Review of: "Global impacts of future urban expansion on terrestrial vertebrate diversity"

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Background:

Its widely known that human socioeconomic activities are accelerating rapidly in the Anthropocene, threatening the ecological, hydrological, and climatic systems on which human welfare depends (Di Marco et al., 2018). It is perhaps less well appreciated that growth in large cities is a core driver of the expanding human footprint (Sun et al., 2020). The United Nations medium fertility model for human population growth projects a global population of about 9.8 billion people by 2050, only 17 years from today, and 11.2 billion by the end of the century. Of these, about 6.7 billion people are expected to live in urban environments by 2050, and about 9.0 billion by 2100 (DESA, 2019).

The actual ecological impact of cities may be estimated as a product of their total population size, the per person consumption (i.e., affluence) of energy and other resources, and certain technological factors that can modify (magnify or mitigate) these impacts (Holdren and Ehrlich, 1974). Despite widely held notions that modern urban lifestyles are more efficient and environmentally friendly, in fact modern city dwellers consume up to four orders of magnitude more energy per person than do people who live in traditional non-urban environments (Burger et al., 2011; 2017).

This consumption includes biological and extra-metabolic forms of energy required for urban life, including renewables and fossil fuels (e.g. transportation of people, food, water and wastes, heating, cooling, lighting, etc.). The interrelated effects of urban activities represent an immensely tangled web, the ecological “footprint” of which has not yet fully described. Although the big picture of human degradation of the atmosphere, biosphere and hydrosphere has been clear for several decades (Ripple et al., 2019), the ecology and conservation of expanding urban habitats remains poorly understood (Rivkin et al., 2019; Rumble et al., 2019; Lambert and Donihue, 2020).

In a pair of influential papers (Kriegler et al., 2014; O'Neill et al. 2014) proposed a conceptual framework for climate-change research that defines five plausible, alternative, social and economic trends over a century timescale referred to as Shared Socioeconomic Pathways (SSPs). The SPP framework deliberately excludes ecological conditions and variables (e.g. biodiversity) related to future climate change by design, describing hypothetical futures in which biodiversity is not affected by further climate change, so that other alternative scenarios can estimate the effects of future climate change on biodiversity and other aspects of the Earth system. The SSP approach has been used effectively to compare the results of alternative greenhouse gas emissions scenarios under different climate policies; e.g. IPCC Sixth Assessment Report on climate change (Zhongming et al., 2021). In an innovative use of the SPP approach, Gao and O'Neill (2020) used a global time series of remote sensing observations to project total urban land use globally by a factor of 1.8 – 5.9 by the end of this century, with fastest urban land expansion occurring in already densely-settled regions of Africa and Asia.

This study

Li et al. (2022) use the SSP scenarios to estimate the effects of global urban expansion in the 2st century on the biodiversity of three groups of terrestrial vertebrates; i.e. amphibians, mammals, and birds, but excluding non-avian reptiles. Depending on the SPP, they project an expansion of total global urban area of 360,000 - 740,000 km^2 by the year 2100, representing an increase of 54 - 111% over that of the year 2015, with the largest loss of natural habitat expected in the temperate broadleaf and mixed forests biomes of northeastern Asia.

Although this study represents a useful contribution to the study of urban effects on biodiversity, there are several issues that must be addressed for future research efforts in this area.

1. Expand the scope of the projected environmental impacts to include other important biodiversity metrics, and freshwater as well as terrestrial taxa. Biodiversity is a multidimensional phenomenon, effectively equivalent to "Life on Earth", and cannot effectively be summarized by species richness, conservation status, or any other single metric (McGill et al., 2015; Magurran, 2021). Other widely used biodiversity metrics include genetic, functional, phylogenetic, ecological, and landscape diversity. Indeed, species richness is often anti-correlated with other important biodiversity metrics; e.g. endemism. Further, biodiversity patterns and processes in terrestrial vertebrates differ strongly from those in freshwater vertebrates, and urban expansion threatens aquatic ecosystems and species even more strongly than their terrestrial counterparts (Albert et al., 2021). Freshwater ecosystems provide irreplaceable services for both nature and society, and are among the most diverse per unit habitat volume on Earth, with more than 140,000 species (i.e., fungi, plants, invertebrates, and vertebrates; c. 12% of all described species) compressed into just 2% of the world's surface area. Freshwater fishes represent about 25% of all continentally distributed vertebrate species.

2. Map the urban growth proportion of terrestrial HANPP (Jenkins et al. 2020; Montero et sl., 2021). The main threats to biodiversity in the 21st Century come from habitat loss and climate change, with secondary impacts to land vertebrates

(tetrapods) from direct predation due to harvesting and hunting (Jenkins et al., 2013; Allan et al., 2019; Harfoot et al., 2021; Murali et al., 2021). Urban expansion is a major driver of biodiversity loss primarily through its effects on global markets and land use changes, habitat loss, and resource consumption, none of which are modelled in this study. The main effects of increased urbanization in the coming decades can be expected from increases in per capita energy and commodity (e.g. food) consumption of urban dwellers. Expanding the urban footprint will be a relatively small part of the problem.

The absolute projected amount of urban area expanded is actually relatively modest in comparison to the greatest conservation threats. The projected accumulated conversion of land across the whole world over the next 85 years is equivalent to a square patch of land just 600 - 860 km (273 - 535 mi) on a side, an area equivalent to only 2.3-4.7 years of Amazon deforestation at current rates (Silveira et al. 2020). To put these estimates into a larger perspective, the average projected rate of urban expansion (4,200 - 8,700 km^2 per year) is only 18 - 37% the c. 23,400 km^2 per year from global wetland loss (Hu et al., 2017), or 11 - 23% the c. 37,500 km^2 per year of global habitat loss from agricultural expansion (Williams et al. 2021).

Furthermore, most of the land areas threatened with imminent urbanization are located near existing large urban areas. These areas are more likely to already be intensively used by human activities, and therefore to have relatively low conservation value as compared with newly deforested areas in the tropics now being converted from primary forest to agricultural and pastoral landscapes (Song et al. 2021).

3. Develop alternative SPPs that model demographic and technological urban responses to projected large-scale climate and economic changes. The five SSPs use in this study assume no demographic or technological changes in response to continued climate change during this century, including changes imposed by known threats; e.g. accelerating sea-level rise, coastal erosion, river basin flooding or regional aridification, nor any of the many feedbacks we can reasonably expect will accompany rapid population growth and the transition to a post-fossil fuel global economy. The main conclusion of this study is an urgent need to develop a “sustainable urban development pathway”, yet such a pathway is not described. None of the purported policy recommendations advanced in the final paragraph offer pathways for demographic and technological urban responses to the projected climate and economic changes

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