

Chapter 10: Urban governance for biodiversity and ecosystem services integrity

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10.1. Introduction

It has been said that the age of empires and the nation state have past, and that we now live in an age of cities. Furthermore, it has been claimed that the battle for sustainability will be won or lost in cities. To a significant degree, sustainability outcomes therefore depend on the effectiveness of the governance regimes of cities across the world. The majority of the world population lives in cities and urban populations are large consumers of ecosystem services (Folke et al. 1997, McGranahan et al. 2005, Grimm et al. 2008) and the primary source of global environmental impacts (Bai 2007). Finding ways to better govern human-nature relations in individual cities and across the global urban system is thus paramount.

The purpose of this chapter is two fold. First, it provides a history of the emergence of an interdisciplinary global urban biodiversity and ecosystem services governance agenda. Second, because there has been no published global synthesis of the urban biodiversity and ecosystem services governance literature to date, it presents an overview of scientific material published on the challenges and opportunities associated with governing urban biodiversity and ecosystem services at the local, national, regional and global scales. The chapter concludes by discussing what is required to improve governance of urban biodiversity and ecosystem services and setting out a critical research agenda to inform future global assessments of urban biodiversity and ecosystem services with respect to governance.

Before establishing where the current interest in governance of urban biodiversity and ecosystem services emanates from it is worth clarifying the term governance, in distinction to government. Governance can be viewed as “all ‘collective action’ promoted as for public purposes, wider than the purposes of individual agents” (Healey 2007:17). This can include semi-autonomous relationships between the authorities on various levels, the civil society and private sector and its dynamics over time, with partly conflicting and overlapping agendas.

The fragmentation of the capacity of the state to influence the urban system in and of itself has been characterized as the shift from government to governance (Rhodes 1997). With this fragmentation comes the need for governments to operate in a world with a range of other actors and factors influencing outcomes (Stoker 1998). This includes recognizing the capacity of civil society (Lee 2003), how some actors have more influence than others (Healey 2007), how governments are influenced by actors and dominant agendas at other scales (Marcotullio and McGranahan 2007), how governance outcomes are shaped outside the arenas of public control, and the limits of the capacity of the present public institutions (Healey et al. 2002). Which factors influence governance and shape outcomes thus depends on the local context.

In this report we focus on both biodiversity and ecosystem services and we are interested in the ecology of cities and ecology in cities (cf. chapter 4). With such a broad scope it is worth highlighting what it is that needs governing and why the city scale is so important.

Generalization is not simple.

Although there are many shared biodiversity and ecosystems problems faced by and emanating from cities, the way in which these manifest in different cities is unique, not least because of the biome or region in which they are situated. Furthermore, each city has a distinctive cultural heritage, development history, planning tradition and social structure. Moreover, the knowledge base about the biodiversity of and in cities is uneven. Earlier chapters in this Report raised many examples of what needs governing and provided examples of how the challenges of protecting and promoting biodiversity and ecosystem service are being met by sector specialists, civil society and governments in cities across the world. This is the first global assessment with a focus on biodiversity and ecosystem governance and so the follow sections examine the emergence of the field and provide a scientific review of the published knowledge on the subject.

10.2. Understanding the historiography of urban biodiversity and ecosystem services governance

Ideas change – and this is no more true than for the work on urban biodiversity and ecological services. The fluid terrain which we are reporting on is made more complex because understandings of cities and ecological systems are both new and changing fairly

rapidly. The values underpinning how cities should be managed have developed dramatically over the last 200 years as cities themselves have grown and, as a result, the nature of the urban ecological interface is not a static field of enquiry. This report represents a significant milestone in which urbanization has finally been recognised as a necessary component of the international biodiversity governance agenda. However, this is a relatively recent development and one that still lacks adequate international take up. Of special concern is the significant portion of the urban world that lacks any meaningful locally-applicable and robust scholarship on ecosystems and biodiversity challenges and opportunities, for whom the value of new scientific research in shaping urban governance is minimal. The overlap between cities that lie in the scientific shadow and cities that are rapidly expanding and are often poorly managed is high; making the geographical expansion of the urban biodiversity and ecosystem agenda a prerequisite for global impact.

The move to greater recognition of urban biodiversity and ecosystem services within science and policy has been accompanied by increasing cross-disciplinary academic efforts and to some extent cross-sectoral professional initiatives. In this section we trace the emergence of an interdisciplinary global urban biodiversity and ecosystem services governance agenda, mindful that acceptance by many may also imply ownership by none.

10.2.1. The emergence of a global urban biodiversity and ecosystem service governance agenda

The relationship between cities and environmental degradation has long been of concern to urban dwellers. It is however more recently that the governance of cities have become directly related to global environmental change and the global environmental agenda (Rees and Wackernagel 1996).

Cities started to grow quite rapidly in Europe and North-America following the industrial revolution. Pollution became a serious issue affecting human health, but urban expansion also impacted the integrity of ecosystems (e.g. through the disruption of the biochemical cycles, Haughton and Hunter 1994). After the Second World War and a following liberalization of global trade, cities developed from having mainly local and regional impact, to becoming global drivers of environmental change (e.g. through land use change, Marcotullio and McGranham 2007, Lieberherr-Gardiol 2008). The massive growth of cities in Africa, Asia and Latin America in the late twentieth century, often without any bulk infrastructure for sewerage or systems of urban regulation to protect the environment resulted in considerable

urban environmental degradation (McGranahan and Satterthwaite 2003, Marcotullio and McGranahan 2007, Pieterse 2008). Indeed it is in these cities of the Global South, where the majority of future global population growth is expected that some of the most severe urban ecosystem and biodiversity challenges lie (Parnell, Simon and Vogel 2007), not least because of their weak systems of formal government and planning (UN Habitat 2007).

The contemporary environmental agenda focusing on global environmental change emerged in the early 1970s. Awareness of environmental degradation and the planet as a system with limits to growth emerged in both civil society and among decision makers (cf. Meadows et al. 1972). Recognising cities as engines of economic growth and centers of production and consumption also implied acknowledging that cities drew on resources from all over the globe (Marcotullio and McGranahan 2007). The interconnected global environmental agenda of cities is thus woven into the history of the wider global environmental agenda (Sánchez-Rodríguez et al. 2005, Seto et al. 2012).

Cities have rarely been a central issue in the international environmental politics arena (Puppim de Oliveira et al. 2011). An early exception is the report *Our Common Future* (WCED 1987), that included a chapter on urbanization and which led to mainstreaming of the term “sustainable development”. It recognized a rapid urbanization at a global scale and the central role of cities in the global economy as “the backbone for national development”, suggesting that the prospect of any city: “depend(ed) critically on its place within the urban system, national and international. So does the fate of the hinterland, with its agriculture, forestry, and mining, on which the urban system depends” (WCED 1987:196). The report had a particular focus on ‘less developed’ countries and highlighted the lack of capacity of local authorities to deal with uncontrolled population growth. Many African and Asian states were described to have institutional structures highly influenced by their time as colonies, with governance systems intended to govern a rural economy and society. The political, institutional and legal frameworks in most Latin-American cities were held to be inappropriate and unable to match the challenges of rapid urbanization (WCED 1987). The report also pointed to national authorities not enabling local authorities to deal with environmental challenges.

The role of local authorities in environmental governance gained further focus during the Earth Summit in Rio de Janeiro in 1992. The event, being a direct follow on from *Our Common Future*, resulted in the initiation of Agenda 21, a program for action addressing

actors at all levels of society and focusing on the promotion of sustainable development. Local authorities were asked to prepare local agenda 21 (LA21) plans based on motivations that included statements such as: “In industrialized countries, the consumption patterns of cities are severely stressing the global ecosystem, while settlements in the developing world need more raw material, energy, and economic development simply to overcome basic economic and social problems.” (UNCED 1992:45). Countries were encouraged to assess the environmental impacts of current urban policies and growth, and cities were advised to establish networks for cooperation and sharing of best practices. Significantly what the LA 21 programme signalled was the importance of cities as sub-national sites of ecosystem government and governance. Since then the issue of the most appropriate scale of biodiversity and ecosystem governance has been an enduring concern.

Concern over defining the most appropriate scale of action is key as cities typically follow a trajectory from very local environmental problems to improving living conditions by dispersing these challenges both spatially and temporarily, consequently having an effect on long term global environmental status (Marcotullio and McGranahan 2007). Reflecting how hard it was to insert the global urban agenda into the international environmental governance arena, McGranahan and Satterthwaite (2003) recall that both the urban parts of Our Common Future and Agenda 21 were almost dropped due to political disagreements. The progress on LA21 in cities was, unsurprisingly then, slow (Allen and You 2002). In 2005, the landmark United Nations (UN) report on ecosystem services, the Millennium Ecosystem Assessment (MA 2005) was launched, which whilst including a sub-section in the ‘Current State and Trends’ Section on ‘urban systems’, was critiqued as urban areas were not substantially addressed throughout the Assessment (Alfsen et al. 2011). More than a decade later, and in the context of a by then predominantly urban world there has been an increasing recognition of cities as actors and important areas of work under the Convention on Biological Diversity, e.g. through the Curitiba declaration in 2007 and later initiatives leading to this report.

