THE MOST IMPORTANT CURRENT RESEARCH QUESTIONS IN URBAN ECOSYSTEM SERVICES

JAMES SALZMAN†
CRAIG ANTHONY (TONY) ARNOLD††
ROBERT GARCIA†††
KEITH HIROKAWA††††
KAY JOWERS†††††
JEFFREY LEJAVA††††††
MARGARET PELOSO†††††††
LYDIA OLANDER††††††††

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† Samuel F. Mordecai Professor of Law, Nicholas Institute Professor of Environmental Policy, Duke University. The authors are most grateful for the generous financial support of the National Academies Keck Futures Initiative.

†† Boehl Chair in Property & Land Use, Professor of Law & Urban Planning, and Chair, Center for Land Use & Environmental Responsibility, University of Louisville.

††† Founding Director and Counsel, The City Project; Assistant Professor, Charles Drew University of Medicine & Science.

†††† Associate Professor, Albany Law School.

††††† Senior Policy Associate, Nicholas Institute for Environmental Policy Solutions, Duke University.

†††††† Senior Staff Attorney and Adjunct Law Professor, Land Use Law Center, Pace Law School.

††††††† Associate, Vinson & Elkins LLP.

†††††††† Director of Ecosystem Services Program, Nicholas Institute for Environmental Policy Solutions, Duke University.

I. INTRODUCTION: THE IMPORTANCE OF URBAN ECOSYSTEM SERVICES

Nature is important to cities, not only for environmental protection, but also for economic productivity, fiscal soundness, community life, and governance. We tend to take nature's ecological systems—or ecosystems—for granted, but they provide critically valuable services to society and to urban areas. Ecosystems help to control natural hazards and climatic threats, such as storm surges and floods, temperature variation, and wind.[1] Ecosystems provide clean water by filtering out pollutants from storm water runoff, streams and rivers, aquifers, and drinking water supplies.[2] They provide refuge and reproduction habitat for plants and animals, thereby facilitating biodiversity. Ecosystems create recreational opportunities and a sense of place, which contribute to our quality of life by enhancing human physical and psychological health. Additionally they facilitate

1. *See, e.g.*, Marcia Silva Stanton, *Payments for Freshwater Ecosystem Services: A Framework for Analysis*, 18 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 189, 192–93 (2012) ("[F]reshwater ecosystems provide . . . mitigation of natural hazards . . . .").

2. *See, e.g.*, Stephen M. Johnson, *Federal Regulation of Isolated Wetlands*, 23 ENVTL. L. 1, 30–31 (1993) ("[I]t is well documented that many types of isolated wetlands play a vital role in protecting water quality by filtering sediments and pollutants out of water and by preventing nutrient overloading.").

food production and local food economies. Well-functioning ecosystems are not only better able to adapt to disturbances, but also strengthen the resilience and adaptive capacity of human communities and cities to withstand environmental alterations or catastrophes.

Economists, ecologists, landscape planners, and legal and policy scholars often use the umbrella term "ecosystem services" to refer to the wide range of values and benefits nature provides.[3] City officials and the public often refer to specific urban ecosystem services with terms such as green infrastructure, low impact development, parks, stormwater best management practices (BMPs), urban trees and forests, watershed management and conservation, wetlands, agricultural lands and soils, and others.[4] Regardless of the different terms, the constant factor is that communities rely heavily, indeed fundamentally, on nature for the continuing benefit from such services.[5] As Gretchen Daily (a professor of environmental science at Stanford University) has observed, "[u]nless humanity is suicidal, it should want to preserve, at the minimum, the natural life-support systems and processes required to sustain its own existence . . . . This is not an academic issue but a matter of social choice today in the context of humanity's cultural heritage."[6]

This is particularly true for cities, where economic productivity, fiscal soundness, community life, and governance are tied to natural surroundings in distinct, unique and generally under-appreciated ways. Because the urbanized world depends on ecosystem services—both inside and outside city boundaries—investing in the provision of ecosystem services will often be more cost-effective than response

3. *See, e.g.*, Thomas C. Brown et al., *Defining, Valuing, and Providing Ecosystem Goods and Services*, 47 NAT. RESOURCES J. 329, 329 (2007) ("Ecosystem services are the specific results of ecosystem processes that either directly sustain or enhance human life . . . .").

4. *See, e.g.*, Bethanne Sonne, *Managing Stormwater by Sustainable Measures: Preventing Neighborhood Flooding and Green Infrastructure*, 27 TUL. ENVTL. L.J. 323 (2014) (discussing methods of stormwater management including green infrastructure, urban tree canopy, land conservation measures, soil and permeable surface management, etc.); Alexandra Dapolito Dunn, *Siting Green Infrastructure: Legal and Policy Solutions to Alleviate Urban Poverty and Promote Healthy Communities*, 37 B.C. ENVTL. AFF. L. REV. 41, 41 (2010) (discussing the benefits provided by green infrastructure).

5. Because different disciplines favor different terms to express the role of natural features providing service benefits, we use the terms "urban ecosystem services" and "green infrastructure" in this article depending on the disciplinary context.

6. Gretchen C. Daily, *Valuing and Safeguarding Earth's Life Support Systems*, *in* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS 365, 365 (Gretchen C. Daily ed., 1997).

actions such as treatment, restoration, and disaster response.[7] For example, when cities use green infrastructure to control and manage stormwater runoff, it will often outperform conventional "gray infrastructure" such as pipes, channels, and treatment facilities.[8] Natural systems can help reduce hurricane impacts, floods, and droughts by storing storm water and providing natural floodplains or reservoirs and storm breaks in coastal areas.[9]

Given the importance of urban ecosystem benefits to surrounding populations, we might expect that ecosystem services would play a prominent role in formulating urban policies, plans, and laws. However, with rare exception, they do not. To be sure, some cities sustain critical watershed protection lands set aside a century ago, while others are pursuing policies to provide and protect ecosystem services and green infrastructure.[10] Many cities though, are experiencing declines in the ecosystems that sustain them. Across the country, we see degraded and destroyed natural features in our urban environments, as well as inefficient land use allocations and development. Metropolitan areas are increasingly losing open space, farmland, and environmentally sensitive lands.[11]

This trend is driven in part by existing legal frameworks that favor property rights, strong loyalties to Euclidean zoning preferences,[12] biases to invest capital in gray infrastructure, and the

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7. *See, e.g.*, Robert B. McKinstry Jr. et al., *Unpave a Parking Lot and Put Up a Paradise: Using Green Infrastructure and Ecosystem Services to Achieve Cost-Effective Compliance*, 42 ENVTL. L. REP. NEWS & ANALYSIS 10824, 10825 (2012) ("Compared to so-called gray infrastructure . . . green infrastructure offers additional advantages: it is more cost-effective and results in additional benefits.").

8. *Id.*

9. *See* Denise R. Johnson, *Reflections on the Bundle of Rights*, 32 VT. L. REV. 247, 259 (2007) (explaining the South Carolina dune system as providing storm breaks to protect human life, property, and wildlife); James Salzman, *Creating Markets for Ecosystem Services: Notes from the Field*, 80 N.Y.U. L. REV. 870, 872 (2005) (explaining that ecosystem services may mitigate droughts and floods).

10. *See* McKinstry, *supra* note 7, at 10824–25 (explaining that Philadelphia is implementing green infrastructure to reduce uncontrolled overflows from its storm water sewer system); Caswell F. Holloway et al., *Solving the CSO Conundrum: Green Infrastructure and the Unfulfilled Promise of Federal-Municipal Cooperation*, 38 HARV. ENVTL. L. REV. 335, 341 (2014) (explaining New York City's Green Infrastructure Plan and Million Trees NYC initiative as addressing water quality and energy concerns through green infrastructure).

11. *See, e.g.*, Sarah B. Schindler, *Of Backyard Chickens and Front Yard Gardens: The Conflict Between Local Governments and Locavores*, 87 TUL. L. REV. 231, 246–52 (2012) (explaining how Euclidean zoning has pushed farmland further from city-centers).

12. *See* Eliza Hall, *Divide and Sprawl, Decline and Fall: A Comparative Critique of Euclidean Zoning*, 68 U. PITT. L. REV. 915, 918 (2007) ("Euclidean zoning reflects functionalist view of the city as a machine, rather than an ever-evolving organism. The theory supports the

frequently occurring mismatched scales between ecosystem functions and governance structures, as well as other drivers. The net result is preference for the built rather than the natural environment. To be sure, sometimes this is perfectly appropriate and cost-effective; yet, in many cases investing in natural systems can provide services to urban communities for less expense than traditional built approaches and can provide significant additional public benefits.[13]

Even where cities provide natural features and benefits, they may provide them inequitably and inefficiently. For example, low-income and minority communities have often received a disproportionately smaller allocation of park resources, storm water control features, and other green infrastructure features.[14] In part, space limitations in urban areas have obstructed diverse urban forest development. Politically, residents of more affluent, suburban areas have been more apt to demand tree plantings and maintenance than urban dwellers. Moreover city officials often lack sufficient information about environmental benefits and ecosystem functions for effective use in urban planning decisions.[15]

Moreover, there are mismatched scales between the services people care about and the governance structures with the authority to manage the natural capital that provides these services. Even where the geographic scale is right, responsibilities for management and policy decisions fall into separate agency or professional/disciplinary silos that ignore the interrelationships among their governance or management functions in an interconnected environment.[16] There are

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view that society functions best when cities and the surrounding land are segregated into districts that strictly limit the uses to which properties there can be put . . . .") (Internal quotation marks omitted).

13. *See* McKinstry, *supra* note 7.

14. *See* Uma Outka, *Environmental Justice Issues in Sustainable Development: Environmental Justice in the Renewable Energy Transition*, 19 J. ENVTL. & SUSTAINABILITY L. 60, 64, 104, 116 (2012) (explaining that low-income communities "bear a disproportionate share of environmental burdens" and suggesting direct funding of green infrastructure in these low-income areas as a way to reduce these burdens).

15. *See, e.g.,* Livia Borak, *Most City Elected Officials Improve Grades on Environmental Issues*, VOICEOFSANDIEGO.ORG (May 9, 2013), http://voiceofsandiego.org/2013/05/09/most-city-elected-officials-improve-grades-on-environmental-issues (explaining that the average grade for San Diego city officials' Environmental Quality Report Cards was a "D+" in 2011, and rose to a "C" in 2012).

16. *See* BARRY DALAL-CLAYTON & STEVE BASS, THE CHALLENGES OF ENVIRONMENTAL MAINSTREAMING: EXPERIENCE OF INTEGRATING ENVIRONMENT INTO DEVELOPMENT INSTITUTIONS AND DECISIONS 18 (2009) ("Experience with truly high level and cross-sectoral environmental mainstreaming (in advocacy, analysis, planning, investment, management, and monitoring) has been limited and scattered to date. There has been little sharing of

often legal uncertainties about how to implement policies, and whether local officials have the necessary authority to use certain governance or management tools.[17] In sum, our cities are less livable, less economically vibrant, less ecologically and humanly healthy, and less socially just than they could—and indeed should—be.

As America, and the rest of the world, becomes increasingly urbanized, these are high priority issues in seeking to improve quality of life. The scholarship in the area, though, has been fragmented by discipline. Some scholars are increasingly studying the relationships between urban governance, including law and urban planning, and ecosystem services.[18] Others have developed assessment, decision-making, implementation, and even structural tools that can aid cities in providing and protecting ecosystem services.[19] However, this literature remains nascent, and much remains to be done.

We seek to help shape the trajectory of this research across multiple disciplines in this growing and critical area. This article brings together the collective insights of scholars and practitioners from a wide range of disciplines—lawyers and urban planners to ecologists and economists—in order to highlight the most pressing research needs. Taking a comprehensive look at the field, we identify the most important research questions that will shape the future of

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experience."), *available at* http://pubs.lied.org/pdfs/17504IIED.pdf.

17. *See* Craig Anthony (Tony) Arnold, *Planning Milagros: Environmental Justice and Land Use Regulation*, 76 DENV. U. L. REV. 1, 71–72 (1998) ("[S]carce government agency resources, political pressures, scientific and legal uncertainty, and the problem of agency capture result in a limited implementation of environmental policy . . . .").

18. *See, e.g.*, URBANIZATION, BIODIVERSITY AND ECOSYSTEM SERVICES: CHALLENGES AND OPPORTUNITIES, (Thomas Elmqvist et al. eds., 2013) (analyzing the potential to plan for ecosystem services and discussing potential problems); Dagmar Haase et al., *Ecosystem Services in Urban Landscapes: Practical Applications and Governance Implications*, 43 AMBIO 407, 407 (Apr. 17, 2014), *available at* http://link.springer.com/article/10.1007/s13280-014-0503-1#page-1 ("This Special Issue aims at bridging the knowledge gap among urbanization, demand creation, and provisioning of ecosystem services in urban regions on the one hand and schemes of urban governance on the other."); Olaf Bastian et al., *Ecosystem properties, potentials and services—The EPPS conceptual framework and an urban application example*, 21 ECOLOGICAL INDICATORS 7 (2012) (providing potential methods to assesss ecosystem services for local practitioners).

19. Much of the initial research has been found in the gray literature supported by the efforts of city governments and non-governmental organizations. *See, e.g., NY City Green Infrastructure Plan and Annual Reports*, NYC GOV. (Sept. 29, 2014), http://www.nyc.gov/html/dep/html/stormwater/nyc_green_infrastructure_plan.shtml (providing for the assessment and implementation of ecosystem services); *see also* The American Rivers Series of Reports, *Reports and Publications*, AMERICANRIVERS.ORG (Sept. 29, 2014), http://www. americanrivers.org/newsroom/resources/going-green-to-save-green-economic-benefits-of-green-infrastructure-practices/ (discussing financing tools for implementing ecosystem services programs).

scholarship on urban ecosystem services.

This article provides a literature review in Section II, discussing the key publications to date and setting out gaps in the legal literature. In Section III, we explore three major categories of research – 1) equitable provision of ecosystem services in urban settings; 2) who pays for ecosystem services and how they pay; and 3) governance structure and institutions. For each, we explain what is known, what we need to know, and how to properly frame the relevant research questions. Section IV summarizes our findings and concludes.

II. THE STATE OF THE LITERATURE ON URBAN ECOSYSTEM SERVICES AND GOVERNANCE

The literature on urban ecosystem services, law, and urban policy is growing but remains incomplete. The field continues to build on economic and ecological studies establishing benefits of ecosystems to society in general,[20] urban-specific research regarding the benefits of ecosystem services,[21] and the benefits of specific ecosystems, such as watershed lands[22] and urban forests.[23] In many cases, research is

20. *See, e.g.,* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS (Gretchen C. Daily ed., 1997) (analyzing potential benefits provided by ecosystem services); Robert Costanza & Herman E. Daly, *Natural Capital and Sustainable Development*, 6 CONSERVATION BIOLOGY 37, 39 (1992) (presenting the idea that ecosystem services provide natural capital); Robert Costanza et al., *The Value of the World's Ecosystem Services and Natural Capital*, 387 NATURE 253 (1997) (elaborating on the way in which ecosystem services provide natural capital).

