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Lone Wolves and Copycats: Assessing Policy and Infrastructure for Flood Hazard and Floodplain Management

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Lone Wolves and Copycats:
Assessing Policy and Infrastructure for
Flood Hazard and Floodplain Management

by

Samantha L. Hamlin

A dissertation submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy
in
Environmental Sciences and Resources

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Abstract

To mitigate flood hazard, which affects millions of people every year, increasing numbers of communities are developing green infrastructure policies to not only mitigate the hazard, but to meet other community policy objectives, as green infrastructure is often cited for the multiple benefits it confers. To support the implementation of policies that help communities meet their policy objectives, however, it is imperative to understand how policy is innovated and adopted. To do so, I applied the internal determinants and regional diffusion models, what I refer to as the lone wolf and copycat models. In policy, a lone wolf innovates a policy to meet a specific, internal objective; this objective may include economic, environmental, or social needs. A copycat evaluates the efficacy of a policy in other municipalities before adopting it for its own use. Because infrastructure is one of the primary routes of implementing flood hazard and floodplain management policies, I developed a framework that describes the relationship between these two models. In this framework, a community may rely more heavily on either gray or green infrastructure, while also being more of a lone wolf or copycat in the ways in which it adopts policy.

Based on this framework, I analyzed four Oregon communities—Eugene, Milton-Freewater, Prineville, and Sherwood—that exemplify these different infrastructure and policy approaches. From this case study analysis, I developed several propositions to explain why each community pursued certain policies. I then expanded this research to floodplain administrators across the state, using a key informant questionnaire to capture the managerial and demographic characteristics that correlate with the adoption of green infrastructure in over 100 Oregon communities. I found that urbanization strongly correlated with the use of green infrastructure, as did a floodplain administrator having

professional experience with flooding, being knowledgeable about flood mitigation infrastructure, and talking more frequently to other floodplain administrators. Finally, I use my research framework for an in-depth case study of the internal determinants model. I focus on a community in the Portland metropolitan area, Sherwood, and a program the community developed in the early 1990s to protect extensive areas of open space, greenways, and floodplains to preserve a unique community identity. In pursuing these objectives, Sherwood spearheaded the creation of the Tualatin River National Wildlife Refuge, the first urban wildlife refuge in the country.

Dedication

Dedicated to my father, Sam Franklin Hamlin.

A promise made is a promise kept.

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First and foremost, I am grateful for the guidance and support of my advisor, Max Nielsen-Pincus. He not only provided the scholarly engagement I needed for embarking on this new journey, his encouragement, engagement, and humor helped make the trip a bit less weary. I am also indebted to the remaining members of my dissertation committee, who enthusiastically supported my interdisciplinary research in all its guises. This includes Randy Bluffstone, who graciously agreed to serve in this capacity and patiently explained some statistical analyses when my reach exceeded my grasp. This also includes Alex Sager, my resident philosopher, who introduced me to political ecology, theories of justice and value, and the moral philosophy of economic analysis.

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IGERT faculty Alan Yeakley deserves special recognition for bringing me on board the Blue-Green Cities research initiative. Through this project, I developed an interest in urban flood mitigation and green infrastructure, spent time at the University of Cambridge, worked in China studying sponge cities, and traveled to London for the first time—all in all,

a fruitful experience. He has continued to support my intellectual pursuits and is a highly-valued mentor.

I would also like to thank Fletcher Beaudoin at the Institute for Sustainable Solutions. Our work created the opportunity to expand my research into a topic that at the time, was novel for me: flooding and floodplain management. Bobby Cochran and Nicole Maness at the Willamette Partnership furthered this research, and I am indebted to Bobby who simply asked me to “say yes” to working with them.

Finally, while I dedicate this dissertation to my father, who did not live to see its completion, I would like to acknowledge mi Madre, who has supported me in more ways than one, to finish this degree.

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Dissertation Introduction

In 2007, the Great Coastal Gale landed in Oregon, Washington, and British Columbia. At 2:30 p.m. on December 1, the Nehalem River, which runs through the town of Vernonia in northwest Oregon, was running at 153 cubic feet per second. Twenty-four hours later, it was up to 1,130 cubic feet per second. Another 24 hours later, on December 3, the Nehalem River discharged at 17,600 cubic feet per second (U.S. Geological Survey Water Data Support Team 2016b). The river was in major flood stage, with its highest recorded crest, 19.10 feet (National Weather Service 2016b). It inundated the small town, flooding homes and business in up to five feet of water, engulfing vehicles, and wiping out roads and communication. The entire town was cut off until the National Guard arrived, evacuating more than 15% of residents in boats and rafts; almost a third of the town residents sought shelter with the Red Cross (Crombie 2007, December 4).

Forty miles to the southeast, Milwaukie, a suburb in southeastern Portland, was also getting hit the by Great Coastal Gale. At 4:30 p.m. on December 1, Johnson Creek, a tributary of the Willamette River that runs through heavily populated East Portland, was discharging at 111 cubic feet per second. After 24 hours, it had almost tripled, to 331 cubic feet per second. And 24 hours after that, Johnson Creek ran at 1,990 cubic feet per second (U.S. Geological Survey Water Data Support Team 2016a). Johnson Creek was also in flood stage and crested at 11.90 feet (National Weather Service 2016a). As it rose, streets flooded and several intersections were closed, “but for the most part, homeowners and businesses weren’t affected much” (Learn 2007, December 3).

What is different about these two cities, so close together and hit by the same storm, but affected so differently? Precipitation levels differed between Vernonia and Milwaukie,

but not as substantially as the impacts: approximately 6.74 inches outside of Vernonia versus 4.94 inches in the Milwaukie area (National Centers for Environmental Information 2016). Both cities are vulnerable to flooding based on the amount paid in National Flood Insurance Program (NFIP) claims (Oregon Department of Land Conservation and Development 2015). How did the same storm with similar precipitation levels in the same region slow the morning commute in one place but require a National Guard evacuation in another? One critical difference is that almost half of Vernonia, 42%, is located within the 100-year floodplain (Oregon Partnership for Disaster Resilience 2012).

Weather-related disasters have caused 90% of natural disasters in the past twenty years, and flooding was responsible for approximately half of those disasters (Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015). As the most common natural disaster in the world, flooding is also the leading cause of fatalities from natural disasters (Doocy, Daniels, Murray, and Kirsch 2013). The United Nations notes two specific factors that play a critical role in determining flood hazard: population growth and “uncontrolled building on floodplains” (p. 5; Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015). As population increases, so too does urbanization, development, and deforestation; individually each factor increases flood hazard, but taken in concert, there is a risk of catastrophic loss because of flooding (Doocy, Daniels, Murray, and Kirsch 2013). Coupled with these contributing factors is climate change. The Intergovernmental Panel on Climate Change forecasts that climate change will very likely cause an increase of heavy precipitation events and flooding in most areas of the world (Bates, Kundzewicz, Wu, and Palutikof 2008). Indeed, a global analysis of the frequency of ‘great floods’—that is, floods

with large discharges (exceeding a 100-year event) in large basins (greater than 200,000 km²) found that not only did the frequency of great floods increase substantially in the twentieth century, but climate models suggest that this trend will continue (Milly, Wetherald, Dunne, and Delworth 2002).

Gray infrastructure projects such as dams and levees have been engineered to protect against flood hazard. Graf (2001) estimated that the US has constructed more than 80,000 dams, many of them at least partially for flood control. Levees, unlike dams, which are also used for irrigation, recreation, and other activities, are constructed solely for flood control. The U.S. Army Corps of Engineers (USACE) estimates that there are approximately 30,000 miles of levees in the US; they are, on average, 55 years old (U.S. Army Corps of Engineers 2018), a legacy of the decades-long ‘levees-only’ policy of the USACE (Randolph 2018; U.S. Army Corps of Engineers 2017b).