Twenty years after the first Rio meeting, the outcome of the Rio+20 meeting recognises that if “well planned and developed, including through integrated planning and management approaches, cities can promote economically, socially and environmentally sustainable societies” and emphasizes “promotion, protection and restoration of safe and green urban spaces; safe and clean drinking water and sanitation; healthy air quality”. This, alongside the introduction of an urban chapter into the fifth assessment report of the Intergovernmental

Panel on Climate Change, gives hope that the urban question is now firmly on the international environmental policy agenda.

Outside of UN processes many cities across high, medium and even low income contexts have continued to try to deal with problems related to environmental risk, ecosystem health and sanitation. Livability and smart growth policies have received an increasing focus in cities located in rich countries, aiming to reduce urban sprawl into surrounding land by cleaning up the core areas of the city like old industrial sites (typically waterfronts) and making city centre life more attractive for middle- and high income citizens that often live in suburbs (Allen and You 2002). Cities in developing countries have also struggled with rapid spatial growth. One third of the children growing up in cities live in slums where they are exposed to polluted rivers and air and hazard pollutants (UNICEF 2012). The environmental dimensions of wider urban problems have thus become much more central, such that it is now almost impossible to uncouple a discussion of urban development from that of the urban environment and its ecological base (Allen 2003, Satterwaite 1997, Swyngedouw 2005).

One aspect of the urban environment that has received relatively poor attention is that of biodiversity. Where there is a global movement to address urban biodiversity concerns it has once again been cities, not nation states, which have been at the forefront of the global mobilisation. Recently initiatives by cities to share best practices and support the aims of the Convention on Biological Diversity (CBD) include support for the Curitiba Declarations (2007, 2010), the Durban commitment (2008) and the Bonn call (2008). During COP9 of CBD, the decision IX/28 was adopted, encouraging parties to recognize cities in National Biodiversity and Action Plans including the preparation of local strategies and action plans, in addition to initiating an evaluation tool for cities - The City Biodiversity Index (CBI). At COP10, decision IX/28 was complemented by a Plan of Action on Sub-national Governments, Cities and Other Local Authorities for Biodiversity, giving further advice to parties and a request for an “assessment of the links and opportunities between urbanization and biodiversity for the eleventh meeting of the Conference of the Parties” (UNCBD 2010: X/22). In June 2012 world leaders met in Rio and highlighted that if “well planned and developed, including through integrated planning and management approaches, cities can promote economically, socially and environmentally sustainable societies” and emphasizes “promotion, protection and restoration of safe and green urban spaces; safe and clean drinking water and sanitation; healthy air quality”. Gradually a global movement for

biodiversity and ecosystem services, that incorporates an overt urban emphasis, is emerging in the international community.

Figure 1 captures the rich tapestry of organisations involved in and driving an urban biodiversity and ecosystem governance agenda at the global scale. These are both formal institutional bodies of the UN system, but also powerful global NGOs such as ICLEI. A number of high profile international meetings have generated consensus on the key issues and parties have made commitments to implement actions to achieve targets. For example the Plan of Action on Sub-National Governments, Cities and Other Local Authorities on Biodiversity from 2010. Learning from past difficulties around implementation, global programmes of action provide the support structures for implementation. Of note in this regard are the diverse major initiatives highlighted in Figure 1. The implementing actors for urban biodiversity thus draw not only on pure ecologists, but also statisticians, planners, medics and social scientists.

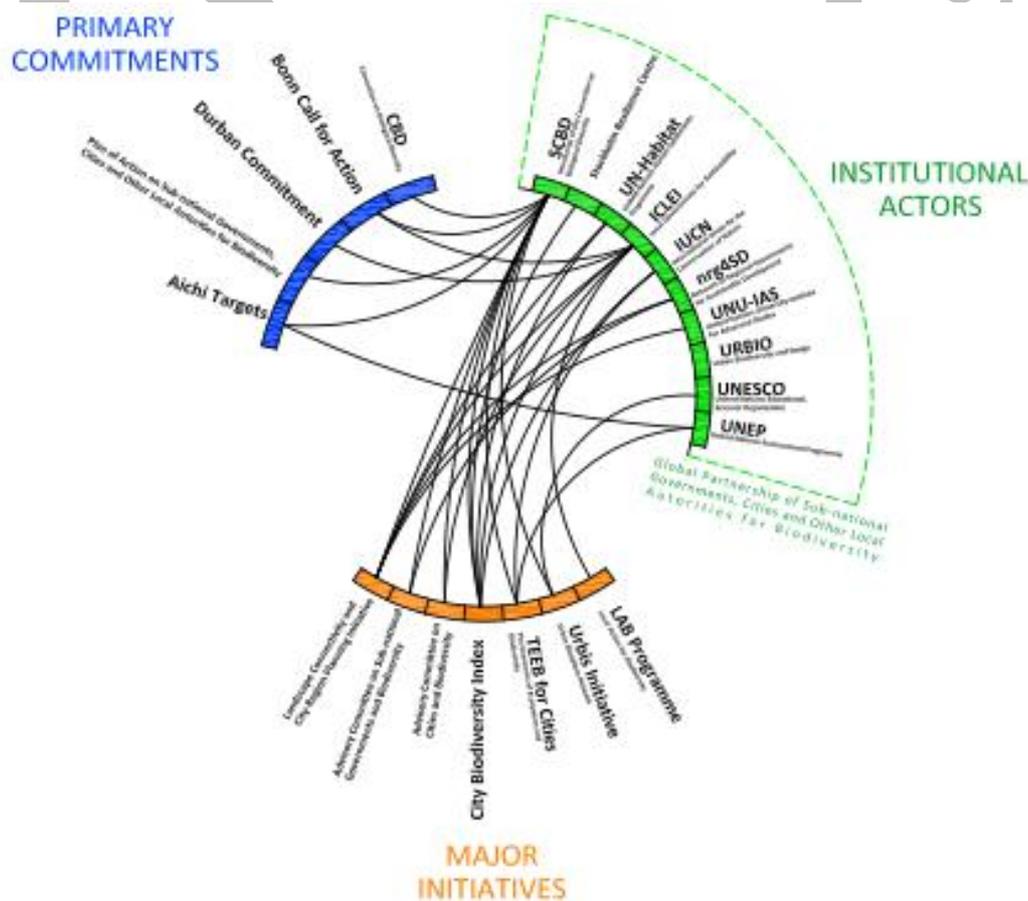


Figure 1. Overview of global governance arrangements for urban biodiversity and ecosystem services

10.2.2. Interdisciplinary perspectives

It is tempting to see the emphasis on human nature interactions as totally new. But this is not the case. There are well-known and established bodies of research exploring human–nature relations in and of cities, from disciplines including geography, history, archaeology and of course planning. Indeed, there is a long history of attention to human–nature relations through design and planning practice (Wilkinson 2012). Since the emergence of town planning as a discipline, human–nature relations have been high-lighted through the Chicago School of planning, the early British town planners such as Ebenezer Howard (1850–1928), Patrick Geddes (1854–1932) and his influence on Lewis Mumford and later on through more detailed practice-based attention of how to design with nature (McHarg 1969). American sociologists at the Chicago school, for example, began investigating human behaviour and the environment in cities already in the 1920’s. From the 1970s, environmental planning emerged as a sub-discipline (Slocombe 1993) and from the 1990s onwards this relationship is explored through the sustainability discourse (e.g. Owens and Cowell 2002, Rydin 2010). Most recently, the emerging field of urban ecology has taken up this interdisciplinary perspective (McDonnell 2011). Urban ecology is defined as “the study of the ways that human and ecological systems evolve together in urbanizing regions” (Alberti 2008:xiv) and “integrates both basic (i.e fundamental) and applied (i.e problem oriented), natural and social science research to explore and elucidate the multiple dimensions of urban ecosystems” (McDonnell 2011:9).

The emergence of the field of urban ecology is significant because urban areas were not a research priority among ecologists until late in the 20th century (Grimm et al. 2008). Born of a narrow focus on urban biotopes and concern over introduced species (Sukopp, 2002), after the 1970s a new approach emerged that focused on the city as a whole, with a focus on energy flow and nutrient cycling in this system (Sukopp, 2002). The more recent development within research on urban ecology views “cities as heterogeneous, dynamic landscapes and as complex, adaptive, socioecological systems, in which the delivery of ecosystem services links society and ecosystems at multiple scales” (Grimm et al. 2008: 756); a change that incorporates the field of landscape ecology (McDonnell 2011). As human dominated systems, a shift from a traditional biophysical focus to a more social and interdisciplinary one is perhaps most logical in cities, and such studies are now increasing in numbers following landmark articles pointing out humans as an important driver of environmental change from the local to the global level (like Berkes and Folke 1998 referred

to in Young and Wolf 2006). Key projects aiming to address the urban-ecological knowledge gap include the recent work on urban long-term ecological research programs (LTER) studying Baltimore, Phoenix and Maryland in USA (Grimm et al. 2000).