21. *See, e.g.,* Per Bolund & Sven Hunhammar, *Ecosystem Services in Urban Areas*, 29 ECOLOGICAL ECON. 293, 293 (1999) ("[Urban ecosystems] generate a range of ecosystem services . . . air filtration, micro climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values."); Jürgen Brueste et al., *Urban Landscapes and Ecosystem Services*, *in* ECOSYSTEM SERVICES IN AGRICULTURAL AND URBAN LANDSCAPES 83–104 (Steve Wratten et al. eds., 2013) (analyzing ecosystem services in urban areas); URBANIZATION, BIODIVERSITY AND ECOSYSTEM SERVICES: CHALLENGES AND OPPORTUNITIES (Thomas Elmqvist et al. eds., 2013), *available at* http://link.springer.com/book/10.1007/978-94-007-7088-1 (providing a detailed analysis of ecosystem services in urban contexts).

22. *See, e.g.,* Travis Greenwalt & Deborah McGrath, *Protecting the City's Water: Designing a Payment for Ecosystem Services Program*, 24 NAT. RESOURCES & ENV'T 9 (2009) (discussing ecosystem services provided by water areas and methods of management).

23. ECOLOGY, PLANNING, AND MANAGEMENT OF URBAN FORESTS: INTERNATIONAL PERSPECTIVES (Margaret M. Carreiro et al. eds., 2008); AMERICAN FORESTS, URBAN ECOSYSTEM ANALYSIS MIAMI-DADE COUNTY UDB AND THE CITY OF MIAMI, FLORIDA (2008), *available at* http://www.systemecology.com/4_Past_Projects/AmforReportMiamiUEA_V4final_lowres.pdf; C.Y. Jim & Wendy Y. Chen, *Ecosystem Services and Valuation of Urban Forests in China*, 26 CITIES 187 (2009), *available at* http://wenku.baidu.com/view/f1375923192e45361066f517.html; Cynnamon Dobbs et al., *A Framework for Developing Urban*

applicable to ecosystems located within urban areas and also to regionally significant ecosystems that serve urban areas, such as regional farmland and soils that provide locally grown food supplies to cities.[24] In the legal arena, much of the ground-breaking work on ecosystem services and law has occurred in the context of federal environmental law and state common-law property doctrines, including nuisance and the public trust doctrine.[25]

A number of seminal publications, such as *The Law and Policy of Ecosystem Services,*[26] *Markets for Nature,*[27] and *Creating Markets*

Ecosystem Forest Services and Goods Indicators, 99 LANDSCAPE & URB. PLAN. 196 (2011), *available at* http://www.srs.fs.usda.gov/pubs/ja/2011/ja_2011_zipperer_ 002.pdf; Francisco J. Escobedo et al.; *Urban Forests and Pollution Mitigation: Analyzing Ecosystem Services and Disservices*, 159 ENVTL. POLLUTION 2078 (2011), *available at* http://www.earthsake.ca/articles/urban_ecology_2_escobedo2011.pdf; Francesc Baró et al., *Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain*, 43 AMBIO 466 (2014), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3989519.

24. Harpinder Sandhu & Steve Wratten, *Ecosystem Services in Farmland and Cities*, ECOSYSTEM SERVICES IN AGRICULTURAL AND URBAN LANDSCAPES, *supra* note 21, at 1, 10–11; Daniele La Rosa & Riccardo Privitera, *Characterization of Non-Urbanized Areas for Land-Use Planning of Agricultural and Green Infrastructure in Urban Contexts*, 109 LANDSCAPE URB. PLAN. 94 (2012).

25. *See, e.g.*, James Salzman, *Valuing Ecosystem Services*, 24 ECOLOGY L.Q. 887, 888 (1997) ("State and federal agencies do understand [ecosystem management's] general importance. A number of laws, including the Clean Water Act, the Endangered Species Act, and the National Forestry Management Act implicitly protect ecosystem services through their habitat protection and planning procedures."); James Salzman et al., *Protecting Ecosystem Services: Science, Economics, and Law*, 20 STAN. ENVTL. L.J. 309 (2001) (outlining governmental initiatives for ecosystem services provision in the U.S. and abroad); J.B. Ruhl & R. Juge Gregg, *Integrating Ecosystem Services into Environmental Law: A Case Study of Wetlands Mitigation Banking,* 20 STAN. ENVTL. L.J. 365, 368 (2001) ("outlin[ing] the background of the federal law and policy of wetlands regulation and the practice of mitigation banking."); James Salzman, *A Field of Green? The Past and Future of Ecosystem Services*, 21 J. LAND USE & ENVTL. L. 133, 137 (2006) ("our laws do not explicitly protect ecosystem services."); J.B. Ruhl & James Salzman, *Ecosystem Services and the Public Trust Doctrine: Working Change from Within*, 15 SOUTHEASTERN ENVTL. L.J. 223, 224 (2006) ("analyz[ing] how natural capital and ecosystem services can be integrated into the public trust doctrine."); J.B. Ruhl & James Salzman, *The Law and Policy Beginnings of Ecosystem Services*, 22 J. LAND USE & ENVTL. L. 157, 163–65 (2007) (analyzing national governments approaches to provisioning ecosystem services); J.B. Ruhl, *The "Background Principles" of Natural Capital and Ecosystem Services—Did Lucas Open Pandora's Box?,* 22 J. LAND USE & ENVTL. L. 525 (2007) (providing a general sense of the common law with respect to ecosystem services); J.B. Ruhl, *Making Nuisance Ecological*, 58 CASE W. RES. L. REV. 753 (2008) (discussing ecosystem services and nuisance common law doctrine); J.B. Ruhl, *Agriculture and Ecosystem Services: Strategies for State and Local Governments*, 17 N.Y.U. ENVTL. L.J. 424 (2008) (proposing "that federal policy support state and local innovations rather than dominate the field as has been the case historically.").

26. J.B. RUHL ET AL., THE LAW AND POLICY OF ECOSYSTEM SERVICES (2007).

27. Barton H. Thompson, Jr., *Markets for Nature*, 25 WM. & MARY ENVTL. L. & POL'Y

for Ecosystem Services[28] provided in-depth analyses of the applicable legal regimes and ecosystem services provision. However, the role of *urban* legal systems in regulating, protecting, and valuing ecosystem services is less well understood. The ground in this area was broken in 2001 with the *Stanford Environmental Law Journal* article, *Protecting Natural Capital through Ecosystem Services Districts*.[29] In that article, Geoff Heal, Jim Salzman, Gretchen Daily and others provided an overview of ecosystem services and the issues involved in designing laws and institutions for properly maintaining ecosystem services, while contemplating the ways in which existing legal regimes act as barriers for effective ecosystem governance. *Protecting Natural Capital* and other articles in the same issue identified for the first time the relevant laws and policies that serve to promote the range of ecosystem services that facilitate and sustain urban living.[30]

The 2007 article, *The Structure of the Land Use Regulatory System*, provided a second systematic example of how legal scholars have addressed the role of ecosystem services in urban planning and governance. The author, Tony Arnold, explored the structural opportunities for, and barriers to, local governments incorporating ecosystem services protections into their land use planning and regulatory activities.[31] The article demonstrated how cities are increasingly using a wide variety of land-use planning and regulatory tools to conserve ecosystems and to capture the services ecosystems provide to society.[32] The article focused on cities using watershed

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REV. 261 (2000).

28. James Salzman, *Creating Markets for Ecosystem Services: Notes from the Field*, 80 N.Y.U. L. REV. 870 (2005).

29. Geoffrey Heal et al., *Protecting Natural Capital through Ecosystem Service Districts*, 20 STAN. ENVTL. L.J. 333 (2001).

30. *See id.* at 335 (arguing for the creation of Ecosystem Service Districts to manage ecosystem services); *see also* Salzman et al., *Protecting Ecosystem Services: Science, Economics, and Law*, *supra* note 25 at 313 ("consider[ing] the steps necessary to integrate the emerging science and economics of ecosystem services valuation within a legal framework of rules and incentives."); Ruhl & Gregg, *supra* note 25 (exploring the practices of wetlands mitigation banking); James Boyd et al., *Compensation for Lost Ecosystem Services: The Need for Benefit-Based Transfer Ratios and Restoration Criteria*, 20 STAN. ENVTL. L.J. 393 (2001) (presenting policies for ecosystem evaluation); Robert L. Fishman, *The EPA's NEPA Duties and Ecosystem Services*, 20 STAN. ENVTL. L.J. 497, 500 (2001) ("several common projects entail significant impacts to ecosystem services and often involve major federal action . . . such as: (1) community development . . . (2) renewable resource use and development on public lands . . . (3) energy production . . . (4) non-energy mineral resource development . . . and (5) water projects and permits for wetland modification.").

31. Craig Anthony (Tony) Arnold, *The Structure of the Land Use Regulatory System in the United States*, 22 J. LAND USE & ENVTL. L. 441, (2007).

32. *Id.* at 486–87, 517–18.

planning and governance as an adaptive and promising means for local government to integrate ecosystem services policies into local planning and law.[33]

The 2011 article, *Sustaining Ecosystem Services through Local Environmental Law*, tackled the extent to which local law and governance can sustain the socially and economically valuable services that ecosystems provide to human communities.[34] Keith Hirokawa linked the literature on ecosystem services law with local environmental law. Hirokawa conceived local ecosystem services protection as a matter of local governance that uses all legal and policy tools available to localities, not just land use planning and regulation. The article presented detailed examples of local laws that protect ecosystem functionality.[35]

In the urban planning context, scholars have begun to develop a body of literature expounding on important ecosystem functions for land use planning, albeit not always by explicitly addressing ecosystem services. Under the guise of planning principles for the "ecological city" or the "biophilic city," this literature is exploring the benefits ecosystems bring to urban development.[36] A subset of the

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33. *Id.* For other sources with a similar focus see, CRAIG ANTHONY (TONY) ARNOLD ET AL., KENTUCKY WET GROWTH TOOLS FOR SUSTAINABLE DEVELOPMENT: A HANDBOOK ON LAND USE AND WATER FOR KENTUCKY COMMUNITIES (2009); Craig Anthony (Tony) Arnold, *Clean-Water Land Use: Connecting Scale and Function*, 23 PACE ENVTL. L. REV. 291 (2006); Craig Anthony (Tony) Arnold, *For the Sake of Water: Land Conservation and Watershed Protection*, 14 SUSTAIN: A J. ENVTL. & SUSTAINABILITY ISSUES 16 (2006); Craig Anthony (Tony) Arnold, *Adaptive Watershed Planning and Climate Change*, 5 ENVT'L & ENERGY L. & POL'Y J. 417 (2010); Craig Anthony (Tony) Arnold, *Fourth-Generation Environmental Law: Integrationist and Multimodal*, 35 WM. & MARY ENVTL. L. & POL'Y REV. 771 (2011).

34. Keith H. Hirokawa, *Sustaining Ecosystem Services through Local Environmental Law*, 28 PACE ENVTL. L. REV. 760 (2011).

35. Hirokawa has also written a series of articles examining the role law and local governance play in providing and protecting specific ecosystem services from urban forests, watersheds, wetlands, climate, and species' habitat. *See, e.g.*, Keith H. Hirokawa, *Sustainability and the Urban Forest: An Ecosystem Services Perspective*, 51 NAT. RESOURCES J. 233 (2011); Keith H. Hirokawa, *Driving Local Governments to Watershed Governance*, 42 ENVTL. L. 157 (2012); Keith H. Hirokawa, *Disasters and Ecosystem Services Deprivation: From Cuyahoga to the Deepwater Horizon*, 74 ALB. L. REV. 543 (2010–11); Keith H. Hirokawa, *Local Planning to Preserve Wetlands Assets: Community, Baselines, and Ecosystem Services*, *in* BEYOND RAPANOS: THE NEXT GENERATION OF WETLAND REGULATION (Kimberly Connolly ed., forthcoming 2014).

36. Some of the most important works include TIMOTHY BEATLEY & KRISTY MANNING, THE ECOLOGY OF PLACE: PLANNING FOR ENVIRONMENT, ECONOMY, AND COMMUNITY (1997); JOHN RANDOLPH, ENVIRONMENTAL LAND USE PLANNING AND MANAGEMENT (2d ed., 2004); STEPHEN R. KELLERT, BUILDING FOR LIFE: DESIGNING AND UNDERSTANDING THE HUMAN-NATURE CONNECTION (2005); RANDOLPH T. HESTER JR., DESIGN FOR ECOLOGICAL DEMOCRACY (2010); IAN L. MCHARG, THE ESSENTIAL IAN MCHARG: WRITINGS ON DESIGN

literature on urban growth and development focuses more on "smart growth" than on the "ecological city" or "biophilic city." The "Smart Growth"[37] literature gives some effective attention to ecosystem services by emphasizing the value of open space and farmland preservation.[38] The "Smart Growth" literature, however, devotes less attention to other ecosystem services aspects, such as water and watersheds,[39] or how high-density development could adversely affect urban ecosystem functions.[40]

Perhaps the most intentional and extensive work to incorporate ecosystem services into urban planning focuses on "green infrastructure's" social, economic, and environmental benefits.[41] The term "green infrastructure" has been used broadly to encompass natural systems and features that have been protected from alteration, restored natural systems and features, and humanly created or engineered bio-physical systems and features. The term is

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AND NATURE (Dean Frederick R. Steiner ed., 2006); TIMOTHY BEATLEY, BIOPHILIC CITIES: INTEGRATING NATURE INTO URBAN DESIGN AND PLANNING (2010).

37. Smart growth policies focus on managing and controlling growth and land development in order to promote compact, livable cities that reject suburban sprawl and automobile-dependent development. Gabor Zovanyi, *The Role of Initial Statewide Legislation in Advancing the Tenets of Smart Growth*, 39 URB. LAW. 371, 371–74 (2007). Zovanyi catalogued the principles of smart growth offered by leading commentators and synthesized them into five major tenets: growth containment in compact settlements; protection of the environment, resource lands, and open space; multi-modal transportation systems; mixed-use development; and collaborative planning and decision making. *Id.* at 379.

38. Smart Growth Network, *National Conversation on the Future of Our Communities* (Feb. 2013), *available at* http://www.smartgrowth.org/nationalconversation/compendium/National_Conversation_Compendium_2_2013.pdf; David N. Bengston et al., *Public Policies for Managing Urban Growth and Protecting Open Space: Policy Instruments and Lessons Learned in the United States*, 69 LANDSCAPE & URB. PLAN. 271, 272 (2004).

