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Title:

Roles for governments and other sectors in the governance of green infrastructure in the U.S.

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Abstract:

This paper argues that government leadership both at the federal and local level remains central to implementing and building green infrastructure for stormwater management. We conducted interviews with more than forty city, federal, and agency staff on how and why they work to implement green infrastructure, and then interpreted the results using the literature from environmental governance and water management. We found that governments and non-governmental actors tend to act in different ways to support green infrastructure. Governments at both the federal and local level often take the lead role in driving green infrastructure via policy and political support, and coordinate measurement of green infrastructure practices, while non-governmental actors lead in information sharing. We also found that governments and non-governmental actors work together to build local capacity by providing resources to support local collaboration and partnerships. This paper concludes by highlighting key areas for collaboration between federal and local governments and non-governmental actors in order to enhance the implementation of green infrastructure.

Keywords:

environmental governance; regulation; green infrastructure; stormwater; policy process; adaptive governance

1. Introduction:

The 1972 U.S. Clean Water Act gave the U.S. federal government important new regulatory powers to govern water pollution. Numerous amendments and court rulings have since modified the interpretation and exercise of these powers (see, for example, Adler et al., 1993; Boyd, 2000; Andreen, 2003). Despite gains in water quality, water pollution remains a significant problem, with more than half of assessed rivers and streams across the country remaining impaired (US EPA, 2016). Urban stormwater runoff is now recognized as one of the leading sources of water

pollution and water quality impairment. Permitting programs for urban stormwater runoff began in the 1990s and continue today (NRC, 2009).

Local governments have long been recognized as important actors in achieving environmental goals both at local and global scales. The 1992 Rio Summit of national leaders and environmental ministers stated that:

> "… the participation and cooperation of local authorities will be a determining factor in [Agenda 21] fulfilling its objectives. Local authorities construct, operate and maintain economic, social, and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and assist in implementing national and subnational environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilizing, and responding to the public to promote sustainable development" (United Nations Environmental Programme, 2000).

Current approaches to stormwater management illustrate the wide-ranging roles of local governments. Local governments can commit to sustained and coordinated stormwater management through plans that last twenty years or more (see, for example, PWD, 2009; NYC DEP, 2016). Local governments can bring unique financial resources and capacity to implement environmental policy and action: the municipal governments of New York, Philadelphia, and Washington D.C., announced $5.3, $2.0, and $2.6 billion stormwater plans, respectively (NYC, 2010; PWD, 2011; DC Water, 2016). In tandem with local government investments, the U.S. Environmental Protection Agency (EPA) provides funding to states via Section 319 funds, often supplemented by additional state funds (Hardy and Koontz, 2007). Even within a single municipality, multiple government agencies are often engaged in active partnerships to address stormwater management.

Given the authority, jurisdiction, and financial capacity of governments, examining how government works with other sectors such as non-profits on stormwater management yields useful insights for practice and scholarship in two areas. First, how governments and non-

governmental actors work together in practice is relevant to the scholarship on adaptive governance, and on environmental governance more broadly. This literature has recently sought to incorporate approaches that emphasize the flexibility of legal instruments (Cosens et al., 2017), recognize how different modes of governance emerge and overlap (Driessen et al., 2012), and articulate the ways that social organizations can support more effective environmental management (Allen et al., 2011). Second, how governments and non-governmental actors work together is relevant to the literature on green infrastructure, which frequently emphasizes the different roles of multiple actors (Shandas and Messer, 2008; Keeley et al., 2013; Flynn and Davidson, 2016; Chaffin et al., 2016).

To show how governments work with non-profits and other organizations, we interviewed more than forty city, federal, and agency staff on how and why they implement green infrastructure. These interviews describe a national view of stormwater management approaches, which complements the deeper but narrower approach of Keeley et al. (2013) , which is based on interviews with a range of actors in two cities. Applying the existing literature on governance and environmental management to the implementation of green infrastructure in the U.S., we find that government – from the federal to the local level – plays a necessary leadership role in how stormwater agencies and managers adapt to new ideas and opportunities. In particular, we focus on three roles for government and other sectors in the governance of green infrastructure in the U.S.: as driver, as coordinator, and as a capacity-builder. From our interviews, we conclude that governments and non-governmental actors tend to act in different ways: governments often take the lead role in driving green infrastructure via policy and political support, as well as coordinating the measurement of green infrastructure practices, while non-governmental actors often lead in information sharing. Governments and non-governmental actors often work

90 together to build local capacity by providing resources to support local collaboration and
91 partnerships. Throughout this paper, we show how governments and non-governmental actors
92 take different roles in leading and supporting the governance of green infrastructure for urban
93 stormwater management. Where previous scholarship on adaptive governance emphasizes non-
94 governmental actors, we show that governments continues to play multiple important roles in the
95 governance of green infrastructure for stormwater management.
96 In the next section we examine the literature on environmental governance, with a focus on
97 adaptive governance. We then discuss our research methods, analysis, and results. We conclude
98 by highlighting key areas of collaboration between federal and local governments and non-
99 governmental actors on green infrastructure.
100
101 2. Literature Review:
102 In this section we first describe the importance of local governments in concepts of governance,
103 and then examine the ways in which governments and non-governmental actors work together to
104 achieve environmental and water quality goals. Finally, we discuss adaptive governance and
105 illustrate the link between social factors and the effective implementation of green infrastructure.
106 Local governments play a critical role in implementing environmental goals, with
107 responsibility ranging from infrastructure development to planning processes to implementing
108 national and state environmental policies (United Nations Environmental Programme, 2000).
109 Scholars use the concept of environmental governance to identify more effective ways to manage
110 environmental problems by emphasizing the networks of, and partnerships between,
111 governments and non-governmental organizations. The definition of governance continues to be
112 refined and applied to new areas, but the term governance has historically been used in three

ways: first, in referring to international cooperation managed by organizations other than formal states; second, as policy implementation (such as "good governance"); and third, as domestic networks of actors tasked with achieving public goals (Fukuyama, 2016). Such governance networks include governments and non-governmental actors, or in some cases, can be networks between governments, such as municipal networks aimed at addressing climate change (Bulkeley, 2005). Given our domestic focus, we use the third definition of governance, that "'*governance' is about establishing, promoting and supporting a specific type of relationship between governmental and nongovernmental actors in the governing process*'" (Howlett and Ramesh, 2014, p. 318, italics in the original).

Embedded in the concept of governance is a normative argument about the most effective way to achieve public goals: "such as 'network governance' or 'collaborative governance' combin[e] the best of both governmental and market-based arrangements by bringing together key public and private actors in a policy sector in a constructive and inexpensive way" (Howlett and Ramesh, 2014, p. 318). Gunningham and Holley (2016) chart out the recent history of Anglo-Saxon environmental governance – and its relationship to regulation and law – by providing context for how government and non-governmental organizations, such as business and NGOs, can work together. For complex environmental challenges, "New Environmental Governance" emphasizes "flexibility, participation, collaboration, learning, and adaptation" (Gunningham and Holley, 2016, p. 283). These approaches range from pragmatism to adaptive management (Holling, 1978; Walters and Holling, 1990) and aim to bridge the gap between traditional approaches to regulation and implementation, to enable "problem solving that is inclusive of local circumstances and able to capitalize on the unique local and other knowledges and capacities of multiple public and private actors" (Gunningham and Holley, 2016, p. 284).