Not all of the work on urban ecology has its origins in the professions or natural sciences. Sociologists and geographers are among the social scientists whose studies, influenced by Marx and his “concepts of labor power, metabolism, and uneven development generated a massive body of work known as political ecology. Political ecologists investigate the production and transformation of social nature and its role in the differentiation of space at a variety of scales with recent emphasis on how society relates to nature to neo-liberal policy frameworks (Pincetl et al. 2011). Urban political ecology research has been especially fruitful in the study of power relations and material flows and fluxes operating across regions and cities c.f the influential work of Swyngedouw (2006).

Over time and through the work of sociologists, economists and psychologists, studies of social and ecological, as well as economic and technical aspects of the city have become more integrated in urban ecology (Young and Wolf 2006). Research, stemming from geography and political science as well as ecology, has broadened its scope from within cities, viewing cities as something separate from the world to a research integrating cities into a wider landscape where they are recognized as global actors of change (in line with Berkes and Folke 1998). A more recent perspective in urban ecology views cities as microcosms – systems where the change predicted in estimates of global environmental change are happening more rapidly. Pioneering social and environmental research is now focussed on how to respond to the catalytic role of cities (Grimm et al. 2008, McDonnell 2011). From a governance perspective recognising that these ‘city microcosms’ are far from closed because the contact between the urban and rural is blurred and the administrative boundaries do not neatly correspond to those of ecosystems, is more relevant than ever

Moving to the global perspective, cities have also been studied as a global network making the planet not only increasingly human dominated, but also urban dominated as “cities need to be viewed as loci in multiple networks of relationships at different scales, rather than as entities” (Ernstson 2010a:537). This interpretation comes from geographers like Beaverstock et al. (2000) in their notion of a world city network or metageography. Swyngedouw and Heynens’ (2003:899) develop this notion of urban political ecology suggesting that “the socioecological footprint of the city has become global. There is no longer an outside or limit

to the city, and the urban process harbors social and ecological processes that are embedded in dense and multilayered networks of local, regional, national and global connections.” This perspective echoes urban ecological studies of cities that view cities as human dominated ecosystems with authors like Bolund and Hunhammar (1999:294) arguing that “when humanity is considered a part of nature, cities themselves can be regarded as a global network of ecosystems.”

Notwithstanding the well-established and disciplinary diverse roots of research on urban ecology, it is true that over the last decades there has been a dramatic increase in awareness of biodiversity and ecological services issues in and of cities. Moreover there has been a massively expanded response from residents, civil society, local government as well as national and international stakeholders concerned to respond to the critical biodiversity challenges presented in and by cities. In an effort to ensure that we maximize the potential of knowledge to inform practice, for scholars to learn from practice and to encourage the documentation and dissemination of pathways to enhance urban biodiversity and ecosystem services, our attention now turns to providing a synthesis of the scientific literature on governing urban ecosystem services.

10.3. Synthesis of the scientific literature on governing urban ecosystem services

10.3.1. Scope of the synthesis

A synthesis of the governance challenges and opportunities relating to urban biodiversity and ecosystem services is presented here drawing on a systematic literature review carried out specifically to inform this Report (Sendstad 2012). The purpose of the literature review was to take a first step towards generating a much-needed comprehensive global assessment of knowledge of urban biodiversity and ecosystem services governance. The rationale for drawing on a systematic review of the academic literature is to be transparent about the scientific foundation of knowledge on governing urban biodiversity and ecosystem services. We recognize that local knowledge, traditional knowledges and other knowledge contained in reports generated outside of academia (ie. grey literature) are also important to the governance of urban biodiversity and ecosystem services. Indeed there is much other material on biodiversity and ecosystem services that is used by cities and urban communities to

inform regulatory, distributive and restorative practices. However, it has not been the purpose in this scientific foundation to address these at this stage.

The synthesis of challenges and opportunities relating to the governance of biodiversity and ecosystem services draws on the published findings of 138 scientific articles published in English in 76 journals. The papers were sourced using categories of words to represent the three main focus areas of the study; **governance** – of **ecosystem services** – in **urban** settings. A full methodological note is set out in Sendstad (2012). It is important to note that the findings highlighted below thus reflect only peer-reviewed knowledge already in the public domain.

Relying on the published academic English language literature creates a significant geographical bias. A summary of countries and cities covered in the articles reviewed is shown in Appendix A. Totally 88 cities or urban regions from 23 countries were represented in studies. There was a clear bias towards Europe (32 studies from 27 cities/urban regions from 9 countries), North-America (28 studies from 26 cities/urban regions in USA and Canada) and China (22 studies of 11 cities/urban regions). In addition to these studies there were also some studies looking at a large number of cities within a given country, e.g. studying land use change response to policy. Africa, South America and parts of Asia are to a large extent missing in the included literature. A reason for this may be limitations due to the selected databases and keyword combinations. Furthermore, in large parts of the world, scientific studies are often published in other languages than English (like e.g. South America and Russia), resulting in potentially valuable studies not being detected by the data base searches. However, the search result might also indicate a more general gap in scientific knowledge about the experiences in these underrepresented regions.

Starting with the existing scientific cannon that speaks to policy is a useful point of departure, but it is imperative that future reviews undertake a geographical and thematic corrective, if necessary embracing grey literature and undertaking primary research to ensure better global coverage and to extend the range of issues profiled.

The absence of published scientific work on many important issues and places, for example from Africa, has to be noted as a major distorter of our collective understanding of the scale and scope of the challenges and opportunities for biodiversity that are presented by urbanization. The fact that many of the global biodiversity governance challenges emanate from specific cities or regions suggests that the currently geographically incomplete

knowledge pool may critically undermine universal responses. Furthermore, the value of the existing scholarship on urban biodiversity governance is undermined by the fact that ideas about biodiversity governance are not universal, nor do ecological management practices necessarily transplant from city to city. Given that the bulk of the world's population lives in those cities which have the least biodiversity research, gaps in the sources that inform governance responses must be highlighted as a serious concern. That said there is, despite a somewhat tardy beginning, now a growing interest in the governance of cities for biodiversity enhancement and protection. There is in other words sufficient scientific evidence that how cities are managed impacts both positively and negatively on biodiversity.

Despite its relative youth, the field of biodiversity and ecosystem services has generated a good deal of peer-reviewed material on issues that are explicitly linked to questions of urban governance (see Figure 2). A number of the earlier chapters in this Report review the state of knowledge in specific sectors and highlight the uneven uptake of the science as well as the geographically distorted limits to knowledge on critical ecosystems on which cities depend and which city growth impacts. Even where there is sufficient science for action, several studies highlight the lack of awareness and narrow understanding of ecosystem functioning among decision makers, suggesting that it is not just residents who struggle to absorb the arguments of science at the local (Moll 2005, Li et al. 2005b), regional (Merson et al. 2010) and global scale (Puppim de Oliveira et al. 2011). It is clear then that advancing the urban biodiversity and ecosystem services agenda is only in part a question of proving the biological science; the dominant challenges lie in the institutional capacity to govern biodiversity and ecosystem services and in shifting the way science is viewed and used in a setting characterised by conflicting views and interests among stakeholders (Sendstad 2012).

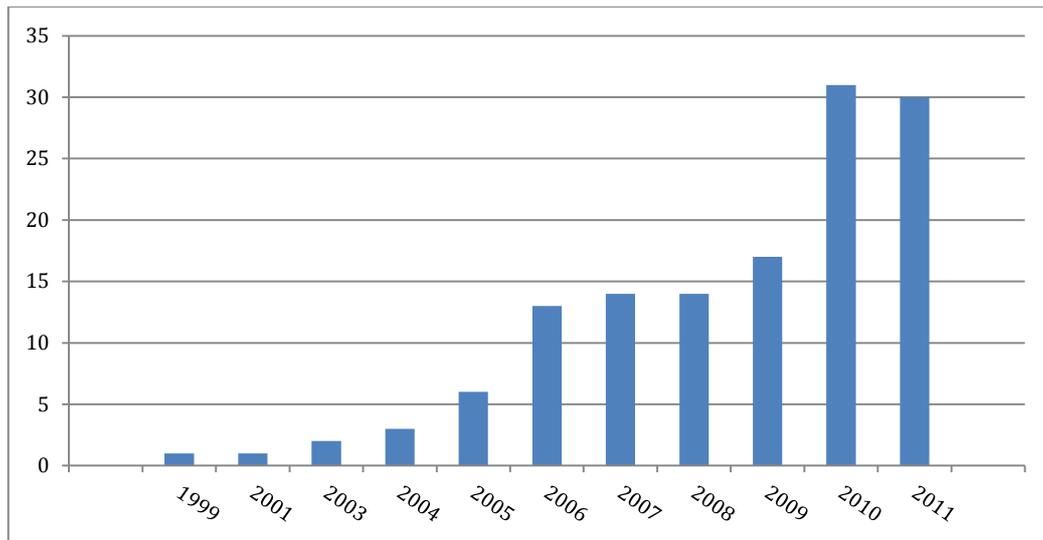


Figure 2. Number of publications sorted by year for studies included in the literature review.