39. Craig Anthony (Tony) Arnold, *Is Wet Growth Smarter Than Smart Growth: The Fragmentation and Integration of Land Use and Water*, 35 ENVTL. L. REP. 10152 (2005). The "wet growth" literature developed at least partly in response to the "smart growth" literature's insufficient attention to water and watersheds.

40. Jamie Tratalos et al., *Urban Form, Biodiversity Potential, and Ecosystem Services*, 83 LANDSCAPE & URB. PLAN. 308, 308 (2007).

41. *See, e.g.*, MARK A. BENEDICT & EDWARD T. MCMAHON, GREEN INFRASTRUCTURE: LINKING LANDSCAPES AND COMMUNITIES (2006); Konstantinos Tzoulas et al., *Promoting Ecosystem and Human Health in Urban Areas Using Green Infrastructure: A Literature Review*, 81 LANDSCAPE & URB. PLAN. 167 (2007) (examining the association between green infrastructure and ecological and human health); Robert F. Young & E. Gregory McPherson, *Governing Metropolitan Green Infrastructure in the United States*, 109 LANDSCAPE & URB. PLAN. 67 (2013) (analyzing whether efforts to expand urban ecosystems are driven by traditional municipal governments or new trans-disciplinary strategies in metropolitan governance). A recent American Planning Association Planning Advisory Service Report focuses on green infrastructure. DAVID C. ROUSE & IGNACIO BUNSTER-OSSA, GREEN INFRASTRUCTURE: A LANDSCAPE APPROACH (2013).

used most often to refer to increasingly favored techniques, technologies, and management approaches to reduce or manage storm water runoff without relying primarily or solely on traditional pipe and concrete "gray infrastructure."[42] The City of Philadelphia, for example, is often praised for its comprehensive, long-term, and innovative green-infrastructure program to control runoff and protect the city's water quality.[43] However, green infrastructure is much broader than merely rain gardens and bioswales, and provides many more benefits than just storm water runoff control. For example, urban trees help not only to control runoff but also to moderate temperatures, contribute to psychological health, minimize soil erosion, sequester carbon, reduce energy costs, enhance a streetscape's walkability, support urban biodiversity, and provide aesthetic beauty.[44] In some places, at least, green infrastructure is beginning to play an important role in urban planning.[45]

Researchers in many disciplines have also developed a significant number of assessment and/or decisional tools to aid urban officials in valuing and protecting ecosystem services.[46] As with other environmental and land-use decision-making areas, concern remains

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42. *What Is Green Infrastructure?*, EPA, http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm (last visited Nov. 9, 2014) [hereinafter *What is Green Infrastructure*].

43. PHILADELPHIA WATER DEP'T, GREEN CITY, CLEAN WATERS 3 (June 2011), *available at* www.phillywatersheds.org/doc/GCCW_AmendedJune2011_ LOWRES-web.pdf.

44. AMERICAN FORESTS, *supra* note 23, at 4–5.

45. Green infrastructure is not an entirely new principle in urban planning. *See* Theodore Eisenman, *Frederick Law Olmsted, Green Infrastructure, and the Evolving City*, 12 J. PLAN. HIST. 287, 288 (2013) (discussing Frederick Law Olmsted's work in the nineteenth century).

46. *E.g.*, NATURAL CAPITAL: THEORY AND PRACTICE OF MAPPING ECOSYSTEM SERVICES (Peter Kareiva et al. eds., 2011); ECON. OF ECOSYSTEMS & BIODIVERSITY, TEEB MANUAL FOR CITIES: ECOSYSTEM SERVICES IN URBAN MANAGEMENT (2011), *available at* http://doc.teebweb.org/wp-content/uploads/Study%20and%20Reports/Additional%20Reports/Manual%20for%20Cities/TEEB%20Manual%20for%20Cities_English.pdf; Erik Andersson, *Urban Landscapes and Sustainable Cities*, 11 ECOLOGY & SOC'Y 34 (2006); Rudolf de Groot, *Function-Analysis and Valuation as a Tool to Assess Land Use Conflicts in Planning for Sustainable, Multi-Function Landscapes*, 75 LANDSCAPE & URB. PLAN. 175 (2006); Benjamin Burkhard et al., *Landscapes' Capacities to Provide Ecosystem Services—A Concept for Land-Cover Based Assessments*, 15 LANDSCAPE ONLINE 1 (2009); Gretchen C. Daily et al., *Ecosystem Services in Decision Making: Time to Deliver*, 7 FRONTIERS IN ECOLOGY & ENV'T 21 (2009). For tools to evaluate the ecosystem services of urban trees and make tree canopy planning decisions, see Sonne, *supra* note 4, at 346 (identifying existing resources like FEMA's Hurricane and Storm Damage Risk Reduction System); *see also* Dapolito Dunn, *supra* note 4 (urging urban leaders' use "quantified methods" to implement and evaluate green infrastructure). For an overview of tools to evaluate the value of watershed protections of a city's water supply, see Greenwalt & McGrath, *supra* note 22, at 10 (listing "best practices" for implementing a Payment for Ecosystem Service (PES) system).

about the accuracy or utility of these tools.[47] Recent scholarship follows the "no-panaceas" approach; scholars study complex environmental-social dynamics,[48] recommending a toolbox—or multimodal approach—over an optimal policy design approach.[49] This pluralistic approach seeks to address policy contexts in which many different values are important; where various ecosystem services might have to be traded off against one another, yet the complexity of interconnected systems elevates the risk that any single policy choice will suddenly and unexpectedly fail due to unanticipated disturbances and responses.[50] In this setting, social-ecological resilience and institutional adaptive capacity become particularly important.[51] Resilience is a system's capacity to adapt to disturbances and changes while retaining its core structure, functions, and processes. "Social-ecological resilience" is the concept that social system resilience (e.g., human communities, political systems, economies) and ecosystem resilience (e.g., watersheds, wetlands, forests, climate) are interdependent in complex, non-linear

47. One researcher makes a compelling case for the integration of ecosystem services into urban planning, but asserts that too little planning-relevant information is known about urban ecosystem services. Jari Niemelä et al., *Using the Ecosystem Services Approach for Better Planning and Conservation of Urban Green Spaces: A Finland Case Study*, 19 BIODIVERSITY & CONSERVATION 3225, 3238 (2010).

48. Elinor Ostrom et al., *Going Beyond Panaceas*, 104 PROC. NAT'L ACAD. SCI. U.S. 15176, 15177 (2007) (outlining articles that help "sustainability scientists to go beyond panaceas").

49. *E.g.*, Daily et al., *supra* note 46; ECON. OF ECOSYSTEMS & BIODIVERSITY, *supra* note 46; Craig Anthony (Tony) Arnold, *Fourth-Generation Environmental Law: Integrationist and Multimodal*, *supra* note 33; CRAIG ANTHONY (TONY) ARNOLD ET AL., KENTUCKY WET GROWTH TOOLS, *supra* note 33. For broader toolbox approaches to ecosystem services generally, see JANET RANGANATHAN ET AL., BANKING ON NATURE'S ASSETS: HOW MULTILATERAL DEVELOPMENT BANKS CAN STRENGTHEN DEVELOPMENT BY USING ECOSYSTEM SERVICES (2009) (Table 5 at pp. 20–22 is an especially helpful visual of different tools); JAMES SALZMAN, DESIGNING PAYMENTS FOR ECOSYSTEM SERVICES, PERC POLICY SERIES REPORT NO. 48 (Roger Meiners ed., 2010).

50. Giulia Wegner & Unai Pascual, *Cost-Benefit Analysis in the Context of Ecosystem Services for Human Well-Being: A Multidisciplinary Critique* 23 (United Nations Environment Programme, Ecosystem Services Economics Working Paper Series No. 13, 2011); Adrienne Grêt-Regamey et al., *Understanding Ecosystem Services Trade-Offs with Interactive Procedural Modeling for Sustainable Urban Planning*, 109 LANDSCAPE & URB. PLAN. 107 (2013); Jari Lyytimäki et al., *Nature as a Nuisance: Ecosystem Services and Disservices to Urban Lifestyle*, 5 ENVTL. SCI. 161 (2008).

51. *E.g.*, Jon Paul Rodriguez et al., *Trade-offs Across Space, Time, and Ecosystem Services*, 11 ECOLOGY & SOC'Y 28 (2006); Garry D. Peterson et al., *Assessing Future Ecosystem Services: A Case Study of the Northern Highlands Lake District, Wisconsin*, 7 CONSERVATION ECOLOGY 1 (2003); *see also* Brian Walker, et al., *Resilience Management in Social-Ecological Systems: A Working Hypothesis for a Participatory Approach*, 6 CONSERVATION ECOLOGY 1, 14 (2002).

relationships.[52] Institutional adaptive capacity is particularly important to strengthening social-ecological resilience, especially in urban areas.[53] Hence the urban ecosystem services literature is beginning to bridge the literatures on resilient cities, social-ecological resilience, adaptive governance, adaptive management, and adaptive planning.[54]

In sum, the role ecosystem services play in urban settings has attracted increased interest but has not yet matured to the point where one can speak meaningfully of the "field of urban ecosystem services." What we know and understand and what we do not yet know and understand can and should shape the direction of research in urban ecosystem services. For example, while we see a growing number of studies addressing urban ecosystem services distribution by race, ethnicity, socioeconomic class, and other demographic characteristics, we do not yet have a systematic and complete set of

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52. BRIAN WALKER & DAVID SALT, RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD xiii (2006). *See generally* Carl Folke, *Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses*, 16 GLOBAL ENVTL. CHANGE 253 (2006) (discussing the origins of the resilience perspective and its development); LANCE GUNDERSON & C.S. HOLLING, PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS XXI, 25 (Lance H. Gunderson & Crawford S. Holling eds., 2002) (identifying ways "economic growth and human development depend upon joint natures of ecosystems and institutions . . . [and] ways to identify, monitor, and maintain those attributes or, if they have been eroded, to restore them).

53. Craig Anthony (Tony) Arnold et al., *The Social-Ecological Resilience of an Eastern Urban-Suburban Watershed: The Anacostia River Basin* (forthcoming 2015).

54. *See, e.g.*, Craig Anthony (Tony) Arnold, *Resilient Cities and Adaptive Law*, 50 IDAHO L. REV. 245 (2014) (discussing both resilient cities and adaptive government); *Project SUPER: Sustainable Urban Planning for Ecosystem Services and Resilience*, BEIJER INST. OF ECOLOGICAL ECON., http://www.beijer.kva.se/research_under.php?id=30 (last visited Nov. 9, 2014) (providing "a foundation for innovation in urban planning and government" intended for use in "urban resilience, governance, and sustainability"). For some of the key works on resilience that are relevant to urban ecosystems, see sources cited *supra* note 33; Hirokawa, *supra* note 34 (stressing the importance of environmental legislation to protect and promote ecosystem services); BRIAN WALKER & DAVID SALT, RESILIENCE PRACTICE: BUILDING CAPACITY TO ABSORB DISTURBANCE AND MAINTAIN FUNCTION ix (2012) (explaining resilience thinking and applying it to "assessing and managing resilience"); BRIAN WALKER & DAVID SALT, COLLABORATIVE RESILIENCE: MOVING THROUGH CRISIS TO OPPORTUNITY 14 (Bruce Evan Goldstein ed., 2012) (treating resilience thinking as practical guidance for methods of adaptation to evolving ecological problems). Numerous organizations focus on enhancing the resilience and adaptive capacity of cities. Among these are ICLEI, the Rockefeller Foundation, the Center for Resilient Cities, the United Nations Office for Disaster Risk Reduction, Next City, the International Federation for Housing and Planning, Ceres and Biophilic Cities. Some resilient-cities scholarship or activities, though, focus primarily on disaster preparedness and risk reduction or on climate change. *See, e.g.*, PETER NEWMAN ET AL., RESILIENT CITIES: RESPONDING TO PEAK OIL AND CLIMATE CHANGE 4 (2009) (identifying peak oil and climate change as two important reasons for cities to focus on resilience).

policy principles to guide decision makers to equitable urban ecosystem services provision.[55] Likewise, too little is known about how urban ecosystem services are financed and insured, and research on this topic needs to be integrated more fully with urban-ecosystem research in fields like ecology, planning, and law.[56] Furthermore, while the growing literature on social-ecological resilience and adaptive governance is starting to address urban ecosystem services,[57] we have yet to fully develop the theory and practice of adaptive and integrated governance structures and processes to ensure urban ecosystem services are provided and that the ecosystems from which these services derive are resilient.[58]

III. PROMISING RESEARCH AREAS

This section explores in detail the three broad research areas of urban ecosystem services. Part A considers the distributional impacts of providing services and the challenges posed by pursuing environmental equity. Part B turns to financing questions. While attractive in theory, providing urban ecosystem services on the ground requires effective funding mechanisms that work across jurisdictions, government "silos" that may or may not be communicating with one another, and private and public ownership. This reality raises very real concerns over who pays, who is paid, and the constraints created by legal requirements and the inertia of the status quo. Part C examines the institutional challenges that arise when meaningfully providing services in the urban landscape. In each part, we explain the basic issues and then identify particularly promising research questions.

A. Equitable Provision of Urban Ecosystem Services

One central question for urban ecosystem services is, "how can these services be provided in both an environmentally beneficial and socially equitable manner?" Environmental inequality occurs when certain population sectors —predominantly low-income and minority populations—either bear a disproportionate burden from industrial pollution sources or receive fewer benefits from environmentally beneficial projects. Environmental justice is "the principle that all people and communities are entitled to equal protection of

55. *See infra* Section III.A and sources cited therein.
56. *See infra* Section III.B and sources cited therein.
57. *E.g.*, Arnold et al., *supra* note 53.
58. *See infra* Section III.C and sources cited therein.

environmental and public health laws."[59]

Since the 1980s, a robust literature has examined the distributional and social justice impacts of environmental hazards and burdens, including health disparities in the population that are exacerbated by the built environment. Social science research has also focused on what causes environmental inequality and how to alleviate it.[60] Research considering equitable environmental benefit provision, like ecosystem services, is far less common.[61] The paragraphs below identify the key research findings regarding the applicable ecosystem services provisions to date.

