The Future of Global Urbanization and the Environment

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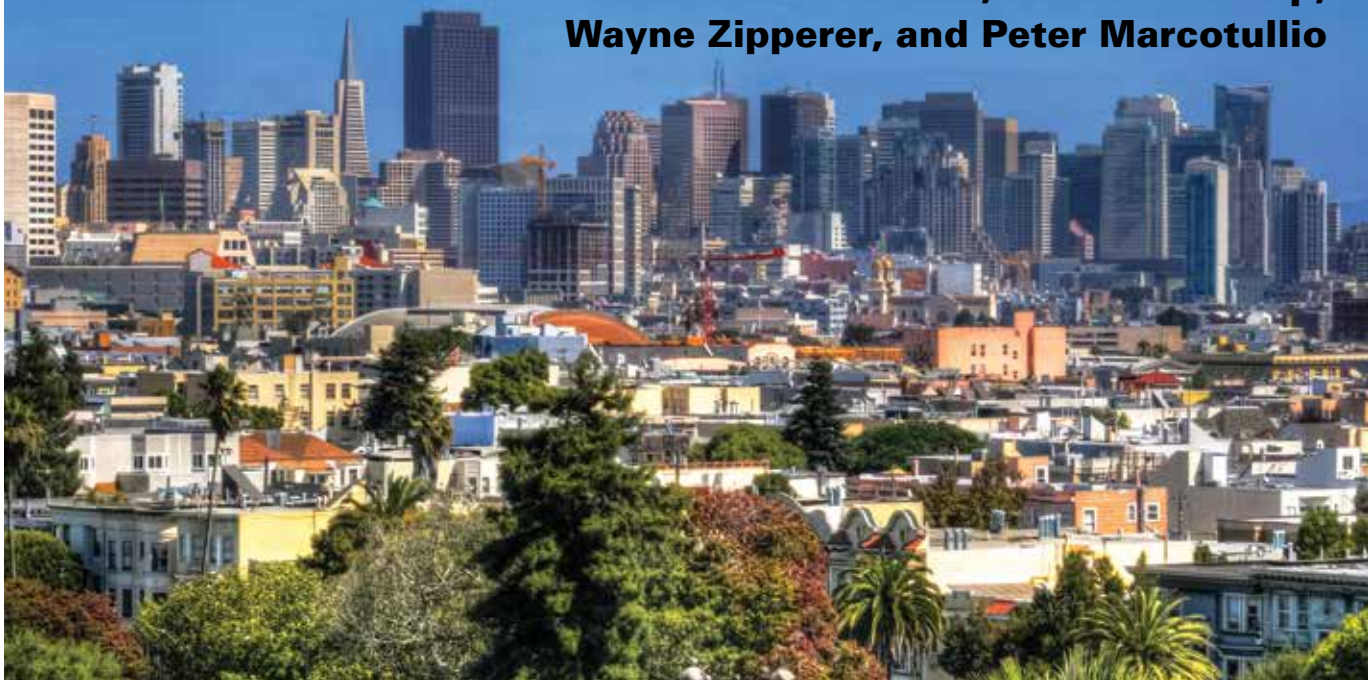

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Giving value to ecosystem services would gain them greater consideration in urban planning, an integral step in conserving biodiversity and ecosystems in the face of widespread urbanization.

In Brief

Using findings of the *Cities and Biodiversity Outlook* (CBO), we propose three specific solutions to mitigate the loss of ecosystem services and biodiversity in our urban and urbanizing landscapes. The CBO identified continued loss of critical habitats for biodiversity conservation and degradation of many important ecosystem services due to urbanization. The fact that most ecosystem services and biodiversity itself are common goods facilitates this loss and degradation. To address this issue, a fundamental solution can be giving value to ecosystem services and biodiversity in the marketplace and firmly incorporating them in urban planning processes.