As flood hazard increases, however, communities are looking for other solutions to mitigate flooding, including green infrastructure and ecosystem-based approaches such as wetland and floodplain protection (Kabisch, Frantzeskaki, Pauleit, Naumann, Davis, Artmann, Haase, Knapp, Korn, Stadler, Zaunberger, and Bonn 2016; Wenger 2015). Green infrastructure is a term that captures a wide range of approaches to sustainable land use and water resource management, and is often used for stormwater management and flood mitigation (Hansen and Pauleit 2014; Tzoulas, Korpela, Venn, Yli-Pelkonen, Kaźmierczak, Niemela, and James 2007). Benedict and McMahon (2006) define green infrastructure as “an interconnected network of natural areas and other spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to

people and wildlife. Used in this context, green infrastructure is the ecological framework for environmental, social, and economic health—in short, our natural life-support system.”

Green infrastructure is often implemented for the ancillary benefits it confers (Tayouga and Gagné 2016). These benefits may include air and water quality improvement, increased biodiversity, carbon sequestration, flood mitigation, and recreation (Benedict and McMahon 2006). In the case of floodplains as green infrastructure, there are numerous benefits to be realized, in addition to flood mitigation, including groundwater recharge, wildlife habitat, and aesthetic and cultural values (Brauman, Daily, Duarte, and Mooney 2007). The multiple benefits of green infrastructure, as well as cost savings over the life of the infrastructure (Talberth, Gray, Yonavjak, and Gartner 2013), are two reasons communities may choose to adopt green infrastructure.

The use of green infrastructure is a policy decision, balancing local planning objectives with regional needs and regulatory requirements. Why some communities adopt policies earlier than others has been the subject of extensive research into policy diffusion, starting with Walker’s Walker (1969) seminal article, which adapted the theory of the diffusion of innovations (Rogers 1962) to policy. Initially, the policy diffusion literature investigated how policy innovations were diffusing between communities: was it simply a function of proximity, or were there factors that predisposed a community to the adoption of innovation? Walker (1969) noted that a policy innovation was simply a policy that was new to the community adopting it, an argument that has continued throughout policy diffusion literature. Berry and Berry (1990) eventually expanded the research on policy diffusion, however, developing the regional diffusion and internal determinants models to explain the innovation and diffusion of policy adoption.

The internal determinants model describes a community that innovates a policy to meet because of internal social, political, or economic characteristics. In order to meet a policy objective, the community develops and implements a policy that meets its specific goals. The regional diffusion model describes a community that adopts a policy after observing its implementation in a neighboring community (Berry and Berry 2014). In this way, the community is able to observe the consequences of a policy to determine if it is a good fit—in other words, other communities function as “policy laboratories” (Matisoff 2008). Berry and Berry (2014) posit that this spread of policy occurs regionally—either between adjacent or proximal communities—because of similar regulatory environments and sociopolitical pressures.

This dissertation investigates the factors that drive communities to adopt green infrastructure for flood hazard and floodplain management. A research framework flows from this, in which I analyze the interaction between the internal determinants and regional diffusion models and the use of gray and green infrastructure. I argue in this dissertation that while there are extensive socioecological benefits to be provided by green infrastructure, it is often indirect factors that primarily drive its adoption. That is, while green infrastructure may be adopted to meet, for example, stormwater management requirements, the choice to do so is often driven by social and institutional factors unrelated to green infrastructure itself.

In the first chapter, I review the literature on flood hazard and floodplain management, the use of gray and green infrastructure for flood mitigation, and modes of policy adoption. I apply this research to four municipal case studies in Oregon to enhance my understanding of the different approaches communities may take for managing flood hazard and floodplains. Through the literature and the case studies, I develop several

propositions to describe the underlying rationale for infrastructure and policy adoption. These propositions are not meant to be testable hypotheses, but rather ways of framing flood hazard and floodplain management within the two dimensions of gray and green infrastructure and the internal determinants and regional diffusion models.

In Chapter Two, I report on the results of a key informant questionnaire to Oregon floodplain administrators to develop hypotheses to explain the likelihood of a municipality adopting green infrastructure. This chapter tests several different characteristics often associated with innovation adoption, including managerial, organizational, and demographic characteristics, as well as a spatial analysis to investigate the regional diffusion model.

In Chapter Three I perform an in-depth case study analysis of the policy process for a floodplain protection program that supported the creation of the first urban National Wildlife Refuge in the nation. In this chapter I examine the horizontal and vertical governance coordination, as well as the strong local leadership to maintain a distinct community identity, that made this possible.

The dissertation conclusion reviews primary findings from each chapter and how they fit together, as well as final thoughts on future directions for research on green infrastructure for flood hazard and floodplain management.

The appendices include a report that was created to summarize the data from the key informant questionnaire. To provide more context to the findings, I summarized the data based on the size of the community. The appendix also includes a copy of the survey instrument.

Chapter One: From gray copycats to green wolves: Assessing policy and infrastructure for flood hazard and floodplain management

Abstract

Flooding has affected well over two billion people. While gray infrastructure like levees and dams has traditionally been used to mitigate this hazard, many communities are looking for other approaches to augment or even replace some of these structural solutions. Propelled by the regulatory support for green infrastructure approaches for stormwater management—which incorporate vegetation into the design—some of these communities are also looking to green infrastructure for flood hazard and floodplain management. This research uses case study analysis to evaluate how these policies are evolving in place and diffusing through policy networks by applying the internal determinants and regional diffusion models. Based on these case studies, I develop several propositions as a way of focusing my findings on the community objectives and policy processes for flood hazard and floodplain management. These findings contribute to the literature on policy innovation and adoption, and further elucidate the nuances of these models in explaining flood hazard and floodplain management.

Key Words

Flooding, floodplain management, internal determinants, regional diffusion, gray infrastructure, green infrastructure

Introduction

Flooding is the most damaging natural disaster in the world today (Opperman, Galloway, Fargione, Mount, Richter, and Secchi 2009). Flooding has numerous impacts, including loss of life, property damage, and loss of livestock and crops; flood-related

malnutrition and water-borne illness are also common (Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015; Office of the Queensland Chief Scientist 2011). Extensive infrastructure damage may also result from flooding, resulting in a lack of clean drinking water and wastewater treatment, as well as limited access to electricity, communication, education, health care, and transportation (Office of the Queensland Chief Scientist 2011). Flooding caused over 170,000 deaths globally between 1975-2000 (University of Sheffield Social and Spatial Inequalities Group and Newman 2006) and 2.3 billion people were affected between 1995 and 2015 at an economic cost of over US\$650 billion (Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015). In recent research on the countries most impacted by flooding, the United States (US) ranked eighteenth, largely because of economic costs (World Resources Institute 2015); fatalities in the US are significantly fewer than in other parts of the world—approximately 100 annually (Centers for Disease Control and Prevention 2014).

There are, however, also substantial benefits from flooding. Floods increase connectivity between rivers and the land, enhancing aquatic and riparian habitats, inundating wetlands, and recharging groundwater (Opperman, Luster, McKenney, Roberts, and Meadows 2010). Numerous fish and plant species also rely on flooding for breeding, dispersal, and migration (Office of the Queensland Chief Scientist 2011; Opperman, Luster, McKenney, Roberts, and Meadows 2010; Postel and Carpenter 1997). Flooding deposits nutrient-rich soil for agricultural production as floodwaters recede (Postel and Carpenter 1997). These ecological effects from flooding may provide several ecosystem services, such as increased fish production, improved recreation areas, improved water availability, and

enhanced soil productivity (Brauman, Daily, Duarte, and Mooney 2007; Opperman, Luster, McKenney, Roberts, and Meadows 2010).

