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News

Eco-metropolis: Re-interpreting ecological conservation in the context of innovative agglomeration

The metropolitan area has long been an important conceptual medium for issues in the study of innovation economics and ecological conservation. Much scholarship on ecological conservation represents a departure from the thought process that urban development is characterized by linear spatial expansion; innovation economists have re-identified contemporary urban development as innovative agglomeration, which generally challenges a fundamental understanding of urban studies. We call for a paradigm shift, proposing an *eco-metropolis* approach to contextualize ecological conservation in innovative agglomeration and discussing how the departure from spatial expansion to innovative agglomeration interacts with other issues like infrastructure, innovation, and financing. We aim to draw attention to the agglomeration effect in public and private spheres and expand this interdisciplinary discussion on coordinating conservation under new circumstances. Ecological conservation and technological innovation are connected in important ways: when big urban centers drive economic growth and innovation, when green technologies draw significant attention during debates on industrial policy and human-environmental relations, and when technological innovations sustain economic growth, urbanization, and ecological conservation, such convening of multiple goals and drives becomes amplified, complex, and important.

1. Innovative agglomeration as a trend for urban development

Recent studies in urban and innovative economics situate innovation in the context of cities. Departing from Schumpeter's account of disruptive innovation as a key for technological change to drive economic growth, Aghion and Howitt offer a deeper explanation of the mechanism of disruptive innovation, arguing that greater input of talents as an innovative factor would increase the success rate of innovation [1]. Studies have focused on the agglomeration of innovative factors to explore various approaches to encourage innovation. The agglomeration of innovative factors, which encompass industrial clusters and human capital accumulations, among others, allows the inclusion of spatiality in discussions of innovation in a broader sense. Big cities, characterized by their concentration of industry, talent, and knowledge and the complexity and intersection of knowledge yielded from such concentration, thus become the primary, if not the only, spatial medium for disruptive innovation.

Economists have provided robust evidence that innovation is an urban phenomenon. In 1990–2009, of all patent applications filed in the United States, 94% were produced in metropolitan areas, and the ten most productive cities in patent applications took up 48% of all patents in this period [2]. The greater likelihood of innovation in urban areas is attributed to the expansion of the agglomerative economy, which is the foundation for economic performance and innovative capacity of cities. One outstanding example is the work by Rosenthal and Strange on agglomeration effects at different levels of spatial aggregation, including the regional, metropolitan, and neighborhood scales. By examining industrial clusters in the northeastern area of the United States, the authors show that, on the regional scale in the northeastern United States, agglomeration of talents in manufacturing industries yields as many as 1200 workers in a two-mile radius. In contrast, on the metropolitan scale of the city of New York, in the manufacturing area of Manhattan that spans about three to five miles, the density of workers in each mile radius exceeds 2400, two times that on the regional scale, meaning metropolitan areas concentrate higher density of innovative production in much smaller spatial capacity [3]. Others have proved that such innovation density applies to more cities in various industries. For instance, Enrico Moretti empirically analyzes why innovation productivity in high-tech sectors like computer science, semiconductors, and biology are concentrated in metropolitan areas and finds that geographical agglomeration results in significant productivity gains [4]. Pierre-Alexandre Balland and others show that innovation concentrates disproportionately in metropolitan areas across the United States, specifically in New York-Boston and the San Francisco Bay Area, proving that as the economic activities become more complex — meaning that it involves higher density of technology, the agglomeration effect becomes more significant [5].

In conclusion, the expansion of agglomerative economy has federated technological innovation, economic growth, and urban development. When growth and innovation become increasingly urban, policy-making and public spending follow suit. This creates resounding advances for urban development, with new challenges and opportunities. For public initiatives to take effect in the urban area, including ecological conservation, they must be contextualized with this perspective.

2. Contextualizing ecological conservation in innovative agglomeration

Imminent responses to the aforementioned trend are apparent

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in the “Building a World-class Eco-metropolis” seminar in Shenzhen, hosted by the Paulson Institute and Shenzhen Foundation for International Exchange and Cooperation on May 30th, 2023. Anointed as the “Biodiversity Charming City” by ICLEI-Local Governments for Sustainability during the COP15 meeting, Shenzhen showcases what an eco-metropolis approach to governance may look like in reality. This seminar footnotes Shenzhen's effort in coordinating an agglomerated economy to support ecological conservation and situates its reflections in the context of global eco-governance.

Applied in the study of urban and innovation economics, spatial agglomeration is seen globally to provide ways to innovative agglomeration, in which urban development is no longer characterized solely by the linear expansion — often unchecked — around a singular or several satellite “city centers”. Instead, the morphology of urban development is increasingly oriented towards the agglomeration of innovative factors, signaling new dynamics and mechanisms for urbanization, thus putting biodiversity maximization and ecological conservation more generally in a different context. This shifting paradigm calls for reflection on many key issues in ecological conservation, as discussed in the conference.