This solution can be achieved with a three-pronged approach: (1) ecosystem services can be conceived as a utility similar to the provision of electricity and water, and cities can structure their governance and urban planning processes to ensure adequate ecosystem service provision; (2) the local level solutions, especially in places where urban expansion encroaches upon biodiversity hotspots, can go a long way in the conservation of biodiversity at the global level; and (3) the well-being of biodiversity and the sustainability of ecosystem services in the face of humanity's massive urbanization require coordination by governments at all levels. Thus, as the world becomes ever more urban, urban decision-makers and citizens will need to not only re-connect to nature, but also adopt policies to integrate nature into our daily lives.

A recent global assessment by hundreds of scientists, the *Cities and Biodiversity Outlook* (CBO) examined how the coming massive global urban growth will interact with the natural world.[1] By 2030, there will be almost 2 billion new urban residents, and this rapid urban growth has significant implications for the fate of human society and the natural world. With one of the sponsor organizations being the Secretariat of the Convention on Biological Diversity (CBD), it is not surprising that the CBO had a strong focus on how urban growth directly and indirectly affected ecosystem services and biodiversity. The CBO also had a strong focus on how cities depend on ecosystem services, the benefits to human well-being provided by nature, and how that dependence will change with rapid urban growth in the coming decades. The report highlights the resulting synergistic effects on ecosystem services and biodiversity of climate change, projected growth of human population in cities, and urban land-use change. In this paper, we not only highlight a few key findings of the CBO, but also present the fundamental challenges that urban growth poses for ecosystem services and biodiversity, potential solutions to address these fundamental challenges, and three specific mechanisms that can help cities harmonize their relationship to ecosystem services and biodiversity.

The Fundamental Problem

The CBO found continued degradation of many important ecosystem services upon which urban dwellers depend. While there are many different causes of this degradation of service, including loss of habitat, climate change, and regulatory and institutional barriers, one fundamental underlying problem was identified in several of the chapters of the CBO: many ecosystem services, in particular regulatory and cultural services,[2] are common or public goods. That is, these ecosystem services are non-excludable goods, in that the benefits they provide are not easily limited to only those who can pay for them, but are freely available to a large set of people.[3] For instance, a large forested patch in an urban region helps to maintain and regulate air quality and temperature locally and potentially regionally, yet these benefits are available to essentially all those near the forested patch, regardless of whether they have paid for their provision.

Key Concepts

- **An international team of more than 200 scientists conducted a global assessment of urbanization and the environment, called the *City Biodiversity Outlook* (CBO), finding widespread degradation of ecosystem service provision for urban residents and a substantial loss of biodiversity in urban and urbanizing areas**
- **The fundamental problem identified by the CBO is that most ecosystem services and the existence value of biodiversity are non-market goods and are not adequately considered in economic or policy decisions**
- **In this paper, we argue that the fundamental solutions to this problem are to quantify the value of ecosystem services for urbanites and to create policy mechanisms that incorporate the value of ecosystem services into economic and policy decision-making. We present three such potential policy mechanisms:**
  - **Cities should consider ecosystem services as a utility they supply to their residents, on par with the provision of electricity and water, and structure their governance and urban planning processes to ensure adequate ecosystem service provision**
  - **As the vast majority of future biodiversity lost due to urban growth will be in a few hotspots in developing countries, local level solutions to safeguard biodiversity in the face of urban expansion would go a long way in the conservation of biodiversity at the global level**
  - **The well-being of biodiversity and sustainability of ecosystem services in the face of humanity's massive urbanization require coordination by governments across multiple scales and jurisdictions**

Both empirical evidence and environmental economic theory suggest that common and public goods are generally underprovided by free markets—a phenomenon called 'market failure'. Since any actions individuals might take that increase ecosystem service provision would benefit people who do not have to pay to receive the benefit, there is little financial incentive for individuals to consider ecosystem services in their decisions. For similar reasons, ecosystem services are often not given adequate weight during policy decision-making processes, although the mandate of some policy makers to consider the greater good can sometimes allow some consideration of ecosystem services. For example, by converting forested lands into new residential areas, the property developers may gain financially off this conversion, but other people in the city at large may lose because of the loss of ecosystem services once forests disappear. Such actions can also lead to intergenerational equity challenges in terms of the benefits derived from the ecosystem services. Property developers have no economic incentive to consider these broader social impacts. Such disconnect is the fundamental problem causing widespread degradation and loss of ecosystem services upon which humans depend.