Policy to address flood hazard and floodplain management aims to balance the tension between flood disasters and beneficial floodplain management. In the United States, federal policies such as the numerous Flood Control Acts and the National Flood Insurance Act granted federal authority to the U.S. Army Corps of Engineers (USACE) to manage flood hazard and created programs like the National Flood Insurance Program (NFIP). State and local governments also have policies and programs that affect flood hazard and floodplain management policy, including land use regulations (Burby 2005; Burby, Deyle, Godschalk, and Olshansky 2000). Several states have statewide land use planning systems that address natural hazards like flooding (e.g., California, North Carolina, and Oregon; Burby 2005). Oregon, for example, has nineteen statewide planning goals with guidelines for both land use planning and areas subject to natural hazards (Oregon Department of Land Conservation and Development 2010). In addition, some metropolitan areas also have regional governments that oversee local planning and land use (Oregon Metro 2016; Regional Plan Association 2017). The Metro regional government for Oregon's Portland Metropolitan area oversees planning for a network of open space and natural areas, including floodplains, within its jurisdiction of three counties and 24 cities (Oregon Metro 1992).

Governance of flood hazard and floodplain management also contributes to decisions about the types of infrastructure communities rely on to balance the tensions between the benefits and costs of flooding. Traditionally, gray infrastructure such as weirs, dams, and levees has been used to mitigate flooding, either by retaining floodwater during periods of inundation, or to move it off the landscape as quickly as possible (Graf 2001;

Wenger 2015). For instance, St. Louis, Missouri is one of many cities that rely on an extensive levee system along the Mississippi River to control flooding, and the repair and enlargement of these levees has enabled the city to increase development along the river (Belt 1975; Pinter 2005; U.S. Army Corps of Engineers 2016). Green infrastructure is often used for stormwater management, but may also be used for flood mitigation relying on natural vegetation and soil properties to slow the entry of water into the hydrological system (Benedict and McMahon 2006). In addition to providing hydrologic benefits, green infrastructure may also provide benefits to water quality improvement, wildlife habitat, recreation, and other human values (Benedict and McMahon 2006).

This paper aims to investigate why some municipalities adopt more comprehensive green infrastructure programs and policies than others. To do so, I begin by reviewing the history of municipally-oriented flood control policy and the emergence of green infrastructure and natural area preservation as a floodplain and flood hazard management strategy and alternative to gray infrastructure, and the different models of policy adoption important to answering this question. In addition, I use several case studies from the state of Oregon, USA to illustrate different influences on green infrastructure adoption and to develop a series of propositions that help explain why some communities develop approaches to floodplain and flood hazard management that are disproportionately dependent on green infrastructure, while others continue to reinvest in grey solutions.

Flood Control Policy and Floodplain Management

Flood hazard and floodplain management in the US are regulated by several federal policies. The first federal flood control regulations were a series of Flood Control Acts that funded flood control projects in different areas of the country, as well as granted authority to

the USACE to oversee flood control projects as a federal activity (Arnold 1988). Most of these USACE flood control projects constructed gray infrastructure, such as the 3,500 miles of levees and dikes protecting cities and agriculture throughout the Mississippi River Basin (U.S. Army Corps of Engineers 2016). This authority has shaped much of the country's topography, especially in cities where flood control projects removed some of the most obvious disincentives to settling and developing floodplains.

One of the prevailing regulations for flood hazard and floodplain management is the NFIP administered by the Federal Emergency Management Agency (FEMA). The National Flood Insurance Act of 1968 created the NFIP while also encouraging state and local governments to create policy that would minimize flood damage in vulnerable areas (Office of the General Counsel 1997). FEMA crafts some of the most important policy for flood hazard and floodplain management through the NFIP. The vast majority (85%) of flood insurance in the US is underwritten by the NFIP, not private insurers (Lehmann 2018, March 18) because of the high risk. Unlike most insurance, in which risk is balanced against the premiums, flood damages are considered so variable and extreme that many private insurance companies are unwilling to underwrite policies (Burby 2001; Michel-Kerjan 2010). The NFIP covers many properties where private insurance would not be available. However, the NFIP requires that participating municipalities meet or exceed minimum standards and requirements, which primarily regulate development in defined floodplain areas (Federal Emergency Management Agency 2005). The NFIP also reflects the effects of the many Flood Control Acts by removing insurance NFIP standards and requirements from floodplains protected by levees managed by the USACE and other entities (Pinter 2005). Burby (2006) refers to the tension created by programs like the NFIP and the government's

flood control authorities as the paradoxes of government disaster policy. On the one hand, the ‘safe development paradox,’ develops from the federal government trying to make hazardous areas safer—for example, by building levees and then removing insurance requirements—but actually substantially increasing the potential for catastrophic losses and property damage should those levees fail. On the other hand, although the local residents bear the brunt of these catastrophes, local officials—incentivized by safe development—do not pay sufficient attention to policies that would limit their vulnerability creating the ‘local government paradox’ (Burby 2006). For example, despite being devastated by the Mississippi River flooding in 1993, St. Louis extensively developed previously flooded areas in the decade that followed (Pinter 2005).

Since 1978, the NFIP has received over \$67 billion in insured claims (Federal Emergency Management Agency 2018d). Although the majority of claims are from Texas and Louisiana, every state in the country has experienced flooding issues. Oregon, the study area for the case studies in this paper, has had approximately \$1 billion in NFIP claims (Federal Emergency Management Agency 2018d). Costs in addition to NFIP claims include damaged infrastructure, crop loss and decreased food production, community displacement, and health impacts (Mallakpour and Villarini 2015). Catastrophic events can increase these costs substantially: Hurricane Katrina was estimated to cost over \$140 billion (Burton and Hicks 2005) and Hurricanes Harvey and Irma each had an economic cost between \$42 and \$65 billion (Stupak 2017, October 2).

Increasingly, however, municipalities are relying on green infrastructure such as open space and floodplain protection to mitigate flooding (Brody and Highfield 2013). While open space can include any area free from development (Kline 2006), floodplains are a specific

type of open space. Floodplains are the low-lying lands adjacent to rivers and streams that are predictably inundated with flood waters of varying depths, and are an interface between terrestrial and aquatic environments (Junk and Welcomme 1990; Tockner and Stanford 2002). During periods of high precipitation and snow melt, functioning floodplains store excess water, temporarily slowing its entry into the hydrological system. After inundation periods, water is slowly released from storage, thereby reducing hazardous flooding and simultaneously recharging groundwater (Tockner and Stanford 2002). The benefits of functioning floodplains are limited or unrealized in systems that have been developed or highly modified; vegetation removal, channelization, paving, dikes, and levees alter the topography and make these areas more susceptible to hazardous flooding (Office of the Queensland Chief Scientist 2011). Although open space protection is not new to planners (Bengston, Fletcher, and Nelson 2004), specifically tailoring open space protections toward floodplain protection for flood mitigation is a relatively innovative approach to managing flood hazard. In the early 1990s policy in the US started focusing on protecting open space, greenways, and floodplains explicitly for flood mitigation (Brody and Highfield 2013). Floodplain protection as a strategy for flood hazard management recognizes the flood mitigation benefits of well-functioning floodplains, and seeks to either preserve them, or enhance them by removing structures or other limits to floodplain function. Protecting floodplains not only increases the water storage capacity of the floodplains, but also decreases the property that is vulnerable to damage (Brody and Highfield 2013), in addition to providing a variety of other social and ecological benefits.

In the US, public policy typically uses the 1% flood to demarcate the difference between a regulated and unregulated floodplain. Formerly called the 100-year flood, which

would inundate a given area known as the 100-year floodplain, this is the flood volume that has a 1% chance of occurring in a given year. The 1% flood area is commonly denoted as the special flood hazard area. Other floods volumes and areas, such as a bankfull flood or the 500-year flood may have important hydrological and ecological significance, but in the US, the special flood hazard area has particular significant to floodplain and flood hazard management in the US.

The majority of flood hazard and floodplain management policy in the US is focused on preparing for and mitigating flood damage. Recognizing that there are benefits from flooding and floodplains, though, the Clean Water Act (CWA) directly supports floodplain management for the benefits provided by functioning floodplains. The CWA regulates water pollution, including physical alterations to aquatic environments (Section 404), which is particularly salient for flood hazard and floodplain management. Jointly administered by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA), Section 404 regulates the discharge of dredge and fill material into waterways. In 1977, President Jimmy Carter cited Section 404 when he issued Executive Order 11988 that floodplains shouldn't be occupied or modified, nor should agencies, either directly or indirectly, support development in floodplains whenever there was a practicable alternative (President Jimmy Carter and U.S. Environmental Protection Agency 1977).