1. Environmental Equity and Urban Forest Cover

Research at the urban level often focuses on urban forestry issues. In their 2004 article, *Inequitable Access to Urban Reforestation: The Impact of Urban Political Economy on Housing Tenure and Urban Forests*, Perkins et al. examined the outcomes of a municipal tree planting program in Milwaukee, Wisconsin and found that programs promoting private participation in tree planting can create inequalities because lower-income neighborhoods with primarily renter-occupied housing may be less likely to participate.[62] In a related 2006 study, Heynen, et al. examined overall tree distribution in the Milwaukee area and found disparities in urban tree cover that were attributed in part to housing dynamics, household income, and

59. Robert D. Bullard, *Environmental Justice: It's More than Waste Facility Siting*, 77 SOCIAL SCI. Q. 493, 493 (1996).

60. *See, e.g.*, Shoba Srinivasan et al., *Creating Healthy Communities, Healthy Homes, Healthy People: Initiating a Research Agenda on the Built Environment and Public Health*, 93 AM. J. PUB. HEALTH 1447 (2003) (discussing health disparities exacerbated by the built environment); Paul Mohai & Bunyan Bryant, *Environmental Racism: Reviewing the Evidence*, *in* RACE AND THE INCIDENCE OF ENVIRONMENTAL HAZARDS 163–64 (Bunyan Bryant & Paul Mohai eds., 1992) (summarizing studies that indicate a pattern of environmental racism).

61. *See, e.g.*, THE JUSTICES AND INJUSTICES OF ECOSYSTEM SERVICES (Thomas Sikor ed., 2013); Joan Flocks et al., *Environmental Justice Implications of Urban Tree Cover in Miami-Dade County, Florida*, 4 ENVTL. JUST. 125, 126 (2011) (discussing inequitable distribution of urban tree cover and the effect on ecosystem services); G. Darrel Jenerette et al., *Ecosystem Services and Urban Heat Riskscape Moderation: Water, Green Spaces, and Social Inequality in Phoenix, USA*, 21 ECOLOGICAL APPLICATIONS 2637 (2011); Henrik Ernstson, *The Social Production of Ecosystem Services: A Framework for Studying Environmental Justice and Ecological Complexity in Urbanized Landscapes*, 109 LANDSCAPE & URB. PLAN. 7 (2013) (relating ecosystem services to environmental justice); Bill M. Jesdale et al., *The Racial/Ethnic Distribution of Heat Risk-Related Land Cover in Relation to Residential Segregation*, 121 ENVTL. HEALTH PERS. 811 (2013).

62. Harold A. Perkins et al., *Inequitable Access to Urban Reforestation: The Impact of Urban Political Economy on Housing Tenure and Urban Forests*, 21 CITIES 291 (2004).

racial and ethnic factors.[63] Landry and Chakraborty found that in Tampa, FL, tree cover on public rights of way was significantly lower in neighborhoods with higher proportions of African-American, low-income, and non-home owner residents.[64] In a similar study, Flocks et al. found that, in the Miami-Dade area, predominantly white neighborhoods tended to have greater tree cover, canopy density, and tree species diversity as well as greater energy savings from urban tree cover.[65] They attributed the uneven urban tree cover distribution to socioeconomic factors such as housing patterns, residential control over the physical environment, financial means, and pre-existing environmental inequality due to the location of environmental hazards.[66] Because neighborhoods in urban areas with little vegetation are more vulnerable to extreme heat events, these inequalities leave low income and minority residents more vulnerable to climate change.[67]

2. Environmental Equity and Park Access

Other research in the urban ecosystem services area focuses on unequal access to urban parks. These studies have been spearheaded by non-profit organizations and federal agencies in developing national, state, and local strategies to alleviate environmental inequalities in park access.

For example, President Barack Obama, in designating a new national monument in the San Gabriel Mountains in Los Angeles County, recently recognized the following:

> We heard from the community, that for a lot of urban families, this is their only big outdoor space. Too many children in L.A. County, especially children of color, don't have access to parks where they can run free, breathe fresh air, experience nature, and learn about their environment . . . . This is an issue of social justice. Because it's not enough to have this awesome natural wonder within your sight—you have to be able to access it.[68]

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63. Nik Heyney et al., *The Political Ecology of Uneven Urban Green Space: The Impact of Political Economy Producing Environmental Inequality in Milwaukee*, 42 URB. AFF. REV. 3, 19 (2006).

64. Shawn M. Landry & Jayajit Chakraborty, *Street Trees and Equity: Evaluating the Spatial Distribution of an Urban Amenity*, 41 ENV'T & PLAN. 2651, 2663–66 (2009).

65. Joan Flocks et al., *supra* note 61, at 129–30.

66. *Id*. at 130–34.

67. G. Darrel Jenerette et al., *supra* note 61, at 2346–48.

68. Pres. Barack Obama, Off. of the Press Sec'y, *Remarks by the President at the Designation of the San Gabriel Mountains as a National Monument*, THE WHITE HOUSE (Oct.

According to the White House statement about the monument, "[i]mproving public access and recreational opportunities within the monument will help address the region's public health challenges. Studies have shown that increasing recreational access to public lands translates to higher levels of youth activity and lower youth obesity rates."[69] It is a historic moment in equitable urban ecosystem services provision when the United States President recognizes that there are disparities in park access for people of color, that this contributes to health disparities, and that state and federal agencies need to address these social justice issues.

President Obama's action is based in part on the National Park Service ("NPS") study of the San Gabriels.[70] The NPS study recognizes that there are unfair disparities in access to green space for people of color and low-income people, that those disparities contribute to unfair health disparities, and that environmental justice requires agencies to address those disparities.[71]

The National Park Service's recent *Healthy Parks, Healthy People Science Plan* compiled extensive evidence-based social science research that identified, "[r]elationships between socio-economic status and participation and access to green space and outdoor recreation."[72] For example, the *Science Plan* reported that "[g]reen spaces and parks, which promote good health, can play an important role in alleviating socioeconomic health disparities."[73] According to the NPS study for the San Gabriels, "the communities with the least amount of access to parks and open space tend to have higher rates of childhood diseases related to obesity such as diabetes."[74] In a

10, 2014, 1:24PM), http://www.whitehouse.gov/the-press-office/2014/10/10/remarks-president-designation-san-gabriel-mountains-national-monument.

69. Off. of the Press Sec'y, *President Obama Designates San Gabriel Mountains National Monument,* THE WHITE HOUSE (Oct. 10, 2014), http://www.whitehouse.gov/the-press-office/2014/10/10/president-obama-designates-san-gabriel-mountains-national-monument.

70. NAT'L PARK SERV., SAN GABRIEL WATERSHED AND MOUNTAINS SPECIAL RESOURCE STUDY & ENVIRONMENTAL ASSESSMENT 93, 179, 218–19, 231–32 (Sept. 2011), *available at* http://parkplanning.nps.gov/document.cfm?documentID=43639 [hereinafter SAN GABRIEL].

71. *Id*.

72. NAT'L PARK SERV., HEALTHY PARKS, HEALTHY PEOPLE SCIENCE PLAN 36–38 (July 2013), *available at* http://www.nps.gov/public_health/hp/hphp/press/HPHP_Science%20Plan_accessible%20version.final.23.july.2013.pdf [hereinafter HEALTHY PARKS].

73. *Id.* (citing R. Mitchell & F. Popham, *Effect of Exposure to Natural Environment on Health Inequalities: An Observational Population Study*, 372 LANCET 1655, 1656 (2008)).

74. SAN GABRIEL, *supra* note 70, at 219 (citing CTRS. FOR DISEASE CONTROL & PREVENTION, INCREASING PHYSICAL ACTIVITY: A REPORT ON RECOMMENDATIONS OF THE

separate study, NPS emphasized that people of color and low income populations still face disparities regarding both health and access to parks.[75] This contributes to health problems and chronic disease.[76] In regard to obesity, for example, "36 percent of black and 35 percent of Hispanic high school students nationwide are overweight or obese, while 24 percent of non-Hispanic white high school students suffer from these conditions."[77]

3. Environmental Equity and Legal Frameworks

A final area of focus for equity and urban ecosystem services research is to develop legal and policy strategies to address these distributional problems. Much of this work has evolved from the advocacy efforts of researchers such as the late Luke Cole[78] and non-profit organizations such as The City Project, located in Los Angeles.[79] The City Project has conducted numerous influential studies of inequitable distribution of parks and other urban infrastructure in Southern California by race, ethnicity, and class, several of which have been used with legal, planning, and political strategies to address these disparities.[80]

TASK FORCE ON COMMUNITY PREVENTIVE SERVICES (Oct. 1, 2001), http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5018a 1.htm).

75. *Id*.

76. *Id*.

77. NAT'L PARK SERV., HEALTHY PARKS, HEALTHY PEOPLE STRATEGIC ACTION PLAN 4 (Nov. 2013), *available at* http://www.nps.gov/public_health/hp/hphp/press/1012-955-WASO.pdf.

78. *E.g.*, Luke W. Cole, *Empowerment as the Key to Environmental Protection: The Need for Environmental Poverty Law*, 19 ECOLOGY L.Q. 619 (1992).

79. *See Mission*, THE CITY PROJECT, http://www.cityproject.org/ (last visited Nov. 25, 2014) [hereinafter *Mission*] (explaining how over the past few decades, a trend has emerged promoting developers and city officials alike to invest in urban renewal – a process whereby bridges, highways, housing projects and public parks are rehabilitated, bringing new citizens back into the city).

80. *See, e.g.*, ROBERT GARCÍA & SETH STRONGIN, HEALTHY PARKS, SCHOOLS AND COMMUNITIES: MAPPING GREEN ACCESS AND EQUITY FOR SOUTHERN CALIFORNIA (2011) (studies showing that the health implications due to lack of places to play are profound.; children and adults who live in communities with recreational facilities are more physically active than those who lack access to these resources, and this is particularly true for low-income communities); Robert García, *The George Butler Lecture: Social Justice and Leisure*, 45(1) J. LEISURE RES. 7–22 (2013) (research showing that children of color living in poverty with limited access to a car have the worst access to parks and physical activity and to schools with five or more acres of playing fields. These children in turn suffer disproportionately from obesity and diabetes); Robert García, *Walk a Mile in My Shoes: Los Angeles Celebrates Anniversaries of the Civil Rights Movement, in New Frontiers for Title VI,* 23 POVERTY & RACE 1 (July/Aug. 2014) (addressing how African-American and Latino communities have struggled to be free of environmental degradation and how they have long strived for equal access to public resources, including parks, recreation and public art)

There is scant legislation addressing environmental justice, so advocates have necessarily been creative and have relied on wide ranging legal and policy instruments. Title VI of the Civil Rights Act of 1964 and its regulations may be applied to prevent minority communities and low-income communities from being subject to discriminatory environmental impacts and effects. Title VI and its regulations promote equity in ecosystem services by prohibiting federal financial assistance recipients—including presumably all state, regional, and local park agencies—from discriminating based on race, color, or national origin in their programs or activities.[81]

A related policy instrument is Executive Order 12898 on Environmental Justice, which requires each federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."[82] This Executive Order has primarily been implemented as part of the National Environmental Policy Act ("NEPA").[83] In 1997, the Council on Environmental Quality ("CEQ") issued guidance for federal agencies to follow in revising their NEPA procedures to incorporate environmental justice concerns.[84] As a result, many federal agencies now address environmental justice in their environmental impact analysis of the activities they undertake and/or permit.

There are several best practice examples applying these laws and policies to promote equitable urban ecosystem services. The site of what is now the Los Angeles State Historic Park could have been

81. *See* 42 U.S.C. § 2000d (1964) ("No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."). The Supreme Court held in the 2001 *Alexander v. Sandoval* case that there is no private right of action for disparate impact under Title VI. 532 U.S. 275, 293 (2001). However, the DOJ interpreted the case to allow federal agencies to use their Title VI regulatory authority to prohibit actions having a disparate impact, and many did so. For departmental regulations adopting Title VI, see, e.g., 43 C.F.R. § 17.1 (1964) (Department of Interior), 40 C.F.R. § 7.1 (2013) (EPA), and 49 C.F.R. § 21.1 (2014) (Department of Transportation).

82. Exec. Order No. 12898 at § 1-101, 59 Fed. Reg. 7,629 (Feb. 11, 1994). *See also id.* at §§ 1-102, 6-604; Exec. Order No. 13045, 62 Fed. Reg. 19,885 (Apr. 21, 1997) (directing each federal agency to identify, assess, and address environmental health and safety risks that may disproportionately affect children).

83. 42 U.S.C. § 4321 *et seq*.

84. COUNCIL ON ENVTL. QUALITY, ENVIRONMENTAL JUSTICE: GUIDANCE UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT (1997), *available at* http://energy.gov/sites/prod/files/nepapub/ nepa_documents/RedDont/G-CEQ-EJGuidance.pdf (last visited Nov. 5, 2014).

used to build warehouses.[85] Instead, the land was utilized in a more public-friendly manner.[86] In 1999, the site was an abandoned rail yard. The City of Los Angeles and wealthy developers proposed building 32 acres of warehouses with federal subsidies on the last vast open space in downtown Los Angeles.[87] Andrew Cuomo, who was Secretary of Housing and Urban Development at the time, withheld any federal funding for the proposed warehouse project unless there was a full environmental impact statement that considered the park alternative and the impact on low income people and people of color.[88] Secretary Cuomo relied on Title VI of the Civil Rights Act of 1964 and its regulations, and Executive Order 12898 on Environmental Justice.[89] Secretary Cuomo acted in response to an administrative complaint filed by community advocates that claimed the warehouse project resulted from discriminatory land-use policies that had long deprived minority neighborhoods of parks.[90] As a result of HUD's decision, the state bought the land for the park.[91] The *L.A. Times Magazine* called the community victory to create the park "a heroic monument" and "a symbol of hope."[92]

The U.S. Army Corps of Engineers' (USACE) draft 2013 study for revitalizing the Los Angeles River is a second example. The USACE study recognized that there are unfair disparities in access to green space for people of color and low-income people living along the river. Those disparities contribute to unfair health disparities within those low-income and minority communities, and environmental justice requires agencies address those disparities.[93] The NPS San Gabriels study discussed above is a third best practice example.[94]

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85. The City Project, *Best Practice HUD Los Angeles State Historic Park Healthy Green Land Use for All* (Sept. 9, 2014), http://www.cityprojectca.org/blog/archives/32984.

86. *Id*.

87. *Id*.

88. *Id*.

89. *Id*.

90. *Id*.

91. *Id*.

92. *Id*.

93. USACE, LOS ANGELES RIVER ECOSYSTEM RESTORATION INTEGRATED FEASIBILITY REPORT 3-61, 3-86–3-87, 5-106 (2013), *available at* http://www.spl.usace.army.mil/Portals/17/docs/publicnotices/DraftIntegratedReport.pdf.

94. *See* SAN GABRIEL, *supra*, note 70, at 93 (finding a high recreational demand in urban areas; by contrast reports from The Trust for Public Land and The City Project indicate that public access for predominantly minority populations to parks and recreation facilities are a serious concern).