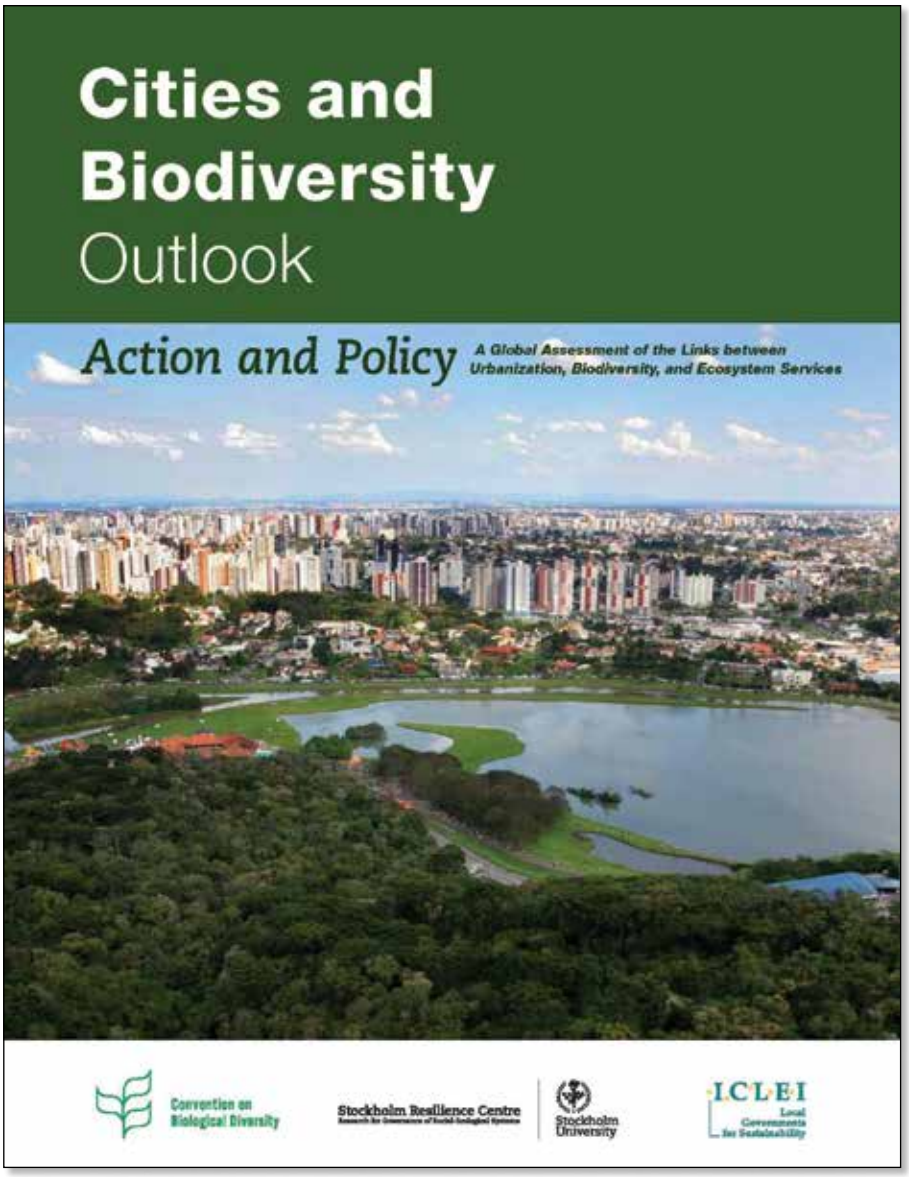
One very important ecosystem service affected by development is freshwater provision.[4] Urban areas depend on upstream natural habitat for regulating water flows, and impact freshwater provisions to downstream communities. Consider the example of the expanding city where forests are replaced by residential areas. This increase in the impermeable surface area leads to increased volumes of surface water runoff, which increases the vulnerability to flooding of downstream communities. Urban landscapes with 50 to 90 percent impervious cover can lose 40 to 83 percent of rainfall to surface runoff compared to 13 percent in forested landscapes.[5]