136 Among these multiple definitions and approaches, scholars highlight the challenge of
137 differentiating between different types of governance especially when "modes of governance
138 tend to build on rather than completely replace one another" (Driessen et al., 2012, p. 157).
139 Scholars are beginning to examine the layering of governance mechanisms, such as
140 incorporating legal tools in adaptive approaches (Cosens et al., 2017; Craig et al., 2017).
141 We identified three different roles that governments and non-governmental actors play in
142 achieving local stormwater goals (going forward, we use the terms "roles" and "modes of action"
143 interchangeably to describe how different actors pursue their goals). We focus on
144 implementation and the perceptions of those actors responsible for translating stormwater and
145 water quality policy goals into local green stormwater infrastructure programs. In Table 1, we
146 show three modes of action for governments and non-governmental actors, and how they relate
147 to examples in implementing green infrastructure.
148

Water Governance Actions	**Implementing Green Infrastructure**
Driver: • More recent modes of environmental governance are built on previous governance approaches (Driessen et al., 2012), therefore early water regulations and subsequent policies and programs continue to influence flexible, adaptive governance approaches.	• Differing perspectives on implementing stormwater management programs reflect the continuation of different approaches to governance (e.g. for stricter laws vs. integrated management, see Cousins, 2017). • Including green infrastructure in legal requirements can encourage agencies to incorporate more learning and experimentation, although the time limitations can constrain adaptive management approaches (Chaffin et al., 2016).
Coordination: • Along with cooperation and collaboration, coordination plays an important role in solving environmental problems, with an	• Sharing regionally salient definitions and approaches aid in complying with requirements while establishing locally relevant standards.

emphasis on information exchange, resource exchange, and integration of activities (Margerum and Robinson, 2015).	• Encourages individuals and organizations to shift existing engineering practices toward more flexible solutions (Carlet, 2015; Cettner et al., 2013; Chaffin et al., 2016).
Capacity-building: • Both governmental and non-governmental actors allocate resources to build capacity to carry out policies and program, such as enforcement (monitoring and sanctions) or increases in efficiency, effectiveness, and responsiveness.	• Given resource limitations for implementing environmental solutions, federal and state funds can support such partnerships and provide technical assistance (Hardy and Koontz, 2007). • The multiple benefits of green infrastructure can provide additional resources (financial, social, organizational) to address stormwater challenges to achieve multiple policy goals.

Table 1 *Three modes of action and related examples from implementing green infrastructure for stormwater management*

2.1. Achieving water quality goals: government and non-governmental actors:

Scholars have discussed the actors and actions involved in environmental policy and management for decades (Driessen et al., 2012). Environmental governance in a broad sense emphasizes "interventions aiming at changes in environment-related incentives" (Lemos and Agrawal, 2006, p. 298), although more specific formulations focus on processes, mechanisms, organizations, and networks that influence environmental outcomes. This broadening of actors and responsibilities plays an important role in how scholars assess the processes and mechanisms related to achieving environmental goals, such as in the ways that global environmental goals are rooted in key local and subnational actors and networks (Betsill and Bulkeley, 2006; Bulkeley and Betsill, 2005). Governance of water goals – water quality and quantity goals – relies on actions at different scales given that challenges may be appropriate to examine at a project, catchment, basin, or even, global scale (Moss and Newig, 2010).

Collaborative partnerships help address the complexity within environmental policymaking and management. This complexity can stem from multiplicity and mix of institutions governing resource management, mixed motivations, and the interconnected nature of many environmental problems (Lubell, 2015). The number, duration, and type of organizations involved in solving environmental problems can vary substantially by location, but such processes require learning, cooperation, and distribution (Lubell, 2013). Scholars continue to refine the distinctions between cooperation, coordination, and collaboration: for example, to Margerum and Robinson, coordination "implies a process of joint decision making that places greater demands on partnership activities…due to high expectations for information exchange, more significant integration of activities and more exchange of resources" (Margerum and Robinson, 2015, p. 54). Other scholars propose cooperation, coordination, and collaboration as a continuum of interaction, yet in practice water management often has a mix of interactions and institutional arrangements (McNamara, 2012).

Previous scholarship emphasizes the outcomes of such partnerships, highlighting key actions related to more successful outcomes. Scholars are just beginning to test empirically whether and how certain group responsibilities can enhance collaboration, such as: "planning, management, outreach, monitoring, coordination, projects, and education" (Scott, 2015, p. 549). While these responsibilities are not always easily distinguishable since a single activity may meet multiple responsibilities (e.g. both outreach and education), Scott (2015) finds that watershed groups that include management responsibilities are associated with better water quality outcomes.

Collaborative watershed management is utilized by policymakers to enhance outcomes, but "the role of government in initiating and supporting collaborative groups" (Scott, 2015, p. 538) is understudied. The "good government" definition of governance that focuses on implementation

187 also highlights that governments have multiple priorities that require implementation capacity.
188 Policy enforcement is often related to government capacity to monitor and sanction, and capacity
189 to provide services is associated with increases in efficiency, effectiveness, and responsiveness
190 (Grindle, 1997). In the more flexible, polycentric paradigm of governance, this type of capacity
191 does not just sit with government, but the capacity to measure, monitor, and enhance compliance
192 may come from watershed partnerships or from non-governmental actors.
193 For stormwater management, federal and state funds are used to encourage such partnerships
194 and provide technical assistance to build local capacity (Hardy and Koontz, 2007). While
195 scholars studying adaptive governance have "address[ed] the broader social contexts that enable
196 ecosystem-based management" (Folke et al., 2005, p. 444), they also increasingly recognize that
197 the legal requirements used in more stringent, earlier approaches to environmental policymaking
198 can be flexible and evolve over time (Cosens et al., 2017). This understanding reflects, what
199 Hacker et al. (2015) call "drift" and "conversion" – drift occurs when "institutions or policies
200 are deliberately held in place while their context shifts in ways that alter their effects" (2015, p.
201 180) and conversion "occurs when political actors are able to redirect institutions or policies
202 toward purposes beyond their original intent" (2015, p. 180). Such opportunities reflect the
203 growing recognition that there are opportunities to design more formal governance tools, such as
204 law, in ways that encourage the coordination and collaboration needed for adaptive governance
205 (DeCaro et al., 2017).
206
207 2.2. Adaptive governance and managing green infrastructure:
208 Allen and Gunderson define adaptive governance as "the institutional framework that deals
209 with social and political dimensions of resource management and that allows adaptive

management to function" (2011, p. 1379). Adaptive governance also aims to address the uncertainty and complexity inherent in managing environmental problems (Chaffin et al., 2014). This emphasis on uncertainty and complexity links adaptive governance to existing policy mechanisms, which "may require that some imprecision and ambiguity of formal regulatory standards and definitions be maintained, as an adaptive arena in which the contending parties can interact, negotiate, and settle and renegotiate the practical meanings as they go along" (Gupta, 2004, p. 142).

