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Research Paper

The importance of land governance for biodiversity conservation in an era of global urban expansion

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ABSTRACT

Mitigating the effects of urban expansion on habitat with high conservation value depends largely on national and sub-national governance that can effectively shape urban growth. This paper is the first study to map urban-caused biodiversity decline and governance. The central goal of this paper is to identify where and how weak governance and future urban expansion may combine to lead to the decline of biodiversity. We identify four categories of countries based on the level of biodiversity impact from urban expansion and governance capacity, as expressed in the Worldwide Governance Indicators. We review the literature of case studies to understand how governance capacity modulates the impact of urban expansion on biodiversity. Our results show that if predicted urban expansion continues, by 2030, more than two-thirds of all species impacted by urban expansion will occur in countries with low levels of political stability or regulatory quality, two factors which were identified as most important in the ability of land governance to mitigate urban threats on biodiversity. Our results suggest that land-use planning cannot be the sole solution for preventing urban-caused global biodiversity decline, but rather that different categories of countries need contrasting conservation strategies. Countries that have high potential biodiversity impact and low land governance capacity require short-term conservation strategies which facilitate public participation, as well as international aid and development to increase governance capacity. Furthermore, enhanced coordination across different decision-making levels is important so that strategies at a single scale do not counterbalance efforts at other levels.

1. Introduction

Urban areas will expand at an unprecedented rate over the coming decades (Seto, Güneralp, & Hutyra, 2012). This rapid urban growth drives the conversion of natural habitat to urban land-uses, which can significantly degrade biodiversity (Elmqvist et al., 2013; Foley et al., 2005; Seto et al., 2012). Land governance can play a key role in mitigating the negative impacts of urban-caused habitat loss on biodiversity, by minimizing urban threats on key biodiversity areas. Effective policy implementation via adequate land-use planning (Halleux, Marcinczak, & van der Krabben, 2012) is essential to control urban threats on key biodiversity areas. While many studies have evaluated conservation priorities globally (e.g. Eklund, Arponen, Visconti, & Cabeza, 2011 for mammals; Giam, Bradshaw, Tan, & Sodhi, 2010 for threaten plant species; Lee & Jetz, 2008 for terrestrial vertebrates), few studies addressed the issue of governance relative to the priorities. Governance capacity is perhaps important to consider where urban growth is expected to occur in areas with natural habitat of high biodiversity value and weak land governance, as these may be areas of lower capacity for land-use planning to mitigate biodiversity loss.

Land governance represents the capacity to address land-use policy choices, enforce relevant regulations, and coordinate with stakeholders and official agencies across different administrative levels of decision-making. Effective land governance facilitates the development and implementation of law, regulations, and institutions that have a role in the management of land resources. However, biodiversity conservation in some places has suffered from weak land administration due to poor institutional capacity (Jepson, Jarvie, MacKinnon, & Monk, 2001; Nepstad et al., 2002; Smith, Muir, Walpole, Balmford, & Leader-Williams, 2003) and insufficient cooperation (Powell, 2010; Scarlett & Boyd, 2015; Segall, 2006; Veldkamp, Polman, Reinhard, & Slingerland, 2011). Weak land governance has prevented successful forest management (Jepson et al., 2001; Nepstad et al., 2002; Segall, 2006) and terrestrial reserve protection (Bruner, Gullison, & Balmford, 2004; Smith et al., 2003). Moreover, urbanization often is fastest in countries with high poverty rates and weak governance (Glaeser, 2014). As a result, it is important to understand how weak land governance can limit the effectiveness of conservation actions to prevent biodiversity

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losses from urban expansion.

This study aims to identify where and how the intersection of weak land governance and future urban expansion may lead to the decline of biodiversity in key geographic areas. First, we identify conservation priorities spatially by the overlap of future urban expansion (Seto et al., 2012), areas of high biodiversity (Jenkins, Pimm, & Joppa, 2013), and country-level Worldwide Governance Indicators (WGI) (Kaufmann, Kraay, & Mastruzzi, 2011). Second, to bridge the knowledge gap between the WGI and land governance, we conduct a content analysis of case studies in the literature to evaluate where low scores on the WGI have been associated with specific types of urban threats to biodiversity. Finally, we identify conservation strategies that could be effective in countries with weak land governance.

2. Methods and materials

2.1. Overlap analysis for identifying areas of biodiversity impact and weak governance

We conduct a two-stage spatial overlap analysis to identify areas of high biodiversity importance that are in countries with weak governance. First, to estimate biodiversity impact, we intersect areas with high probability (> 75% of all estimates) of future urban expansion by 2030 (Seto et al., 2012) with biodiversity maps of mammals, birds and amphibians (Jenkins et al., 2013). To project global future urbanization, Seto et al. (2012) conducted 1000 estimates of aggregate amount of urban expansion by randomly drawing 1000 values each from the corresponding probability density functions of projected GDP and urban population based on the Global Rural-Urban Mapping Project, and country-level GDP projections by the Intergovernmental Panel on Climate Change Special Reports on Emissions Scenarios. Then they used GEOMOD, a spatially explicit grid-based land-use change model (Pontius, Cornell, & Hall, 2001), for simulating the spatial distribution of the 1000 urban expansion estimates by using slope, distance to roads, population density, and land cover as the primary drivers of land change.