Finally, the Obama Administration's Affordable Care Act, enacted in 2010, provides protections against health discrimination based on race, color, national origin, limited English language proficiency, immigration status, and other characteristics in Section 1557 of the Act.[95] Section 1557, which references Title VI, may enable advocacy focused on achieving greater access to park resources in disadvantaged communities.[96] The Act also includes physical activity, healthy land use, and infrastructure projects as part of its mandate for wellness and prevention.[97] While these provisions have not yet been applied in practice, they may provide additional legal tools along with Title VI and Order 12898 to promote equitable urban ecosystem services.

The City Project, a non-profit civil rights and environmental justice organization in Los Angeles, has developed a framework for using the Civil Rights Act of 1964 and its implementing regulations, Executive Order 12898 on Environmental Justice, sections of the Affordable Care Act, and parallel state laws to advocate successfully for greater park access in Los Angeles County. The City Project, with diverse allies, submitted public comments reflected in the NPS study for the San Gabriels, the USACE study for the Los Angeles River, and the HUD decision that led to the creation of the Los Angeles State Historic Park discussed above.[98] In other cities, grassroots advocates and government leaders or planners have relied on various planning and legal tools in pursuing fairness and community health in

95. Patient Protection and Affordable Care Act, Pub. L. No. 111-148, §1557, 124 Stat. 119, 121 (2010). Section 1557 references prior laws that protect against health discrimination, including Title VI of the Civil Rights Act. The Act also includes physical activity, healthy land use, and infrastructure projects as part of its mandate. *Id.* at §§ 4001, 4201, 4306, 124 Stat 119, 539-87 (2010). *See also* TEX. HEALTH INST., THE AFFORDABLE CARE ACT & RACIAL AND ETHNIC HEALTH EQUITY SERIES: REPORT NO. 4 PUBLIC HEALTH AND PREVENTION PROGRAMS FOR ADVANCING HEALTH EQUITY iii–xii, 33–34, 41–46, 48 (Dennis P. Andrulis, et al. eds., 2013) (explaining the disparities in access to quality health care for racially, ethnically, and linguistically diverse patients and how the Affordable Care Act offers an opportunity to create a more equitable health care system); AM. PUB. HEALTH ASS'N, ISSUE BRIEF: PREVENTION PROVISIONS IN THE AFFORDABLE CARE ACT 6–9, 11, 18 (Gail Shearer ed., 2010) (discussing how § 2705 of Title I prohibits discrimination against individuals based on health status such as requiring higher premiums or denial of coverage).

96. *Id*.

97. *Id*.

98. *See About the City Project: History*, THE CITY PROJECT, http://www.cityprojectca.org/about/history.html (last visited Nov. 30, 2014) (quoting the Environmental Justice Head of the EPA, Lisa Garcia, commending The City's Project's equitable development work that led to the creation of the Los Angeles State Historic Park and calling their efforts "real community lawyering and [an]inspiration").

urban ecosystem services policies.[99] The results may provide an empirical foundation for pursuing new and innovative research into the ways law can facilitate distributional equity.

4. Providing Environmental Benefits Equitably

Research in this area should address the overall spatial distribution of environmentally beneficial projects in an urban area to ensure that disadvantaged communities are also chosen as sites for projects providing ecosystem services. The following questions identify pressing research needs concerning equitably providing ecosystem services in urban areas: (1) How should cities incorporate environmental equity into their planning for ecosystem services? Much like federal agencies following the adoption of the Clinton era executive order mentioned previously, cities may need their own guidance as to how to incorporate environmental equity and justice concerns into their planning processes. (2) Should certain ecosystem services (e.g., parks and green space) be prioritized over others according to the preexisting levels of environmental inequality in a community? Disadvantaged communities may have markedly less environmental amenities (and thus ecosystem services) than their more advantaged counterparts. Therefore, there may be a deficit to make up for and disadvantaged communities may need to be prioritized in new project placement. (3) If certain ecosystem services are targeted based on preexisting inequality, how do cities and local governments decide which inequalities to address first? For example, does a city prioritize alleviating urban heat island effects in more vulnerable communities to allow those communities to better adapt to climate change? Alternatively, does the city prioritize providing green space and park access to communities? (4) What policies could enhance choices that achieve greater environmental equity as well as other urban community goals? Often the natural infrastructure that supports targeted ecosystem services (e.g., increased storm water retention) will provide additional co-benefits (e.g., reduced local heat island effect, improved air quality, and expanded recreational opportunities).

5. Preventing Unintended Consequences

Providing urban ecosystem services through green infrastructure

99. An American Planning Association's Planning Advisory Service Report addresses many of these issues and tools. CRAIG ANTHONY (TONY) ARNOLD, FAIR AND HEALTHY LAND USE: ENVIRONMENTAL JUSTICE AND PLANNING 53–54 (2007).

often offers the positive externality of environmental amenities. When these environmental amenities are substantial enough to alter property values, some population segments (renters for example) may be priced out of the very same low-income and minority communities that the ecosystem services were originally intended to help.[100] Research is needed to better understand the dynamics of gentrification and urban displacement and how to ensure that the low-income and minority communities are not uniformly priced out of neighborhoods they have inhabited for decades.

Some of the questions that remain unaddressed in this area of research include:

(1) What is the empirical evidence proving that green infrastructure or other projects that provide greater ecosystem services in the community lead to gentrification or displacement of disadvantaged communities? There is much that we do not understand about the dynamics of gentrification. Research in this area should examine the circumstances under which disadvantaged communities benefit from gentrification and under which such communities are harmed by gentrification. (2) Are there policy mechanisms around the country that cities have used successfully to prevent gentrification and displacement following the introduction of environmental amenities? Researchers should assess which tools cities are electing to use as well as the efficacy of these tools for addressing equitable ecosystem services provision. (3) What types of powers do cities need to be granted in order to prevent gentrification and displacement resulting from expanding ecosystem services in the community? And (4) do any cities have these necessary powers in place and, if not, what would be required to adopt them? Local governments may need additional authority from state governing bodies to deal with gentrification and displacement issues.

B. Payments for Urban Ecosystem Services

Green infrastructure such as watershed protection areas and parks have traditionally been financed and maintained as part of city infrastructure supported by taxes, fees, or public bond measures.[101]

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100. *See, e.g.*, Jeffery James Minton, *Rent Control: Can and Should It Be Used to Combat Gentrification?*, 23 OHIO N.U. L. REV. 823, 823–24 (1997) ("Based upon an initial increase in the demand for housing, a gentrifying neighborhood puts continuing pressures on landlords to increase rents for all tenants and attract more upper-income residents. This unfortunately leads to displacement of existing low income residents . . . .").

101. *See, e.g.*, Jeffrey Hughes, *Bottom-Up Financing Options for Green Infrastructure: What*

However, many types of ecosystem services can only be provided on a meaningful scale if they take place across mixed public and private lands.[102] For example, effective green infrastructure programs to reduce runoff and stormwater flows require city-wide deployment of green rooftops, rain gardens, rain barrels, and permeable pavement, among other measures—a feat that would require broad cooperation amongst public and private landowners on a citywide scale.[103] This section explores some approaches government entities may use to fund ecosystem services directly and the tools they can use to encourage private property owners to pay for providing such services in the urban environment, highlighting areas where additional research is needed.

Incorporating ecosystem services into the urban landscape will generally require a change in land use practices or in the pattern and location of developed areas, and the installation of physical assets to provide the desired benefits. As a result, an initial concern is whether the party receiving the ecosystem services should pay for the service itself or for the land use practices and physical assets that are required to provide the service, i.e., for the green infrastructure or the service provision. For example, if wetlands are created or restored to address water quality issues, the initial construction costs of the wetland can far exceed the ongoing maintenance costs that will be incurred once the wetland is established and providing ecosystem services.[104] In these cases, if the entity paying for ecosystem services is limited to paying for the services themselves, the payments offered may be

Will Your Approach Be?, ENVTL. FIN. BLOG (Nov. 5, 2014), http://efc.web.unc.edu/2014/10/08/bottom-financing-options-green-infrastructure-will-approach/ ("Revenue from the [stormwater] fees has to support a range of structural ("gray infrastructure") and management initiatives, but the city has also freed up some funds to begin rolling out innovative [green infrastructure] programs—often leveraging stormwater fees with grants funded by state taxes.").

102. *See* McKinstry Jr. et al., *supra* note 7, at 10829 (explaining that Philadelphia has initiated Green Infrastructure programs on private land "where the city's cost per greened acre . . . is less than or equal to the cost per greened acre that the city would have to spend to accomplish the same results on publicly owned land.").

103. *See What is Green Infrastructure*, *supra* note 42 (describing several methods to reduce stormwater runoff).

104. Once installed, any physical assets may require ongoing maintenance to ensure that they continue to provide the desired ecosystem benefits. In fact, in a recent evaluation of green infrastructure projects funded under the American Recovery and Reinvestment Act, the EPA concluded that "proper maintenance is essential to maximizing the environmental, social, and economic benefits of green infrastructure, as well as ensuring that projects perform as they were designed to." EPA, THE IMPORTANCE OF OPERATION AND MAINTENANCE FOR THE LONG-TERM SUCCESS OF GREEN INFRASTRUCTURE 30 (2013), *available at* http://water.epa.gov/grants_funding/cwsrf/ upload/Green-Infrastructure-OM-Report.pdf.

insufficient to encourage private landowners to provide the initial ecosystem service benefits.[105] Without financing to address upfront costs, fees collected may also be insufficient to support ecosystem services benefits from public or private infrastructure.

Emphasizing the co-benefits[106] of installing green infrastructure for private property owners is a way in which cities can make urban ecosystem service provision more attractive investments. For example, while a private property owner cannot prevent the public as a whole from benefitting from the storm water reduction benefits of his rain garden (as positive externalities), the property owner may obtain other aesthetic, recreational, and property value benefits that offset his capital costs to provide the ecosystem service.[107] Alternatively, cities might offer property owners reduced storm water fees if their properties provide floodwater services.[108]

While there have been several studies on the cost-effectiveness of installing green infrastructure to mitigate storm water impacts,[109] there is sparse literature on the long-term costs to maintain these

105. *See* McKinstry Jr. et al., *supra* note 7, at 10829 (explaining that "requiring payments from those that do not pay their fair share of the costs of the [Green Infrastructure] Program" in many cases falls short in encouraging green infrastructure investments by private residents and with regard to fee reductions as incentives).

106. Co-benefits are those benefits that are not the direct goal of a regulatory program, but are additional benefits to the public or the environment that result from a particular action. Co-benefits come in a variety of forms, including economic (cost savings), public health, and environmental. For a discussion of the co-benefits of sustainability strategies, see Yvonne Hunter, *The Co-Benefits of Sustainability Strategies*, WESTERN CITY (Sept. 2009), http://www.westerncity .com/Western-City/September-2009/The-Co-Benefits-of-Sustainability-Strategies/ ("Sustainability strategies save money, conserve resources for future generations, improve public health, respond to climate change and make communities more attractive places to live.").

107. *See, e.g.*, Nancy Stoner, *Green Solutions for Controlling Combined Sewer Overflows*, 21-SPG NAT. RESOURCES & ENV'T 7, 10 (2007) ("[Green Infrastructure] also has the added benefits of improving urban aesthetics, increasing property values, and providing wildlife habitat and recreational space for urban residents.").

108. *See* McKinstry Jr. et al., *supra* note 7, at 10829 ("Under the program, [Philadelphia] will provide credits [to stormwater fees] for property owners that employ green infrastructure . . . ." However, "[i]n many cases…the carrot of reduced fees is insufficient to encourage the undertaking of some of the largest, most cost-effective projects on privately owned lands.").

109. *See, e.g.*, *What is Green Infrastructure*, *supra* note 42 (explaining that "green roofs" are cost-effective in dense urban areas where land values are high and "permeable pavements" are cost-effective where land values are high and where flooding or icing is a problem); JENNIFER DILL ET AL., DEMONSTRATING THE BENEFITS OF GREEN STREETS FOR ACTIVE AGING: FINAL REPORT TO EPA (2010) (detailing a study on the cost-effectiveness of "green streets"); AMERICAN RIVERS ET AL., BANKING ON GREEN: A LOOK AT HOW GREEN INFRASTRUCTURE CAN SAVE MUNICIPALITIES MONEY AND PROVIDE ECONOMIC BENEFITS COMMUNITY-WIDE (2012) (explaining cost-effectiveness of various green infrastructure projects).

ecosystem services as well as the costs to install and maintain other natural infrastructure such as parks, urban trees, and stream buffers, to provide ecosystem services beyond storm water mitigation in the urban environment. Topics ripe for future study are: (1) research that compares the installation and maintenance costs for the assets that provide ecosystem services with the monetized benefits of ecosystem services (which can include the public's willingness to pay for the benefits) so as to determine whether potential payments for ecosystem services would be sufficient to cover the capital costs required to provide them. (2) Research on whether the additional ecosystem service benefits provided by green infrastructure are useful in assessing stormwater surcharge levels that may be necessary to encourage property owners to implement green infrastructure measures to mitigate storm water. Similarly, analysis to quantify the co-benefits of other natural infrastructure (e.g. street trees, green roofs, etc.) can help inform policies that support those structures.

Accounting also matters with respect to actual ecosystem services provision. The Government Accounting Standards Board (GASB)[110] uses traditional accounting methods for valuing infrastructure, which does not allow for inclusion of the broader suite of benefits that green infrastructure provides.[111] As a result, the broader benefits that green infrastructure can provide to the public and the differences in maintenance approaches between green and gray infrastructure types are not considered in determining the value of green infrastructure assets. This makes it difficult for municipalities to evaluate whether it makes sense to invest in developing new green infrastructure, whether to replace gray built infrastructure, or whether to maintain existing assets. GASB has been exploring how a broader "ecosystem services" accounting method might work.[112]

Future research in this area should support GASB efforts to explore developing practical standards for green accounting that

110. The Governmental Accounting Standards Board (GASB) sets standards of accounting and financial reporting for state and local governments in the United States. GOVERNMENTAL ACCOUNTING STANDARDS BD., FACTS ABOUT GASB (2014), *available* at http://www.gasb.org/resources/ccurl/124/357/Facts%20about%20GASB%20%2820132014%29.pdf.

111. *See* D. Cosman et al., *How Water Utilities Can Spearhead Natural Capital Accounting*, 2 SOLUTIONS J. 28, 28–31 (Jan. 2012), *available at* http://www.thesolutionsjournal.com/node/ 1018.

112. *See generally* FINANCIAL ACCOUNTING FOUNDATION, GASB, TECHNICAL PLAN FOR THE FINAL THIRD OF 2013: POTENTIAL TOPICS 15 (2013), *available at* http://www.gasb.org/resources /ccurl/640/101/ Potential%20Projects,0.pdf ("[I]t is important to consider reporting changes in fair value from a broader perspective of fair value changes in any type of asset or liability.").

would recognize the costs and benefits of ecosystem services as assets.