In addition to the flexibility of these formal mechanisms, adaptive governance "is dependent on adaptive co-management, and adaptive co-management is most effective when there is: leadership with vision for the system of interest; legislation favoring adaptive management; funds for adaptive management; monitoring of the ecological system; information flow (i.e., cross-scale linkages); a variety of sources of knowledge; and a venue for collaboration…" (Allen et al., 2011, p. 1343). The multiple actors that facilitate effective co-management comprise the adaptive governance framework for managing green infrastructure. Our findings parallel the features that contribute to effective management by both governments and non-governmental actors, such as political leadership for green infrastructure, flexibility in regulations that allow for adaptive management, resources from public and private funds that support green infrastructure, responsibilities for measurement and monitoring, and information transfer across networks, municipalities, and within regions.

The implementation of green infrastructure projects and programs therefore illustrates how the adaptive governance framework can be applied to environmental problem-solving. Green stormwater infrastructure allows local applications of stormwater management practices that allow for "a high degree of flexibility that can be tailored to the needs of particular communities"

(Stoner, 2007, p. 9). The concept of flexibility for policy is rooted in allowing for increased choice (Bennear and Coglianese, 2012) and "the capacity of both regulators and regulated entities to adapt their behavior in response to new opportunities" (Fiorino, 2004, p. 395). Recently, scholars have emphasized the link between adaptive management and green infrastructure, reiterating the ways that regulatory compliance and legally established targets such as consent decrees can both constrain and encourage adaptive management (Chaffin et al., 2016). Inertia from decades of institutional know-how and accepted engineering practices is a recognized challenge of green infrastructure programs (Carlet, 2015; Cettner et al., 2013). Green infrastructure requirements for stormwater management, however, as compared to gray infrastructure, can spur "cultural shifts" (Chaffin et al., 2016, p. 437) that encourage the legally responsible parties to think beyond engineered solutions.

Implementation of green infrastructure is constrained not just by management approaches, but access to resources, public perception, politics and technical expertise (Keeley et al., 2013). Emphasizing how green infrastructure also enables other co-benefits can build stronger coalitions and support for green infrastructure projects. Additional co-benefits include recreation or physical activity, mental health benefits from access to green space, public health benefits related to disease control, carbon sequestration, economic benefits, increases in property values and the development of social capital (Coutts and Hahn, 2015; Mekala et al., 2015). This growing emphasis on co-benefits does not replace the need for water quality and ecological benefits but provides new opportunities to address multiple public priorities, such as jointly addressing water quality and economic revitalization (Keeley et al., 2013).

3. Research Design

We conducted qualitative, semi-structured interviews with 35 municipal and water agency staff and seven officials from the U.S. Environmental Protection Agency (EPA), at both the regional and federal levels. To select interviewees, we corresponded with each regional EPA office (ten total) to identify a set of municipal departments or water agencies actively pursuing green infrastructure in response to stormwater issues. Additionally, regional offices suggested appropriate individuals in each locality that would be knowledgeable about green infrastructure policies and programs. This strategy helped us identify a broad sample of individuals active in green infrastructure projects and programs. In total, our sample was comprised of twenty-five individuals working in municipal departments, ten in regional planning agencies or regional sewer authorities, five EPA regional employees, and two EPA headquarters employees.

All interviews were conducted by phone and lasted from 44 minutes to 1 hour and 37 minutes with 1 to 3 interviewees. Interview questions covered location-specific policy details and information on the implementation of green infrastructure, with questions: on the definition of green infrastructure, regulations and requirements; drivers of and motivation for using green infrastructure; and key actors and departments. Additional questions covered financing of green infrastructure, long-term maintenance, co-benefits of green infrastructure, and public engagement. The first round of analysis examined the motivations for, challenges in implementing, and perceived benefits of green infrastructure. Next, we examined the responses within each of these areas to identify key similarities and differences across interviewees. Finally, we grouped the responses into those that illustrated governments as driver, coordinator, and capacity-builder. We analyzed the data by quantifying the frequency of key concepts mentioned in the interviews and then identifying quotes that represent issues mentioned by multiple interviewees. We use both frequency counts and representative quotes in our findings

279 section. Our interviews sampled individuals working in local governments and water agencies
280 across the U.S., rather than comparing the experiences of governments to non-governmental
281 actors or multiple actors in a given jurisdiction. While our sample represents the perspective of
282 governments in the implementation of green infrastructure, future research is needed to compare
283 and contrast the perspective of governments with non-governmental actors and community
284 organizations.
285
286 4. Findings
287 The growing literature on adaptive governance focuses on the ad hoc and temporary partnerships
288 that assist in ongoing environmental management. We found that governments – from the federal
289 to local level – plays a necessary leadership role in how stormwater agencies and staff implement
290 green infrastructure. We highlight three modes of action that underpin green infrastructure
291 implementation in the U.S.: as driver, as coordinator, and as capacity-builder. Our findings
292 suggest that these three modes of action include the following roles for governments:
293 • *Governments as drivers*: regulatory requirements and local political support for green
294 infrastructure;
295 • *Governments as coordinators*: support from governments in providing common
296 definitions and best practices (filling an information gap) and assisting in measurement of
297 impact an effectiveness of green infrastructure;
298 • *Governments as capacity-builders*: support for local collaboration and partnerships.
299 The illustrative quotations used to support our findings are *italicized*, followed by parentheses
300 with a de-identified description of the interviewee (for example, "local stormwater manager"). In
301 these quotations, we find greater emphasis on the role of governments in encouraging adaptive

management for green infrastructure projects. Assessing the role of governments, compared to non-governmental actors, highlights the important role that governments play in motivating green infrastructure and sustaining measurable work toward water quality goals. For practitioners and policymakers, we argue that funding and management strategies should strengthen, not separate, the relationship between non-governmental actors and government, both of which are essential to adaptive governance frameworks for green infrastructure.

4.1. Governments as drivers

Governments as a driver of green infrastructure highlights the importance of regulations and local political leadership in supporting the implementation of green infrastructure programs. Green infrastructure, as a "*tool in the toolbox,*" (local stormwater manager) for stormwater management, has built on decades of experimentation with watershed planning in response to the Clean Water Act and is increasingly tied to other local sustainability and environmental planning initiatives. This section examines the distribution of drivers for green infrastructure mentioned by interviewees and the role of local politics and political champions in encouraging green infrastructure. In Table 2, we present frequency counts of the first and second drivers of green infrastructure as referenced by interviewees.[1]

Driver 1	Frequency	Percent	**Driver 2**	Frequency	Percent
Regulation	20	57.14%	Co-benefits	13	37.14%
Public Advocacy	6	17.14%	Cost	6	17.14%
Stewardship	4	11.43%	Regulation	5	14.29%
Co-benefits	2	5.71%	Sustainability	5	14.29%
Climate Change	1	2.86%	Public Advocacy	4	11.43%
Cost	1	2.86%	Future Regulation	1	2.86%
Sustainability	1	2.86%	Land-use	1	2.86%
	35	100%	Total	35	100%

[1] Exemplar quotations for all cited motivations are provided in Appendix 1.

