11 Ecology in the Urban Century: Power, Place, and the Abstraction of Nature

James Evans

Humans are now an urbanized species, with over half of the global population living in cities—a proportion forecast by the United Nations to rise to 75 percent by 2050. At the same time, the Intergovernmental Panel on Climate Change has claimed with 95 percent certainty that climate change is being driven by human activities, prompting scientists to herald the advent of the Anthropocene, a new era in which humans have become the main drivers of environmental change. The challenge of securing a sustainable global future has become a question of taming the environmental impacts of cities. Within this context, ecology has emerged as a technology of governance, promising a way to manage human relations with nature in more sustainable ways. As in the nineteenth century, when crusading sanitarians and engineers tamed death and disease with modern infrastructures supplying water and energy, so in the current urban century, urban ecology is being herlded as being capable of arresting environmental destruction with closed loop systems and adaptive management. Ecology is the scientific assumption lying behind every rhetorical "eco" preface, providing a compass to navigate safe passage to the promised land of sustainability.

The irony of this redemptive role is that ecology originated as a discipline not primarily concerned with people. Environmental historians have offered compelling accounts of how concepts like *succession* and *ecosystems* embody the specific characteristics of the rural and wilderness areas in which early ecologists worked.[1] Sometimes the parallels are literal: the idea of "pioneer" plant communities was derived from research conducted on the vast plains of the Midwest in early twentieth-century America, across which human pioneers had moved barely a century earlier. One particularly stubborn consequence of this has been the hardwiring of cultural preferences for "wild" environments into the scientific models of

ecology itself, which tend to value equilibrium systems.[2] When we come to human-dominated systems this has made life difficult. Urbanization results in extremely disturbed systems, where the creative destruction wrought by capitalism in the form of constant development and redevelopment creates an inherently dynamic landscape. In ecological terms cities make little sense, they fit none of the models, and tend to be cast (traditionally at least) as a form of "anti-life."[3]

Until the 1990s the ecological study of cities was largely confined to a handful of German ecologists trapped on the urban island of West Berlin and to the coffee table publications of a few curious naturalists. The Rio Earth Conference in 1992 changed this dramatically, prompting ecologists to call for a "new ecological paradigm" that places humans within ecosystems rather than separate from them.[4] In this era of urbanization,[5] applying systems ecology to cities to develop technologies of ecological governance holds great appeal as it suggests that they are coherent, knowable, and manageable entities.[6] The prize of managing urban ecosystems more sustainably is substantial: cities consume 70 percent of natural resources and produce 80 percent or carbon emissions. They are home to a growing majority of the world's inhabitants and must increasingly adapt to the consequences of a changing climate. No longer simply a curiosity, urban ecology is supposed to facilitate low carbon transitions and help city dwellers adapt to rising temperatures and increasingly extreme weather events. As if that weren't enough, its proponents highlight significant physical and mental health benefits and property price uplift that accrue from proximity to nature.

Urban ecology has gone from subdisciplinary backwater to hot topic, viewed as a key disciplinary ingredient in the quest for sustainability. But perhaps more than any other science, ecology reflects the places in which it is practiced. This chapter explores how urban ecology dovetails with the rise of ecological governance and the suite of ecological planning and policy tools like ecosystem services, green infrastructure, and resilience that accompany it. These highly mobile global policy discourses increasingly frame debates over urban futures, but are characterized by a series of tensions that hamper their application. This chapter critically examines these tools and the forms of urban ecological research through which they are practised and produced. It identifies a gap between the discursive power of urban ecological governance and the relatively modest transformations wrought in cities on the ground and discusses some of the implications of this gap.