Freshwater provision has significant externalities, but also has some characteristics of a private good. On the one hand, urbanization affects land cover which in turn affects the quantity and quality of water available for other users downstream. Unless restricted by government policy or regulation, cities tend to degrade the water quality of downstream water sources, either through diffuse pollution (e.g., sedimentation from construction, polluted stormwater runoff) or point source pollution (e.g., wastewater release). On the other hand, urban areas require water. Water is directly needed for human use, and supports a variety of other secondary ecosystem services (e.g., recreation, biodiversity, transportation). Many cities go to great lengths to safeguard their water source, and have a direct financial stake in the health of this water source.

Another example of market failure is not adequately considering the cultural ecosystem services provided by the urban forest, especially parks, during urban planning process. These cultural services are vital for human health and well-being, and include recreational value, aesthetic benefits, and benefits to human physical and mental health. Since city environments can be stressful for inhabitants, the recreational aspects of urban ecosystems are among the highest valued ecosystem services in cities. Parks, forests, lakes, and rivers provide a manifold of possibilities for recreation, thereby enhancing human health and well-being.[6] Unfortunately, many of these areas are lost or degraded during urbanization, which could have been prevented to some extent through an integrated planning process.

The CBO also found continued loss of biodiversity due to urbanization. Although the CBO stressed that urban areas continue to harbor important elements of biodiversity, the net impact of urban growth globally is a loss of biodiversity. Much like the situation with ecosystem services, the maintenance of biodiversity is not adequately considered in the economic decisions of individuals or in the policy decisions of governments. Despite the considerable importance of biodiversity, both for the maintenance of ecosystem services and for the value many people place on its existence, it is generally afforded little economic importance during decisions of urban planning and growth.

Cities are often located in areas of high biodiversity richness and endemism (along coastlines, some islands, and major river systems), and therefore, have a significant direct impact on biodiversity.[7] Examples of biodiversity hotspots include the Mediterranean Basin, Atlantic Forest, California Floristic Province, and Indo-Burma and Sundaland which contain nearly all Southeastern Asian urban lands (27, 000 km^2). Direct impact includes habitat loss, fragmentation and degradation of remaining blocks of natural habitats, the increase in non-native invasive species, and the loss of sensitive indigenous species. Moreover, the urban land in biodiversity hotspots have already affected ecoregions that contain 10 percent



Secretariat of the Convention on Biological Diversity (2012)

The *City Biodiversity Outlook* presents a global assessment of urbanization and the environment.

of terrestrial vertebrates,[8] and future urban area in hotspots is forecast to increase by about four times globally from 2000 to 2030.[9]

Protected areas (PAs) have been one of the main tools used to limit biodiversity loss due to habitat conversion. Urban expansion is expected to continue near PAs, at least at the same pace as elsewhere across most of the world.[10] In fact, the amount of urban land near PAs is expected to increase around the world, on average, by more than three times between 2000 and 2030 (from 450,000 km^2 circa 2000), with China developing the most urban land within 50 km of its PAs by 2030. The largest proportional change, however, will likely be in Mid-Latitudinal Africa where urban land near PAs is estimated to increase 15 to 25 times by 2030.