Table 2 *Summary of Drivers of Green Infrastructure (35 interviewees)*

4.1.1. Regulation as a driver of green infrastructure implementation

Among the interviewees, 20 of 35 cited regulation as a key driver for green infrastructure, meaning they emphasized regulatory compliance, permitting, or mandatory planning before other motivations for green infrastructure. An additional five interviewees mentioned regulation as a secondary driver, with one interviewee highlighting future regulations as an impetus for green infrastructure:

> *"We just keep hearing how it's something that EPA is really pushing and pushing more and more, and we know that there will be a point where there is an absolute requirement. So, we are really wanting to understand [green infrastructure] more and get some demonstration projects"* (local government employee).

The push from the EPA was cited by multiple interviewees and is tied to compliance with permitting requirements, such that:

> *"…we make sure that we are in compliance with that permit… so that's why we have an interest in low-impact development. In addition to our stormwater group, development services have an interest in low-impact development because we have done some pretty extensive education and outreach with them on the importance of it and why they should care about low-impact development – because EPA is really pushing it, it's not going away. This is something we need to pay attention to, and it just makes sense – cleaner, greener cities*" (local government employee).

Or as another interviewee explained: "*the origin of green infrastructure for watershed protection was regulatory compliance*" (local watershed program manager).

Additionally, we show in Table 2 that regulation is not the only driver of green infrastructure, with the additional drivers of public advocacy, co-benefits, cost, and sustainability also frequently cited. Yet it is also difficult to completely disentangle regulatory motivations from other drivers, finding that regulation underlies other motivations as well. For example, while the quotation below focuses on cost reductions, the requirements to spend capital on combined sewer overflows stems from the Clean Water Act:

> *"One thing people shouldn't be thinking about is that this [is a] question of gray infrastructure or green infrastructure. It's really gray and green. There's no way that a city could solve its combined sewer problems with just green infrastructure…. My sense is that if you put green infrastructure in; you're probably shaving 10 to 20-percent of your capital cost. So right off the bat, green infrastructure is more cost effective"* (county water authority manager).

Additionally, the regulatory requirements for planning and permitting provided organizations with opportunities to push for a new mode of stormwater planning. Similar to references to cost-effectiveness, collaboration among advocacy organizations and public participation in stormwater matters are, at times, linked to regulatory requirements. An interviewee in Pittsburgh emphasized that plans can provide organizations with helpful guideposts for further discussion and planning:

> *"Initially, the motivating factor was a grassroots campaign by an organization called the Clean Rivers Campaign. They were looking at the consent decree and consent order, wet weather feasibility, and long-term control plans from Alcosan and other folks in the region that were going to be strictly gray plans. The [initial] plan was, we got nine billion gallons of water overflowing into the rivers; we're going to build giant tunnels, and, then, pump it and treat it so that we don't have sewage going into the rivers"* (local water authority manager).

While in some cases interviewees emphasized cost-effectiveness or stewardship before direct regulatory compliance, our interviews and analysis show that government regulation and acceptance of green infrastructure as a solution for stormwater management also play critical roles in motivating the use of green infrastructure. Stormwater management has shifted from only gray (e.g., strictly engineering) solutions to both green and gray solutions which require engagement with the community to achieve other co-benefits:

> *"Putting in another pipe is not always the best solution…when you can do things with green infrastructure, such [as] the permeable pavers that enhance the community, increase the property value, and spur redevelopment in an area. It also allows us, especially in some of the areas that have been more disenfranchised over a long period of time, for us to do things that can help enhance the community and improve the quality of life. We want to be able to improve the quality of life of our ratepayers and our constituents with our projects"* (local stormwater manager).

Regulation and the promise of future requirements continues to guide the adoption and implementation of green infrastructure, not only as a solution to stormwater problems, but as a way to develop co-benefits such as beautification, air quality, and flooding.

4.1.2. Local political support for green infrastructure

In addition to regulatory action, governments drive green infrastructure through local leadership and political will. Interviewees emphasized that support for green infrastructure for stormwater is highly political, from references to broader political cultures to specific moments of government leadership. As one interviewee said:

> "*…that two tiers, committed staff and the high-level political support, is the only way to get green infrastructure. You need both, that's the take home of my last 15 years*" (local green infrastructure specialist).

Interviewees referenced politicians and political support in a number of ways, with the most frequent references to political support as: first, providing the momentum for green infrastructure and, second, integrating green infrastructure and stormwater management into other critical municipal initiatives. Influential elected officials were mentioned by 16 interviewees, with an emphasis on mayoral influence and leadership in garnering broader support for green infrastructure, which was mentioned by 8 interviewees. Furthermore, four interviewees mentioned the importance of appointed officials such as municipal commissioners, three other interviewees mentioned the role of city council, and one mentioned a congressional champion.

Support from political leadership was described as a key factor in "*making a successful program*" (local director of public works) and that it is not just one-time support, but "*continued public pressure and political support to keep trying this path because it is the less certain path. It is a new technology and a whole new comfort zone*" (local water utility employee). In cases

where local political champions aligned with green infrastructure, interviewees described this way:

> "*critical to the success of [a green infrastructure program] because he supports the ordinance changes and all of that…the way that we did that was doing the demonstration projects, and then making sure that the mayor and city council got out there to see the demonstration projects and heard from the community about how they want more projects like that done and I feel it's a smarter way of doing it. I think that that political leadership really needs to be established early on*" (local director of public works).

Conversely, locations without strong champions have more difficulty in pursuing green infrastructure programs:

> *"I think the other thing that comes into play is the political climate. We've never really had any kind of politician who has led a charge for infrastructure and used it to [create] a positive spin in the community, kind of like Philadelphia recognizing that they needed to revamp some of their neighborhoods and utilize one program with another. We just don't have that political climate here. It tends to be very conservative, and it's very much focused around not raising taxes and not having any adverse financial impact on the community"* (local public works employee).

Additionally, interviewees highlighted the importance of ongoing political leadership for long-term support and allocation of resources.

> *"The local champion was the local councilman…he wanted to find a way to use green infrastructure to manage the smaller rain events and we got going to do a pilot and then he left, and everything just stopped. The elected officials there just didn't understand it, didn't believe it, didn't want to spend money, didn't want to spend time. So, we never went any further than just beginning to design a pilot program for them* (regional EPA employee)*."*

As this quote from an EPA interviewee illustrates, political support is not a silver bullet and political support for green infrastructure can result in different on-the-ground outcomes. Even when local leaders translate ideas into organized action, such as the creation of the Anacostia Waterfront Corporation in Washington D.C., which "*was dissolved when that mayor's term ended*" (local stormwater manager) it was nevertheless an "*impetus for green infrastructure and*

policy moving forward" (local stormwater manager) and formed an objective pursued later by other municipal departments in Washington D.C.

Local political leaders are powerful allies for stormwater management because they "*are interested not just in solving the combined overflow problem but also in making a greener city. That's where green infrastructure starts to come into the picture*" (regional sewer district manager). They help translate and integrate stormwater initiatives into broader city efforts on sustainability and complete streets.