1. Public Funding of Ecosystem Services Projects

Municipalities, in particular, face limitations on funding sources that may be available to implement ecosystem services programs.[113] Since many states and municipalities are unable to run budget deficits, any funding they receive for ecosystem services provision must be backed by an accompanying revenue stream.[114] Thus the two primary mechanisms for public funds to support ecosystem services projects would be either: (1) allocating a portion of tax revenue to ecosystem services projects or (2) issuing revenue bonds. While the authors are not aware of any current legal restrictions that would broadly prevent allocating general tax revenues to ecosystem services projects, in the current climate of constrained municipal and state budgets, it is not likely that many governments will be able to allocate significant tax revenue to ecosystem services projects.

If states and municipalities turn to revenue bonds to fund ecosystem services projects, there are significant limitations on bonding authority that may impair their ability to obtain sufficient funding. For example, the Internal Revenue Code imposes limitations on using tax-exempt bonds to raise funds for projects that will occur on private property.[115] This limits the ability of cities to raise capital for activities like rain gardens, green roofs, and retention basin retrofits by private home and business owners.[116] For example, the Texas State Constitution expressly prohibits public funds expenditure for the improvement of private property.[117] Future research in this area should address municipal bonding rules in the

113. *See, e.g.*, McKinstry et al., *supra* note 7, at 10831 ("Funding these projects . . . creates additional challenges. Because the city, like other municipalities, is a creature of state law and can only exercise the powers that it is given by the state, it must assure that its Program and financing will satisfy the requirements of state and local law . . . .").

114. For a summary of state balanced budget requirements, see NAT'L CONFERENCE OF STATE LEGISLATURES, NCSL FISCAL BRIEF: STATE BALANCED BUDGET REQUIREMENTS 1–4 (Oct. 2010), *available at* http://www.ncsl.org/documents/fiscal/StateBalancedBudget Provisions2010.pdf.

115. *See* 26 U.S.C. § 150(b)(5) (2006) ("If financing is provided with respect to any facility from the proceeds of . . . a tax-exempt bond, such facility is required to be owned by a governmental unit or a 501(c)(3) organization as a condition of such tax exemption[.]").

116. *See* McKinstry Jr. et al., *supra* note 7, at 10831 ("[I]f the city uses tax-exempt financing, it must comply with the requirements of the Internal Revenue Code and the regulations of the Internal Revenue Service. Each of these issues must be addressed by any public entity seeking to implement a green infrastructure program . . . .").

117. TEX. CONST. art. XVI, § 6 (Vernon's, Westlaw through 2013 Third Called Session of 83rd Legislature).

various states in order to understand the full extent of the limitations on using revenue bonds to fund green infrastructure projects as well as the additional costs involved if taxable bonds must be issued. Additionally, future scholarship should focus on whether public ownership of an easement avoids the Internal Revenue Code restrictions on using tax-exempt bonds for private property projects. Finally, if public financing is used to support projects on private property, research will be needed on the types of verification procedures or mechanisms required to ensure that public funds expenditure is in compliance with the Internal Revenue Code restrictions and any other legal requirements that may limit municipalities' power to spend money on green infrastructure.

Another significant issue that arises when using revenue bonds to fund ecosystem services projects is what portions of those projects the bonds can actually cover.[118] Ecosystem services provision typically requires some type of physical infrastructure installation as well as the ongoing infrastructure maintenance.[119] In many cases, funds raised by revenue bonds can be used to acquire new physical capital, but there may be restrictions on using bond funds to pay for ongoing operations and maintenance costs associated with ecosystem services provision.[120]

A recent report on green infrastructure published by the U.S. Environmental Protection Agency notes that to date, most operations and maintenance costs for green infrastructure projects are merely rough approximations based on engineering estimates.[121] Additional experience with actual projects is needed to verify the costs of maintaining green infrastructure. As a result, there is not yet

118. *See* McKinstry Jr. et al., *supra* note 7, at 10832 ("The Pennsylvania Constitution, like many other state constitutions, generally prohibits the use of public funds, such as the proceeds of governmental tax-exempt revenue bonds, for private purposes."); *see also* Rachael E. Salcido, *The Success and Continued Challenges of the Yolo Bypass Wildlife Area: A Grassroots Restoration*, 39 ECOLOGY L.Q. 1085, 1119 (2012) ("Some portion of the habitat restoration may be addressed in a bond measure, voted on by the public. Thus, public support for restoration must be pursued as a strategy to support passage of a bond and continued funding in the future.").

119. *See generally* Bosire Maragia, *The Indigenous Sustainability Paradox and the Quest for Sustainability in Post-Colonial Societies: Is Indigenous Knowledge All That Is Needed?*, 18 GEO. INT'L ENVTL. L. REV. 197, 206 (2006) ("Ecological sustainability requires regulating human activity to ensure the quality and quantity of ecosystem services such as air, water, and soil are maintained and preserved . . . .").

120. *See* McKinstry Jr. et al., *supra* note 7, at 10832 ("In order to use bond proceeds to pay for the development and maintenance of green infrastructure on both privately and publicly owned land [in Philadelphia], the green infrastructure projects must meet the definition of 'project' under the Philadelphia Bond Act and must become part of the System.").

121. *What is Green Infrastructure*, *supra* note 103, at 7.

sufficient data to determine whether operations and maintenance costs associated with ecosystem services projects pose a significant impediment to the broad-scale implementation of green infrastructure if public funds are not available to cover the ongoing costs. Future research on this topic should evaluate the extent to which municipal bond funds can be used to support ongoing operations and maintenance expenditures. Additionally, further research is required to more fully understand the actual operations and maintenance costs associated with maintaining ecosystem services projects once they are constructed.

Regardless whether funding is derived from taxes or revenue bonds, some states and municipalities may face legal restrictions on their ability to spend public funds for urban ecosystem services provision. Utility regulatory commissions are typically charged with procuring the lowest cost service available in order to protect consumer rate-payers.[122] Therefore, if green infrastructure programs for storm water retention, as an example, are selected as an alternative to large, traditional gray infrastructure, then states and municipalities may be limited in their ability to adopt such programs or to fund any costs that go above and beyond those required by a non-ecosystem services approach.[123] Not all states are uniform in their requirements to provide the lowest cost service, however.[124] Some states provide for consideration of other factors in the public interest beyond the lowest cost service, such as the need for diverse energy sources.[125]

Municipalities that directly operate public utility services may have opportunities to charge special fees that provide revenue for

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122. *See generally* 73B C.J.S. *Public Utilities* § 123 (2014) ("Generally, a public utility regulatory commission must ascertain the value of the property used and useful in the public service for the purpose of determining what rate will be reasonable.").

123. Note that in fact one of the major reasons for promoting green infrastructure programs is that they are projected to result in significant cost savings when compared to gray infrastructure. However, green infrastructure project costs will be highly location and context specific.

124. *See, e.g.*, Michael Krancer, *Did Pennsylvania Just Change the Way States Talk to Businesses About Energy?*, FORBES (Jan. 22, 2014, 3:45 PM), http://www.forbes.com/sites/michaelkrancer/2014/01/22/did-pennsylvania-just-change-the-way-states-talk-to-businesses-about-energy/ ("[Governor Tom] Corbett also details Pennsylvania's energy source diversity: coal, oil and natural gas, nuclear, wind, solar, geothermal, hydro, biomass, biofuels, hydrogen fuel cells, and combined heat and power. Which does he favor? None. He embraces an 'all of the above and below' energy policy. Yes, he's determined to reduce greenhouse gas emissions and make energy more affordable for consumers and businesses. But he's also keen on exploiting all of those energy sources. The first really isn't possible without the latter.").

125. *Id.*

ecosystem services projects. For example, some municipalities, like Philadelphia, impose a surcharge for stormwater that is related to the amount of impervious surface on a property.[126] These funds could be used to provide public funding for green infrastructure projects that minimize stormwater flows. Philadelphia additionally charges non-residential properties with a stormwater utility fee based on the amount of impervious surface on a property; property owners can reduce their storm water fees by implementing green infrastructure projects on their property.[127] Future research should examine public utility commission regulations to determine whether legal reform is necessary to permit payment for ecosystem services. Furthermore, it remains unclear exactly what would happen if government agencies decide to invest in advanced planning and public infrastructure development only to find that the need for these projects and fees to pay the debt on them fail to materialize or decline over time.

2. Encouraging Private Parties to Pay for Ecosystem Services

Given the limitations on using public funds for ecosystem service activities, enhancing the ability of states and municipalities to create incentives for private parties to invest in the infrastructure and land management practices that promote and sustain ecosystem services is critical. Possible strategies for incentivizing private investment range from voluntary conservation easements to additional regulations that require investing in or preserving ecosystem services.[128]

Private sector investment in ecosystem services can prove attractive for compliance purposes when such investment strategies can be demonstrated to result in lower costs for regulated entities as compared with conventional investment approaches. There are numerous examples of parties adopting ecosystem services practices to fulfill requirements under the Clean Water Act, including using riparian shade to address thermal total maximum daily load requirements. For example, ATI Wah Chang, a specialty metals

126. *See* McKinstry Jr. et al., *supra* note 7, at 10829 ("In 2008, Philadelphia began assessing stormwater fees for existing nonresidential properties based on a ratio of impervious surface area to gross property area."); *see also* Philadelphia Water Dep't, *Reduce Your Stormwater Fees* (2014), http://www.phillywatersheds.org/whats_in_it_for_you/reduce-your-stormwater-fees.

127. *See* sources cited, *supra* note 126.

128. *See* McKinstry, *supra* note 7, at 10832 ("[Philadelphia] has made . . . low-interest loans available to private landowners, where the installation of green infrastructure on private land will be most cost-effective . . . . [T]o assure 'public ownership' of the asset . . . the city requires that the landowner agree to a deed restriction or easement in order to qualify for a grant or loan . . . .").

manufacturer, and Weyerhauser, one of the world's largest private owners of timberlands, joined with the cities of Albany, New York and Millersburg, Oregon, to formulate a unique solution to excessively warm effluents being released into Oregon's Willamette River.[129] They constructed 39 acres of wetlands designed to cool effluent and meet applicable TMDL requirements.[130] The resultant Albany-Millersburg Talking Water Gardens is designed to cool nearly 13 million gallons of water from industrial and municipal sources each day and also provides co-benefits such as nutrient removal prior to discharge.[131]

Traditionally, conservation easements have been used to preserve open space in rural settings.[132] To create a conservation easement, the property owner generally agrees to preserve the land as open space in exchange for a direct payment from the government, a tax benefit, or some other benefit conferred by the government.[133] The same concepts could be applied in the urban environment to create space for ecosystem services. For example, where open space exists along floodways, municipalities could seek voluntary dedication of easements to leave such space open as a spillway for flood-waters.[134]

Similarly, municipalities could potentially seek dedicated conservation easements over green roofs, requiring owners to maintain them over time. For the property owner to receive tax benefits, though, the conservation easement must be dedicated to a government entity or to a qualified land trust. The receiving entity must satisfy a set of rigorous practices for establishing, monitoring, and maintaining the easement to ensure that the conservation goals continue to be served and that IRS standards have been satisfied.[135]

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129. *See* CITY OF ALBANY, TALKING WATER GARDENS TECHNICAL PROFILE 3 (Aug. 2010), *available at* http://twg.cityofalbany.net/wp-content/uploads/2010/08/Talking-Water-Gardens-Technical-Profile-August-2010.pdf (discussing how cities that saw an opportunity for a combined municipal-industrial solution realized it would produce greater overall environmental benefits).

130. *Id.*

131. *Id.*

132. James W. Ely, Jr. & Jon W. Bruce, THE LAW OF EASEMENTS & LICENSES IN LAND § 12:2 (2014).

133. *Id.*

134. For an example of a flood conservation easement deed, *see* CAL. DEP'T OF WATER RES., CONSERVATION AND FLOOD EASEMENT DEED, *available at* http://www.water.ca.gov/floodmgmt/fpo/sgb/fpcp/docs/Sample_Conservation_and_Flood_Easement.pdf (last visited Nov. 9, 2014).

135. 26 C.F.R. § 1.170A-14 (2009). Many state and local governments that wish to receive

With regards to encouraging increased private investment in ecosystem services, more research is needed to understand the extent to which conservation easements or similar voluntary easements could be employed in urban settings to enhance ecosystem services provision. Such research should include geospatial and ecological analyses to determine where opportunities for easements exist and their potential for resilience to changing conditions. Economic analysis is required to determine what types of incentives may be necessary to secure voluntary easement dedication. Legal research is needed to better define how to structure such easements—particularly if they are applied to novel ecosystem services such as green rooftops.

States and municipalities may also be able to use their land use planning authorities to incorporate space for ecosystem services into city general plans and master plans for larger developments. In amending city general plans, there may be opportunities to designate particular tracts of land for ecosystem services, requiring future development meet certain conditions that secure the desired ecosystem services.[136] City planners should start paying particular attention to identifying the specific opportunities that cities can use to begin incorporating ecosystem services requirements into their master plans. Relatedly, city planners must consider and determine whether incorporating ecosystem services into their city's master plans will actually increase adherence to and enforcement of such plans.

States and municipalities could also condition future development permits on the adoption of particular measures to promote ecosystem services. This can be done through municipal ordinance, on a permit-specific basis, or as a combination of the two.[137] For example, Atlanta has a post-development stormwater management ordinance that requires new development and redevelopment projects implement measures to control stormwater runoff once construction is complete.[138] This ordinance was recently

conservation easements have established government land trusts to receive and hold them or designated agencies to have the power to receive or hold particular kinds of conservation easements.

136. *See generally* JULIAN CONRAD JUERGENSMEYER & THOMAS E. ROBERTS, LAND USE PLANNING AND DEVELOPMENT REGULATION LAW 13–38 (2d ed. 2013) (describing the history of and legal authorities for local planning, including amendments to comprehensive plans, planning for environmental considerations, and judicial deference to plan amendments).