The CBO stresses, however, that significant biodiversity remains in urban areas globally. Williams et al. (2009) identified three sources of species in urban landscapes: (1) native species originating in the area itself; (2) native species occurring regionally; and (3) non-native species introduced by humans or naturalized in the region. Changes in any of them may affect species diversity in a city. Analyses of long-term species records provide insights into how these sources change, with species richness in group 1 tending to decline and species richness in groups 2 and 3 often increasing, leading to biotic homogenization.[11] Although the general pattern is of a decline in native-species richness, it can still comprise 50 to 70 percent of total species richness in a city.[12]

Finally, the CBO stressed that urbanization is a complex phenomenon tightly linked to a number of other development processes. It is counterproductive for policymakers to consider urbanization solely as a problem, since it is an unavoidable part of economic development and population growth. A more useful way to think about global urbanization is as both a challenge to the sustainability of our planet's natural systems and as a tremendous opportunity to change how cities structure and function.[13]

The Fundamental Solution

If the fundamental environmental problem with urbanization is that most ecosystem services and biodiversity are common or public goods that are not adequately considered in economic or policy decisions, what is the fundamental solution? Here, we suggest that one part of the solution must be giving value to ecosystem services and biodiversity in market decisions, as well as bringing new regulatory mechanisms and infrastructure systems in urban governance for the efficient management of ecosystem services and conservation of biodiversity.

This overarching solution is so general that it may seem obvious, and there are of course myriad specific ways that governments at various levels (municipal, regional, or national) can intervene to give value to biodiversity and ecosystem services. In this paper, we offer three specific mechanisms towards reaching the fundamental solution. While our experience as lead editors shapes our suggestions, these three specific mechanisms are in no way exhaustive. Other potential mechanisms exist, and the mechanisms that are effective in one city may not be effective in other cities due to local ecological or socioeconomic circumstances.

Treating Ecosystem Services as an Urban Utility

Cities worldwide are structured to have different departments or utilities that provide key services to their residents: clean water, electricity, sanitation services, and many more. These services are now generally either directly provided by publicly owned entities, or by private companies that are employed by and strictly regulated by the cities they serve. While it is easy now for many urban residents to take these publicly-guaranteed services for granted, they have not always been considered as an essential urban service. For instance, water provision and waste disposal have been at different points in history seen as primarily the responsibility of individual households, only becoming a generally accepted publicly-guaranteed service in the 19th century.[14] Electricity provision only came to be seen as a publicly-guaranteed service in the 20th century, and in recent decades, some cities have begun to view cheap wireless internet access as a similar common good they can provide to their citizens.

We suggest that cities need to consider the provision of key ecosystem services on par with the other services they supply to their citizens. Currently, ecosystem services are considered piecemeal by existing municipal departments or agencies: the water utility might think about hydrologic regulating services upstream of reservoirs, the parks department might think about the recreational value of open space, and the electricity provider might try to promote shade trees to reduce summer air-conditioning costs. Certain ecosystem services lack any advocates. For instance, few cities have departments with institutional mandates to facilitate carbon sequestration. Moreover, this piecemeal arrangement means that it is difficult to fully account for the multiple benefits that natural habitats provide in a city or region. For instance, a water utility may consider source watershed protection for its benefits to raw water quality, but will tend to consider any recreational benefits that might occur with conservation as incidental to its mission.

What if public utilities engage in payments for ecosystem services (PES)? This requires a change in mindset, but also in pricing and related regulatory mechanisms of utilities. Unfortunately, there is currently little research on how this may work in

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Residents enjoy Boston Common on a spring day. Urban parks have recreational and aesthetic value, and contribute positively to the mental and physical health of urban dwellers.

practice.[15] One example is incentives put in place for public water utility districts in California to participate in innovative finance mechanisms.[16] A component of this initiative involves paying landowners upstream to better manage their lands, avoiding increases in pollutant loads caused by land change. However, pricing mechanisms such as PES are only part of the solution and may need to be replaced or complemented with other mechanisms depending on the specific ecosystem-service bundle in question. Moreover, the whole infrastructure network upon which utilities for delivering their services may need to be reformed to reflect the type of ecosystem services. For instance, the concept of green infrastructure, also called integrated infrastructure, envisions a more landscape-oriented approach that integrates various resource flows and is a promising alternative to prevailing paradigm in infrastructure construction and management.[17]

Some cities are already beginning to think in a more integrated fashion by having sustainability offices that write sustainability plans for the city. These plans are supposed to have integrated environmental goals, and can serve to coordinate the actions of different urban agencies so that they provide maximum benefit for citizens. However, sustainability offices often have limited budgets and resources, and do not have any direct authority over the agencies whose actions the sustainability plan is supposed to coordinate. What would it look like if the sustainability office in a city had as its mission to provide the full spectrum of ecosystem services to its citizens, and managed the budget and resources that were to create the green infrastructure to provide those ecosystem services?