> *"The previous mayor and this [current] mayor created and embraced a sustainable DC plan that includes restoring our rivers to the fishable and swimmable conditions…green infrastructure is absolutely a critical piece to achieving that goal…DC has really embraced the role of trying to be a leader in sustainability and being [at] the forefront in a lot of ways. We've got buy-ins from the highest levels, and I think that helps a lot"* (local stormwater manager).

Regulatory motivation can provide the long-time horizons needed to achieve water quality goals, but local politicians can link broader regulatory goals to ongoing initiatives that resonate with local communities. As presented in Table 2, regulation is not the only driver of green infrastructure, public advocacy, and co-benefits play important roles in garnering support green infrastructure projects and programs. This requires not only a top-down push from government, but coordination with bottom-up actors. As an interviewee from Pittsburgh noted,

> *"The current new mayor is very keen on green infrastructure… [so] we've got pretty good top-down as well as bottom-up support for this as we're moving forward now. Until just recently, within the last year or so with the new mayor, we really didn't have a good working relationship with the city offices in the sense that we could call on them and talk to them openly about the policy initiatives that they did as the city…. Now, there's some synergy and a lot more cooperation on this issue. I think people are beginning to understand that stormwater crosses a lot more boundaries politically and departmentally than they had thought"* (local water authority manager).

4.2. Sharing Coordination: Information and Measurement

Understanding governments as coordinators builds on the relationships established via political leverage and policies that, as described above, create "*some synergy and a lot more*

cooperation" (local water authority manager). While governments as drivers focus on (1) translating federal policies to local priorities and (2) the role of local political actors as champions for green infrastructure, the role of governments as coordinators examines how governments can help coordinate opportunities for, and understanding of, green infrastructure across national, state, and local levels. We identified two key areas for the role of coordinator: information sharing and measurement. In this case, we find that the EPA, municipal networks to share best practices, and regional organizational all play important roles in coordinating information on, and measurement of, green infrastructure.

4.2.1. Information sharing

Information sharing about green infrastructure policies, programs, and designs occurs in both vertical and horizontal directions – from federal down to local governments and horizontally, typically, between local governments. A critical transfer of knowledge and information is occurring at the regional level, with organizations partnering with their regional network of cities to establish design standards appropriate for regional ecological and hydrological characteristics. First, this section will examine the ways which EPA helps coordinate across localities. Second, we highlight how information is being shared horizontally, which supports the active role of governments in adaptive governance. Third, we discuss the ways that regions are propagating best practices and regionally relevant design strategies.

4.2.1.1. EPA Coordination: definitions and information

The EPA, both at the federal and regional level, plays a critical role in helping local agencies and organizations understand what it means to establish a green infrastructure program. EPA's role in this form of coordination does not mean that they always initiate the idea of green infrastructure, for example, the origin of low impact development and then green infrastructure is often attributed to local actors in Maryland. However, EPA efforts to coordinate among localities

help establish basic definitions and encourage regions to adapt the meaning of green infrastructure to their local conditions. For example, the EPA Region 6 office deals with localities with "*significant climate zone concerns and in how they all have to deal with green infrastructure and what green infrastructure means to them is completely different than it means to others*" (regional EPA employee) and so Region 6 aims to help "*them understand what green infrastructure meant to them…that green doesn't necessarily mean green vegetation because in [the] New Mexico area and in more arid areas….we had to help them understand that xeriscaping could be and is green infrastructure [and that] all we are trying to do with stormwater, if you were to implement more green infrastructure in the stormwater realm, it was designed to be able to treat what we are looking for it to treat*" (regional EPA employee).

Across non-EPA interviewees, five attributed their definition of green infrastructure as stemming from or associated with EPA's definition, one connected it to U.S. Fish and Wildlife Service, and two mention BMPs (best management practices). Yet like the use of BMP – a term used in the Clean Water Act – 17 interviewees also used language that parallel's EPA's definition of green infrastructure, such as "*mimick[ing] natural processes*" (local engineer) or "*hydrological processes*" (regional flood control district employee) or capturing "*where it falls*" (regional sewerage district employee). Table 3 provides examples of three EPA definitions of green infrastructure and three parallel interviewee definitions. Government agencies help both to customize and standardize what it means to use green infrastructure to manage stormwater.

EPA Definitions

Green infrastructure uses natural systems and/or engineered systems **designed to mimic natural processes** to more effectively manage urban stormwater and reduce receiving water impacts. These systems are often soil or vegetation-based and **include planning approaches such as tree preservation and impervious cover reduction**, as well as structural interventions such as rain gardens and permeable pavements. By maintaining or restoring the **hydrologic function** of urban areas, green infrastructure treats precipitation as a resource rather than waste, and can play a critical role in achieving community development as well as water quality goals (US EPA, 2013).	Green infrastructure practices **mimic natural hydrologic processes** to reduce the quantity and/or rate of stormwater flows into the combined sewer system (CSS). By controlling stormwater runoff through the **processes of infiltration, evapotranspiration, and capture** and use (rainwater harvesting), green infrastructure can help keep stormwater out of the CSS. (US EPA, 2014).	Green infrastructure includes a range of approaches for **managing stormwater near where it falls**. Most green infrastructure uses the natural processes of soils and vegetation to **capture, slow down, and filter runoff,** often allowing it to recharge ground water, but some practices **collect and store** rain water for future use (Kramer, 2014).
Interviewee Definitions		
"We define green infrastructure as small-scale stormwater management practices, non-structural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of development on water resources" (local director of public works).	"Well, we define green infrastructure as really anything that is managing stormwater in a way that more closely mimics the natural hydrological cycle. That can be through stormwater management practices that retain and infiltrate water or stormwater practices that capture water for reuse. But, any type of practice that holds on to stormwater and does not release it back to our sewer system is really what we're considering green infrastructure. Anything that reduces runoff" (local stormwater manager).	"The way that we define it…is that we will capture rainwater and treat it – if it's stored, treat it where it falls using natural solutions – natural techniques versus letting it run off and get into either a combined sewer system or into our MS4 – our streams, rivers. And, basically, within the combined sewer system, we have green infrastructure that is focused more on quantity and volume, and in the MS4 [Municipal Separate Storm Sewer Systems] area, it's focused more on water quality and treatment" (local MS4 program manager).

518 **Table 3** *Example EPA Definitions and Interviewee Definitions*

EPA's influential role in stormwater management was mentioned by individuals working in agencies and organizations across the country. While information from EPA to regulated entities is available online, in presentations, and workshops, the challenge is making that information locally meaningful and easily available. In some cases, such as integrated planning, EPA's planning model is transferred to local agents. For example,

> *"[the] 83-municipality area is split up into seven watersheds, and we have one of them that we are focusing on first to use an integrated watershed management approach, which is an EPA model for addressing many regulatory issues with water quality altogether and in a more cost-effective way than doing it one-by-one. This watershed has – half of it is in the City of Pittsburgh, and the other half of it is 11 other municipalities. This is kind of a test case for how we can collaborate. We've had a number of meetings with the municipal engineers in those communities, and we try to share data about their sewer systems and do water quality testing in that area, and we'll be developing a plan for that area"* (local water authority manager).