The Rise of Ecological Governance

In 2006 the United Kingdom's Department for Environment, Food and Rural Affairs held a meeting in central London to review its research program to establish an evidence base for the adoption of ecosystem services as the foundation for national policymaking.[7] The ecosystem services approach is typical of an increasingly influential set of ecological policy tools that have emerged in response to ecological crisis. The meeting was memorable not for the bad coffee or for the sterile conference room that seemed at odds with the magnificent Georgian building in which it was housed, but for an exchange between a well-known professor and the senior government official who up until that point had sat in pinstriped silence observing proceedings, content to let his minions remind the academic audience of the desired outcomes from the work. The professor stood up and proclaimed that the ecosystem services approach was unable to provide the kind of comprehensive basis for decision-making that was sought because of the difficulties in determining the subjective values of different environmental goods to different people in different places. His outburst was preceded by a circular discussion about the policy implications of valuing a single plane tree in London at one million pounds on the basis of its positive impact on house prices, as against a Scottish pine forest that is rarely used by humans and is by comparison relatively worthless.[8] Riled into action, the senior government official retorted that the department had already decided to use the ecosystem service approach as the basis for its policymaking. It was their job to "make it work"; that was what they were being paid for.

The episode sticks in the mind as an example of the all-too obvious ways in which power sometimes shapes the types of knowledge that gain wider political traction, in this case through the demand from policymakers for ecologically informed tools to better govern society's relations with nature. But the "just make it work" line belies a disjuncture between the promise of ecosystem services as a policy approach and its realities as a scientific planning tool. Alongside ecosystem services, green infrastructure and resilience have emerged in the last fifteen years as a familiar conceptual lexicon for those working in urban environmental planning. All three offer an idealized and universally applicable form of ecological governance, but are based on highly abstract and stylized models of nature (and the relation of society to it).

Take green infrastructure, for example. Originating as a conservation tool for understanding how habitat patches maintain biodiversity in landscapes fragmented by human land uses (like roads, housing, and so on), it has developed into a fully fledged planning concept that is used to capture the multiple functions of green space, for example absorbing rainfall while also providing recreational space. The idea of infrastructure offers a proactive discourse of green space as "doing something" useful for society, but further it suggests a narrative of necessity.[9] Infrastructure is something that we have to have and fits neatly with established approaches to planning, which are familiar with surveying, analyzing, and planning so-called "grey" infrastructures like roads and sewers. In *The Wealth of Nations* Adam Smith assigns the task of constructing and maintaining infrastructure to "the sovereign," who is responsible for "erecting and maintaining certain public works and certain public institutions, which it can never be the interest of any individual or small number of individuals to erect and maintain."[10] Infrastructure is a collective good and as such implies the need for a collective approach.

The ecosystem service approach is often used to value the services provided by various pieces of green infrastructure, although the two approaches differ critically between advocating individual payment for services and simply using the value of services to justify collective investment in the service provider. Lele's memorable analogy is the difference between paying for a hot dog and investing in a hot dog stand, with the inference that it makes little sense to talk of "investing" in a hot dog.[11] Green infrastructure has been conceived of as a form of ecological modernization that promises a win-win approach to planning whereby environmental improvements lead to social and economic benefits. As Maarten Hajer says, "talking about nature as infrastructure creates a link to the importance of nature as amenity (which is essentially a functional idea), but also allows for an engineering approach to nature. If nature is seen as infrastructure, we can also make a move from conservation to the actual creation of new (and better?) nature."[12] Green infrastructure has become firmly entrenched in actual planning practice. Whereas ecosystem services have been pushed to high level policymakers through international consultants and the UN-backed Millennium Ecosystem Assessment, green infrastructure resonates at local and regional levels and propagates through nongovernmental organizations' (NGO) planning networks.[13] The paucity of critical work on green infrastructure perhaps reflects its politically benign exterior, but the idea of nature as essentially

malleable and improvable points to an underlying set of beliefs about the relations between society and the environment that warrants further attention in practice.[14]