Building an eco-metropolis involves more than natural infrastructure. The spatial aggregation of the urban-rural binary follows the premise that urban area is limited in size and that natural infrastructure, defined as “the network of land and water bodies that provide ecosystem services for human populations” [6], is key to securing non-polluted water for urban residents and protecting biodiversity for a region. While this remains true today, the capacity of natural infrastructure is increasingly challenged under today's urbanization, when innovative agglomeration concentrates population and industries into small urban spaces to achieve higher productivity for innovation. As shown above, such density is expected to grow even higher, rendering natural infrastructure's capacity for ecological conservation non-sustainable. Therefore, a new *eco-metropolis* approach is called for to contextualize ecological conservation in the new paradigm of innovative agglomeration.

2.1. Eco-metropolis: beyond natural infrastructure

John MacKinnon's study, as presented in the conference, reveals that biodiversity conservation should not be strictly demarcated by the proximity to the city center. Nor should ecological reserves and green lands be allocated around the city in simplistic terms. Using the example of the Beijing Olympics, he argues for the absence of ecological division between urban and rural and illustrates how urban planning with an improved understanding of ecological conservation can achieve both cost-efficiency and environmental improvement in urban life.

MacKinnon sets an important tone with regard to natural infrastructure: an eco-metropolis is not simply about more green land and greater intensity in biodiversity; it is about building a city in which the practice and mentality of conservation is organically integrated into city planning. Much previous infrastructure construction and development, seen on the global scale but particularly in China, has contributed to unchecked spatial expansion of urban built areas and diminishing urban ecological and green space. An *eco-metropolis* approach emphasizes integrating conservation both as a concept and a practice into urban planning in coordination with innovative agglomeration. The ecological performance of an eco-metropolis ought not to be assessed solely in terms of the density of natural infrastructure or the monitoring of air quality; in practice, this linear assessment would often encourage the administration to pursue statistical targets at the expense of growth and leave other important conservation goals unattended to because they are difficult to be parametrized for policy implementation. Instead, it should be about re-engineering an urban life that tolerates a high density of innovative factors, treats agglomeration as a premise, and harnesses an ecology that is friendly to agglomerated urbanization. It shouldn't always require more spaces in the urban area to be converted into green land and water bodies; it asks for better ways to let nature do its work. MacKinnon introduces concrete and cost-efficient ways to achieve this, from introducing eco-gardens as suitable breeding habitats, rethinking “pests” as an indispensable part of the ecosystem to reducing ecologically inappropriate approaches for the sake of artificial aesthetics of the urban landscape. As he rightfully remarks, “Nature does it best, and nature does it for free.” An eco-metropolis allows “Nature” into the urban planning process as a designer in both ecological and aesthetic sense.

2.2. Eco-metropolis enhanced by technological innovation

Ecological conservation does not constitute a dichotomy in which innovation and urban expansion jeopardize the integrity of ecological systems. On the contrary, current scholarship shows that conservation under the *eco-metropolis* approach needs technological innovation to imagine ways for ecology to coexist in an agglomerated urban life. Andrew Farnsworth's presentation provides an example of a productive intersection between technological innovation and ecological conservation by introducing a bird migration monitoring tool developed as part of the BirdCast project in a consortium of the Cornell Lab of Ornithology, Colorado State University, and the University of Massachusetts Amherst. Using weather surveillance radars to survey biological activities in the atmosphere, this research consortium produced quantitative analyses based on first principles of migration ecology, statistics, and machine learning that highlight bird migration signals distinct from meteorological phenomena. Moreover, these analyses avail the 30-year radar data archive, creating a longitudinal analysis of migration traffic, direction, speed, and altitude. One study from this group, elucidated by Dokter et al., in 2018, allows researchers to assess continental biomass flows systematically, which presents opportunities for researchers to identify approaches to improve survivorship for birds in non-breeding habitats like metropolitan areas [7]. Another study — by Horton et al. (2019) — defines the risks of exposure to human activities, specifically light pollution, in the largest 125 cities in the contiguous United States, again highlighting an opportunity for understanding, action, conservation, and change. According to Farnsworth and his team of collaborators and colleagues, one viable way to improve things is to look at the issue of light pollution in cities. Indoor and outdoor lighting in cities presents a major hazard for nocturnally migrating birds — light attracts and disorients birds and causes collisions directly and indirectly. If such light pollution from human activities in urban centers remains unchecked, for example, in the utility of indoor office illumination, the mortality rate for birds could be 76 % higher in the worst-case scenario [8]. Bird migration research in these peer-reviewed studies highlights some simple solutions to protecting birds and, as such, enhancing biodiversity in urban and built settings — reducing the intensity of urban lights with a strategically designed lights-off schedule that is supported and enacted based on a data-driven approach, birds' migration behaviors can proceed in more typical manners as humans adjust their activities to allow such behaviors to return to these states [9].

These studies provide a sound example for reflection on the *eco-metropolis* approach to ecological conservation. Biodiversity conservation, namely bird migrations, can be achieved in metropolitan areas simply by working out a lights-out schedule that is informed and attentive to bird migration patterns. The *eco-metropolis* approach aims to find smart ways empowered by technological

innovation to coexist with the ecosystem. The point is not to overlook the cost-efficiency ratio or to slow the agglomeration process but to be informed and attentive to the ecosystem. Empowered by innovation, conservation could be cost-efficient and simple in an agglomerated metropolis.