Additionally, EPA and state environmental agencies play a role in providing guidance and information to permitted entities as they continue to incorporate green infrastructure into their plans and programs. Here, EPA plays an important role in coordinating and then synthesizing information across jurisdictions. EPA is positioned to gather specific information and relate it to the broader set of activities occurring in an area or particular watershed. For example, for the Metropolitan Sewer District of Greater Cincinnati, "*all of [the] reports on our website and those are done in a way that Ohio EPA can use that information and feed that information into their assessment of the waterways"* (regional sewerage district employee). This is particularly salient as places look to one another for best practices and lessons learned but also recognize that approaches to green infrastructure and local conditions may differ. For example:

> "*the more this continues to be utilized by larger communities; then we will continue to see the field adjust. And, I think also direction from the EPA and the DEC. I know [that] for our consent decree, or our administrative order, is very different from Cleveland in the fact that we analyze for green infrastructure first*" (local sewer authority employee).

4.2.1.2. Horizontal information sharing: best practices and policy options

Knowledge development and information sharing about green infrastructure and watershed planning has occurred from EPA to permittees, but there is also substantial horizontal sharing of information. Interviewees indicated there is a balance between sharing best practices from national and regional green infrastructure leaders and customizing green infrastructure solutions to local conditions (ecological, political, and cultural).

> *"There's so much good EPA information, and even Oklahoma State here is one of the leading places that has a good environmental program that really touts low-impact development. There's a lot of good resources to draw from, both nationally and in Oklahoma. It's kind of really more networking with our peer cities to really try to get some things rolling…I think we all really have a lot of the resources, and probably more information on LID and green infrastructure than we can ever read. But, really, just kind of directly implementing it and getting it localized to really take hold in your specific areas is the challenge I think that we're facing specifically here, anyway"* (local stormwater manager).

As discussed earlier, government agencies help coordinated and summarize information across localities, and then local jurisdictions translate elements of what works in other places into meaningful local solutions.

> *"I think just generally speaking, we always look at, in a way, what other cities are doing. And particular cities that are kind of our same size, have kind of the same permit, drivers that have somewhat of the same climate, and that kind of stuff…I appreciate looking at and gleaning information and knowledge from all the very successful programs out there. But, sometimes it is hard when you're translating that to your policymaker when they're like, but you're not comparing apples and apples, so to speak"* (local water quality project manager).

Despite the challenges of direct comparisons, cities actively learn from one another, such as, "*bringing in folks from the East Coast [to Missouri] to talk about green infrastructure and look at what Maryland had done in particular*" (senior manager regional planning council).

Interviewees described horizontal information sharing as opportunities to learn from places that have already used and tested new technologies, such as porous pavement, and then

using those experiences to make modifications to practices in their own jurisdictions. For example,

> "*The City of Austin had only allowed porous pavement for water quality purposes in pedestrian land uses…. After a significant benchmarking effort on other municipalities and jurisdictions, we got a consensus that the folks who had been early adopters of that technology really had not found these worst case scenarios of stormwater hot spots in certain applications. And, so, what we did is we increased the allowable use for water quality purposes to include vehicular uses like parking lots, like interior roadways"* (local engineer).

As more places implement green infrastructure, interviewees described a desire to learn from other places, "*that are implementing these strategies and for us to have guidance from the EPA and put us all together and where we can share our knowledge and exchange information"* (local engineer). The key task now is moving beyond the more common examples:

> "*like Philadelphia or Seattle… [since developers are] interested in making a living doing development and trying to change their point has been difficult for them to accept. But, we have some success stories that we've tried to share, but they want another city in the South that's had no problems at all with this before they're willing to conceive that it might a good idea"* (local public works engineer).

These quotes indicate that places have the desire and need to learn from the experience of many other places.

4.2.1.3. Regional organizations: design specifics and knowledge sharing

At a regional level, design manuals play in important role in communicating standards and green infrastructure options to developers and municipalities. An interviewee from EPA Region 7 highlighted that, "*the [places] that share information have regional planning agencies that, I think, try to be the ones to teach these smaller cities some of the more progressive – not just for stormwater but a lot of different things – and they've been, I think, fairly successful in at least providing technical assistance and training to some of the smaller cities*" (regional EPA

employee). At the regional scale, therefore, there is a critical area of collaboration between regional planning entities, inter-governmental organizations, and local governments, all of which act to translate between governance and government rules. Like local jurisdictions, the process of developing a manual is transferred laterally between places interested in developing green infrastructure in their area.

> *"We have a manual. It is called The Mid-America Regional Council, APWA BMP Manual. Our whole region has adopted this manual in some form, generally, so different cities, counties adopt it on their own terms. Mid-America Regional Council is our nine-county governmental planning body. If there is something that Mid-America Regional Council has available, then the more of us that can adopt things that they have developed, the more it brings consistency to our region… For private development, we have the BMP Manual that is required to be followed; it's a series of calculations they go through. My understanding is that it's based on the system that…Prince George's County, Maryland did"* (local landscape architect).

Design manuals play an important role in communicating with the private sector, a key player in achieving the scale needed to manage stormwater with green infrastructure. This is not a new concept but gaining traction in multiple regions:

> *"As we invest all the money in many EPA regulations for combined sewer overflows, and clean water, and all those things that we can't keep adding burden to the system over and over again. So, back in 1999, the council adopted a stormwater management manual. It basically says you do new or redevelopment then you need to start managing as much water as you can at the source as opposed to passing it downstream into the system"* (local stormwater manager).

Manuals vary from regional networks, like the Mid-America Regional Council to "*the New York State Stormwater Management Design Manual*" (local sewer authority employee) to Arkansas' "Evaluating and Conserving Green Infrastructure Across the Landscape" to Chattanooga's "Rain Water Management Guide." Manuals help local governments coordinate with developers, as well as to transfer lessons within regions and to support the calls for more locally specific practices and information. Manuals can be updated iteratively and with public participation to "*provid[e]more detail, lessons learned – on what we've seen on the construction side, what*

we've seen on the design side –in order to help make those projects more effective going forward" (local MS4 program manager).

4.2.2. Measuring green infrastructure impacts

Interviewees highlighted ongoing challenges in measuring the impact of green infrastructure, but that EPA policy and assistance plays a critical role in coordinating data collection. In particular, measuring the efficacy and co-benefits of green infrastructure are key areas for coordination. From the seven EPA interviews, with both regional representatives and the federal headquarters, two primary themes emerged related to the EPA's challenges and role in measurement: (1) balancing the needs of different communities and (2) uncertainty. Just as local entities are interested in seeking information that is more specific and relevant to local conditions, the EPA recognizes that coordinating across localities requires attentiveness to what different communities need:

> *"Now we're looking at how do we try to compare apples-to-apples? When other communities are putting in central performance standards or identifying that this particular installation meets their 80th percentile, or the 90th, whatever they choose to do because there's not a performance standard in their permit yet. So, that's where we are now, how do we get that support out there, how do we fund something like that type of research, and how do we come up with something, an easy potential tool or model to be able to help them do that"* (regional EPA employee).