By contrast, resilience thinking is more explicitly concerned with the relationships between society and the environment. Originating in the work of North American ecologist "Buzz" Holling, *resilience* is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks.[15] Using the example of budworm outbreaks in the spruce-fir forests of eastern Canada, Holling argued that persistent natural systems are not characterized by stability but by instability.[16] Holling's work influenced the 1999 establishment of the Resilience Alliance, an international collaboration among ecologists and ecosystem management scholars from across the Western world. This group developed the concept of the social-ecological system,[17] which applied resilience thinking to human-dominated systems. Developed in the 1990s and elaborated in two edited volumes with contributors from all over the world,[18] this approach suggested that social and ecological systems are linked through a series of physical feedback mechanisms. Knowledge about the local ecosystem is essential to the functioning of a social-ecological system and must be captured by institutions that can translate it into management practices. The idea of social-ecological systems was subsequently applied to urban contexts,[19] and it became an organizing concept for the Stockholm Resilience Centre, established in 2007.

The lexicon of urban environmental planning is astonishingly consistent. It is hard to find a conservation planning document for an urbanized region that does not use green infrastructure as its basis, justifying its value through general appeals to the ecosystem services that it provides society.[20] Resilience has found its way into numerous policy documents and often appears as a guiding principle.[21] In policy documents about regional resilience again ecosystem services are usually suggested as a way to quantify the value of different socio-ecological processes.[22] Currently these approaches tend to remain confined to conservation strategies and regional planning documents, rather than being deployed as the basis for mainstream decision-making (which remains dominated by economists). In practice the rhetoric is defeated by the difficulties of governing something as complex as a city as an ecosystem; for example, there is simply insufficient environmental data to do so, and traditional institutional arrangements militate against

large-scale landscape interventions. Even a coherent conceptual understanding is lacking—the striking observation from a cursory analysis of the policy and academic literature is that research teams tend to work with one approach.[23] An analysis of keywords listed in paper titles and abstracts in the fields of ecosystem services, green infrastructure, and urban resilience indicates that 13 percent of green infrastructure papers and 21 percent of resilience papers mention ecosystem services, whereas only 10 percent of ecosystem service papers mention resilience. This drops to just 2 percent of ecosystem service papers mentioning green infrastructure. The relationship between resilience and green infrastructure is weakest, with 2 percent of resilience papers focusing on green infrastructure and 4 percent of green infrastructure papers focusing on resilience.[24]

Despite this unevenness, ecological governance holds strong appeal for policymakers looking for a more scientific basis for urban environmental management. The next section considers a large-scale field experiment underway in Baltimore, which is notable for bringing these three ecological approaches together to study the city as a coherent system. It is perhaps unique in being the place where the model of ecologically based governance is being deployed and tested most seriously, and offers a window onto both the potential and the limits of urban ecology to reshape cities.

Baltimore: Ecological Laboratory for the Urban Century

Funded by the United States National Science Foundation from 1980 up to the current day, the Long Term Ecological Research (LTER) program represents the flagship environmental science research programme in the United States, comprising twenty-four ecologically diverse sites, an annual direct budget of almost $20 million, and approximately 1,100 scientists and research students. Two metropolises (Phoenix and Baltimore) were added to their portfolio of sites in 1997, and both projects were granted second-phase funding in 2004. Led by influential urban ecologists Nancy Grimm at Arizona State University and Steward Pickett at Baltimore, respectively, both research teams adopted a large-scale ecosystems approach, both sold themselves on the potential to use their cities as field laboratories, and both emphasized the virtues of a comparative approach between cities. The project married shifting scientific funding priorities for large-scale applied work capable of producing scalable findings with the needs of two

cities (Baltimore and Phoenix) under pressure to deal with growing environmental externalities in more efficient ways. This section focuses on the Baltimore research, which has established the city as a laboratory for the staging of large scale socio-ecological experiments that aim to understand and manage the dynamic processes that give rise to the urban landscape.