10.3.2. Urban biodiversity and ecosystem services: governance challenges

10.3.2.1. Do we have enough science to inform implementation?

At the highest level there is a lack of scientific knowledge, especially about urban ecosystem structure and function (Boyer and Polasky 2005; Niemelä et al. 2010). The urban governance literature is similarly weak on issues of urban environmental governance (Wilkinson, 2012). As urban governance capacity to implement the findings of scientific research improves, the extent of the pure science gap will become more obvious, especially in cities that currently lack a tradition of using scientific support for ecosystem management. In some cities there is available science to better inform the governance decisions of city managers and the published literature is skewed to these well-resourced and well-researched places (see for example Stockholm in Appendix A).

There are numerous examples of science undertaken at the urban scale. Science that may be especially useful for city practitioners includes knowledge of the habitat requirements of particular species, pre-urban landscape characteristics, thresholds of ecosystems, level of uncertainty (Wolch 2007). The earlier chapters of this Report set out the science of relevance to the city scale for specific ecosystem services. At this stage it is important to underscore the point that has been made repeatedly, that there is a spatial mismatch between where the

scientific studies occur and where the world's urban ecosystem and biodiversity problems manifest. But the problem is not simply the absence of science.

Planners and decision makers, even those committed to a more evidence-based practice (Alonso and Heninen 2011) are not always able to use the publications of scientists for a number of reasons. First, practitioners struggle to accommodate the uncertainty that scholars outline (Fang et al. 2006, Niemelä et al. 2010, Su and Fath 2012). Second, at the local level in particular, there is a dearth of specialist ecological data and analysis needed to support legitimate regional planning and policy development (Peterson et al. 2007, Mendiondo 2008, Boyer and Polasky 2005). Third, while there are often specialist studies available, there is a lack of scale and context appropriate scientific tools and methods to capture the complexity of interacting systems, the limits of ecosystems and the drivers of change (Merson et al. 2010, Puppim de Oliveira et al. 2011). Finally, even in contexts where decision makers have access to relevant knowledge, it may take time before this has an effect on policy, public awareness and political action (Lieberherr-Gardiol 2008; Niemelä et al. (2010: 3238). One study from New York Metropolitan Area suggested that the connection between science and policy was weak due to the scientific view being considered just one of many stakeholders involved in decisions (Alfsen-Norodom et al. 2004). Furthermore, while some see linking science and the views of stakeholders as offering potential for knowledge co-production (Bayá Laffite 2009), there are significant paradigm conflicts to be dealt with in mediating urban biodiversity and ecosystem service issues.

10.3.2.2. Political as well as intellectual legitimacy are key

Cities themselves are complex systems and introducing a new emphasis on the science of ecology into how urban areas are managed presents real challenges not least because of the lack of political legitimacy traditionally associated with 'green issues'. Achieving the necessary political support and changing the habits of residents is also made difficult by the lack of awareness about the diversity of nature, its complexity, as well as human dependence on ecosystem functions across scale (Borgström et al. 2006, Wolch 2007). Some studies suggest that a personal experience may be important for caring about the protection of nature (Dearborn and Kark 2009). In a study by Jim and Chen (2006:342) in Guangzhou (China), residents placed high values on services like air quality and aesthetic enhancement in contrast to facilitation of biodiversity, water treatment, and flood abatement, suggesting that they were unable to value what they could not see or had not experienced directly.

10.3.2.3. Integrating environmental equity and justice

Governance or management of urban biodiversity and ecosystem services inherently raises questions of environmental equity and justice across spatial and temporal scales. Biodiversity and ecosystem services are often not equally distributed within the city (Li et al. 2005); low income and minority groups tend to have lower access and be disproportionately burdened by environmental hazards (Bullard 1997, Adamson et al. 2002, Wolch 2007, Boone 2010, Perkins 2010). In Cape Town, rapid urbanization has led to increasing social inequity related to environmental risk as settlements of poor communities are constructed in areas vulnerable to natural disturbance, further undermining the natural protection of these areas and access to other ecosystem services, while wealthy and spacious suburbs are growing elsewhere (Ernstson et al. 2010a).

Poor people may be perceived as responsible for environmental degradation in spite of having a relative low per capita impact (Zérah 2006, D`Souza and Nagendra 2011). Ecosystem degradation may however be an important cause of urban poverty (MA 2005). Moreover, people who have a higher per capita responsibility for degradation of ecosystem services are often not the ones experiencing the cost. Costs related to environmental degradation leading to quantitative or qualitative loss of biodiversity and ecosystem services may be displaced across temporal and spatial scales. Environmental inequity may also occur between urban and rural regions (see e.g. Gutman 2007, Sarker et al. 2008), but following globalization equity is not merely a local or regional issue. The social and ecological costs of improved urban living conditions can be transferred through global trade flows (Hagerman 2007, Meng 2009). The role of institutions and institutional mechanisms in facilitating and influencing people's access to ecosystem services is critical for addressing distributional issues, ensuring that ecosystems are managed in a fair and equitable manner to all involved stakeholders. Payments for Ecosystem Services (PES) schemes are by some considered to be a more efficient approach to biodiversity and ecosystem services conservation. PES schemes do however not necessarily integrate concerns of equity, "possibly even accentuating poverty and equity gaps by putting a cost-effective price to previously low priced or free services." (Pascual et al. 2009)

10.3.2.4. Gaps in institutional capacity undermine governance effectiveness

The single most important barrier to more effective ecosystem service management in cities that is identified in the academic literature is that of the institutional capacity of formal

authority and structures, including the ability of such structures (most often local government) to plan and regulate ecosystem services. Further dimensions of the institutional gap relate to the ability of the responsible parties to acquire and handle relevant urban scale information and cooperate across levels of environmental and urban decision-making. This is not just a local problem, as national and international levels of governance have rarely focused on cities in negotiating policies on the governance of ecosystems (Puppim de Oliveira et al. 2011).

Introducing new governance systems for urban biodiversity and ecosystem protection in cities is not simple. Examples from China are illustrative. Here the central planning system was developed before decision makers had any significant awareness of the value of integrating environmental concerns into urban planning (Fang et al. 2006, Xu et al. 2011). Embracing the value of ecosystem services often means setting the economic imperatives of city development against the ecological. Findings from a study of Beijing showed that practically this means that compensation mechanisms may fail to protect green areas from real estate development if the fee developers must pay to build on green areas is significantly lower than the income prospects (Li et al. 2005a). Li et al. (2005a:330) further found that the design of the green areas in Beijing focused more on "beautification" than on conserving the ecological value as habitat. The Chinese experience is not unusual; cities everywhere are having to devise new norms and standards and embed the regulatory and enforcement practices into the planning systems to ensure ecosystem integrity. For most cities this is an incremental and even ad hoc process that has not delivered a perfect ecosystem management system and the tricky thing is that fragmented governance may erode the ecological integrity by lack of holistic planning and responsibility (Alfsen-Norodom et al. 2004). This was the case in Toronto where an ecological valuable moraine area was developed piece by piece, due to approvals from different authorities (Wekerle and Abbruzzese 2010).

10.3.2.5. Navigating competing urban priorities

Pressure for economic growth, jobs and housing leads to pressure on ecologically valuable areas and several studies suggest that ecosystem services are given a lower priority compared to housing (Barthel et al. 2005, Asikainen and Jokinen 2009, Wekerle and Abbruzzese 2010), infrastructure, or jobs (Li et al. 2005a, Peterson et al. 2007, Wekerle et al. 2007, Wang et al. 2009), even if there are strategies in place to protect areas of particular value (Jonas and Gibbs 2003, Li et al. 2005a, Ozawa and Yeakley 2007. Bengston and Youn (2006) suggest

that this ranking is not just political, but that conventional planning facilitates growth and does not weigh the full range of ecosystem services into when adjudicating development decisions.

Not all decisions that militate against effective ecosystem service management can be attributed to higher political priorities winning over the long-term sustainability of cities. The multi-scalar dynamics of the ecosystem create major urban governance challenges because decisions cross scales of government and have long term implications that extend beyond the period for which elected officials are responsible.

10.3.2.6. Governance challenges related to scale mismatch and trade-offs

Challenges and tradeoffs related to temporality and scale can be seen as core governance dilemmas. The literature indicates that temporal, spatial, and functional mismatches, between ecosystems and the institutions managing them may be an overarching challenge in ecosystem governance (cf. Lee 1993, Cumming et al. 2006), although scale-mismatch in urban areas as a concept is mentioned overtly in relatively few studies (Borgström et al. 2006, Ernstson 2010b), it is a dilemma that permeates the literature either because of fragmented governance (where several jurisdictions exist within the city or the urban-rural region) or because ecosystem functioning does not align with administrative boundaries (Borgström et al. 2006, Wekerle and Abbruzzese 2010). A particular challenge related to spatial mismatch concerns how urban areas link to their regional to global sources of ES (Alfsen-Norodom et al. 2004, Blaine et al. 2006, Gutman 2007, Sarker et al. 2008, Puppim de Oliveira et al. 2011). Studies of aquatic ecosystems and water quality find that land managers upstream can influence ecosystems in cities without taking the needs of urban people downstream into account (Blaine et al. 2006, Sarker et al. 2008). Urban residents however draw on resources from all over the world (Alfsen-Norodom et al. 2004), without necessarily paying the full cost related to ensuring the integrity of the relevant ecosystems (Puppim de Oliveira et al. 2011).