Minimizing habitat and biodiversity loss and limiting degradation of ecosystem services also require cities to integrate ecological knowledge into their urban planning practices.[18] Specifically, urban planning practices need to become more attuned to conservation of biodiversity and preservation of ecosystem services

that are of critical importance for the inhabitants of the urban areas.[19,20] In this respect, the dissemination of information and connection of science to practitioners is an important aspect of formulating sound urbanization strategies that explicitly acknowledge and consider conservation of biodiversity. However, one of the critical prerequisites to ensure this integration is that urban planners be equipped with the requisite institutional capacity to integrate policies and manage natural resources directly.[21,22]

Novel ecosystems, communities composed of both native and nonnatives species, which occur often on sites previously cleared because of anthropogenic activities, may give us insights into how future ecosystems in urban landscapes may function. Often these areas are managed with intention to be restored to a state reflecting conditions prior to urbanization. This is often a futile attempt; instead, these novel ecosystems should be viewed positively for their contributions to society rather than being treated as inferior to natural communities. In fact, novel ecosystems are critical ecological areas in both shrinking and expanding cities, where these areas can be managed to provide a variety of ecosystem services, including water, fuel, and food, as well as recreation.

Local Efforts to Protect Biodiversity Hotspots under Urbanization Pressure

As discussed above, the biodiversity impact of cities tends to be concentrated in particular cities located in high biodiversity areas. Another way to measure the biodiversity impacts of cities is to calculate for the ecoregions of the world the expected number of endemic vertebrate species that might be lost due to urbanization (Figure 1). The total number of species lost depends on the amount of urban growth (and hence habitat loss) expected between 2000 and 2030, the endemic species richness, and the species area curve assumed. In this simple case, we assume a linear species-area curve, although in actuality the shape of the curve will vary among taxa and geographic region. Note that regardless of the species area curve that is assumed, the spatial concentration of endemic richness and urban growth implies that endemic species loss is highly concentrated. The 25 most threatened ecoregions, 3 percent of all ecoregions globally, account for 50 percent of the expected loss. Urban growth in just 10 percent of all ecoregions accounts for 78 percent of the expected loss. Thus, actions to maintain biodiversity in a relatively small number of ecoregions could have a disproportionately large benefit in terms of avoiding biodiversity loss for urbanization.

Of the actions proposed to ameliorate urban effects on biodiversity, setting aside large parcels of native habitats in those parts of the biodiversity hotspots facing urbanization pressure may provide the best opportunity for regional floral and faunal species to persist. These protected areas would need to be large enough to contain the spectrum of natural disturbances as well as native habitats. With land conservation, a number of landscape designs are possible. For instance, one design for large parcels would make these areas composed of multiple-utilization zones.[23] The interior zone would be road-free and managed to conserve native flora and fauna. By comparison, the perimeter would serve as a buffer that is used for multiple benefits and linked to other areas. An example would be the Tijuca Forest in Rio de Janeiro, Brazil. Large parcels can, to some extent, buffer local climatic changes and contain more individuals of a single species, thus enhancing its genetic breadth. Even these large areas, however, will not be immune to human intrusions; natural resource managers must also continually adapt to changing circumstances.

The conservation of large parcels of natural habitats brings into play debates over whether we should preserve large versus numerous small areas of native habitats. With climate change and the rapid changes brought about by urban land-use conversion as well as intensive utilization by rural populations, larger areas may be able to buffer against better than smaller sites, especially for native faunal species. Nonetheless, smaller protected areas can also play a critical role for human use by maximizing ecosystem services for water, fuel, and food to minimize intrusions into the larger areas. In addition, both large and small parcels could be used to enhance species migration across inhospitable habitats, thus facilitating species relocation.