Ten years later, the 1987 amendments to the CWA expanded the National Pollutant Discharge Elimination System (NPDES) permitting requirements to include stormwater discharges from municipal separate storm sewer systems to control the amount of polluted stormwater entering waterways, often through combined sewer overflow systems (U.S. Environmental Protection Agency 2018b). These amendments have resulted in a strong

incentive for green infrastructure approaches to flood hazard and floodplain management because of the need to reduce stormwater pollution for NPDES permitting. Since 2007, the EPA has released a set of policy memos explicitly supporting the use of green infrastructure for NPDES permits and combined sewer overflow system management (U.S. Environmental Protection Agency 2017).

Gray and Green Infrastructure

Stormwater management and flood mitigation infrastructures are typically defined on a spectrum of gray to green infrastructure (Figure 1; modified from Davies, MacFarlane, McGloin, and Roe 2006). Gray infrastructure is used to move water off the landscape as

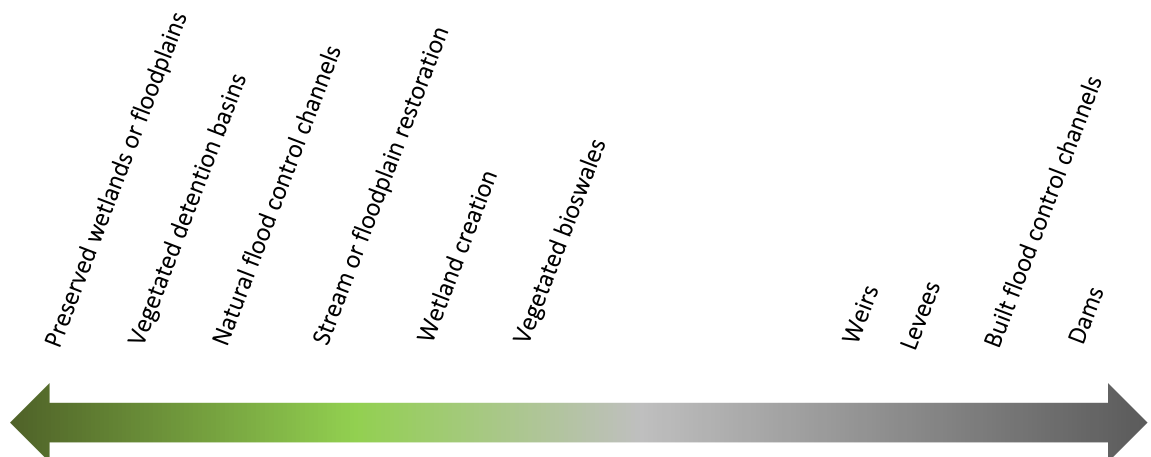


Figure 1. A spectrum of green to gray infrastructure for flood hazard and floodplain management. The green end of the spectrum includes more ecologically-based infrastructures such as preserved wetlands and floodplains, as well as stream and floodplain restoration. Vegetated bioswales, while still considered green infrastructure, are typically highly engineered and contain concrete or similar materials. The gray end of the spectrum includes weirs, which sit directly in rivers to moderate streamflow; levees, which may be earthen or concrete; and dams and other flood control structures.

quickly as possible: combined sewer overflow systems contain stormwater runoff, levees hold floodwater back during periods of inundation, and dams are frequently designed to stabilize the hydrological system against seasonal variability (Graf 2001; Holloway, Strickland

Jr, Gerrard, and Firger 2014). Even though levees often increase flow velocity, channelization, and upstream flooding, they are commonly used for flood control (Criss and Shock 2001; Heine and Pinter 2012); for example, the National Levee Database, which tracks USACE and non-USACE maintained levees, currently records almost 30,000 miles of levees in the US (U.S. Army Corps of Engineers 2018). There is a continued legacy of using gray infrastructure for flood prevention and flood control, as institutions and public perspectives toward flooding were formed when this engineered approach to controlling floods was prevalent (Lennon, Scott, and O'Neill 2014).

Another type of gray infrastructure that influences flood hazard is impervious surfaces. As population increases in an area, so does development, which increases the amount of impervious surface like roads, parking lots, and buildings. When it rains, water can no longer infiltrate the ground to be held in the soil and slowly released to streams; instead, this rain becomes stormwater runoff and either enters surface drainage systems or runs directly into streams and other waterbodies (Walsh, Roy, Feminella, Cottingham, Groffman, and Morgan II 2005). In addition, development typically requires the conversion of open space such as agricultural and forestlands, which further lessens water infiltration. This increase in surface water runoff and streamflow velocities, coupled with impeded water infiltration and storage, substantially alters hydrological systems and increases flood vulnerability and severity (Brody, Zahran, Highfield, Grover, and Vedlitz 2008).

Green infrastructure may be used to mitigate stormwater runoff or flood hazard. When used for stormwater management, green infrastructure aims to control stormwater at the source by using facilities such as vegetated bioswales and detention basins (U.S. Environmental Protection Agency 2000). Green infrastructure is most often used for

stormwater management because the biggest regulatory push has come from the EPA, which began “strongly encouraging” its use in 2007 for stormwater and nonpoint source pollution (Grumbles 2007, March 5). In keeping with its institutional mandate, the EPA now defines green infrastructure as “a comprehensive approach to water quality protection defined by a range of natural and built systems that can occur at the regional, community, and site scales” (U.S. Environmental Protection Agency 2010:2). The definition I use in this paper comes courtesy of Benedict and McMahon (2006), which incorporates different scales and functions for green infrastructure:

We define [green infrastructure] as an interconnected network of natural areas and other spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife. Used in this context, green infrastructure is the ecological framework for environmental, social, and economic health—in short, our natural life-support system (Benedict and McMahon 2006:1).

Regardless of application, the concept of green infrastructure as a nature-based solution underscores definitions of green infrastructure; the function and scale of the infrastructure often determines the definition that is used (Allen 2012; Koc, Osmond, and Peters 2017). For instance, the definition used by the EPA works well when using vegetated bioswales to manage stormwater; the EPA’s definition does not work so well when crafting policy to widen riparian buffers for downstream flood mitigation. As a nature-based solution, there are frequently ancillary benefits conferred by green infrastructure beyond their designated function, including air and water quality improvement, carbon sequestration, and habitat provisioning (Tayouga and Gagné 2016; Thorne, Lawson, Ozawa, Hamlin, and Smith 2018), as well as improved physical and mental health, enhanced community cohesion, and aesthetic values (Thorne, Lawson, Ozawa, Hamlin, and Smith 2018). The term itself continues to evolve as it is used in different applications, in different contexts, and at

different scales (Koc, Osmond, and Peters 2017; McDonald, Allen, Benedict, and O'Connor 2005; Tayouga and Gagné 2016).

Why Do Communities Adopt Green Infrastructure for Flood Hazard and Floodplain Management?

Municipalities typically have agency over stormwater management systems, as well as open space protection and development within their boundaries. Why some communities rely more of grey infrastructure while others heavily invest in green infrastructure is the primary question invoked by my dissertation. Over the last several decades the types of infrastructure and policy available to manage floodplains and flood hazard has changed dramatically. In many municipalities there is a strong historical legacy of dams, dikes, levees, weirs, and other hardened gray infrastructure used for flood control. However, recognizing the limits of gray infrastructure and potential for catastrophic failure (e.g., Hurricanes Katrina and Sandy), some municipalities have employed other solutions.