On a broader scale, innovation focuses on the voices of various technological fields and draws public attention towards new conservation practices. In light of putting conservation into effort, sustaining an informed public debate is critical. Departing from the example above, aeroecology stands alone as a study of biological activity in the airspace above our planet, but it also integrates completely, spanning a diverse array of domains that include biology, meteorology, physics, machine learning, human behavior, and technology [10]. This discipline is already informing conservation at local and regional scales. Increasingly, these scales are expanding and highlighting the potential for continental and hemispheric impacts. Two laws were ratified in 2022 in New York City regarding light pollution reduction. Their passage was driven by bird migration science provided in testimony during legislative sessions and referenced specifically in the city's local laws [11]. Broadcast television channel 10 Tampa Bay reported numerous cases of bird migration as detected in weather, with broadcast meteorologists on live television highlighting the power of monitoring birds and their importance for conservation. Moreover, the BirdCast website attracted nearly 500,000 visitors last year, and recent migration-focused Cornell Lab of Ornithology webinars saw more than 2500 people sign up for a migration webinar. The extensive reach and engagement of this project have also been documented on social media, reaching over 4 million people since June 1st, 2022 (see: https://lookerstudio.google.com/u/0/reporting/c0252049-7789-455d-bc91-cb81958c6ad8/page/ctMvB). As this case study shows, it is equally important for innovators to inform the public debates to coordinate conservation initiatives.

2.3. Eco-metropolis financed by agglomeration economy

One of the main findings in Balland's work is that the economy's complexity is positively correlated to spatial agglomeration. In his case study on the communication and digital sector, when technological innovation achieves fast growth, highly educated talents in Science, Technology, Engineering, and Mathematics (STEM) fields continue to centralize in metropolitan areas. Simultaneously, service industries tied to the communication and digital sector also concentrate in metropolitan areas. The service industry centralization results in higher density and complexity in the division of labor, amplifying the support of high-end manufacturing and complex knowledge spillovers [5].

Balland's finding speaks to a general effect of the agglomeration economy, and one of the service industries that tend to centralize in metropolitan areas alongside the agglomeration trend is the financial sector. Innovative agglomeration creates a more vibrant urban economy, yielding more companies, more private capital available for investment, and more sophisticated financial services. To this extent, Eric Swanson's presentation at the conference further shows that under the vibrant agglomeration economy, there can be more possibilities for private capital to finance and join ecological conservation instead of leaving conservation entirely up to public spending that, more often than it should, finds itself inadequate and belated for initiatives like this. According to the Paulson Institute report on global biodiversity conservation, “as of 2019, current spending on biodiversity conservation is between USD 124 billion and USD 143 billion per year, against a total estimated biodiversity protection need of between USD 722 billion and USD 967 billion per year. This leaves a current biodiversity financing gap of between USD 598 billion and USD 824 billion per year.” [6].

Based on the Paulson Institute report, Swanson's presentation overviewed how the private sector can be pivotal in financing and supporting ecological conservation. The presentation also delved into the various financial and policy mechanisms in which the public and the private sectors shall coordinate to issue joint efforts towards this direction. Swanson introduces China's Mangrove Bond Concept as a case study to showcase what such public-private coordination could look like. Under the national goal of cultivating 19,000 ha of mangrove by 2025, the Chinese government plans to issue CNY 4.5–9 billion worth of bonds for mangrove conservation. In conjunction with this, it would also allocate smaller regional bonds for provinces and cities, particularly those designated for water and wetland conservation. While the government assumes the responsibility of issuing the bond and managing the restoration of mangroves, several commercial banks have expressed interest in managing the bond issuance, and non-governmental partners are expected to play a vital role in implementing conservation initiatives.

In a broader sense, public-private coordination in financing ecological conservation is a powerful but complex system that involves many challenges. As shown in the original report, the government must institute the right regulatory environment, smart incentives, and market structure for the private sector to channel funding into conservation initiatives. Closing the financing gap for conservation is possible, but it would require a greater extent of public-private coordination than most other industrial policies. It would take both political leadership and a dynamic market economy to ensure that “Nature” is appropriately valued. The kind of top-down leadership and market economy can and does exist in the current agglomerated metropolis, making it the key vehicle to manifest such coordination.

3. Concluding remarks

In this correspondence, we bring up the concept of *eco-metropolis* as an approach to ecological conservation. Departing from the recent studies of urban and innovation economics on agglomeration, we argued that paradigms of ecological conservation should shift towards agglomerated metropolitan areas. Distinguished from the demarcation of urban-rural dichotomy, an *eco-metropolis* approach to conservation should go beyond building natural infrastructure and embrace both the robust technological innovation and the private sector financing that can only be found in metropolitan areas. Agglomeration certainly poses new challenges and opportunities for conservation. Researchers, governmental bodies, and entrepreneurs need to look for coordination in making informed eco-attentive decisions.

Declaration of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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