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Title: Luxury effects on biodiversity in NYC parks

Abstract:

Urban wildlife worldwide are facing similar environmental challenges. Increases in noise, light at night, heavy metals, non-native species, heat island effects, and impervious surfaces, result in spatially distant cities often resembling each other more than they do the surrounding natural habitat. However, within urban landscapes there is also relatively unexplored heterogeneity. The size, connectivity, and general maintenance of green spaces are unevenly distributed and known to covary with socioeconomic variables such as household income and historical redlining. The "Luxury Effect" describes a phenomenon where biodiversity is positively correlated with household income. To date, the strongest support for the luxury effect comes from arid regions, where wealthy neighborhoods use more water and benefit from a subsequent richness of plant communities. Here, we will investigate whether there is support for the luxury effect across taxa in New York City. We will conduct surveys of birds and insects across green spaces managed by New York City Parks in Manhattan and the Bronx. We predict that surrounding household income levels, race, and historical redlining will predict biodiversity, but that the direction of the effect will vary across taxonomic group. We will compare our results with biodiversity predictions based on iNaturalist and eBird data to investigate potential biases in user demographics. Results will shed light on how socioeconomic heterogeneity in cities can lead to the reorganization of animal communities.

Background:

In the context of simultaneous climate and biodiversity crises, understanding patterns of biodiversity is crucial in order to preserve the wide array of life present on this planet for future generations. According to the latest WWF report (2022), global populations of birds, fish, amphibians, reptiles, and mammals have suffered an average loss of 69%, with North America specifically seeing average losses of 20%. Urban development has been a direct and indirect driver of biodiversity declines, and these impacts are set to ramp up given that more than two thirds of the world's population will live in cities by 2050 (UN World Urbanization prospects highlights 2018). Thus, studying urban ecology is of critical importance, not only to preserve the myriad of lifeforms on this planet, but also due to the vital ecosystem services which a bio-diverse ecosystem provides (Zari 2018).

The ecology of urban areas differs in spades from the prototypical ecology seen in more natural areas. Urban development often leads to small, highly fragmented green spaces, leading to less species dispersal and gene flow (Lepczyk et al. 2017). Moreover, the novel features of urban spaces can lead to organisms' adaptive cues being tricked into preferring habitats with reduced fitness, in a process termed an 'ecological trap'. For example, Artificial Light at Night (ALAN) tampers with insects' ability to navigate using light, leading to higher rates of predation and overall declines in insect populations (Owens et al. 2020). Therefore, much of urban ecological research

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has focused on quantifying the level of urbanicity of sampling sites spanning an urban-to-rural gradients, to understand the relationship between urbanization and species declines.

However, even within a single municipality, not all urban areas are the same. It has recently become evident that socioeconomic and historic factors shape the distribution of ecological resources, such as canopy cover (Schwarz et al. 2015), tree and bird biodiversity (Aznarez et al. 2023), and insects (Adams et al. 2020). The impacts of socioeconomic and historical disparities on biodiversity have been termed the 'Luxury' and 'Legacy' effects respectively. Indeed, traditional urban gradient approaches are inadequate in describing heterogeneity within urban landscapes, and how this influences which species will survive, or decline. An emergent framework in urban ecology incorporates factors such as age of urbanization, socioeconomics, and legacies of land use to describe the local environmental conditions, and how they impact the ecological response in the city (Ramalho & Hobbs 2012).

Despite the groundbreaking work done to better describe the complex urban environment, there is still a major gap in data concerning how the Luxury and Legacy effects impact biodiversity patterns in cities. For example, tests of the Luxury Effect have more commonly been done in arid landscapes, where water resources are inequitably distributed according to affluence, resulting in more green space in wealthier neighborhoods (Leong et al, 2018). Less is known about how socioeconomics may influence biodiversity in regions of temperate deciduous forest. Additionally, since the term was coined in 2003 (Hope et al., 2003), most studies have focused on quantifying biodiversity of plants, with those targeting animals biased strongly towards birds. Very few studies have considered how the socioeconomic landscape of cities may be influencing insect diversity. Different taxa rely on different types of habitat characteristics, so may be responding to urban heterogeneity differently. For example, wealthier neighborhoods may have more trees that support high bird biodiversity, but may still be lacking in other types of resources (e.g. leaf litter, native flowers) required by the terrestrial insects they rely on. Terrestrial invertebrates are an ecologically important but overlooked taxonomic group that.

This study will fill that gap with data on bird and insect biodiversity, covering sites with a wide range of socioeconomic conditions. We will conduct surveys of birds and insects across green spaces managed by New York City Parks in Manhattan and the Bronx. We predict that surrounding household income levels, race, and historical redlining will predict biodiversity, but that the direction of the effect will vary across taxonomic group. We will compare our results with biodiversity predictions based on iNaturalist and eBird data to investigate potential biases in user demographics. Results will shed light on how socioeconomic heterogeneity in cities can lead to the reorganization of animal communities.

Methods:

We will sample bird and terrestrial insect diversity across 8 parks in New York City. We have selected four parks located in Manhattan (Central Park, Morningside Park, Highbridge Park, Inwood Hill park) and four in the Bronx (Van Cortlandt Park, Pelham Bay Park, Soundview Park, Crotona Park). Sites were selected based on known variation in socioeconomic conditions of the surrounding neighborhoods, but without previous knowledge of local biodiversity.

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We will visit each park once per month from December 2023 – May 2025. Each visit will consist of walking a regular transect (not deviating from walking paths) from 9-11am. To sample bird diversity, we will identify any birds we see using binoculars, and record the distance from observer using a viewfinder. Each transect will last 2 hours, or until I the entire length of the park has been travelled (whichever comes first). To sample terrestrial invertebrates, we will collect two handfuls of ground leaf litter material (leaves, sediment, and any inhabiting invertebrates), at three random points along the transect. Total collected materials will not exceed a 1-gallon ziplock bag, per survey. Collected materials will be brought back to our lab facilities and processed through a Tullgren funnel, in order to separate and identify leaf litter invertebrates. During this process, invertebrates will be separated from leaf litter materials and collected into ethanol, where they will be preserved until identification. Invertebrates will then be identified to genus or species.

Each transect will be recorded using Gaia GPS, to keep the pace and length of time consistent across samples. Additionally, we will collect environmental data, such as air quality ($PM_{2.5}$,CO_2,Humidity), Temperature, and wind speed. We will use publicly available datasets to calculate impervious surface cover, Artificial Light At Night (ALAN), and socioeconomic indicators (median household income, demographics, etc.) surrounding each park. All data analyses will be carried out using the R programming language, and geospatial analyses will be carried out using QGIS. To our knowledge, no state or federal permits are required for scientific collection of terrestrial invertebrates.