Ecologists in Baltimore have been seeking to understand how the city's ecosystems change over time by studying the interaction of a range of factors, from hydrology and biodiversity to patch dynamics and soil studies. The Baltimore project states that "its goal is to develop a thoroughgoing understanding of metropolitan Baltimore as an ecological system, and to share this understanding with educators and decision makers."[25] Baltimore represents the cutting edge of ecological work that seeks to move from seeing human activity purely as an external factor causing disturbance to ecosystems to being a driver and limiter of ecological processes in its own right. The overall project is framed by the concept of resilience, conceiving Baltimore as a linked socio-ecological system. Taking an adaptive approach, the project involves staging experiments by altering the green infrastructure in parts of the city to enhance key ecosystem services.

At the core of the work, in addition to the $20 million annual budget, is a nearly $1 billion, six-year experimental manipulation of nitrogen exports in the watershed to improve drainage infrastructure. Like many cities with a primarily industrial heritage, Baltimore is characterized by aging infrastructure and a decrepit sanitary sewer system, much of which is over one hundred years old. Leaks and gradual seepage, accompanied by the occasional yet spectacular sewage fountain, have caused declining water quality, and in 2002 eventually led to a legal action from the US Environmental Protection Agency under the Clean Water Act. In addition to paying $600,000 in fines stipulated in the resulting agreement, city officials had to agree to invest $900 million in sewer upgrades. The wider Baltimore County settled on a similar agreement in reparation for over six hundred spills between 1997 and 2005, providing further money for environment projects to keep nitrogen and phosphorus out of the Chesapeake Bay. These federal mandates opened up opportunities for ecologists to work closely with urban planners and administrators to undertake experimental planting to manage runoff using green infrastructure.

The most intense experiments took place in Watershed 263, a 930-acre area spread over eleven densely populated neighborhoods of west and

southwest Baltimore, which drains to Baltimore Harbor's tidal estuary of the Middle Branch of the Patapsco River, near the mouth of Gwynns Falls. Over three quarters of the area of this entirely urbanized watershed, with its mix of residential, commercial, industrial, institutional, and open-space uses as well as roads, parking lots, and vacant or abandoned properties, is impervious to water. In terms of infrastructure, it includes thirteen miles of storm drains that are over three feet in diameter and that converge into one twenty-five-foot diameter outfall. Public open space associated with schools and parks accounts for approximately 30 percent of the watershed, with trees shading only about 5.5 percent of the area compared to 17.32 percent for the city as a whole. The area is economically depressed and predominantly African American, and the Baltimore LTER and its focus on technologically mediated management have echoes of World Bank–style development initiatives, lending a normative liberal politics to the selection of the Gwynn Falls area as one in need of improvement.

Terming it a "natural experiment," the research team undertook extensive greening to increase canopy cover and decrease impervious surfaces especially on vacant and public land. The project team hardwired monitoring equipment into the green infrastructure to provide a basis for adaptive management, aiming to enhance the reduction of pollution through intervening in specific areas and adapting subsequent policy and regulation in response to the results of infrastructure improvements. If experimenting in situ produces more accurate scientific models,[26] then the idea was that "urban ecologists could use designed experiments as a management tool to predict, monitor, and regulate urban ecological patterns and processes."[27] These interventions are monitored in terms of their effects on pollution and runoff, while long-term species surveys of different plots across the city determine the relationship between patch origin, size, adjacent land-use type, and species composition and abundance.

This long-running ecological research project has led attempts to understand the city as an urban socio-ecological system in order to enhance its resilience, building upon the work of the US Long Term Ecological Research network of which the project is part.[28] Accordingly the project is also researching what it calls "social ecology," or the capacity of people to either damage or enhance the ecological functioning of the urban landscape. Although the concept of the social-ecological system emerged from work conducted at the Stockholm Resilience Centre,[29] it has been used by the