137. *Id.*

138. *See* ATLANTA, GA., SUBSTITUTE ORDINANCE ch. 74, art. X § 12-O-1761, Section 9

modified to require that projects treat the first inch of storm water with green infrastructure.[139]

While such permitting requirements have the potential to be important tools, they are subject to legal restrictions under the takings doctrine. The takings doctrine prohibits "taking" private property for public use without just compensation.[140] The doctrine includes those regulations that are so intrusive that they are equivalent to a physical occupation of private land by the government.[141]

Technically, requirements to install or preserve ecosystem services would be exactions. Exactions are concessions that the government seeks from developers or property owners in exchange for permits to develop or redevelop land, but they can become regulatory takings if the government seeks too much. The Supreme Court has determined that exactions are only valid to the extent that they have a significant nexus with and are roughly proportional to the projected impacts of the proposed development.[142] For example, requiring a new development in a flood plain to leave open space to serve as a spill way would be constitutional so long as the amount of open space required was roughly proportional to the projected additional impacts caused by the proposed development. The Supreme Court's recent decision in *Koontz v. St. Johns Water Management District* held that requirements to pay money can be exactions, and thus also subject to takings analysis.[143]

(Jan. 2013), *available at* http://www.atlantawatershed.org/default/?linkServID=95836454-BAB0-48DC-AAB E36297717215C&showMeta=2&ext=.pdf ("The stormwater management plan shall detail how post-development stormwater runoff will be controlled or managed . . . . The stormwater management plan must ensure that . . . opportunities are being taken to minimize adverse post-development stormwater runoff impacts from the development.").

139. *Id.* at Section 11; CORY RAYBURN, IMPLEMENTING GREEN INFRASTRUCTURE: ATLANTA'S POST-DEVELOPMENT STORMWATER MANAGEMENT ORDINANCE 1 (Mar. 2013), *available at* http://www.atlantawatershed.org/default/?linkServID=513ADAB0-6965-4F92AEB B38FC264C3 DF6&showMeta=2&ext=.pdf.

140. U.S. CONST. amend. V.

141. *See* Lucas v. South Carolina Coastal Council, 505 U.S. 1003, 1016 (1992) (quoting Agins v. City of Tiburon, 447 U.S. 255, 260 (1980) ("[T]he Fifth Amendment is violated when land-use regulation 'does not substantially advance legitimate state interests *or denies an owner economically viable use of his land*.'").

142. *See* Dolan v. City of Tigard, 512 U.S. 374, 386 (1994); Nollan v. Cal. Coastal Comm'n, 483 U.S. 825 (1987) ("[W]e must first determine whether the 'essential nexus' exists between the 'legitimate state interest' and the permit condition exacted by the city. If we find that a nexus exists, we must then decide the required degree of connection between the exactions and the projected impact of the proposed development.").

143. Koontz v. St. Johns Water River Water Mgmt. Dist., 133 S.Ct. 2586, 2599 (2013).

In light of recent takings case law, additional research should seek to provide clarity on the constitutional limits of municipalities' ability to exact ecosystem services provision—or related in lieu fees—to seek new development permits. In addition to expanding legal research efforts, empirical research pertaining to cities' practices with respect to green-infrastructure exactions is also needed. For example, following the *Dolan v. City of Tigard* decision, social scientists discovered that cities had mostly been under-exacting, not over-exacting; the Supreme Court's decision actually empowered cities to seek more exactions, contrary to some commentators' initial concerns.[144]

3. Liability, Compliance, and Insurance Issues

A significant number of recent green infrastructure projects undertaken by municipalities have arisen from obligations under legal settlements. These projects often address cities' liability for discharges from their stormwater or combined sewer outfalls that exceed the limits set in permits issued under the Clean Water Act. The consent decrees settling these lawsuits may call for some green infrastructure elements to be included in plans to reduce a city's storm water discharges.[145] For example, the recent modification to the consent decree for the City of Chicago requires implementation of the Green Infrastructure Plan.[146] The Plan itself has numerous required elements including that the city agency "work with partners and stakeholders to plan legal and institutional mechanisms (1) to preserve and maintain constructed green infrastructure projects that are put in place under Section III and (2) to ensure that future site or land use changes do not result in losing the runoff reduction benefits of green infrastructure projects."[147] Similarly, the recent modification to the consent decree for the City of Seattle encourages the city to use green infrastructure measurements, as appropriate, in its long-term

144. Ann E. Carlson & Daniel Pollak, *Takings on the Ground: How the Supreme Court's Takings Jurisprudence Affects Local Land Use Decisions*, 35 U.C. DAVIS L. REV. 103, 105 (2001).

145. *See* EPA, CONSENT DECREE PROVISIONS ADDRESSING SUBSTITUTION OF GREEN INFRASTRUCTURE CONTROL MEASURES FOR PLANNED GRAY INFRASTRUCTURE CONTROL MEASURES, *available at* http://www.water.epa.gov/infrastructure/greeninfrastructure/uploaf/gi_supplement2.pdf (last visited Nov. 9, 2014).

146. Consent Decree, United States v. Metro. Water Reclamation Dist., No. 11-cv-08859 at ¶ 43 (N.D. Ill. Dec. 14, 2011).

147. *Id.* at app. E.

control plan.[148] The 2010 modification to New York City's combined sewer overflow consent decree calls for the replacement of some gray infrastructure with green infrastructure projects.[149] Threatened financial liability for city agencies or utilities relating to the management of their storm water discharges and combined sewer outputs creates both legal and political justifications. For example, cities can use their obligations as leverage to charge fees to sewer users that can be used for green infrastructure projects or to appropriate general funds to purchase and install liability-offsetting green infrastructure.

Research into funding sources used to meet consent decree obligations may shed light on mechanisms that could be used to publicly finance ecosystem services projects. Relying on urban ecosystem services to meet compliance obligations could provide an important incentive for increased service provision, but this raises a host of challenges. Some pressing unanswered questions include: (1) what is the potential for an opportunistic strategy using consent decrees to drive major investments in urban ecosystem services across cities?; (2) how can cities and municipalities promote greater reliance on urban ecosystem services for regulatory compliance?; (3) how do cities develop consistent and credible compliance metrics for urban ecosystem services?; (4) in the event that green infrastructure measures fail or do not provide the expected level of services, what are the consequences of noncompliance?; (5) can municipalities still be required to make additional investments in traditional "gray" infrastructure to meet the law's substantive requirements?; (6) apart from consent decrees, what other alternative compliance and enforcement pathways for ecosystem service approaches are feasible?; and (7) if natural infrastructure fails to provide the expected benefits, who bears the liability for that failure?

The above examples raise numerous interesting questions that will be applicable to all ecosystem service projects. These questions include: (1) how should liability for ecosystem services projects be handled?; (2) what types of insurance may be available to protect a party in the event of an ecosystem services failure?; and (3) how can compliance with ecosystem services requirements be measured?

While the proliferation of green infrastructure requirements in

148. Consent Decree, United States v. Seattle, No. 13-cv-678, at 62 (W.D. Wash. Apr. 16, 2013).

149. Order on Consent, *In re* Violations of Art. 17 of the Envtl. Conservation Law, DEC Case No. CO2-20110512-25 (Oct. 11, 2011).

the Clean Water Act consent decrees provides an important example of the opportunities to increase ecosystem services applications, it also demonstrates a genuine liability limitation. The general framework of the major environmental laws in the United States relies on compliance with substantive numeric standards as measures of both environmental quality (e.g., the Clean Air Act's National Ambient Air Quality Standards or the Clean Water Act's Water Quality Standards and effluent limitations) and facility-specific compliance (typically through applicable facility-specific emission rates).[150] In addition, the legal framework of American environmental statutes imposes separate and distinct numeric standards for each pollutant, often ignoring green infrastructure co-benefits that might improve environmental performance across several measures but fail to meet all numeric standards.[151] While ecosystem service programs can be designed to meet particular environmental quality objectives, research on their ability to meet specific numeric performance criteria is limited.[152] As a result, entities using ecosystem services to meet substantive legal obligations may find that they are left with residual risks and additional compliance costs if the ecosystem service projects fail to function as designed.

Entities adopting ecosystem service approaches to meet legal obligations may wish to purchase a type of pollution liability insurance that would provide protection in the event that the project fails to deliver the required services. Moreover, when ecosystem service projects require financing for major physical infrastructure, it may be impossible to finance a project if it cannot be insured.[153]

While, in some respects, uncertainty over how well a particular ecosystem service project will perform seems like a novel risk, all pollution control technologies have some risk of failure from mechanical breakdowns. Viewed in this light, the risk of using ecosystem services for compliance with U.S. statutory pollution limitations can be managed in much the same way that the traditional

150. 42 U.S.C. § 7409 (2014); 33 U.S.C. § 1313 (2000).

151. Examples include the Clean Air Act's National Ambient Air Quality Standards and the Clean Water Act's Effluent Limitations.

152. There are ecosystem service programs in the EPA, but much work remains in order to refine the project designs to ensure that they can meet numeric, legally enforceable performance criteria.

153. *See, e.g.,* Bruce Aylward & Ray Hartwell, *Financing Ecosystem Service Markets: Issues and Opportunities*, INST. OF NATURAL RES. (July 2009), http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/14290/Financing%20Ecosystem%20Service%20Markets%20-%20Issues %20and%20Opportunities.pdf?sequence=1.

risk of pollution equipment failure is managed. Theoretically, this alternative option should also be insurable.

A further complication arises when many of the activities needed to guarantee ecosystem services provision outside the control of the entity with the compliance obligations. For example, a municipality using green infrastructure to comply with a Clean Water Act storm water requirement must rely on many individuals acting on their private property to insure that the storm water reduction benefits are achieved.[154]

Another way to address the risk of provision failure is by issuing time-limited credits that can be re-issued if a project continues to perform the ecosystem services expected of it. For example, in Washington, D.C.'s stormwater program, a landowner can be issued tradable credits for green infrastructure installed on his private property.[155] The credit is valid for a three-year period.[156] If during that three-year period the District government learns that the landowner has not maintained the project, the landowner is required to pay back any funds received from selling stormwater credit.[157] If, at the end of the three-year period, the project continues to function as intended, a new credit can be issued after inspection by the District government.[158]

Further research efforts in this area should generally address the insurability of ecosystem services. Specific questions that are ripe for answering include, (1) what insurance products are appropriate for urban ecosystem services?; (2) would insurance cover the physical aspects of the ecosystem services project itself or just cover the service that it is supposed to be providing?; (3) can existing insurance products provide coverage that is sufficient to protect against the loss or failure of ecosystem services or are new products needed?; (4) if insurance is infeasible, is self-insurance by the party responsible for providing the service possible?; (5) can insurance protect against the risk of failure or noncompliance of a green-infrastructure project that depends on coordinated activities by multiple public and private parties to maintain their components of the ecosystem services

154. *See, e.g.,* McKinstry Jr. et al., *supra* note 7, at 10831(discussing Philadelphia's incentives for private property owner's to manage stormwater runoff on their property).

155. *See generally* D.C. MUN. REGS. tit. 21 §§ 527–33, (2013) *available at* http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/page_content/attachments/2013%20SW%20Rule.pdf (authorizing the distribution and tradability of Stormwater Retention Credits).

156. *Id.* at § 531.10.

157. *Id.* at § 532.5.

158. *Id.* at § 531.10.

project?; (6) what contractual terms could provide adequate protections against this risk in the case of payments for ecosystem services?; and (7) what are the costs of monitoring green-infrastructure projects for performance, and what are the related administrative costs of administering a time-limited credit system?

C. Governance

In the context of this article, "governance" refers to more than just "government." It includes governmental, civil society and private market actors as well as the relationships between these actors and the legal and civil norms that they establish to address a particular need or interest.[159] More specifically, as it pertains to environmental matters, governance can be defined as "the articulation of new institutional formations to meet the growing complexity and scale of ecological challenges."[160]

The services that ecosystems provide to urbanized areas are both dynamic and multifaceted, varying in scale and effectiveness.[161] As a result of this complexity, identifying the appropriate governance structures to ensure sustainable ecosystem services provision to urban residents can be difficult. For example, where a watershed extends beyond a single city's boundaries, which governmental entities, non-governmental organizations, and private market interests should be at the table to make policy decisions that affect how this important resource is used? What legal arrangements should be adopted or private market mechanisms created to ensure that this water resource is properly managed and not depleted to an unsustainable level?

These and many other questions relating to the governance of ecosystem services for urbanized areas are beginning to be

159. CATHY WILKINSON, ET. AL., URBAN GOVERNANCE OF BIODIVERSITY AND ECOSYSTEM SERVICES 540, 540 (2013); *see also* INTERNATIONAL UNION FOR CONSERVATION OF NATURE, GOVERNANCE OF ECOSYSTEM SERVICES: LESSONS LEARNED FROM CAMEROON, CHINA, COSTA RICA, AND ECUADOR 1, 5 (Thomas Greiber & Simone Schiele, eds., 2011), *available at* https://portals.iucn.org/library/efiles/documents/EPLP-079.pdf (describing governance as the sum of many individuals and arrangements that people and institutions either have agreed to or perceive to be in their interest).

160. Robert F. Young & E. Gregory Mcpherson, *Governing Metropolitan Green Infrastructure in the United States*, 109 LANDSCAPE & URB. PLAN. 67, 68 (2013).

161. *See* Bradley C. Karkkainen, *Collaborative Ecosystem Governance: Scale, Complexity, and Dynamism* 21 VA. ENVTL. L. J. 189, 194–97 (2002), *available at* http://www.law.virginia.edu/lawweb/lawweb2.nsf/0/2ba27078dc464a84852569700060de96/$FILE/HDOCSscalecomplex.pdf (describing three propositions about ecosystems: (1) that ecosystems matter in environmental decision-making; (2) that ecosystems are complex and dynamic; and (3) that most ecosystems are "human-influenced or human-dominated").

investigated by various disciplines including urban ecology, economics, sociology, and the law. Cathy Wilkinson and her co-authors recently scrutinized 138 peer-reviewed scientific articles, from different disciplines published between 1999 and 2013, that purportedly examine the challenges and opportunities relating to governance of biodiversity and ecosystem services in urban areas.[162] Despite the number of articles published, Wilkinson's literature review lead her to conclude that "there is a lack of scientific literature on urban environmental governance."[163] While the current literature may be lacking, Wilkinson and her co-authors identify numerous important themes that emerge from the articles that will require further research. These themes include understanding the role political and intellectual legitimacy play for green issues in current political systems;[164] the importance of integrating environmental equity and justice into ecosystem services governance;[165] how to address gaps in institutional capacity that undermine governance effectiveness;[166] the need to navigate competing urban priorities;[167] challenges arising from scale mismatch;[168] and policy trade-offs.[169]

The Ecosystem Services Partnership (ESP)[170] has similarly

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162. WILKINSON, *supra* note 159, at 550–51.

163. *Id.* at 553; *see also* Robert F. Young & E. Gregory McPherson, *Governing Metropolitan Green Infrastructure in the United States*, 109 LANDSCAPE AND URB. PLAN. 67, 67 (2013) ("In addition, researchers note that efforts to institutionalize environmental governance strategies have been under-developed and under-researched").

164. *See* WILKINSON, *supra* note 159 at 554 ("Introducing a new emphasis on the science of ecology into how rural urban areas are managed presents real challenges – not least because of the lack of political legitimacy traditionally associated with 'green issues'").