I examined policy innovation and adoption to help explain the characteristics correlating to or predicting the adoption of policy. Infrastructure may have been selected decades ago in a community, but as historical legacies age, current decision-making continues. As new policy is adopted, implementation of selected strategies for flood hazard and floodplain management begins, including (re)investing in different types of infrastructure. To understand the approaches to community floodplain and flood hazard management, I examine the factors that may influence infrastructure policy choices. With green infrastructure use increasing, some research has applied policy diffusion and adoption to green infrastructure to help understand what influences the implementation of green infrastructure for floodplain and flood hazard management. Although much research

focuses on the barriers, I highlight the characteristics that enable green infrastructure adoption.

Policy Innovation and Adoption

Policy research generally describes two models for analyzing policy innovation and adoption at the municipal level: the internal determinants model and the regional diffusion model (Berry and Berry 2014). These models are based on Rogers' seminal work, *Diffusion of Innovations* (1962), which was soon applied to policy diffusion (Walker 1969). For an innovation to be successful, community leaders and residents need to be receptive, perceiving the innovation as beneficial (Bassett and Shandas 2010). A policy innovation refers to a policy that is new to the community adopting and implementing it (Berry and Berry 2014; Damanpour 1987; Walker 1969). As Damanpour later stated, "Innovation does not occur when a new idea is generated, but rather when that new idea is put into use.... Organizations adopt innovation in order to maintain or enhance their performance. Innovations cannot influence performance until they have been actually used" (Damanpour 1987:676). Berry and Berry modified policy diffusion, creating the internal determinants model and regional diffusion model, which emphasize the dual influences of local character and nearby communities in policy adoption and diffusion (1990). The internal determinants model, or, for simplicity, the lone wolf model, describes policy innovators and frames policy innovation and adoption as a function of internal economic, political, or social factors (Berry and Berry 2014). The regional diffusion model, or copycat model, describes policy adoption as a clustered, regional phenomenon, in which innovation spreads between communities through policy networks (Bassett and Shandas 2010; Berry and Berry 2014; Walker 1969)—i.e., communities view neighboring communities "as laboratories for policy experimentation"

(Matisoff 2008:535). There are several mechanisms that facilitate regional diffusion, including learning, imitation, normative pressure, coercion, and competition. For example, regional diffusion via competition occurs when a municipality decides to adopt a policy to be more competitive with other municipalities, either by gaining an economic advantage, or by preventing other municipalities from gaining an economic advantage (Berry and Berry 2014). Policy innovation and adoption is often described with the internal determinants and regional diffusion models, but they are not mutually exclusive. Berry and Berry (2014) posit that policy adoption may be a function of both internal determinants and regional diffusion, and Newmark (2002) hypothesized that these two models exist on a continuum.

Lone Wolves and Copycats

Given that gray and green infrastructure exist on a continuum, as do the lone wolf and copycat models, I propose that they can be arrayed as orthogonal dimensions of flood hazard and floodplain management (Figure 2). I use this framework to develop propositions that help explain floodplain and flood hazard policymaking. Municipal policy processes occur in a certain place, at a certain time, for a specific purpose, and it is to be expected that while any given policy process can be arrayed on these orthogonal dimensions, a community as a whole is more complex and may not fit neatly into one of these quadrants.

A gray copycat describes a traditional approach to flood hazard management, using gray infrastructure like hardened flood control channels and levees, as the USACE built in many communities around the country. A green copycat is a case indicative of the spread of green infrastructure between communities for stormwater management, as well as flood hazard and floodplain management. A green lone wolf (hereafter referred to as a green wolf) describes innovative communities that adopt green infrastructure because they believe the

potential benefits in meeting internal planning objectives outweigh the risks. A gray wolf describes a case in which an innovative approach is being implemented to use hardened infrastructure for flood hazard and floodplain management.

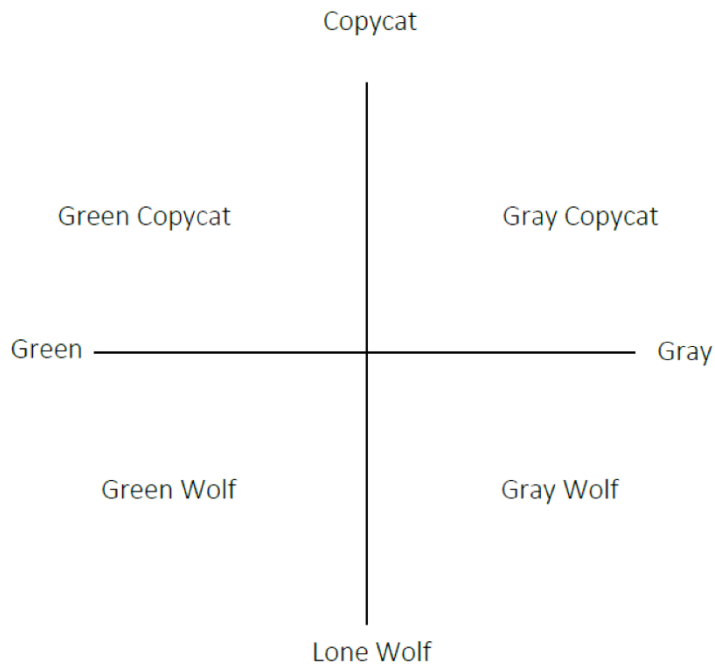


Figure 2. A conceptual framework for the interaction of gray and green infrastructure with the internal determinants (i.e., lone wolf) and regional diffusion (i.e., copycat) models. The lone wolf and copycat model are on the y-axis, and infrastructure type is on the x-axis. The interaction of these two dimensions of flood hazard and floodplain management create four archetypes: The gray copycat, green copycat, green wolf, and gray wolf. Each of these describes a different approach to flood hazard and floodplain management, based on infrastructure used and mode of policy adoption.

Researchers have attempted to determine which characteristics correlate with the adoption of innovation in a community, analyzing policies ranging from technological innovation in public libraries (Damanpour 1987) and state lottery adoption (Berry and Berry 1990) to climate change (Matisoff 2008; Sharp, Daley, and Lynch 2011) and stormwater management (Carlet 2015; White and Boswell 2007). Broadly speaking, adoption of policy innovations may be related to managerial (e.g., manager's age or professional membership), organizational (e.g., size of municipal government and its financial resources), and

demographic (e.g., city size or per capita income) characteristics. Baldrige and Burnham (1975) argued that individual characteristics are important when an individual is the innovation adopter; if an organization is the innovation adopter, however, organizational characteristics are more important. No unanimous predictor of innovative policy adoption has been identified, and some authors have failed to identify clear trends between policy types and adoption predictors. This is unsurprising, given earlier conclusions by Damanpour (1987), who clarified that when we refer to policy innovation and adoption, all innovations are not equal, nor are the processes by which innovation are adopted.

All of these characteristics—managerial, organizational, and demographic—have one commonality: they are aspatial. Diffusion of innovation theory, however, posits spatial diffusion. Walker argued that if the theory is correct, there should be regional clustering; he did find such a pattern, albeit not as neatly as expected (1969). When Berry and Berry developed their internal determinant and regional diffusion models, they hypothesized that the likelihood of the lottery policy being adopted would be positively related to the number of neighboring states who had already adopted a state lottery (1990). The authors later developed a more nuanced theory related to diffusion through space, arguing that spatial diffusion does not have to be defined solely by adjacency, but instead might be through membership in a collective region (Berry and Berry 2014). Like other factors, there have been mixed results for regional proximity and regional diffusion, but in recent research on climate change policy in cities and counties, proximity was one of the most significant drivers predicting the adoption of climate protection agreements (Yi, Feiock, and Berry 2017). There are two primary explanations for the mechanisms of regional diffusion. It may be that governments within the same region have similar economic, environmental, and

social issues, and are responding to similar demands and influences, creating the perfect ‘policy laboratory’ for observation and potential adoption (Berry and Berry 2014). Another explanation is more bottom-up: when residents or municipal leadership become aware of a new policy or program in other communities, they may begin to think of it as a legitimate state responsibility, and demand the same for their own community: “Once a program has gained the stamp of legitimacy, it has a momentum of its own” (Walker 1969:890).