Baltimore project team to understand how the urban mosaic functions at the scale of the city. This point is picked up in Pickett and colleagues' review of urban ecological systems,[30] which argues that urban ecological planning tends to be based on principles and cases rather than data and an understanding of processes. The problem identified is that the former approaches struggle to manage the kinds of "novel ecological circumstances" that cities will experience under a rapidly changing climate. This argument is reminiscent of debates from the first half of the twentieth century over the ability of ecology to generate scientifically valid knowledge about causal processes, given its field-based methods and emphasis on the identification of patterns.[31]

The Baltimore project uses computer modeling to understand how different variables affect one another in the city, and seeks to abstract from the specificities of Baltimore through the idea of *syndromes*, or commonly occurring sets of urban environmental characteristics that have predictable functions. The inference is that cities will then be susceptible to standardized management interventions. In capturing general sets of traits rather than a specific set of rules about function, the notion of syndromes owes more than a passing resemblance to Elinor Ostrom's diagnostic approach to Common Pool Resource Management (perhaps no coincidence as Ostrom worked with resilience scholars in her later career).[32] Within this conceptual framework the diagnosis of "symptoms" enables corrective management. The danger of viewing cities as sick patients, though, is that it reproduces the idea that urban nature is a degraded form of "real" nature, echoing the pathologies of the city—like crime and pollution—identified by the writers of sociological urban ecology in the 1970s. Of course that movement lacked any real empirical or explanatory basis, unlike the large-scale and long-term urban ecology research programs occurring in places like Baltimore, which collect large amounts of data to enable a process-based approach.

As an experimental site Baltimore has become emblematic of a specific brand of urban ecology that seeks to meet the demand for data-driven technologies of conservation to underpin sustainable urban management. That said, how generalizable the findings about urban resilience from Baltimore are remains an "open question for now."[33] Baltimore's modern history of deindustrialisation seems quite extreme, compared for example to Stockholm or an East Asian city. At a deeper level, the kind of complex adaptive systems that inform resilience thinking purports to be general and universal,

and yet enrolls researchers into the specific systems that they study. In Baltimore the city is transformed from the object into the subject of research; it is a system or laboratory that is simultaneously altered by research as it is conducted.[34] Within this context there is no distance between scientific work and its practical application—a situation that empowers ecologists, Geographical Information System scientists, and environmental scientists not only to engage with but also to stand in for urban planners and policymakers who are traditionally responsible for managing the city. Seen in this light, ecological research is both an applied mission to transform nature in place and an attempt to discern and abstract a set of universally replicable rules and knowledge for use elsewhere. The next section considers these dynamics.

Place, Power, and the Abstraction of Nature

In Baltimore's Watershed 263 ecologists have directly shaped urban nature, building the indicators, designating the sites, defining what counts as desirable nature, and most importantly, installing it in the urban landscape. Ecology intervenes as a form of delegated power provided by the avoidance (or impossibility) of positive action from traditional urban actors. But while the Gwynn Falls study demonstrates the power of ecological perspectives to shape the urban landscape, it simultaneously highlights the inability of ecological science and policy tools to address the pressing social and spatial rifts that characterize contemporary cities. What does monitoring of nutrient loading and urban resilience have to say about massive unemployment? It would be difficult to imagine a scenario in which someone watches David Simon's television series *The Wire*, set amid the poverty and corruption of West Baltimore, and concludes: "You know what Baltimore could really use? A multimillion-dollar investment in monitoring, research and experimentation with nutrient loading in its urban streams and wastewater system."[35] In this way, such research shares much with other technocratic urban governing techniques, ranging from sustainable development projects to so-called Smart Cities, which are disconnected from everyday life and the wider political and economic structures that shape it.

