

## Let's Not Forget the Biodiversity of the Cities

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### ABSTRACT

Cities contain over half of the world's population and are the source of many anthropogenic effects on the world's biota. Close examination of San Juan, Puerto Rico, a tropical city, reveals a significant green infrastructure. The city contains natural and human-constructed forests, urban aquatic systems with native and introduced species, and a thriving and diverse biota adapted to urban conditions. It behooves tropical ecologists to pay attention to the biodiversity of urban environments to learn lessons about ecological persistence and adaptation to novel anthropogenic environments.

*Key words:* novel ecosystems; Puerto Rico; San Juan; urban forests; urban rivers.

THE PROPORTION OF THE WORLD'S POPULATION that lives in cities recently reached 54 percent; it is 94 percent for the Island of Puerto Rico, where I live. Some of the most controversial anthropogenic effects on biodiversity originate in cities, including global and local species extinction, fragmentation and diversification of the landscape, habitat conversion, homogenization, and/or diversification of the biota, creation of new habitats, introduction of species, alteration of genomes, and ecological novelty. Heat islands, or the higher air temperature of cities compared with the rural surroundings, anticipate global warming scenarios. Although cities have historically been places where human creativity, economic activity, and innovation have soared, their biology and ecology have received little attention, particularly tropical cities. In fact, the stature of cities as ecological assets is low (but see Lugo 1991 for a more positive spin). With the increasing importance of cities as the habitat for the majority of humanity it is time for ecologists to take a critical look at them, particularly because cities can be made ecologically diverse places with a substantial complement of biodiversity.

A group of ecological and social scientists of which I am a member has just started studying San Juan, the capital of Puerto Rico, as a socioecological system (<http://sanjuanultra.org/>). So far the ecologists have been the most surprised by what we are finding. Three examples will suffice to make the point that a tropical city is a place where biodiversity and humans can share space in harmony: the urban forest, an urban river, and the overall composition of the urban biota.

'Urban forest' is a geographic descriptor for the forest cover of a city, but ecologically that forest is composed of four major types (Lugo 2002): natural forest stands that somehow survived the expansion of the city, natural corridors along riparian zones, artificial corridors along streets and avenues, and 'green oases' or forests constructed by people. The city also has scattered vegetation and individual trees that, combined with the four forest types, form the city's canopy and vegetation cover. This vegetation is a critical

component of the urban green infrastructure. The natural corridors and forest stands retain the native plant species composition and species density that they exhibit in rural areas, and they represent a core of native species richness within the urban environment. The artificial corridors and green oases have novel mixtures of native and introduced species, reflecting the choices made by people as well as the constraints of the new environmental conditions that result from the construction and maintenance of the city and its infrastructure. For example, we found 34 tree species (seven native and the remainder introduced) in 1 ha of 18-yr-old green oasis in San Juan (Román Nunci *et al.* 2005). The point to an ecologist is that the city is not as barren and devoid of biodiversity as it appears when we only focus our sights on the constructed portion and fail to take a broader view of all its spaces, constructed or not.

We expected not to find much biota in the Río Piedras, an urban river with its whole watershed embedded in the urban matrix and its deteriorated water quality with millions of fecal bacterial colonies per 100 mL, high nitrogen and phosphorus concentrations, and sediment loads ranging from hundreds to thousands of tons per day depending on the magnitude of the rainfall events. We were wrong. The aquatic species list now exceeds 30 taxa, including seven native fish species, a new shrimp record for the island, a new freshwater sponge record, and fish biomass that is among the island's greatest. Our views of nature's capacity to persist in urban environments changed instantly, and we are now engaged in comparisons of urban and pristine streams to learn more about the mechanisms of persistence and resilience in natural ecosystems.

The overall composition of the biota in tropical cities is perhaps the most exciting and greatest challenge to ecologists. Cities are heterogeneous with respect to the kinds of environmental conditions that they contain. The idea that they are homogeneous is a myth based on a narrow perspective of what the city really is. Within the city limits of San Juan one finds natural and artificial wetlands, forests on karst, volcanic, alluvial, and artificial substrates, streams, and widely varying channels depending on alterations to channel morphology and hydrologic conditions. New substrates for biodiversity occur throughout from different kinds of pavements,

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to roofs, to all kinds of soils with different degrees of compaction and surface temperatures. This diversity of habitats contains a diversity of biota that somehow completes its life cycles within the city and form vibrant and functional communities of plants, animals, and microbes. Thus, it is not surprising that the number of species and abundance of resident as well as introduced avian species increases with urbanization in northeastern Puerto Rico (Vázquez Plass 2008).

In short, the city presents many environmental challenges to the biota (environmental filters *sensu* Ricotta *et al.* 2009) as well as opportunities for ecological and evolutionary innovation and diversification over spatial and temporal scales. The city is the birthplace of new community types, it provides places for the establishment of introduced species, and sustains the formation of novel combinations of species assemblages, all waiting for ecologists to make sense of them (see Lugo 2009).

Many studies of cities in the temperate zone are now appearing in the literature (*e.g.*, Plowes *et al.* 2007, Croci *et al.* 2008, Schaefer 2009, Shochat *et al.* 2010), but studies of tropical cities are lagging. With the expansion of urban populations in the tropics, it behooves us as tropical ecologists to study the ecological novelty of the city and in so doing contribute to the betterment of the quality of life of tropical peoples. At the same time we can improve ecological understanding of the role and resilience of the biota while showing the way to an enlightened practical approach to biodiversity conservation.

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