Next, we compare our biodiversity impact maps with the WGI, which evaluates countries on six national dimensions: Voice and Accountability (VA), Political Stability and Absence of Violence/Terrorism (PV), Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL), and Control of Corruption (CC) (Kaufmann et al., 2011) (See Appendix A for WGI measurement). We aggregate the biodiversity impact maps to match the national resolution of the WGI using average number of species per urbanized pixel. The average biodiversity impact and the WGI are categorized into classes of low and high influence using the Jenks natural break classification method, which optimally minimizes average variance of each class and maximizes the variance between classes, thus creating four categories with different levels of urban expansion and land governance (2 biodiversity classes × 2 governance classes). Additionally, we estimate the proportion of urbanization impact on biodiversity richness by different governance indicators using the following formula:

$$P_{i,j}^{H} = \frac{UB_{i,j}^{H}}{UB_{i,j}^{L} + UB_{i,j}^{H}} \quad \text{and } P_{i,j}^{L} = \frac{UB_{i,j}^{L}}{UB_{i,j}^{L} + UB_{i,j}^{H}} \tag{1}$$

where i represents the vertebrates; j represents the WGI indicators; H represents high level of the j indicator; L represents low level of j indicator. P represents the proportion of urbanization impact on biodiversity; UB represents the area size of urbanization on biodiversity areas of the i vertebrate in the areas with high (i.e. H) level or low (i.e. L) level of j indicator.

2.2. A content analysis for recognizing causal relationship between land governance, urban growth and biodiversity outcomes

To understand the potential impact of weak land governance on biodiversity, we conduct a literature review and synthesize case studies published in English found in the Web of Science. Our content analysis focuses on three major questions related to land governance in managing urban expansion on biodiversity areas:

1. What is the empirical evidence that scores on the WGI relate to specific types of urban threats to biodiversity?
2. Is there evidence that land governance can minimize the negative effects of urban expansion on areas with high biodiversity importance?
3. What conservation strategies are appropriate for different types of urban growth and different levels of governance capacity?

First, we evaluate the relationships between the WGI and seven classifications of urban threats categorized from McDonald et al. (2009): habitat loss, habitat degradation, habitat fragmentation, overexploitation, invasive species, changes of animal's behaviors, and the spread of wildlife diseases. We use the seven classifications, the six WGI indicators, and land governance as key words for selecting articles. Second, based on an examination of the case studies, we create a conceptual framework to describe the mechanisms by which the WGI scores are related to land governance and hence to the ability to modify potential threats to biodiversity. Finally, we synthesize conservation strategies appropriate for different types of urban growth impacts on biodiversity and governance capacity.

3. Results

3.1. The geography of biodiversity impacts and land governance

Based on our overlap analysis, countries with high predicted urban impact on biodiversity and relatively weak governance are located primarily in Africa, Latin America and Southeast Asia (Fig. 1. For fine-level mapping see Appendix B). We categorize individual countries into four quadrants based on different levels of biodiversity impact and governance. Countries with low biodiversity impact and high governance (BLGH) are primarily located in Europe. These countries have high regulatory quality and high political stability, but are expected to experience relatively low levels of urban expansion and thus will have low biodiversity impacts. A second group of countries, including Namibia and Malaysia, have high urban growth impact on biodiversity and relatively high land governance capacity (BHGH). These are places that are experiencing extensive urban growth, but also have the institutional capacity to shape or govern land outcomes. A third group of countries is categorized as having low urban growth threats on biodiversity and low governance (BLGL), including Russia, China and India. In each of these three groups, either the threats to biodiversity due to urban growth are low or governance capacity is high, and thus we consider them as relatively low threats to biodiversity. However, the fourth group of countries are those where biodiversity impact is expected to be high and governance is low (BHGL), such as Brazil, Nigeria and Indonesia. Here, we select Regulatory Quality (RQ) and Political Stability and Absence of Violence/Terrorism (PV) as representative indicators of land governance (For the rest of the WGI indicators see Appendix C).

We also estimate the proportion of urban growth impacts on biodiversity in countries with different capacities for land governance (Fig. 2). The results indicate that more than three-quarters of the biodiversity impact (82% of urban-impacted mammal, 83% of urban-impacted avian and 77% of urban-impacted amphibian) will occur in countries with low scores for political stability (PV) (i.e., political unstable countries). We also find that more than two-thirds of the biodiversity impact (68% of urban-impacted mammals, 71% of urban-