10.3.2.7. Effective ecosystem and biodiversity governance requires collaboration

Governing ecosystem processes requires co-ordination across levels of policy and legislation as typically all spheres or tiers of government are involved in urban ecosystems services in some way (see Box 1) (Peterson et al. 2007). A common issue is that policies focus narrowly on endangered species or habitats, without incorporating ecosystem change over time

(Asikainen and Jokinen 2009, Ernstson et al. 2010b). In Sweden, Elander et al. (2005) found that it was challenging for urban planners at the local level to implement national biodiversity strategies, since they were too general and abstract. Bomans et al. (2010) also point out a weakness in spatial policy based on coarse mono-functional categories, unable to take into account transformations in multiple land uses and related values tied to the rapidly changing urban landscape. Numerous studies indicate a lack of regulation connecting urban consumers of ecosystem services and the people managing the resources they depend on outside the city boundaries (Blaine et al. 2006, Gutman 2007, Sarker et al. 2008, Puppim de Oliveira et al. 2011, Meng 2009). Most cities lack formal regulation, but ironically comprehensive public regulation (standards) and the associated bureaucracy can also hinder green innovation (Karvonen 2010). For all cities, especially those with weak local government (Bayá Laffite 2009), the challenge is how to work with other stakeholders and communities with strong local knowledge of the ecosystems and their uses (D`Souza and Nagendra 2011).

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Box 1. Cooperation is necessary for effective urban ecosystem management

Coordinating all the actors and tasks necessary to respond to fragmented, heterogeneous and dynamic ecosystems in cities involves significant cooperation.

Partnership is a cornerstone of urban ecosystem integrity as:

1. Responsibility for ecosystems is typically shared between government, traditional authorities, major public utilities and other agencies. In other words cities do not themselves have all the powers needed for the task.
2. Cities do not always have the political commitment or fiscal and institutional capacity to govern ecosystems, even if they have the mandate.
3. Different municipal departments may have conflicting priorities even on the same ecosystems and invariably there are tensions about priorities.
4. Lack of communication between relevant public and private actors involved in management across the urban landscape may hinder a coordinated approach, both within and between adjacent green areas.
5. Lack of regional coordination between adjacent municipalities with planning authority may be a barrier.
6. Cities may depend on ecosystem services, which for a large part, are provided by ecosystems beyond their jurisdiction and control.
7. Lack of regional coordination may hinder management due to conflicts between administrative units or conflicts may hinder regional coordination.
8. If individual cities or city regions implement efficient policies for this may have a limited global effect if others do not.
9. Insufficient public budgets for protection, maintenance and enhancement of ecosystem services has led to governments transferring management responsibility to private actors, including volunteers or the private sector in public Private Partnerships
10. Voluntary/non-governmental organizations have mixed attitudes to working with government but civil society is often involved (directly or indirectly) in urban ecosystem management, making it a critical partner.

Sources: Puppim de Oliveira et al. 2011; Wekerle et al. 2007; Wekerle and Abbruzzese 2010, Hutton 2011; Meng 2009; Blaine et al. 2006; Mendiondo 2008; Erntson et al. 2010b; Barthel et al. 2005; Borgström et al. 2006b; Karvonen 2010; Li et al. 2005b; D`Souza and Nagendra 2011; While et al. 2004, Hutton 2011, Schmidt and Morrison 2011; Li et al. 2005b, Hagerman 2007, Alonso and Heninen 2011, Antrobus 2011, Wilson and Hughes 2011; Rosol 2010; Pincetl 2010; D`Souza and Nagendra 2011.

10.3.2.8. Governance failures in urban ecosystem and biodiversity management

Even where the various parties are able to work together to design policy and regulations there are typically major problems of government associated with enforcement (Li et al. 2005a, Bayá Laffite 2009, Xu et al. 2011). Even if regulations do have an effect, they may not stop fragmentation of habitats over time (Wekerle et al. 2007). In a study of loss of riparian habitat in Portland, Hillsboro and Oregon City, it was found that even though most development projects were hindered, a few larger projects permitted led to loss of ecological function (Ozawa and Yeakley 2007).

Even more common than governance failures in granting permission for dubious projects is the failure to monitor ecosystem integrity over time, one reason for this is the absence of robust scientific monitoring data, which makes it hard to implement regulations or develop a comprehensive knowledge base for management. This has, for example, been found to be a problem in China (Meng 2009). It is not just the absence of monitoring but also the failure to include all relevant variables of the complex systems and variables across all important scales, that erodes the legitimacy of the administrative governance of ecosystems (Blaine et al. 2006; Ernstson et al. 2010b; Meng 2009, Wilson and Hughes 2011; Yli-Pelkonen et al. 2006). These weaknesses in governance capacity are not unique to ecosystem service management (Romero-Lankao and Dodman 2011) but they are especially serious in this domain for, as Baird argues, “unless we significantly reduce the lag time between occurrence of stress and management response we run the very real risk of irreplaceable loss of critical ecosystem functions” (2009:9).

10.3.3. Urban biodiversity and ecosystem service: opportunities

The scientific literature reviewed by Sendstad (2012) generated a rich set of insights into the opportunities for governing ecosystem services in an urban world, though careful interpretation of results is needed as opportunities include recommendations from case studies or more theoretical studies that have not necessarily involved assessment of success in practice. Although cities have not traditionally been central to ecological management, it is clear that this is a rewarding scale of action and that targeting better ecosystem service governance in cities presents a grand opportunity to promote resilience. Drawing only from published work, we have grouped lessons from innovative experiences in urban practice into five sub sections: ecological management at the city scale; opportunities to expand conventional planning; innovations in urban economics and fiscal management and the role of civil society. Table 1 (see the end of Section 10.3.3) summarises some of the broad range of tools and approaches identified in the literature for governing urban biodiversity and ecosystem services.

10.3.3.1. Bringing ecological management to the city - principles and approaches

Creating city wide networks of connected green areas, including water bodies and coastal zones to support species movement brings conventional ecological management to the urban scale and expands the traditional scope of urban government (Bolund and Hunhammar 1999, Yue et al. 2009). These networks, sometimes referred to as green infrastructure (cf. Antrobus 2011, Yu et al. 2011), connect the city to the wider landscape, with gradients or distinct zones with different degrees of human use (e.g. Li et al. 2005a, Borgström et al. 2009). Some urban ecological studies encourage management of a spectrum of habitats and a patchy landscape to achieve high levels of biodiversity (Barthel et al. 2005, Jim and Chen 2008b) and to support native species adapted to the local environment, within this structure (Arifin and Nakagoshi 2011, Puppim de Oliveira et al. 2011). Establishing extended protected areas or green belts within the urban limits (as in Mumbai eg. Zérah 2006) ensures ecological connectivity and also to create opportunities for recreation and food security (Bolund and Hunhammar 1999, Borgström et al. 2009; Barthel et al. 2005). Larger green areas can, if well maintained, appropriately protected, and connected to a green area network, provide habitat for species sensitive to disturbance and form the backbone of a bigger green infrastructure (Colding 2007, Borgström et al. 2009, Jim and Chen 2008b). For example, the Bogor botanical garden

(97 ha) has a rich variety of species and habitats and is important for local biodiversity (Arifin and Nakagoshi 2011). Some species depend on larger unfragmented areas, and typical urban parks may be too small to maintain viable plant and animal populations (Bolund and Hunhammar 1999, Borgström et al. 2009).

In planning and designing urban areas Colding (2007) recommends striving for clustering of different types of urban green patches, both public and privately owned, to increase habitat connectivity across the landscape, complementing habitat functions, and nurture key ecosystem processes essential for the support of biodiversity. The inclusion of private or common areas can also make the effects on ecosystem services of cuts in public spending on green areas less severe (Colding 2007) while areas under informal or traditional management can contribute to ecological integrity (c.f. Andersson et al. 2007) or even be incorporated into the design of new eco-cities (Arifin and Nakagoshi 2011).

Open space management is not the only ecological practice now undertaken in cities. Restoration or protection policies targeting keystone species can support a number of additional species (Barthel et al. 2005 and references therein). It is often challenging to enhance green areas in cities that are already densely covered by buildings and infrastructure. Access to ecosystems tends to decline with building density, but in a study of five UK cities, Tratalos et al. (2007) found variation in effects of density, offering hope for existing built up areas.

In cities having degraded ecosystems, restoration may be the most appropriate solution to ensure access to ecosystem services (Seabrook et al. 2011:409) (see Box 2).