This disconnect matters on the ground as ecological tools empower some actors and disempower others.[36] Green infrastructure has been promoted by and is enacted largely by landscape architects, planners, and

conservationists through a managerial approach. Putting ecosystem services into practice requires different skill sets, ones that empower economists, social scientists, and psychologists to discern financial values from quantitative and qualitative datasets and favoring policymakers and planners with the ability to understand and interpret these kinds of knowledge. Resilience and socio-ecological systems privilege the ecologist, albeit one who can link socio-ecological flows to financial and economic imperatives.[37] Within the technocracy of ecological governance each policy tool empowers subtly distinct groups of actors and types of knowledge. Just as the emergence of the sanitarian city in the nineteenth century required a new cadre of urban planners, engineers, and public health experts, so the shift from the sanitarian to the sustainable city involves a renegotiation of professional roles. The danger of this is that it displaces local voices and actors from the arena of urban transformation.

The adoption of conceptual frames like resilience reflects a desire to lend extra scientific credibility to urban governance, but gives rise to an exertion of power without any formal power being attributed. As any practising urban ecologist will attest, ecologists and their interventions play only a very modest role in directly transforming the cities in which they work. The greater effects of their work are to reproduce global discourses of urban ecological governance and the promise of systematic and generalizable knowledge through scientific knowledge production. Ecologists must first *extract* knowledge from cities through intensive, long-term field studies, if they are to subsequently *abstract* it as a generalized body of urban ecological knowledge to sustain the universal approaches of ecological governance. It is precisely the impossibility of ever collecting perfectly representative data and the prohibitive costs of collecting comprehensive data for every city that necessitate the abstraction of general principles for urban governance. Baltimore is the place in which ecologists are trying to explain the trademark functions of urban ecology, translating field studies into generalizable principles of the kind that can underpin the scientific management of the sustainable city.

The inherent tension between ecology as a field science reliant upon particular places and its urge to establish principles explains the slippage when specific approaches are rolled out as general fixes. For example, Stephanie Pincetl's critique of the million-tree initiative to plant large numbers of trees in several major US cities suggests that the ecological services provided

by different species in different places vary hugely and are poorly understood. A type of tree that sequesters carbon in the midwestern climate of Chicago may do nothing in Los Angeles.[38] The assumed ecological benefits from widely regarded "good policies," like simply planting lots of trees, are largely a matter of faith. Resilience represents a discursive ecological policy tool, which frames systemic approaches within a model of how society functions. As an umbrella goal for cities and regions it is hard to argue with, but what it means on the ground as a governance tool at the local level is less clear. Its success in penetrating national and international policy networks stands in contrast to the difficulties of implementing it as a meaningful basis for decision-making in local and regional contexts.[39]

Of course the tendency of environmental discourse to trade in global claims, which assume singular conceptions of citizenship and place, is not new. Talking about the emergence of global climate science in the 1990s, Jasanoff and Wynne argue that its establishment involved "not only the international coordination of assessment and policies but also the difficult task of harmonization at the cognitive level."[40] By "cognitive harmonization" they mean the processes by which ways of defining, conceptualizing, and measuring objects of research achieve general acceptance among scientists, funders, and policymakers. Environmentalism has evolved through a series of acceptances that goes something like this: global environment = global environmental problems = global environmental solutions, with each stage corresponding roughly to the 1960/1970s, 1980s/1990s, and 2000/2010s, respectively. The Future Earth program provides a recent example. Established in 2012 by the International Council for Science, an NGO based in Paris, this ten-year international research initiative aims to develop the knowledge for responding effectively to the risks and opportunities of global environmental change and to support the shift toward global sustainability. Mimicking the International Panel for Climate Change, its goal is to mobilize thousands of scientists from around the world to establish a coherent platform from which to engage high-level policymakers and other stakeholders "to provide sustainability options and solutions in the wake of Rio+20 [the United Nations Conference on Sustainable Development, 2012]." Global environmental science since the turn of the millennium has created an industry in global solutions, of which Future Earth reflects a recent and extreme version. This cognitive

harmonization is now extended to the management of cities as well. The rational and data-centric approach of this brand of urban ecology shares much with the technocentric discourse of Smart Cities, which increasingly holds sway as the solution to urban sustainability challenges, especially in the context of the construction of new cities in the Far East. In the urban century the boundaries between the urban and the environmental solution industries are becoming increasingly blurred.