Variation is not just associated with permits, but the capacity to monitor and manage varies with other characteristics such as size. It is "*the cities that are really thinking about it have the wherewithal – DC and Philadelphia and Seattle and Portland –the smaller cities usually just put in, they have some requirement and they put it in and they can't step back and see a signal yet*" (federal EPA employee). Such patterns reinforce the importance of coordinating knowledge within a region and horizontally across many cities.

Uncertainty in measuring the performance of green infrastructure is a critical challenge to effective implementation and the EPA is working with cities to address these concerns.

> *"One of the reasons that there has been pushback on green infrastructure is because if you think about it, you're taking a decentralized approach to stormwater management….With green infrastructure you have potentially tens of thousands of practices all across the landscape, so the question is how do you maintain those, how do you account for them, how do you ensure their practicing as designed, how do you even know they're there….The other thing is, how the systems perform, this is a longstanding issue, even with gray infrastructure…how do you understand how to optimize it? How do you create these systems to be resilient, to help ensure that you're meeting your performance goals, as they work together – in synergy if you will. We are still trying to work out those sorts of things*" (federal EPA employee).

In practice, measuring how much stormwater green infrastructure will capture and how to effectively operate a decentralized system remains a challenge:

> *"Accounting-wise, your gray is big, it's massive and you can account for how much stormwater you are going to accumulate in your holding tank. Whereas, the green is pretty dispersed throughout the communities and I think some concern as to how they keep track of it, how they account for it, how they are sure these things are operating the way that they are supposed to"* (regional EPA employee).

Over time, with more projects implemented and information shared across localities, "*people are starting to weigh the benefits…and make more informed decisions*" (federal EPA employee).

Paralleling EPA's concerns, non-EPA interviewees highlighted their ongoing efforts to measure the impacts of green infrastructure and enhance their understanding about the co-benefits of green infrastructure. Measurement varies across localities, from interviewees with "*monitoring capabilities at every single site we construct*" (local stormwater director) to "*not individual site monitoring any of our projects, [rather they are] designed to generally accepted engineering standards in the state stormwater design manual*" (local sewer authority employee), to "*common sense engineering green design"* (local stormwater manager), but there was a consistent recognition that understanding and measuring impacts requires "*a long-term outlook*" (local public works engineer). Additionally, measuring the impacts of green infrastructure was highlighted as a key area for partnerships between local jurisdictions and the EPA; from "*work[ing] jointly with the USGS and EPA and some universities to measure individual BMP*

effectiveness" (regional sewerage district employee) to 319 grants and university partnerships, monitoring and measuring green infrastructure requires long-term commitment. Coordinating relevant information networks and meaningful measurements illustrate the role that governments plays in structuring information sharing and measuring of green infrastructure across the country.

4.3. Governments as capacity-builders

Critical partnerships with and funding from the EPA enhance local capacity across the country. Furthermore, EPA devotes resources to encourage local collaborations critical to an adaptive governance paradigm. As articulated by the interviewee from Fort Collins, CO:

> *"…if we're going to reduce non-point source pollution we all have to work together. It's important that we don't each do our own thing but work cooperatively across sectors. So, it could be academic research, industry, private you know, and then public officials, like me, and the federal government, and the state government. All of us working together on improving the state of the art would be really – is very important. The EPA is funding a program here at CSU, at Colorado State University, it's called the CLEAN Center, and that's what it's trying to do is bring in all these officials together"* (local engineer).

Similarly, the interviewee from San Mateo County cited:

> "*grant funding from EPA to convene a stakeholder roundtable process to try to really push that issue and say, what do we need to do to get green infrastructure integrated into all these issues [climate change and drought] and identify what the barriers are and come up with what are the solutions to overcome those barriers*" (county program coordinator).

Of the 35 non-EPA interviewees, 17 cited funding from either the EPA or state environmental agency, with 3 of the 17 indicating funding from both federal and state sources. Comments about funding sources highlight the joint effort between government agencies and non-profit organizations to support green infrastructure financially, 6 interviewees noted funding from foundations, conservation organizations, or environmental trusts.

Interviewees suggest that EPA funds projects or programs – as mentioned by Fort Collins and San Mateo County – which build local capacity by supporting local collaboration and partnerships. Additionally, interviewees highlighted partnerships between the EPA and local

jurisdictions in order to understand and assess the performance of green infrastructure projects. Adaptive management for green infrastructure at the project-level engages both governments and non-profits. For example, the City of Tulsa "*monitor[s] of some of the specific BMPs with our partners – with USGS, US EPA, various universities*" (local government employee). Other project-level experimentation between EPA and municipalities resulted in building more modular and flexible systems. As one federal EPA interviewee shared, "*we've seen in Cincinnati, our Office of Research and Development had put in some section, what you get is initial clogging in the first quadrant…but then the water runs off into the other sections and still infiltrates, so you're still achieving your water quality goals. And so, you design the system to partially fail but still perform as you need it to.*" The EPA also partners with local agencies to build capacity to move project designs towards more adaptive practices, such that "*you don't want to design with stasis in mind, you don't want to just put the thing in the ground and say 'we're done'…you can design it with modularity in place. You can put inserts into them, there are all kinds of things you can do. You can change your media mix, change your maintenance frequency. There are lots of solutions. You can use systems to reduce the risk of failure"* (federal EPA employee).

Both as capacity-builders and as drivers of green infrastructure projects, governments encourage structured (and mandatory) opportunities for regulated entities to experiment via regulatory permitting and planning processes. While some of government's capacity-building stems from grants and EPA-to-local entity partnerships, the federal government is also building capacity within regional and federal offices in order to practice "*adaptive management between permit terms, because there's not a one size fits all sort of mindset that we can establish in the regulations themselves, just by its very nature we have to take the on the ground lessons that*

753 *come in through the annual reports, through the information that's gleaned in that one permit*
754 *term and use it to write more targeted and accurate provisions in the next permit*" (regional EPA
755 employee). The funding and partnership opportunities, combined with coordination efforts on
756 information sharing and measurement, illustrate the government's role in insuring that solutions
757 are adaptable and locally specific in addition to aiming towards long-term goals.

758
759 5. Discussion
760 The role of governments in coordinating and capacity-building supports the regulatory efforts
761 driving green infrastructure deeper into the planning and development processes of jurisdictions,
762 such that there is "*a good feedback mechanism and a way to assess and change midstream, not*
763 *[to] set 20 to 30-year vectors that you can't deviate from to improve performance and reduce*
764 *cost*" (federal EPA employee). As researchers and practitioners consider adaptive management,
765 not just as a strategy for natural areas, but as a strategy for managing urban, socio-environmental
766 impacts, government agencies play critical roles in enabling capacity and information-transfer
767 that encourages adaptive management practices. Governments and non-governmental
768 organizations both play important roles in adaptive governance, but at times one may function
769 more effectively as a lead, and the other may function more effectively in a support role.
770 Governments may be positioned to take the lead or encourage certain practices that allow for
771 more adaptive approaches on-the-ground, while other situations are more suited for leadership
772 from non-profits and the private sector. We summarize these findings in Table 4.