Much of the research on the adoption of green infrastructure conforms to previous research on policy innovation and adoption. For example, Carlet (2015) analyzed the adoption of green stormwater infrastructure using technology acceptance theory, organizational theory, and diffusion of innovation theory. She found that a manager’s attitudes and age had a significant effect on the likelihood of adopting green infrastructure (Carlet 2015). A recent literature review identified six major socioecological factors that influence the adoption of green infrastructure: ecosystem services provisioning, education, financial incentives, planning recommendations, laws and policies, and coordination among actors (Tayouga and Gagné 2016). Coordination among actors clearly dovetails with the regional diffusion model; it is described as “knowledge diffusion among groups in a coordinated network” (Tayouga and Gagné 2016:9).

While the use of green infrastructure continues to expand, there are numerous barriers to its implementation. In a national survey by the Clean Water American Alliance, respondents identified numerous technical and physical, legal and regulatory, community and institutional, and financial barriers to the adoption of green infrastructure (Abhold, Loken, and Grumbles 2011). These barriers included restrictive definitions of green infrastructure, rigid municipal codes and ordinances, lack of funding or data on maintenance costs, and lack

of public support or private leadership (Abhold, Loken, and Grumbles 2011). Later research on urban flood hazard management in Portland, Oregon also identified a lack of political will, leadership, and vision as challenges to implementing blue-green infrastructure for practitioners (Thorne, Lawson, Ozawa, Hamlin, and Smith 2018). Brown and Farrelly (2009) also analyzed the barriers to adoption of sustainable urban water management. After reviewing 53 studies, the authors concluded that socio-institutional barriers, rather than technological barriers, are the main impediment to the adoption of sustainable urban water management systems. The barriers the authors identified included limits of regulation, insufficient resources, poor organizational commitment, path dependency, lack of political and public will, and limited community engagement (Brown and Farrelly 2009). Many of these community and socio-institutional barriers are not concrete, often involving perceptions and attitudes that can be extremely challenging to overcome (Abhold, Loken, and Grumbles 2011; Brown and Farrelly 2009; Carlet 2015).

Methods

To understand the types of infrastructure currently being used for municipal flood hazard management, how existing infrastructure was selected, and how current policy decisions were being made, I developed case studies using four Oregon municipalities. Each case study was selected based on preliminary research that indicated case study communities were good examples of innovative policy decisions about either gray or green infrastructure for floodplain and flood hazard management. To develop each case study, I visited each case study community for one to three days, interviewed and interacted with local floodplain managers, kept field notes, and augmented my observations with literature designed to elaborate on the major observations made in each case study.

I used an informal descriptive case study format to write each of the four cases (Yin 2014). The descriptive format allowed me to take propositions based on findings from the literature and illustrate the strengths and weaknesses of each proposition as observed in real examples. The four selected Oregon communities—Eugene, Milton-Freewater, Prineville, and Sherwood—were examples of different approaches to flood hazard and floodplain management, relying on gray or green infrastructure, as either lone wolves or copycats.

Before visiting each community, I contacted key informants, requested interviews, and also requested recommendations for others to interview. For each community, I completed a document review and site visit, during which I completed semi-structured interviews with one or more key informants and a tour of the community's streams and floodplains, flood and floodplain management infrastructure, and other relevant features. I interviewed 24 key informants among the four communities: one in Eugene, three in Milton-Freewater, seven in Prineville, and thirteen in Sherwood (Table 1). All but three of these interviews were recorded and transcribed; for those that were not recorded due to interviewee preference or technical difficulties, I took notes and transcribed the content of the interview within 24 hours. I used the interview notes and transcriptions, as well as document analysis, to develop a case description that provide richness to the literature-based propositions about lone wolves and copycats adopting green and grey infrastructure policy for floodplain and flood hazard management.

Table 1. The professional association of interviewees in each of the case study communities: Eugene, Milton-Freewater, Prineville, and Sherwood. Respondent numbers are included for references within the text.

Community	Professional Association	Respondent
Eugene	Consultant and retired City of Eugene	1
Milton-Freewater	Water Control District	2
	City of Milton-Freewater	3
	Watershed Council	4
Prineville	Watershed Council	5
	City of Prineville	6
	City of Prineville	7
	City of Prineville	8
	City of Prineville	9
Sherwood	Oregon Department of Fish and Wildlife	10
	Oregon Department of Transportation	11
	Metro regional government	12
	Metro regional government	13
	City of Sherwood	14
	Retired City of Sherwood	15
	Retired City of Sherwood	16
	Retired City of Tigard	17
	Friends of the Tualatin River National Wildlife Refuge	18
	Clean Water Services	19
	U.S. Fish and Wildlife Service	20
	Retired U.S. Fish and Wildlife Service	21
	Retired U.S. Fish and Wildlife Service	22
	Retired U.S. Fish and Wildlife Service	23
	Retired U.S. Fish and Wildlife Service	24

Results

Gray Wolf: Milton-Freewater

Milton-Freewater, Oregon manages flood hazard and floodplains with a strong historical legacy of gray infrastructure. A small town of 7,070 people in northeastern Oregon (Portland State University College of Urban & Public Affairs 2017), Milton-Freewater sits less than two miles from the Washington State border, and is adjacent to the Walla Walla River. In 1951 the USACE began building extensive levees along the Walla Walla River where it runs through the town: 4.2 miles of levees on the east side of the river and 5.3 miles

of levees on the west side of the river (U.S. Army Corps of Engineers 2010a; U.S. Army Corps of Engineers 2010b; U.S. Army Corps of Engineers 2010c; U.S. Army Corps of Engineers 2010d). Levees maintenance is the jurisdiction of the Milton-Freewater Water Control District, whose annual revenue wasn't sufficient to maintain, much less repair, the levees. The Water Control District estimated the need for approximately \$75,000 annually for levee maintenance and repair; however, revenues were only about \$24,000, which was primarily used for vegetation removal per USACE requirements (Respondent 2). The Water Control District placed a bond initiative on the ballot two different times to raise money to repair the levees, but failed both times (Respondent 2). Then, in 2006, the USACE classified the levees' condition as "unacceptable," meaning they were no longer considered viable for flood control (Oregon Solutions 2009). For Milton-Freewater, an "unacceptable" rating meant that large portions of the town were no longer protected by levees, and without protection, these portions of Milton-Freewater would, after over 50 years, be considered part of the special flood hazard zone and require flood insurance (Committee on Levees and the National Flood Insurance Program Improving Policies and Practices, Water Science and Technology Board, and Division of Earth and Life Studies 2013; Pinter 2005). The impact of the unacceptable rating would require many residents and private property owners to start purchasing flood insurance through the NFIP. Community leaders decided that the trajectory created by the degraded levee system was unacceptable and instead developed an effort to raise the money—\$4.1 million—required to repair 5.5 miles of levees as required by the USACE. A bond initiative was placed on the ballot for a third time, and with marketing support from Blue Mountain Community College, it passed:

It was just great to see a community that's been struggling to pass school bonds [pass the levee bond]. It's just a depressed community. There used to

be a lot of packing houses here, vegetable canning, fruit packing—and a lot of that industry is gone. There’s a lot of unemployment, a lot of older people that don’t want to pay new taxes. To get the community to agree to tax itself was a real challenge (Respondent 4).

Repair of the Walla Walla River levees in Milton-Freewater fulfilled FEMA’s requirements to exempt the areas protected by the levees from the special flood hazard zone. In the City News of Milton-Freewater, a quarterly newsletter for Milton-Freewater, the City Manager announced, “Yes, it’s true! We are out of the flood zone!” (Hall 2013; Oregon Solutions 2009). While the costs of levee repair were extensive, for many people the increase in annual property taxes was considerably less than a potential increase in flood insurance premiums (Respondent 4). The Water Control District considered the regulatory relief worth the expense. One interviewee commented that interacting with the USACE was preferable to interacting with FEMA: “They mapped the floodplain up on a hill. FEMA has their head where the sun don’t shine” (Respondent 2). Given the historical legacy of levees being used for flood control, continuing their use is not innovative—a small community raising over \$4 million to repair them is. The Milton-Freewater Water Control District went on to win an award for engineering excellence for their work (Anderson Perry & Associates 2016).