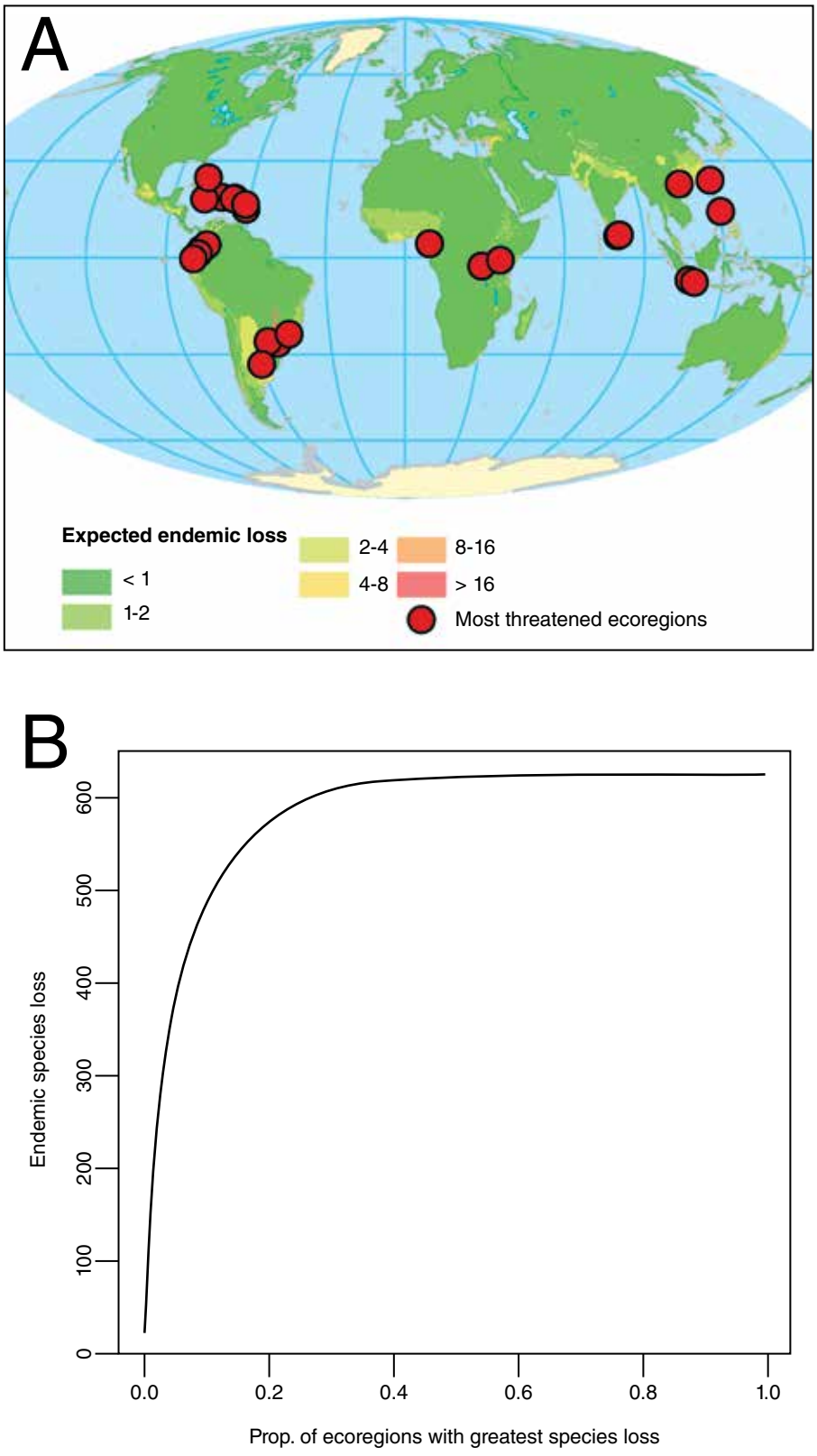
International Coordination for Urban Sustainability

