Ecological homogenization of urban America

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Abstract

Urban, suburban and exurban ecosystems are important and increasing in the U.S. An apparent, but functionally untested result of urban land use change is homogenization across cities, where neighborhoods in very different parts of the country have similar patterns of roads, residential lots, commercial areas and aquatic features. We hypothesize that this homogenization also involves ecological structure and functions relevant to ecosystem carbon and nitrogen dynamics, with continental scale implications. Further, we suggest that understanding urban homogenization will provide the basis for understanding the impacts of urban land use change from local to continental scales. We will use datasets ranging from household surveys to soil and vegetation sampling to regional-scale remote sensing across six metropolitan statistical areas (MSA) that cover the major climatic regions of the US (Phoenix, AZ, Miami, FL, Baltimore, MD, Boston, MA, St. Paul, MN and Los Angeles, CA) to determine how household characteristics correlate with landscaping decisions, land management practices and ecological structure and functions at local, regional and continental scales. This research has the potential to transform both understanding of an important and increasingly common ecosystem type ("suburbia") and the capacity to scale the effects of local land use change to regional and continental extents. We will determine how urban land use change has affected carbon storage and nitrogen pollution at multiple scales, and further understanding of how humans perceive, value and manage their surroundings.

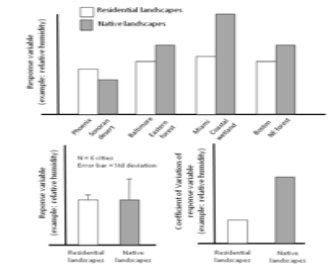

Figure 1. Hypothesized ecological structure in residential landscapes across four US cities, showing that a) differences between residential and native ecosystems within each city will be greater than the differences between residential ecosystems in different cities and b) that differences in native ecosystems across the continent will be larger than differences in urban and suburban ecosystems across the continent.

What City is This?

One of the pictures above is a neighborhood in Boston, the other is in Phoenix. Which is which?* Why do they look so similar? What are the effects of this "urban homogenization" on air and water quality and biodiversity in these neighborhoods and in the U.S. as a whole? What are its effects on the quality of life for people living in these neighborhoods and in the U.S. as a whole? *Answer in lower right corner of poster.

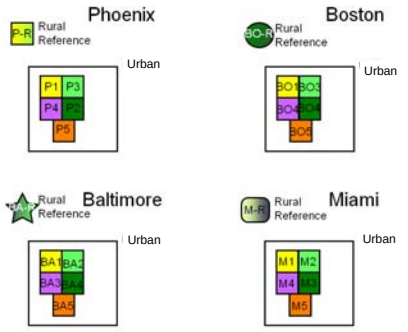

Figure 2. Hypothesized relationship between lifestyle characteristics and landscaping, where neighborhoods with similar lifestyle characteristics across different cities will have more similar landscaping preferences and practices than nearby neighborhoods within the same city with differing lifestyle characteristics, e.g., yellow neighborhoods in different cities (P1, BO1, BA1, M1) are more similar than yellow and green neighborhoods within a city (e.g., P1 vs P2 and P3).

Key Questions and hypotheses:

1. Does urbanization lead to a homogenization of ecological structure such that residential land parcels and neighborhoods in different cities are more similar to each other than to native ecosystems in their own metropolitan area in terms of plant community composition and aboveground biomass, soil carbon and nitrogen pools and isotopes, microclimate and hydrography?

2. What are the continental-scale effects of urban homogenization on ecosystem function? If residential ecosystems in biophysically dissimilar regions are more similar to each other than to their respective native ecosystems, we hypothesize that urban homogenization leads to increases in ecosystem carbon sequestration, soil nitrogen (total and reactive) pools, and denitrification.

3. Can parcel-level information obtained from remote sensing and socio-demographic data be used to scale the effects of urban land use change and homogenization to regional and continental scales? We hypothesize that detailed household survey and vegetation and soil data will allow us to scale urban ecological responses from parcels to neighborhoods and whole regions (metropolitan statistical areas) and that broad-scale socio-demographic and remote sensing data will be predictive of variation in ecosystem structure and function within and among cities. If so, we will be able to evaluate the effects of urban land use change on ecosystem structure and function at the continental scale.

Preliminary Results

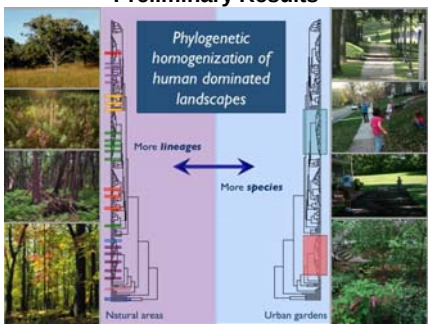

Figure 3. Phylogenetic diversity in 137 privately managed yards change along a gradient of housing density in the Minneapolis-Saint Paul metropolis, Minnesota, USA and in a "natural area" at the nearby Cedar Creek Ecosystem Science Reserve. Although yards had more species per hectare than natural areas, yard species were more closely related to each other. The high number of exotic yard species increased the yard flora's phylogenetic relatedness in comparison to species of Cedar Creek causing a degree of phylogenetic homogenization within yards. The urban environment and homeowners' preferences select for trait attributes and phylogenetic lineages that can colonize and persist in yards. As yard species disperse beyond household boundaries, their functional attributes will affect ecosystem processes in urban environments and beyond. From Knapp et al. (2012, Ecology in press).

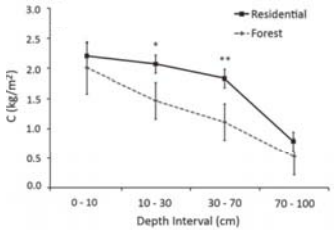

Figure 4. Soil carbon at four depths in 33 residential parcels and 8 forest reference parcels in the Baltimore metropolitan area. Urbanization increased carbon sequestration in soil. If this pattern occurs in all cities, the result would be an increase in soil carbon sequestration at the continental scale. Note that we expect the urbanization effect on soil carbon to be much more marked in arid cities (Phoenix, LA) than what was observed in Baltimore. From Raciti et al. 2011, Ecosystems 14:287-297).

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The neighborhood on the left is in Boston.