebush (*Encelia farinosa*), which is also common in urban landscapes. This experiment consists of 40 brittlebush plants at each of three different sites: a mesic, suburban yard and a desert remnant within the city, and a contiguous Sonoran desert site outside the city. Treatments include exclusion of avian predators (via netting) and ground dwelling predators (via metal flashing) as well as supplemented water and the respective non-treatments (i.e., no cage, no flashing, no supplemented water) in the three different habitats in a 2 x 2x 2 factorial design (with 5 replicates of each treatment at each site).

Insect 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). Insect herbivores increased when water was supplemented in the outlying desert area, but not in the desert remnant or in the highly modified human habitat, the suburban yard, within the city. Exclusion of ground-dwelling predators had no effect on herbivores in any of the three habitats. These results suggest more top-down control from birds in urban areas and greater resource-based, or bottom-up, control of insect herbivores in outlying deserts.

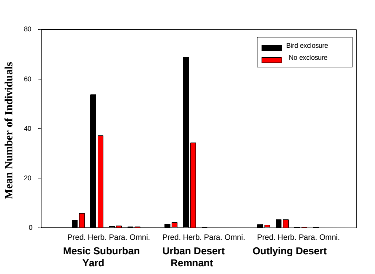

Figure 2. Results of excluding birds from brittlebush plants at mesic, desert remnant and outlying desert sites on abundances of arthropod predators, herbivores, parasites and omnivores. Exclosure treatments significantly altered herbivores, but not other arthropod groups.

Discussion

Counter to conventional ecological expectations, predation by birds (top-down forces) becomes the primary force controlling arthropods on urban plants in contrast to outlying deserts, where limiting resources (bottom-up forces) dominate. How do we explain this shift in trophic control? Other experiments in CAP LTER (e.g., Shochat 2004, 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.

The combination of bottom-up (for birds) and top-down control (for arthropods) contrasts sharply to the less human-dominated habitats into which the Phoenix metropolitan area is rapidly expanding (Fig. 3) Shifts in control of food web dynamics are likely common in urban ecosystems, and are influenced by complex human social processes and feedbacks.

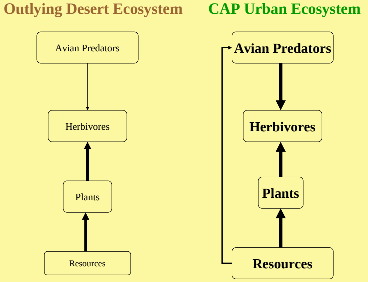

Figure 3. Hypothesized control of outlying desert and urban food web based upon our experiments. Size of text and thickness of arrows indicates relative biomass and strength of interactions, respectively. Bottom-up forces dominate desert ecosystems whereas top-down and bottom-up forces regulate urban ones.

Acknowledgements

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

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