Gray Copycat: Eugene

After Portland, Eugene is the second largest city in Oregon, at approximately 155,000 people (U.S. Census Bureau 2016b). Located in Oregon’s Willamette Valley, the Willamette River runs through the northeastern part of the City. In the western part of Eugene, Amazon Creek drains over 21 square miles—almost half of the City’s land area (U.S. Census Bureau 2017)—eventually entering Fern Ridge Reservoir to the west of the city before draining to the Willamette through the Long Tom River. The extensive gray infrastructure built by the USACE in Eugene, Oregon describes a gray copycat that is

nonetheless moving toward green. In 1946, following years of flooding, the U.S. Army Corps of Engineers channelized and reinforced large portions of Amazon Creek, including a 1.75-mile concrete trapezoidal flood control channel (City of Eugene 2016). This approach to flood mitigation was common at the time, with the USACE engineering extensive gray infrastructure in many communities (Arnold 1988).

Over the intervening decades, the city has developed around and adjacent to Amazon Creek. In 2002, the City of Eugene and the Long Tom Watershed Council partnered with several other agencies to restore portions of Amazon Creek, including planting native vegetation, protecting the headwaters, and remeandering the stream where possible (Long Tom Watershed Council 2002; Schneider 2013). Portions of the concrete flood control channel have been cut out to create a ‘green pipe,’ a vegetated channel for water conveyance (Respondent 1). The efforts by the city were part of a larger restoration project, the West Eugene Wetlands Plan, which sought to balance wetland restoration in west Eugene with economic development (City of Eugene and Lane Council of Governments 2004). Developed by the West Eugene Wetlands Partnership (now the Rivers to Ridges Partnership), the project used land acquisition, levee setbacks, habitat restoration, community engagement, and environmental education to protect 3,000 acres of wetlands and uplands along 12,000 linear stream feet (Cooperative Conservation America 2017; Respondent 1). The complex now includes the Meadowlark Prairie, Bertelsen Nature Park, and the Tsal Luk-wah ‘River of Grass’ Wet Prairie Remnant, all of which adjoin Amazon Creek (City of Eugene 2006; City of Eugene n.d.). Initial work began in the Meadowlark Prairie with levee setbacks, which reconnect the creek to its floodplain, while still providing flood protection (City of Eugene 2006). The main driver for this project was the discovery

that some of the best remaining wet prairies in the Willamette Valley were in the heart of Eugene's industrial area and the community sought to protect these while supporting sound economic development and educational and recreational opportunities (City of Eugene and Lane Council of Governments 2004; Cooperative Conservation America 2017).

This extensive restoration highlights that a gray copycat may shift toward adopting innovative policy more indicative of a green wolf. However, even though these aspects of Eugene's green infrastructure and floodplain management policy are indicative of a green wolf, policy is substantially constrained in areas of the city that have developed along the built flood control channels. While restoration and levee setbacks were possible along undeveloped sections of Amazon Creek, "the concrete channel is the one exception to that. It's all urbanized right up to the edge of the concrete.... You're not going to remove [that development]—it'd be hundreds of houses and businesses to actually go back and bring that to a more natural system" (Respondent 1).

Green Copycat: Prineville

Prineville, Oregon sits in central Oregon's high desert with the Crooked River running directly through town. Prineville has a population of approximately 10,000 people (Portland State University College of Urban & Public Affairs 2017). In 2005, city leaders recognized that Prineville's wastewater treatment plant was had reached its design capacity and that an upgraded facility was needed (Anderson Perry & Associates 2010). At the time, the City of Prineville contracted with outside engineering firms for facility plans; it was one of these plans that focused on constructing a wastewater treatment plant (Respondent 6). As the Chief Engineer stated, the facility plan basically said, "Prineville, you're going to become a big city, and lagoons are something little cities do. You need to look at a mechanical

treatment process” (Rulseh 2018). The City supported the construction of a new mechanical wastewater treatment plant, at a cost of \$62 million, in order to meet future needs and support continued economic development. System development charges, fees used to cover the costs of capital improvements needed to support residential and commercial development, would undoubtedly increase. The mayor at the time said, “We knew our rates would skyrocket. If we had to raise our system development charge fees, we couldn’t be competitive with the rest of Central Oregon for new business and new homes” (Kent 2015). The increase in system development charges was substantial. System development charges (SDCs) for a new homes increased from \$3,800 to \$9,147; monthly sewer rates also tripled (Rulseh 2018). By 2008, in response to the increased costs, the City was considering alternatives to mechanical treatment, including constructed wetlands at a cost of approximately \$9 million, that would also create ancillary benefits such as park space, recreation, and water storage (Chaney 2010; Kent 2015). After preliminary analysis to determine the ecological and hydrological impact of building the wetlands, the project was approved, costing only \$7.7 million, which was reduced to \$4.75 million due to the City receiving several grants (Rulseh 2018). The groundbreaking ceremony celebrating the completion of the 120-acre Crooked River Wetlands Complex was Earth Day, April 22, 2016 (City of Prineville 2016). The City Engineer noted the impact on system development charges as support for the project:

We were drastically higher than any of our neighboring communities. It was tough if you wanted to come to Prineville and build a home. And imagine if you wanted to build a manufacturing facility that would have an impact on our treatment plant equivalent to 100 homes. That became a real hindrance to economic development. The City Council said, “This wastewater treatment plant is breaking our back—we can’t afford this plan” (Rulseh 2018).

While constructing wetlands for water treatment isn't new—the EPA published seventeen case studies on the subject in 1993 (U.S. Environmental Protection Agency 1993)—Prineville borrowed the idea from one community in particular, clearly illustrating the regional diffusion model. The Chief Engineer noted that in their research, they discovered a community in eastern Oregon, La Grande, that was releasing treated effluent into a wetland managed for wildlife by the Oregon Department of Fish and Wildlife (Oregon Department of Fish and Wildlife 2008; Rulseh 2018). This solution addressed the water treatment needs of the community while revitalizing an important wetland (Oregon Department of Fish and Wildlife 2008). “The wetland was starved for water, and [La Grande] essentially negotiated a contract to provide its effluent to the wetland. We investigated that and started doing due diligence to determine if we could construct our own wetlands” (Rulseh 2018). The choice to construct wetlands adjacent to the Crooked River to meet the Prineville's regulatory and economic objectives, as well as environmental goals, illustrates a community that looked to its neighbors, such as La Grande, Oregon, to find a successful policy that could be used for its own objectives and available resources. Regional diffusion in this case was spurred by the need to regain competitive standing in the economically growing region of central Oregon.

Green Wolf: Sherwood

In 1990, the Sherwood, Oregon was home to approximately 3,100 people on the southwestern outskirts of the Portland Metropolitan Area. Since then, the population has increased to 19,350 in 2017 – a 500% growth rate (Portland State University College of Urban & Public Affairs 2017). The Tualatin River, a tributary of the Willamette River in northwestern Oregon, runs directly north of town, and two tributaries of the Tualatin River,

Cedar and Rock Creeks, run directly through Sherwood. In anticipation of increasing population growth impacts, community leaders in the early 1990s started to address the impacts of growth in their municipal planning. To protect the many natural features of the community, the city of Sherwood codified planning objectives that included goals to “achieve the maximum preservation of natural features” and to “minimize the adverse effects of human activity on the natural environment” (City of Sherwood 1991a). The city identified 476 acres as open space (19% of the city); 424 of those acres were designated as wetlands, floodplains, and other significant natural areas (City of Sherwood 1994). To preserve these areas, the city began a project to acquire and protect floodplains using three different economic and regulatory incentives: outright purchase, density transfer, and SDC credits. Within a five-year period, ~335 acres of floodplain had been protected, laying the groundwork for the federal creation of the Tualatin River National Wildlife Refuge (Respondent 15). Sherwood was one of the initial sponsors of the creation of the refuge, and a Sherwood couple donated 12 acres of land to demonstrate local commitment to Congress (Respondent 15). Initial plans for the refuge ended at the city’s edge; however, because the city had focused its efforts on protecting the floodplains of a tributary of the Tualatin River, the U.S. Fish and Wildlife Service was ultimately persuaded to extend the boundary of a newly designated National Wildlife Refuge to include the municipal floodplain, making it part of the 1,238-ha refuge (Respondents 15, 21, and 22).