773

Governance Actions	**Mechanisms**	**Government Role**	**Non-Governmental Role**
Driver	*Regulation*	Lead	Supportive
	Local Political Support	Lead	Supportive
Coordinator	*Information Sharing*	Supportive	Lead
	Measurement	Lead	Supportive
Capacity Building	*Project Funding*	Shared	Shared

	Project-level experimentation	Shared	Shared

Table 4 *Sharing of responsibilities between governments and non-governmental entities*

First, we find that within regulatory and local policy drivers for green infrastructure, governments – often at the state level for regulation and at the local level for policy – takes on the leadership role over long periods of time. Local organizations that comprise the broader governance structure can support governments by better orienting regulatory drivers to local conditions or encouraging the integration of green infrastructure into other planning initiatives, such as sustainability efforts. Second, coordination activities, which organize relevant information and standards, require that governments and non-governmental actors work together to implement policies and programs (e.g. design manuals and standards) that account for change and flexibility. For example, information manuals are often encouraged by government, but regional partnership takes primary responsibility since they can more effectively establish a process to continually update design manuals to account for conditions across the region and new technologies. In turn, regulatory permits can cite standards set in manuals, allowing for more flexible, regionally-specific design specifications that can be modified outside of the permitting process. This evidence supports the notion that flexibility can be associated with coordination processes, not just collaborative processes, and can work across layers of governance (e.g. both centralized regulation and more polycentric regional partnerships). Third, funding and experimentation that build capacity for improving and implementing green infrastructure projects can fall to both governments and non-governmental actors, we see funding streams coming from both governments and non-profits in collaborative efforts across sectors. The interviews conducted for this research represent a range of local experiences and EPA perspectives, we find that implementation of green infrastructure is often shared between actors. Policy development

and planning perspectives can take advantage of moments where either governments or non-governmental actors, or a mix, can respond effectively.

6. Conclusion

We find that the governments – from the federal to local level – plays an important role in how stormwater agencies and managers adapt to new ideas and opportunities. We highlight three modes of action that underpin green infrastructure implementation in the U.S.: driver, coordinator, and capacity-builder. We find that,

1. policy drivers play a critical role in encouraging green infrastructure: regulatory drivers tie local programs and projects to long-term water quality goals and local political efforts craft stormwater programs that resonate with local communities;
2. governments coordinate information and measurement across jurisdictions, and supports opportunities for local non-governmental actors to enhance regional information dissemination and revision;
3. governments and non-profit organizations, together, provide the funding needed to establish key collaborations and project-based experimentation with green infrastructure technologies.

While adaptive management emerged to address ecological challenges such as the Florida Everglades, which has been, "governed by rules and procedures that are no longer fitting and appropriate to accomplish a highly complex and multi-objective mission" (Gunderson and Light, 2006, p. 329). It has sense been applied to other ecological management problems at a variety of scales, such as the Great Barrier Reef, river basin management, and international fisheries management (Schultz et al., 2015). Adaptive management – and the associated political and

819 social institutions and organizations – is now being applied to urban and regional problems that
820 involve socio-environmental systems, such as urban stormwater (Chaffin et al., 2016).
821 Green infrastructure provides opportunities for governments and non-governmental
822 actors to associate water quality goals with other public priorities, such as urban livability
823 concerns, ecosystem services, and climate change. Our findings show that for adaptive
824 governance, the focus on specific partnerships and cases of full-fledged collaboration may
825 overlook some of the ways that governments and non-governmental actors are introducing
826 flexibility and learning into existing policy requirements. As McNamara (2012) describes a
827 continuum of cooperation to collaboration, this paper provides support for looking at the diverse
828 ways that governments can support non-profits, regional organizations, and networks of actors to
829 achieve environmental goals. One of the most useful findings from our paper, in our opinion, is
830 for practitioners in both governments and non-governmental sectors to see that many cities are
831 trying to collaborate in different ways.
832 While our research focused on the perspective of governmental and agency staff, future
833 research should examine the nature of interactions between governments and non-governmental
834 organizations to better understand the conditions under which these actors either takes the lead or
835 supports the other. Additionally, our emphasis on governments reinforces the notion that policy
836 is not static but evolving in concert with internal and external pressures. Future research should
837 examine the relationship between federal and local policy initiatives to better understand how
838 local jurisdictions and policy entrepreneurs "convert" key federal policies, like the Clean Water
839 Act, into locally salient environmental programs (Hacker et al., 2015). We encourage future
840 research to focus on how governments and non-governmental actors can work together to
841 achieve urban water quality goals.

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Appendix 1.

CODE	EXAMPLE QUOTATION
STEWARDSHIP	I would say we've had a long history of this area, first of all, being very conservative and tied to the land. It's a very agricultural area, so I think that we've been very innovative in a lot of things that we've done for a long time, back when we implemented a water system, it was very early on in terms of the formation of a water company here. I think that when you look at stewardship towards our resources, there's been a long history of being good stewards of our environment.
REGULATION	For capital projects, we have a couple of different mechanisms that trigger the projects. Speaking specifically to water services projects, we have two main sources of water quality, green solutions projects. One is through our Overflow Control Program, so we are under a consent decree for combined sewer overflows where it is a 25-year consent decree.
FUTURE REGULATION	We just keep hearing how it's something that EPA is really pushing and pushing more and more, and we know that there will be a point where there is an absolute requirement. So, we are really wanting to understand [green infrastructure] more and get some demonstration projects.
COST	We're finding out that it is a fairly cost-effective measure for us. When you are looking at a lot of these projects, you're looking at we're utilizing either right of way that we already own that putting in another pipe is not always the best solution when you can think about – you can do things with green infrastructure, such the permeable pavers that enhances the community, increases the property value, and spurs redevelopment in an area.
CO-BENEFITS	Higher value to our ratepayers. We have very little space, so it's trying to get the most use of, most use of the space that we are in for multiple goals.

CLIMATE CHANGE	In the Plan Cincinnati, a lot of the impetus behind that was a lot of the climate change and the conversations back in 2007. In fact, that was listed in the document as the impetus for city council to embrace that. I think MSD, as a city department pulled into that, but I think it's a little broader for MSD because of stormwater is a natural function and the stormwater has traditionally been managed in natural systems, so, the idea of bringing back a natural management of the water, rather than an engineered tunnel with pumping systems, that there as some interest in pursuing that, and that would seem to be more economical long-term and sustainable for our community.
PUBLIC ADVOCACY	My experience has been that the public, by and large, just really likes green infrastructure. First of all, they like green space that is maintained. They like innovation. They really look at piping even though it quite often is the best solution; they look at it as though it's 19th Century kind of stuff. They really like seeing innovation, and they like to see governmental entities cooperating with one another. They particularly like seeing cost savings although that I think is elusive.
SUSTAINABILITY	I think it's a broad sustainability vision is one thing. The previous mayor and this mayor have created and embraced a sustainable DC plan that includes restoring our rivers to the fishable and swimmable conditions. And I think green infrastructure is absolutely a critical piece to achieving that goal.
LAND-USE	I think the other thing is that we have a lot of vacant properties in Cleveland, Detroit, Cincinnati, and people want these properties permanently repurposed, so, that's another motivator.

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