Pressure from policymakers to simply "make it work" highlights the disjuncture between abstracted global discourse of urban nature and the embedded and messy realities of ecological research underpinning them. This deficit of scientific understanding is of course cast as a solvable problem, discussed in terms reminiscent of the arguments put forward by climate modelers in the 1990s whereby more money to do more research that will collect more data to produce better models will fix the problem. Ecological governance here runs aground on a familiar shore: the inherent specificity of environmental processes in different places at different times. What is interesting, and it formed the starting point for this chapter, is the way in which urban ecological approaches have spread so rapidly, becoming entrenched in mainstream global discourse (and funding priorities) in spite of their inherent difficulties.

Conclusions: (Dis)Placing Ecology

Almost without anyone noticing, urban ecology has become a foundational ingredient of governance in the Anthropocene. Dovetailing neatly with other technocentric approaches like Smart Cities, technologies of ecological governance are increasingly promoted as approaches to urban management. The appetite of policymakers, funding bodies, and planners for ecologically informed decision-making tools has grown in tandem with the emergence of an increasingly influential set of research institutes and NGO networks that promote different approaches around the world. The growing rhetoric of global solutions finds expression in an increasingly complex mixture of approaches on the ground, nourished by a growing reliance on long-term and large-scale scientific research. There is clearly value in understanding the processes and practices of knowledge generation and translation that underpin urban ecological governance. For example, how do

ecological governance models originate and circulate through research and consultancy networks? The knowledge produced by ecological research is "placed" in the sense that it is generated through intensive, long-term field experiments, but it must subsequently be displaced through processes of abstraction that allow it to move around the world as a basis for ecologically informed planning. To study such things means being attentive to the actual practices and concepts of ecologists through which "truth" is squeezed out of field sites.[41]

Initiatives like Future Earth and approaches like resilience resonate with the dream of rational management that underpins the Modernist project, but ecology is an inherently field-based science that resists generalizations of the kind required by scientific management. As Holling stated twenty years ago, "Knowledge of the system we deal with is always incomplete. Surprise is inevitable. Not only is the science incomplete, the system itself is a moving target."[42] Statements like this are almost mystical in their simultaneous recognition and simplification of complexity within an over-arching theory of change, but are typical of what we might call "ecological gurus" who populate an emerging cabal of policy-focused global scientists. What Ernstson and Lewis call the "alchemy of transformation" subsumes geographical difference within a one-size-fits all understanding of how change takes place over time.[43] Here the abstractive urge reduces space to time, subsuming local ecologies under standardized tools and techniques. Politically, abstraction privileges scientific forms of knowledge as the basis for decision-making, thereby insinuating a democratic deficit within current models of urban nature.[44] Practically, the lack of executive power afforded to ecologists means that little changes on the ground anyhow. Returning to the opening anecdote, the problem with "making it work" concerns what is lost in terms of the ability to produce genuinely democratic and local urban transformations. Understanding the abstractive moments and scientific practices through which global claims intersect with local place is necessary to open up the possibility of recognizing and nourishing more multiple and nuanced ecologies. Unfortunately the obsession of national funding bodies and global scientific councils with data, process, and scalability is moving ecology away from heterogeneity rather than toward it. Whether the richness of multiple Earths can be captured by the language of systems, services, and syndromes is the question at hand.

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Notes

1. Worster 1994; Kingsland 2005.

2. Cronon 1995.

3. Sukopp 2003, p. 295.

4. Alberti et al. 2003.

5. Ljungkvist et al. 2010.

6. Ernstson et al. 2010.

7. The term "ecosystem service" refers to the delivery, provision, protection, or maintenance of goods and benefits that humans obtain from ecosystem functions (Millennium Ecosystem Assessment 2003).