Box 2. Examples of urban ecological restoration

Several studies recommend restoration and present related opportunities, in particular related to networks of green areas (Li et al. 2005a, La Greca 2011), parks and forests (Li et al. 2005a, Perkins 2009, Xu et al. 2011), grasslands (Xu et al. 2011), wetlands (Jansson and Colding 2007, Tong et al. 2007, Xu et al. 2011), brown fields (Franz et al. 2008), estuaries (Weinstein and Reed 2005), rivers (Li et al. 2005a, Tong et al. 2007), creeks (Karvonen 2010) and watersheds more generally (Mendondo 2008, Karvonen 2010). Such restoration projects can include innovative experimental approaches to restore ES, like storm water management in streets and using ecorevelatory design (Karvonen 2010). It is highlighted as crucial in restoration efforts to identify the problem causing degradation, desired and feasible outcomes to be monitored, and the tolerance of the system to deal with disturbance (Mendondo 2008). It can be useful to have a good understanding of pre-urban landscape characteristics, like vernal pools and grasslands, to inform restoration efforts and consider if such features could be obtained under urban conditions (Wolch 2007). When reconstructing connectivity it is also important to consider the habitat requirements of relevant species and how each of them can move in the wider landscape (Wolch 2007) and thus how different green areas can complement each other in terms of habitat function (Colding 2007). Also, non-traditional features of green areas, like golf courses, can be valuable in this effort, representing an opportunity for management to align conservation, restoration and recreation and support critical ES functions like pollination (Colding and Folke 2009).

Where it is not possible to restore and sustain urban ecosystems in a state similar to what has been earlier due for example, to irreversible changes and disturbance, some studies argue that one should rather aim for a stable supply of critical ecosystem services and conserving species that are adapted to human presence (Weinstein and Reed 2005, Weinstein 2008), or reinvent urban landscapes recognizing novel ecosystem features (Seabrook et al. 2011). A more recent approach to enhancement of urban ES is reconciliation ecology, based on an assumption that urban landscapes are different and thus require a different approach compared to more traditional endeavours (Dearborn and Kark 2009). The approach aims to reconcile urban habitats with their natural analogues, e.g. modifying walls to support climbing vegetation, prepare nesting places for predatory birds on high rise buildings, or

build green walls and roofs with substrates supporting different species of plants and arthropods (Lundholm and Richardson 2010). This kind of green innovation can also supplement more traditional restoration efforts by e.g. enhancing connectivity and habitat diversity in the urban landscape.

10.3.3.2. The ecological redeployment of traditional planning and management tools

Well established cities have at their disposal a huge array of convention urban planning tools and instruments, including regulation and zoning. Numerous studies highlight the importance of strong legal protection to avoid ecosystem degradation and maintain or enhance various ecosystem services (Borgström et al. 2009, Wang et al. 2009, Huang et al. 2011, Morimoto 2011, Xu et al. 2011). There are several approaches to regulating areas of importance for ES, and managing the city as a part of the surrounding landscape (Li et al. 2005a, Xu et al. 2011), like smart growth policies and zoning (Hutton 2011). A number of case studies, in particular from Chinese cities, present detailed suggestions for urban planning with a focus on enhancing green infrastructure and limit encroachment (e.g. Xu et al. 2011, Liu et al. 2012). Zoning may allow a city to prioritize areas for different purposes with varying building densities and regulations of human activity, make sure to protect areas valuable to ecosystem services provision, and plan their linkages (Lieberherr-Gardiol 2008, Weinstein 2008, Asikainen and Jokinen 2009, Hutton 2011, Yong et al. 2011). Rather than aiming to separate social and ecological aims in distinct zones, Borgström et al. (2009) suggest integrating them in the urban landscape matrix with the aim of having connected green areas to conserve local biodiversity values, planning to maintain ecosystem services both at temporal and spatial scales, and also prioritize neighborhoods with a lack of access to ecosystem services. The importance of applying such a multifunctional landscape perspective has been emphasized in several studies (Bolund and Hunhammar 1999, Lundy and Wade 2011), and Hagerman (2007) presented a common strategy aiming at increasing access to green space and general quality of life (liveability) in the urban centre to reduce sprawl.

Another regulatory approach to enhance ecosystem services is to set targets for minimum green coverage across the city (Arifin and Nakagoshi 2011) and riparian area next to rivers for habitat protection, enhancing connectivity, and flood protection (Ozawa and Yeakley 2007). The potential value of traditionally, privately or commonly owned land in cities could be enhanced by incorporating them into an ecological zoning or amending their regulation. Authorities may set baseline requirements for management of privately owned land (Harman

and Low Choi 2011), like incorporating tree planting and maintenance in building regulations (Davies et al. 2011) or create more onerous demands (Harman and Low Choi 2011). In addition to regulation of non state land, public authorities can sometimes choose to use established planning codes to acquire private land for safeguarding ecosystem services for the public good (Blaine et al. 2006, Vejre et al. 2010, Morimoto 2011). Where local planning codes are not strong enough, national and global treaties may also influence land use within and outside the cities' jurisdiction (Lucero and Tarlock 2003, Asikainen and Jokinen 2009).

Outside of regulation and zoning, planning tools being used by ecologists are mainly related to mapping and visualising information on land characteristics and land use; numerous approaches exist as to how this can be done. There are disagreements as to which approach/tool is more appropriate, e.g. how detailed qualitative/quantitative data is required. Commonly applied tools include e.g. remote sensing via satellite images for detailed management of green areas (Moll 2005), linking land use to ecosystem features through a categorization system (Liu et al. 2012), developing sets of indicators on different levels to facilitate long term monitoring of ES (Li et al. 2009). The traditional planning rubric of mapping and monitoring is now being extended with ecological footprint analysis. This comprehensive tool is being applied to support cities in assessing their cities global impact, potential ecological deficit and thus vulnerability, setting targets and track progress. Some cities and urban communities have started to test this approach (e.g. Cardiff, London) (Wackernagel et al. 2006).

10.3.3.3. Economic instruments and valuation tools

There is an increased focus on financial tools in urban management generally and ecosystem service interventions in particular. The economic instruments include monetary and non-monetary valuation tools for assessing and prioritizing urban interventions. Monetary tools are being applied to enhance ecosystem integrity through city dwellers paying for land management protection, maintenance or enhancement of ecosystem service quality outside city boundaries (Gutman 2007, Xu et al. 2011), adding to regulatory frameworks and incentive mechanisms connecting users and managers (Boyer and Polasky 2005, Sarker et al. 2008). In a survey among urban Australians, Zander et al. (2010) found that residents were often willing to pay for conservation of rivers upstream. Non-monetary evaluations use indicators to set targets and monitor change in ecosystem function over time and assess how the ecological health of a city relates to human welfare (Dobbs et al. 2010).

There are some warnings over the limits to monetary or non-monetary valuations' ability to adjudicate decisions on all services across spatial and temporal scales, and authors warn that economic valuations that raise awareness among decision makers and others about the importance of such services may not always enhance protection (Boyer and Polasky 2005, Hougner et al. 2006). Ecological accounting can potentially help avoiding undervaluation of ecosystems in planning, and support more appropriate compensation mechanisms (Li et al. 2005a, Bengston and Youn 2006, Wang et al. 2009, Gaudi et al. 2010).

Several articles argue that taxes should be used to ensure public interest in multiple ecosystem services (Li et al. 2005b), including property tax reduction in exchange for commitment to protect and manage important habitat on people's properties (Alonso and Heninen 2011), or compensating land owners for restricted development rights (Bengston and Youn 2006). One may also use tax and other fiscal incentives for investing in green innovations such as incentivizing green roofs for limiting storm water runoff (Carter and Fowler 2008). Public budgets can also be used to provide seed funding to support establishment of civil society initiatives, e.g. efforts targeting communities with lower access to ecosystem services (Warren et al. 2011, Wilson and Hughes 2011).

10.3.3.4. Civil society – a source of legitimacy, knowledge and management capacity

Civil society associations have an important role in ecosystem governance, as groups raise their voice for threatened ecosystem services, or trigger political action to avoid environmental degradation in general (e.g. While et al. 2004, Barthel et al. 2005, Bengston and Youn 2006, Peterson et al. 2007, Grimm et al. 2008, Asikainen and Jokinen 2009, Barthel et al. 2010, Wekerle and Abbruzzese 2010, Ernstson et al. 2008, Ernstson et al. 2010b, Arifin and Nakagoshi 2011, Morimoto 2011). Civil society initiatives reportedly built networks and mobilized action to influence decision makers, compensating for fragmented governance in Toronto (Wekerle and Abbruzzese 2010). Other studies suggest that the development of NGOs could contribute to increasing awareness among citizens, contribute to green space management effort and a more structured contact between citizens and public administration (Jim and Chen 2006).

Participatory governance creates a foundation for collective action through creating shared visions/scenarios (Peterson et al. 2007, Seymoar et al. 2010). Government agencies/local authorities have increased their capacity by cooperating with professional civil society organizations in activities like the Los Angeles mass tree plantings (Pincetl 2010). Adaptive

co-management strategies in Stockholm focus on urban gardens and parks, highlighting how user groups can be recognized as sources of local ecological knowledge and management capacity to support ecological processes and respond to change (e.g. Barthel et al. 2005, Colding et al. 2006, Andersson et al. 2007). Participatory management endeavours can also enhance other social benefits. Perkins (2009) showed how urban greening programs in poor neighborhoods using volunteers contributed to both enhanced ecosystems, increased ecological awareness and gave people commonly excluded from the job market valuable work experience.