165. *See id*. ("Ecosystem degradation may, however, be an important cause of urban poverty.")

166. *See id.* at 555 ("The most frequently documented barrier to more effective service management in cities 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 regulated ecosystem services.").

167. *See id*. ("One of the greatest difficulties for municipalities is to introduce a new policy priority into an already resource-stretched institutional environment." Further, the article states that "Biodiversity does not simply compete with other spending or development opportunities.").

168. *See id*. at 558 ("The literature indicates the temporal, spatial, and functional mismatches between ecosystems and the institutions managing them may be an overarching challenge in ecosystem governance.").

169. *See id.* ("It should however be recognized that governing urban ES [ecosystems] is not merely about finding synergies, but can often entail navigating trade-offs.").

170. The Ecosystem Services Partnership consists of academic, institutional and individual members that seek to enhance communication, coordination, and cooperation to conceptualize and apply ecosystem services.

identified governance as a critical research need.[171] Why is it important? According to ESP, "power struggles and conflicts affect the way ecosystem services are valued and affect activities and practices. In this sense, questions of justice, equity as well as distributional aspects have to be considered and reflected on," including the need for understanding the means and scope of stakeholder participation.[172]

Given the lack of a comprehensive understanding of governance in managing ecosystem services and its importance to healthy ecosystems and societal wellbeing, many critical questions remain that merit further study. In the paragraphs below, we reiterate research themes identified by Wilkinson and others. We also provide specific questions that we believe are essential to gaining greater insight into how governance structures can be arranged to meet urban populations' increasing ecosystem services needs.

1. Scale of Action

As mentioned previously, ecosystem services can be provided at various spatial and temporal scales depending upon the type of service. Water filtration services from forested lands within a watershed often occur at a regional scale spanning multiple political jurisdictions.[173] Services provided more locally, such as bio-retention swales or rain gardens to mitigate stormwater flow, are often within a single entity's control.[174] Services also vary across time scales. For example, management decisions about the mix of ecosystem services provided today may impact the extent to which ecosystem services are available to future generations.[175] As a result, governance for

171. *See* ECOSYSTEM SERVS. P'SHIP, *Portland TWG Founding Document*, http://www.es-partnership.org/esp/80348/7/0/50#Refs (last visited Nov. 9, 2014).

172. *Id*.

173. *E.g*., New York City Watershed Memorandum of Agreement, art. I § 2, 2 §3, 2 (1997). New York City's watershed, which supplies approximately 1.5 billion gallons of water daily to city residents, spans over 1,900 square miles. It consists of portions in eight counties, sixty towns, and twelve villages.

174. For example, New York State municipalities that operate municipal separate storm sewer systems (MS4) must adopt a Stormwater Management Program that requires the review and approval of post-construction stormwater pollution prevention plans prepared by construction sites operators. Under the state's Stormwater Management Design Manual, green infrastructure techniques like bio-retention swales are to be used to mitigate stormwater flows. DEP'T ENVTL. CONSERVATION, NEW YORK STATE STORMWATER MANAGEMENT DESIGN MANUAL: CHAPTER 5, GREEN INFRASTRUCTURE PRACTICES 5-43 (Aug. 2010), *available at* http://www. dec.ny.gov/ chemical/29072.html. (last visited Nov. 9, 2014).

175. *See* Ademola K. Braimoh, Julius I. Agboola & Suneetha M. Subramanian, *The Role of Governance in Managing Ecosystem Service Trade-offs,* 3 IHDP Update 23 (2009) (noting that

urban service provision cannot be one-size-fits-all.

The spatial and temporal aspects of ecosystem services affect how governance structures might be formed and raise several important issues. First, where service-sheds cross political boundaries, does that impede ecosystem service protection efforts? If so, how have actors overcome this challenge? Is voluntary, inter-municipal cooperation a viable option to address these cross border ecosystem services?

Second, it is important to know whether certain levels of government are more effective in administering particular policy mechanisms (e.g., property law, zoning, voluntary programs, payment for ecosystem services, etc.). For example, are local services that are provided locally—such as green infrastructure at the site level—more efficiently provided by municipal officials than services that are provided regionally, despite the fact that both are achieving water quality benefits? A regional service could be precipitation filtered by forested lands in distant areas within a large watershed.

Third, how do governance mechanisms address temporal challenges related to service provision where the current generation's near-term needs are valued more than future generations' long-term needs? How is this affected by the perspective of current actors involved in ecosystem services provision and consumption?

2. Parties and Participation Processes

Ecosystem service stakeholders span a wide range of actors, including providers, beneficiaries, and institutional intermediaries. Which stakeholders participate and how these parties interact is critical to the management choices that determine how ecosystem services are administered. In considering which parties should participate, a number of important questions are raised that require careful evaluation. For example, does the scale or type of ecosystem that governance activities address, affect which stakeholders participate in governance or the degree and methods of their participation? Conversely, how do stakeholders' particular interests as governmental entities, non-governmental organizations, or private market actors influence their involvement in managing certain resources? Another critical issue is whether future generations are represented in discussions regarding ecosystem services management. Should someone represent the interest of actors whose future needs

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temporal ecosystem service tradeoffs are driven by society's short term needs).

may be very different from those of today's generation? Finally, even where the appropriate stakeholders are identified and included, it is also important to understand how information flow between various levels of governance actors either promotes or impedes decision-making concerning ecosystem services.

In addition to determining the participating parties, it is also crucial to assess which decision-making processes will engage the widest range of stakeholders effectively in ecosystem services governance over time. Is it the current legislative process? Litigation? Current legal and regulatory regimes will need to be evaluated to determine whether they are sufficient to address all stakeholders' needs. Similarly, other participatory processes, such as consensus building,[176] should be explored to see if they are better able to engage the necessary stakeholders in ecosystem services decision-making.

3. Regulatory Support

Ecosystem services vary in their economic value and relationships with legal and economic institutions and norms. Some services are given a strong value by existing policy/regulation (e.g., the Clean Water Act gives value to stormwater mitigation). Others do not have a clear regulatory mechanism giving value to them (e.g. the Surface Mining Control and Reclamation Act as it pertains to mountaintop removal). Understanding which ecosystem services are highly valued by current law and policy is important to identifying current "gaps" that allow some ecosystem services to be overlooked by policymakers. By identifying those gaps, specific programs targeted to maintain or enhance that ecosystem service can be developed along with the supporting governance structure.

4. Competing Priorities

Current fiscal constraints, shrinking state and municipal staffs, and competing interests among stakeholders render it important to

176. Consensus building is a process that allows various stakeholders to work together to develop a mutually acceptable solution. *See* Heidi Burgess & Brad Spangler, *Consensus Building*, BEYOND INTRACTABILITY (Sept. 2003), http://www.beyondintractability.org/essay/consensus-building ("[Consensus building] allows various stakeholders (parties with an interest in the problem or issue) to work together to develop a mutually acceptable solution."). It is based upon elucidating the shared stakeholders' interests, the free exchange and development of salient information, and strong public participation. *See* SEAN NOLON, ONA FERGUSON & PAT FIELD, LAND IN CONFLICT 11 (2013) (describing the mutual gains approach to consensus building).

know how ecosystem services are prioritized among the many governmental responsibilities. Studies suggest that ecosystem services are given a lower priority than economic development, housing, and infrastructure.[177] Understanding how communities value ecosystem services against other governmental functions and why they do so will be helpful in identifying governance mechanisms that might reorder these priorities. For example, if municipal fiscal constraints are a driving force behind ecosystem services being prioritized below housing, could non-governmental actors fill the capacity void through cooperative efforts with other organizations?

5. Environmental Objectives Across Government Departments

The links between human land management actions and the level of ecosystem function are quite complex, depending on the ecosystem function in question, local ecological context, and specific management action characteristics. Moreover, land management to maintain or enhance a particular ecosystem function may have tradeoffs, degrading ecosystem function in other respects.[178]

The following questions aim to uncover how land managers consider these complexities in achieving specific environmental objectives, given that institutional structures are not generally designed to address these cross boundary interactions. (1) What is the link between resource management and service provision? How do governance structures influence what is measured and how this is counted? (2) How can actors overcome agency configurations with a narrow focus to promote multi-faceted ecosystem service provision (e.g., not just stormwater here and habitat there)? (3) Are there example cities with strong sustainability, or similar, offices or plans that have been able to overcome narrow agency focus? Are these offices effective? If so, why are they effective? (4) Are comprehensive and individual-agency planning processes capable of optimizing multiple services provided simultaneously? What roles do or can adaptive planning processes have?

6. Accounting for Ecosystem Services

Ecosystem services provision may compete with traditional infrastructure in competitive budget provision environments to help

177. *See* WILKINSON, *supra* note 159, at 557 (noting that long-term ecological decisions "extend beyond the period for which elected officials are responsible.").

178. *See generally* Ademola, *supra* note 175, at 22–23 (discussing spatial and temporal forms of ecosystem service tradeoffs).

defray compliance obligations already faced by a government entity. Moreover, regulatory systems have not traditionally focused on green infrastructure as a means to achieve compliance. This is due in part to inadequate information.

Characterization of the ecosystem services that are provided in urban areas can facilitate a location–specific valuation and help to discern the ecosystem conditions in local areas and their relationship to communities. Specifically, such characterization can assist communities in prioritizing trade-offs from the menu of ecosystem services that are subject to local pressures and needs. Some communities have partnered with governmental and nongovernmental entities to value the ecosystem services available from particular resources in particular locations. Examples include the work done to value urban forest services,[179] the long-standing and continuing work to value wetlands in the context of artificial wetlands and wetland enhancements,[180] and the varieties of open space values and storm water control benefits through green infrastructure.[181] Overall, though, little is understood about the ways and methods that ecosystem service values might be incorporated into local decision-making.[182] At a minimum, there needs to be a more grounded understanding through detailed case studies of how local governments practically rely on ecosystem services.

Avenues ripe for further research and scholarship are: (1) compile an ecosystem services inventory of the relative costs and benefits of service provision, and how service provision can conflict, in order to facilitate a deeper understanding of urban ecosystem trade-offs. (2) Conduct economic studies to fill gaps in the valuation of urban ecosystem services, so as to lead toward robust meta-analysis

179. *See, e.g.,* DAVID J. NOWAK, USA FOREST SERV., ECOSYSTEM SERVICE VALUATION OF THE URBAN FOREST, *available at* http://nyc.cce.cornell.edu/UrbanEnvironment/EnvPublicHealth/ForestRespHealth/UrbForRespHealthSymposium/Documents/Nowak%20-%202008%20Urban%20Forestry%20Resp%20Health%20Symposium.pdf (last visited Nov. 30, 2014).

180. ANDREA GHERMANDI ET. AL., TINBERGEN INST., VALUES OF NATURAL AND HUMAN-MADE WETLANDS: A META-ANALYSIS W12516 (2009), http://onlinelibrary.wiley.com/store/10.1029/2010WR009071/asset/wrcr12617.pdf;jsessionid=5B1F04461A002551894A42FCC82118A6.f02t02?v=1&t=i35gvepe&s=08c8b9898ad0df52ab1b72aaf26035511bb2aa28.

181. *See, e.g.*, *How Cities Use Parks for Green Infrastructure*, AM. PLANNING ASSOC., https://www.planning.org/cityparks/briefingpapers/greeninfrastructure.htm (last visited Nov. 30, 2014) (discussing the benefits of enhancing green infrastructure through the use of city parks).

182. Eeva Primmer & Eeva Furman, *Operationalising Ecosystem Service Approached for Governance: Do Measuring, Mapping and Valuing Integrate Sector-Specific Knowledge Systems?*, 1 ECOSYSTEM SERVICES 85, 87 (2012) ("The added usefulness of valuing ecosystem services as well as transferring and generalizing these values and applying them in concrete decision-making situations require further attention.").

development and reduced uncertainty in benefit-transfer methods for urban systems. This would reduce costs and time associated with monetizing services. (3) Identify traditionally leveraged policies for ecosystem services provision, as well as the non-traditional approaches that have been employed and could be translated to more widespread implementation. Finally, (4) determine how information on the efficacy of specific ecosystem services can be provided among different actors so that the governance system is able to adapt to changing circumstances.

7. Ownership, Enforcement, and Sanctioning

Both scholarship and anecdotal evidence note multiple instances of ecosystem services being impeded by "administrative silos." Ecosystem services require very different administrative structures and management than those associated with traditional gray infrastructure. Scales and maintenance requirements differ, as do affected and responsible individuals. Particularly in situations involving multiple individuals or communal ownership—such as in the case of distributed green infrastructure in urban environments—it can be a challenge to identify responsible parties and enforce management responsibilities.

Some pressing questions pertaining to managing and enforcing ecosystem service programs include: (1) what are the pathways for managing urban ecosystem services? Are there examples of decentralized services management and, if so, how have these been initiated/implemented? (2) How is enforcement and ownership structure tied to compliance? (3) What can the behavioral sciences tell us about the methods that best develop environmentally responsible behaviors among individuals and organizations? In other words, do these behavior-shaping methods include robust stakeholder participation in rule development and/or participation in rule enforcement? What are the implications for cognitively framing ecosystems and their values to urban communities?

8. How Does Governance Influence Adaptive Management?

There is an established and expanding literature on adaptive governance and ecosystem resilience.[183] Implementing multiple management strategies or adopting new governance structures is

183. *E.g.*, Carl Folke, et al., *Adaptive Governance of Social-Ecological Systems*, 30(1) ANN. REV. ENVTL. RESOURCES 441, 441 (2005).

easier said than done, however. In light of the benefits identified with adaptive management and adaptive governance structures, how can real-world constraints be overcome to better accommodate ecosystem services provision? Areas for research concerning adaptive management include: (1) identifying institutional limitations that may prevent the ability to revisit decisions affecting service provision; (2) understanding the relationships among adaptive management, adaptive planning, and adaptive governance—particularly at the local scales at which cities operate; (3) learning how resilience science can be employed practically and concretely to identify specific thresholds in urban ecosystems that could trigger their collapse or substantial transformation if crossed; and (4) discovering how those thresholds can be integrated into urban ecosystem services policies.

IV. CONCLUSION

Whether described as green infrastructure, urban ecosystem services, or some other term, there is undeniably growing interest across the country in using natural features and managed landscapes to provide valuable services to city residents. In certain circumstances, the benefits nature provides for human health and well-being are likely to be both extensive and important in urban spaces. Not surprisingly, the challenges of providing urban ecosystem services to date have largely been analyzed through specific disciplinary perspective—legal scholars writing for lawyers, urban planners writing for their community, etc. This article has sought to bridge disciplinary divides by bringing together active researchers from a range of fields to identify the most important research questions raised by urban ecosystem services provision. Our hope is that the issues and challenges identified above will catalyze directed research in this burgeoning and important field.