8. These debates have generated much discussion and research; for example, see Bolund and Hunhammer (1999); Boyd and Banzhaf (2007); Gómez-Baggethun et al. 2010).

9. Lennon 2014.

10. Smith 1976, quoted in O'Neill 2013, p. 443.

11. Lele et al. 2013.

12. Hajer 2003, p. 106.

13. Lennon 2014.

14. Wright 2011.

15. Walker et al. 2004.

16. Budworm is usually controlled by natural predators but is occasionally responsible for major outbreaks that destroy mature fir trees. Between outbreaks the firs tend to out-compete the spruce and birch, which suffer more from crowding, producing a forest dominated by firs. But given the combination of large numbers of fir trees and a succession of dry years, budworm populations can escape the control of their predators and cause another outbreak. The outbreak ends when the budworm

population destroys so much of the fir population that it undermines its own food source and the budworm population collapses. Periodic fluctuations in the form of budworm outbreaks are essential in maintaining the budworm, its predators, and the diversity of trees in the forest.

17. Berkes and Folke (1998) characterize socio-ecological systems as coherent interacting systems of biophysical and social factors, which can be defined at different spatial, temporal, and organizational scales and which form a "dynamic, complex system with continuous adaptation." The socio-ecological systems approach suggests that social and ecological systems are linked by multiple feedbacks and display common properties, such as resilience and complexity.

18. Berkes and Folke 1998; Berkes, Colding, and Folke 2003.

19. Elmqvist et al. 2004; Ernstson et al. 2010.

20. Lennon 2014.

21. For example, ICLEI—Local Governments for Sustainability 2009.

22. Ernstson and Sörlin 2013; Lewis and Ernstson 2019.

23. Exceptions tend to be more focused on urban systems rather than scientific ecology per se (Schäffler and Swilling 2013).

24. This analysis was conducted using the Web of Science, including both scientific and social scientific publications between 1970 and 2012.

25. Pickett, Cadenasso, and Grove 2004, p. 3.

26. Cook et al. 2004, p. 467.

27. Felson and Pickett 2005, p. 555.

28. Grimm et al. 2013.

29. There is an important parallel story to be told about how researchers at the Stockholm Resilience Centre have used the city of Stockholm to develop a related conceptual understanding of the city as socio-ecological system (Henrik Ernstson, pers. comm.), as well as about the relationship between these researchers and those working as part of the LTER projects in the United States developed in the 1990s and 2000s (personal commentary Steward Pickett).

30. Pickett et al. 2011, p. 334.

31. Kohler 2002.

32. Ostrom 2007.

33. Pickett et al. 2011, p. 356.

34. Evans and Karvonen 2011.

35. I am indebted to Joshua Lewis for this observation.

36. Ernstson and Sörlin 2013.

37. Nelson 2014.

38. There is a direct analogy with electric vehicles, which are eco-friendly in California due to the high proportion of clean energy supplying the grid, but produce more carbon than conventional vehicles in Chicago due to the reliance on coal for power generation. When it comes to sustainability, place matters.

39. Resilience thinking has spread rapidly within the environmental policy arena because it promises a way to adapt to the kinds of environmental changes and uncertainty that underpin the Anthropocene (Davoudi 2012). But applying scientific theory to explain the social world is not without its problems. By internalizing crisis, resilience mirrors and reproduces more right-leaning political discourses of individuals (or communities or cities for that matter) fending for themselves in the face of crisis (Evans 2011; Turner 2013).

40. Jasanoff and Wynne 1998, p. 47.

41. See Jens Lachmund's (2013) account of the origins of the Berlin School of urban ecology for an excellent treatment of how place shapes science and vice versa.

42. Holling 1993, p. 553.

43. Ernstson and Lewis 2013. Also see Lawhon, Ernstson, and Silver (2013) for a discussion of how ecology might be "re-localized" from and through the global South.

44. Swyngedouw and Ernstson 2018.

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