Solutions to reconcile the ongoing urbanization and conservation require policies that work in harmony across scales, from local to regional to global, and across political jurisdictions. In particular, establishing effective biodiversity conservation strategies in regions that are expected to undergo significant urban expansion require coordinated efforts among multiple cities, provinces, and even countries. Such coordination, however, has been hard to achieve even among conservation bodies under existing regional and global governance mechanisms.[24] The recently formed Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES: www.ipbes.net) aims to remedy this lack of coordination by, among other things, conducting periodic sub-regional, regional, and global assessments on the state of the planet's biodiversity, its ecosystems, and the essential services they provide to society.[25] Established in April 2012, the IPBES will act as an independent intergovernmental body, much like the Intergovernmental Panel on Climate Change (IPCC) and will be

open to all member countries of the United Nations. Clearly, the impacts of urbanization on biodiversity are critical enough to be included in these assessments. In this vein, the CBO—as endorsed by the CBD—is the first ever comprehensive assessment of the interaction of cities and biodiversity and ecosystem services.

However, many biodiversity hotspots threatened by urban growth are located in developing countries, which may have limited financial resources to devote to land protection. Moreover, since the attention of municipal governments in developing countries is often understandably focused on things like providing clean drinking water and sanitation to their burgeoning urban population, biodiversity protection may not be seen as a municipal priority. However, globally, there is substantial interest in preventing massive biodiversity loss in these biodiversity hotspots that face continuing urbanization. We suggest that this spatial disconnect between those making the decisions in cities in biodiversity hotspots and those who care about the biodiversity losses can be overcome by a global effort to protect these biodiversity hotspots from further urban encroachment. This effort must include focusing conservation funding from organizations and governments in the developed world to these hotspots in the developing world.

Several biodiversity hotspots and, in some cases, protected areas, span across national borders. In such cases, challenges posed by urbanization to biodiversity conservation and ecosystem service preservation cannot solely be met by local-level solutions; they require policy responses on a broader scale, and thus call for appropriate strategies with sufficient breadth to be developed at the national and international levels. The implications of urbanization in such biodiversity hotspots and protected areas for their biodiversity and ecosystem functioning can be more accurately



Courtesy of the authors

Figure 1: Expected endemic vertebrate species lost due to urban area expansion. The number of species lost depends upon the amount of urban growth expected between 2000 and 2030, the endemic species richness, and the species area curve assumed. The 25 most threatened ecoregions are shown with red dots (A). The majority of species loss due to urbanization will be in a small fraction of ecoregions (B). See text for details.

assessed through trans-border regional cooperation between the countries involved.[26] Two examples are the Indo-Burma and Himalaya hotspots, which are undergoing rapid urbanization,[27] and span multiple jurisdictions within and among countries. There have been developments towards such cooperation between China and India in the region though obstacles remain.[28] A promising initiative of such regional cooperation involves the Mediterranean Basin hotspot, arguably the most human-modified of all hotspots. MediverCities, an initiative in the making, aims to create a network of cities focused on biodiversity around the Mediterranean Basin.[29] Though not established to address urban-related biodiversity concerns, the Association of Southeast Asian Nations (ASEAN) Centre for Biodiversity is another example of regional cooperation that can readily serve as a platform for the coordination of urbanization and biodiversity conservation in Southeast Asia.

Notwithstanding uncertainties inevitable in any study on the future trends, it is increasingly clear that urbanization will continue to impact biodiversity and ecosystem services around the world. It is also clear that most of these impacts will take place in the developing world with limited means to address each and every challenge urbanization presents. We put forward three potential solutions to address this challenge: (1) treating ecosystem services as an urban utility; (2) local efforts to protect biodiversity hotspots under urbanization pressure; and (3) international coordination for urban sustainability. Each of these solutions is currently being experimented with in different locations with varying levels of success. It is clear that as urbanization increases, however, urban decision makers and citizens will need to not only re-connect to nature, but adopt policies to integrate nature into our daily lives. S

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Preserving large parcels of native habitats in areas under urban pressure would protect regional biodiversity. An existing example is the Tijuca Forest in Rio de Janeiro, Brazil.

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