A central opportunity of greater civil society engagement in the ecosystem service agenda is the fostering of ecological citizenship; a new set of values reframing the relationship between people and nature, reframing rights and obligations, and supporting changed behaviour (Moll 2005, Li et al. 2005b, Jim and Chen 2006, Hagerman 2007, Wolch 2007, Karvonen 2010). Healthy ecosystems are seen as shaping local identity, providing a sense of place and fostering deeper insight into nature (Yli-Pelkonen et al. 2006). Ecological citizenship may also have a wider scope, like experienced in Seattle where some have been inspired by bioregionalism and the abundant nature in the Pacific Northwest, leading to an increased desire to live in balance with the natural surroundings (Karvonen 2010). In Portland, restoration of a river was related to a regional identity – 'people of the Salmon' (Karvonen 2010:173). It has also been suggested that ecological citizenship may have a broader application, as captured in the following quote; "With respect to the environment, the urban ecological citizen is one whose rights include environmental justice but whose duties and obligations are defined by their ecological footprint: our production and consumption habits." (Wolch 2007:379).

Table 1. Summary of some of the broad range of tools and approaches identified in the literature for governing urban biodiversity and ecosystem services

TOOLS AND APPROACHES	DESCRIPTION	EXAMPLE	REFERENCES	Scale of action*
URBAN DESIGN				
Larger green areas	Ensure protection of larger less fragmented green areas connected to other green areas in the city as a source of biodiversity and habitat for less disturbance tolerant species e.g green belts or larger urban parks	Bogor, London, Mumbai, Seoul, Stockholm	Bolund and Hunhammar 1999, Barthel et al. 2005, Bengston and Youn 2006, Zérah 2006, Colding 2007, Borgström et al. 2009, Arifin and Nakagoshi 2011	Local-Regional
Bioswales	Street design that hinders surface run off		Grim et al. 2008, Karvonen 2010	Local
Pervious paving	Street design that hinders surface run off		Karvonen 2010	Local
Green roofs and other forms of vertical greening	Provide habitat, insulate, reduce urban heat island effect and energy use related to heating/cooling of houses due to its insulation effect		Li et al. 2005a, Oberndorfer et al. 2007, Carter and Fowler 2008, Dvorak and Volder 2010, Karvonen 2010, Xu et al. 2011	Local
Urban agriculture	Community gardens for poverty reduction; enhancing food security, nutrition and economic status. Urban gardens can also be a food security mechanism, be important learning arenas and reduce the ecological footprint of cities.	Bangkok, Badulla, Matale, Moratuwa, Matara, Rosario, Seattle	Alfsen-Norodom et al. 2004, Lieberherr-Gardiol 2008, Seymoar et al. 2010	Local-Regional-Global
REGULATION OF LAND USE				
Zoning	Zoning may allow a city to prioritize areas for different purposes with varying building densities and regulations of human activity, make sure to protect areas valuable to ES provision, and plan their linkages	Vancouver, Kyoto	Borgstrom et al. 2006b, Hutton 2011, Morimoto 2011	Local-Regional
Higher level policy	National/Regional law limiting urban expansion into valuable green areas	Tampere	Asikainen and Jokinen 2009	Local-Regional
Baseline requirements of private management	Set baseline requirements for management of privately owned land like incorporating tree planting and maintenance in building regulations. This may include incentive measures for added efforts.		Harman and Low Choi 2011	Local
Ensuring access/property rights	For private persons to invest in structures supporting ES, like trees, it is important to ensure long term access/property rights in e.g. urban gardening		Barthel et al. 2010	Local
Evidence based management/planning	Legal tools can be used to require that planning should be based on available ecological knowledge, and include the knowledge and opinions of participants		Yli-Pelkonen et al. 2006	Local-Regional
PLANNING TOOLS				
Satellite images	Satellite images covering larger areas were combined with high-resolution images to inform management	Charlotte, Salem	Moll 2005	Local-Regional
Indicators monitoring ecosystem change	Indicators on different levels to set targets and measure and monitor ecosystem state over time	Gainesville	Li et al. 2009, Dobs et al. 2010	Local-Regional
Biotope Area Ratio	Biotope Area Ratio (BAR) to map surface types	Berlin and Seoul	Lakes and Kim 2012	Local-Regional
Scenario development	Development of scenarios to inform planning and stakeholder processes, e.g.		Mendiondo 2008, Mitsova et al. 2011	Local-Regional –

	using multi-criteria evaluation			Global
Ecological footprint analysis	Ecological footprints can track progress, provide early warning, support setting targets and <i>drive positive policy change</i> .		Wackernagel et al. 2006	Global
Knowledge management systems	Regional ecological knowledge database that are regularly updated to inform planning	South East Queensland	Peterson et al. 2007	Regional
ECONOMIC INSTRUMENTS AND VALUATION TOOLS				
Payment for ecosystem services/environmental management	Monetary tools can be applied to enhance ES through city dwellers paying for ecosystem management they benefit from, adding to regulatory frameworks and incentive mechanisms connecting users and managers. It can also be useful for raising awareness of the value for conserving ecosystems		Boyer and Polasky 2005, Gutman 2007, Sarker et al. 2008, Xu et al. 2011	Local-Regional-Global
Non-monetary valuation tools	Non-monetary evaluation may use indicators to set targets and monitor change in ecosystem function over time and how it relates to human welfare		Dobbs et al. 2010	Local-Regional-Global
Tax measures	Property tax reduction in exchange for commitment to protect important habitat on people's properties, incentives for investing in green innovation or compensating land owners for restricted development rights		Bengston and Youn 2006, Carter and Fowler 2008, Alonso and Heninen 2011	Local
Public funding/awards	Seed funding to support establishment of civil society initiatives, e.g. efforts targeting communities with lower access to ES. Public funding or awards can also support dispersal of best practises and continued effort	Bankok, Badulla, Matale, Moratuwa, Moratuwa and Matara, Seattle	Seymoar et al. 2010, Karvonen 2010, Warren et al. 2011, Wilson and Hughes 2011	Local-Regional
Green budgets	Having a separate budget line for urban greening		Seymoar et al. 2010	Local-regional
Green procurement	Public institutions having green procurement policy, e.g. hospital buying organic food. Such projects can contribute to to general awareness raising.	Vienna	Lieberherr-Gardiol 2008	Local-regional-Global
PRINCIPLES				
Connectivity	Managing/planning a city wide network of connected green areas of different sizes connecting the city to the wider landscape (green infrastructure). This entails including green areas with varying characteristics, management and ownership.		Bolund and Hunhammar 1999, Li et al. 2005a, Colding 2007, Yue et al. 2009, Xu et al. 2011	Local-Regional
Diversity	Management of a spectrum of connected habitats to achieve high levels of biodiversity		Barthel et al. 2005, Jim and Chen 2008b, Colding 2007	Local-Regional
Native species	Support native species adapted to the local environment	Bangkok, and in Badulla, Bogor, Matale, Moratuwa, Moratuwa, Matara.	Seymoar et al. 2010, Arifin and Nakagoshi 2011, Puppim de Oliveira et al. 2011,	Local-Regional
Systems thinking	Holistic management, including control of all pollutants and general dynamics of the ecosystem		Meng 2009 (focus on watersheds)	Local-Regional
Change	Focus on nature management as an ongoing process where one recognize nature as ever changing and dynamic accros scales and adapt institutions and plans to this		Peterson et al. 2007, Asikainen and Jokinen 2009	Local-Regional

Experimentation	Experimentation to foster learning and innovation: Pilot projects can over time be scaled up experiments to inform policy and create awareness, also across cities. Model cities can support others.	E.g. Dongtan (China)	Borgstrom et al. 2006b and references therein, Economy 2006, Wackernagel et al.2006, Lieberherr-Gardiol 2008, Mendiondo 2008, Baptista 2010,	Local-Regional-Global
Different kinds of knowledge	Be open for the value of different kinds of knowledge, both scientific and non-scientific		Borgstrom et al. 2006b and references therein, Asikainen and Jokinen 2009, D'Souza and Nagendra 2011, Evans 2011 and references therein	Local-Regional-Global
Context	Adapting biodiversity policies to the local context, considering place bound issues of equity and multiple social and ecological factors of relevance	Malmö	Elander et al. 2005, Quastel 2009	Local
Leadership	Foster leadership e.g. through awards or trainings targeted to individuals, communities or cities	National Conference of Mayors (USA), Bangkok, Badulla, Matale, Moratuwa and Matara. Review of urban policy England	Pincetl 2010, Seymoar et al. 2010, Wilson and Hughes 2011	Local-Regional-Global
Synergies	Link ecosystem services to other benefits enhancing human welfare and view ES as an integrated part of urban functions	Bangkok and in Badulla, Matale and Moratuwa, Matara, Manchester, Seattle	Elander et al. 2005, Seymoar et al. 2010, Karvonen 2010, Antrobus 2011	Local-Regional-Global
Mainstream	Mainstream plans for ES governance across other relevant policies	South East Queensland	Peterson et al. 2007	Local-Regional-Global
Cooperation and learning	Facilitate networks of people involved in urban sustainability across actors on different levels - departments, private sector and civil society to enhance learning and formal support for ES governance.	Bangkok, Badulla, Matale, Moratuwa, Matara, Seattle, New York, and South East Queensland	Baya Laffite 2009, Young 2010, Seymoar et al. 2010, Karvonen 2010, Schmidt and Morrison 2011	Local-Regional-Global
Reconcile urban habitats with their natural analogues			Lundholm and Richardson 2010	Local

* Scale of action: "Local" generally refers to the urban jurisdiction, in contrast to "regional", which refers to the city and its surrounding hinterland, often regulated under a higher level of jurisdiction. "Global" refers to issues that cross national borders and commonly across the major continents.

10.4. Concluding Discussion

The *Cities and Biodiversity Outlook – Action and Policy* together with this scientific foundation reflect the significant shift in attention to urban biodiversity and ecosystem services in global policy forums and urban governance structures that operate at the national and local scales. Key purposes of this chapter have been to situate the emerging field of urban biodiversity and ecosystem governance and to provide the first comprehensive global synthesis of researched scientific material on the governance of biodiversity and ecosystem services. The absence of such a synthesis review represented a significant gap in knowledge which this chapter has begun to address. As was shown in Figure 2, it really is only over the past ten years that significant attention has begun to be paid to the governance of biodiversity and ecosystem services in urban settings in the scientific literature.

With respect to the policy agenda, the synthesis review of the literature presented here confirms that cities have a critical role to play in the governance of biodiversity and ecosystem services. Whilst the actors that typically lead governance of urban biodiversity and ecosystem services are typically drawn from across the state, in particular government based planning and environmental management actors, this is not always this case and it is not the case at all in places with very weak states. Very well capacitated governments are able to engage with and work extensively with civil society but the absence of strong local/regional/national management other global stakeholders/institutions and local organizations are left to drive much of the biodiversity and ecosystem service agenda. In places where there is no or limited urban governance capacity residents carry the brunt, through mostly informal micro solutions. The governance of urban biodiversity and ecosystem services will only be successful with collaborative, cross-scale efforts that better prioritize the value of biodiversity and ecosystem services through urban governance. Good management of the urban landscape for biodiversity can only be achieved with the collaboration of multiple jurisdictions and a large number of public and private actors. These actors need to come from all levels of decision-making, from national, sub-national, and local governments to UN and other international organizations, citizen groups, scientists, NGOs, and businesses both large and small.

The synthesis review shows there is already significant scientific knowledge to inform action (see Table 1 for summary of tools and approaches identified in the literature for governing urban biodiversity and ecosystem services). However it also reveals the limitations of the

current knowledge base given the unevenness of the geographical coverage of research published in English in scientific journals. Notably, the current scientific literature pays least attention to those areas in the Global South with the highest rates of urbanization that are the most vulnerable areas in terms of their exposure to risk and their capacity to respond to future challenges. This unevenness in the knowledge base presents a significant challenge to the global research community. Subsequent efforts must not only engage with the non-English scientific literature and monographs, but also transparently and robustly engage with the grey literature. A key opportunity in tapping into the grey literature is to access more examples of initiatives to govern urban biodiversity and ecosystem services that have been assessed to some degree. This is a useful complement to the scientific literature on the governance of biodiversity and ecosystem services which is dominated by theoretical and general case studies overviews, as distinct from robust evaluations of the success or otherwise of governance initiatives in practice.

For the battle for sustainability to be won, biodiversity and ecosystem services in and of cities must be better governed. There are significant challenges, but also many many solutions already being successfully put in practice in cities. Addressing inequities in the impacts on biodiversity and ecosystem services generated by cities, the impacts endured by cities and the uneven capacities of cities to govern must be a priority.

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Appendix A

Geographic coverage (region, country, city/city-region) of scientific literature review drawn on in the synthesis that informed this Chapter

Source: Sendstad 2012

Region	Country	City/City-region	Reference
Asia	China	Beijing	Li et al. (2005a), Li et al. (2008), Yue et al. (2009), Gaodi et al. (2010), Xu et al. (2011), Yang et al. (2011), Yu et al. (2011)
	China	Changshu	Li et al. (2010)
	China	Foshan	Yong et al. (2010)
	China	Guangzhou	Jim and Chen (2006), Guo et al. (2007), Jim and Chen (2008a), Su and Fath (2012)
	China	Jining City	Li et al. (2009)
	China	Rizhao City,	Wang et al. (2008)
	China	Shenzhen	Li et al. (2010a)
	China	Shiyao City	Dong et al. (2011)
	China	Taiyuan City	Liu et al. (2012)
	China	Urban forest in China	Li et al. (2005b)
	China	Water control in China	Meng (2009)
	China	Wenzhou	Tong et al. (2007)
	China	Xiamen	Fang et al. (2006)
	India	Auroville	Kapoor (2006)
	India	Bangalore	D'Souza and Nagendra (2011)
	India	Mumbai	Zérah (2006)
	Indonesia	Bogor/Jakarta and Sentul	Arifin and Nakagoshi (2011)
	Japan	Kyoto	Morimoto (2011)
	Japan	Tokyo	Gadda and Gasparatos (2009)
		Republic of Korea	Seoul
	Sri-Lanka/ Thailand		Seymoar et al. (2010)
	Taiwan	Taipei	Jim and Chen (2008b), Huang et al. (2011)
Europa	Austria	Vienna	Lieberherr-Gardiol (2008)
	Belgium	Flanders (region with urban centres)	Bomans et al. (2010)
	Denmark	Copenhagen	Vejre et al. (2010)
	Finland	Lahti	Niemelä et al. (2010)
	Finland	Tampere	Asikainen and Jokinen (2009)
	Finland	Vantaa (in the Helsinki metropolitan area)	Yli-Pelkonen et al. (2006)
	Germany	Berlin	Rosol (2010), Lakes and Kim (2012)
	Germany	Leipzig–Halle	Kroll et al. (2012)
	Germany	Ruhr	Franz et al. (2007)
Italy	Catania	La Greca et al. (2011)	

	Sweden	Stockholm	Bolund and Hunhammar (1999), Jansson and Nohrstedt (2001), Barthel et al. (2005), Borgström et al. (2006b), Colding et al. (2006), Hougner et al. (2006), Andersson et al. (2007), Jansson and Colding (2007), Ahrné et al. (2009), Barthel et al. (2010), Ernstson et al. (2010)
	Sweden	Stockholm/Göteborg/Malmö/Uppsala/Linköping/Örebro	Elander et al. (2005), Sandström et al. (2006)
	Sweden	Studied 1869 nature reserves in Southern Sweden, considering urbanization	Borgström (2009)
	Switzerland	Zürich	Schulz and Schläpfer (2008)
	United Kingdom	Cambridge and Waveney	Jonas and Gibbs (2003)
	United Kingdom	Edinburgh, Glasgow, Leicester, Oxford and Sheffield	Tratalos et al. (2007)
	United Kingdom	National measures towards urban green space in England	Wilson and Hughes (2011)
	United Kingdom	Leicester	Davies et al. (2011)
	United Kingdom	Manchester	Gill et al. (2008), Antrobus (2011)
	United Kingdom	Manchester and Leeds	While et al. (2004)
North-America	Canada	Vancouver	Lieberherr-Gardiol (2008), Quastel (2009), Hutton (2011)
	Canada	Toronto	Wekerle et al. (2007), Wekerle and Abbruzzese (2009)
	USA	Akron and Cleveland	Yadav et al. (2012)
	USA	Boston and Springfield	Warren et al. (2011)
	USA	Charlotte (North Carolina), Roanoke (Virginia) and Salem (Oregon)	Moll (2005)
	USA	Chicago	Young (2010)
	USA	Columbus	Styers et al. (2010)
	USA	Detroit	Nassauer et al. (2009)
	USA	Gainesville	Dobbs et al. (2011)
	USA	Illinois	Jaffe (2010)
	USA	Los-Angeles	Wolch (2007), Pincetl (2010)
	USA	Miami-Dade and Gainesville	Escobedo et al. (2010)
	USA	Milwaukee, Wisconsin	Perkins (2009) , Perkins (2010)
	USA	New Mexico	Lucero and Tarlock (2003)
	USA	New Orleans, Phoenix	Ernstson et al. (2010a)
	USA	New York	Alfsen-Norodom et al. (2004), Blaine et al. (2006)
	USA	North Carolina	Bendor and Doyle (2010)
	USA	Portland, Hillsboro and Oregon City	Ozawa and Yeakley (2007)

	USA	Portland, Oregon	Hagerman (2006)
	USA	Seattle	Robinson (2008), Karvonen (2010)
	USA	274 metropolitan areas	McDonald et al. (2010)
South-America	Argentina	Rosario	Lieberherr-Gardiol (2008)
	Brazil	Buenos Aires and Sao Paulo	Bayá Laffite (2009)
	Brazil	Curitiba	Lieberherr-Gardiol (2008)
	Brazil	Sao Paulo	Mendiondo (2008)
Australia, New Zealand	Australia	Auckland	Grimm et al. (2008)
	Australia	Melbourne	Grimm et al. (2008)
	Australia	South East Queensland	Peterson et al. (2007), Sarker et al. (2008), Harman and Low Choy (2011), Schmidt and Morrison (2011)
	Australia	Sydney	Merson et al. (2010)
Africa	South Africa	Cape Town	Ernstson et al. (2010b)
	South Africa	Port Alfred, Grahamstown and Somerset East	Kuruneri-Chitepo and Shackleton (2011)

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