Sherwood sought to protect community identity by protecting its natural amenities. Engaged city staff and citizens wanted to maintain a community identity that was separate from Portland and other neighboring cities (Respondents 15, 21, 23, and 24):

[A community leader] was heavily involved...in trying to preserve wetlands, floodplains, other natural areas. Then there were other people in the

community who were also interested in natural areas, and people who were trying to differentiate Sherwood as a community from the whole rest of the metropolitan area, instead of just making it another neighborhood or nameless suburb.... One of the ways they wanted to do it was providing a green buffer between Sherwood and the rest of the metro area (Respondent 24).

The City of Sherwood considered the creation of the Refuge an excellent solution to protecting open space and floodplains, and preserve a unique community identity in perpetuity (Respondents 1 and 9). Doing so required engagement between the Sherwood municipal government, especially the Planning Department, as well as local farmers, and the USFWS. Local farmers owned much of the land that the USFWS would be approaching to purchase for the Refuge. Land acquisition for the Refuge required landowner buy in (Respondent 11). There was initially some trepidation on the part of farmers about dealing with USFWS; these concerns were largely put to rest, however, when a member of a prominent farming family returned from Idaho to talk to local farmers about his personal experience with the USFWS:

Unbeknownst to [the USFWS] was [he] had some interactions with the Fish and Wildlife Service quite a few years before on a small hydroelectric project in Idaho. There were several agencies involved, [including] the Federal Energy Regulatory Commission, there was the State of Idaho Fish and Game..., the Fish and Wildlife Service, and there were some others. He was pretty unhappy with most of the agencies—[he] felt they were jerking him around, except for the Fish and Wildlife Service.... He felt they treated him fairly.... When he came to the meeting [about the creation of the Refuge], [he] stood up and said in front of all the other farmers there, he says, “I had this experience with the Fish and Wildlife Service in Idaho. They’ll treat you fairly, they’re not going to jerk you around, they’re not going to speak with forked tongues, you can trust them, don’t worry about it.” Any opposition or skepticism that was on the part of the [agricultural] community dissipated because of [him] (Respondent 11)

Sherwood protected greenways, open space, and floodplains in order to preserve a unique community identity. This focus on community identity not only shaped local

planning and management, but also helped shape federal policy in the creation of the Tualatin River National Wildlife Refuge and exemplifies the importance of internal social motivations in the guidance of a green wolf.

Discussion

The four Oregon case studies—Eugene, Milton-Freewater, Prineville, and Sherwood—represent four different policy processes for flood hazard and floodplain management. There is a wide range of gray and green infrastructure being used in each community, either the result of contemporary policy decisions (e.g., the West Eugene Wetlands Plan) or the historical legacy of USACE-designed gray infrastructure (e.g., the levees in Milton-Freewater). These case studies were developed based on two primary themes from the literature: the use of gray and green infrastructure for stormwater and flood hazard and floodplain management, and the internal determinants and regional diffusion models for policy adoption.

From the four case studies I developed five propositions to discuss my findings. These propositions were developed as a way of focusing my findings on the community objectives and policy processes for flood hazard and floodplain management. The thread connecting these propositions is goal of flood hazard and floodplain management. Each community demonstrated varied reasons for selecting their approach towards that goal and the intent of the propositions is to make sense of that variability.

Proposition 1: A historical legacy can constrain future policy decisions.

Past policy decisions can set a community on a path that may be extremely difficult to change. Path dependence—i.e., “What happened at an earlier point in time will affect the possible outcomes of a sequence of events occurring at a later point in time” (Selbmann

2015:2)—can be seen in each community in this analysis. Sherwood’s policy decisions helped create a national wildlife refuge within its city limits. Prineville has foregone the construction of a wastewater treatment plant and has instead created extensive treatment wetlands. Built flood control channels in Eugene continue to be maintained to protect the extensive urban development that relies on this protection. The construction of levees for flood control in Milton-Freewater in the 1950s continues to steer current flood control policies.

Milton-Freewater, in particular, exemplifies a more focused definition of path dependency: “Structures, which emerged in a curious historical initial configuration, subsequently tend to reproduce themselves” (Selbmann 2015:2). Starting in the 1860s, the USACE had a ‘levees only’ policy for flood control that lasted for several decades (U.S. Army Corps of Engineers 2017b). Even after the policy itself was abandoned, thousands of miles of levees continued to be constructed, often in concert with flood diversion channels and spillways (Maass 1951; Randolph 2018). The passage of the 1936 FCA, granting authority to the USACE to manage and engineer federal flood control projects, coupled with the 1944 FCA, which authorized a multipurpose approach to water management, “put the Corps firmly into the reservoir construction business” (U.S. Army Corps of Engineers 2017c). Following World War II, the construction of multipurpose projects by USACE, which typically included hydropower dams, levees, and flood control channels, expanded considerably (U.S. Army Corps of Engineers 2017c). The National Flood Insurance Act of 1968 was designed to address the ramifications of these policies, which created a culture and a policy landscape in which it was considered safe to develop and live in floodplains protected by this flood control infrastructure (King 2012). Communities continued to grow and develop, often extensively in the floodplain, around, and up to, levees and flood control

channels. The passage of the National Flood Control Act, and the NFIP provision that areas behind levees are not in the regulatory floodplain, have created a strong historical legacy and path dependency in flood hazard and floodplain management: Decisions made decades ago continue to steer current and future decisions, as seen in the case studies of Milton-Freewater and Eugene.

Proposition 2: Communities can circumvent the historical legacy of past decisions and adapt to a more green infrastructure approach.

The historical legacy of some infrastructures has been documented to create a path dependency in a community (Park, Seager, Rao, Convertino, and Linkov 2013).

Communities with gray infrastructure designed and constructed decades ago have evolved with the legacy of the goal to control flooding and keep people and property safe so that development could continue. Many communities with this historical legacy of gray infrastructure have developed around it, making it extremely difficult to try to use natural approaches like green infrastructure for floodplain management (Park, Seager, Rao, Convertino, and Linkov 2013).

The City of Eugene demonstrates, however, that even within the confines of hardened infrastructure, policy can be used to increase ecological connectivity, restore habitat, provide environmental education, and improve recreational opportunities (Cooperative Conservation America 2017). When wetlands were identified in the City's industrial area they were considered problematic, as they have a propensity to flood and need to be filled if the area is going to be developed (City of Eugene and Lane Council of Governments 2004). This perception was not unique to Eugene, as wetlands are frequently filled to make way for development or agricultural production (Zedler and Kercher 2005). The West Eugene Wetlands Plan, however, documents a shift in how wetlands were

perceived in the City. After extensive research and wetland inventories, the City determined that not all wetlands are created equal. Some were fully-functioning wetlands and wet prairie grasslands, while other wetland areas were lacking the biota and abiotic characteristics needed for full functioning. Characterizing wetlands in terms of function allowed the City to determine their suitability for economic development or other community objectives. Low-functioning wetlands were deemed appropriate for continued economic development that wouldn't substantially impact wetlands habitat and connectivity. Fully-functioning wetlands were considered more suited for preservation to fulfill other planning goals such as stormwater runoff treatment and water quality improvement, flood mitigation, and recreational opportunities, as well as habitat and biodiversity protection (City of Eugene and Lane Council of Governments 2004). Shifting the focus from wetlands as a land use problem to be overcome for economic development to a feature with amenity value helped Eugene circumvent the historical legacy of gray infrastructure within the community.

Proposition 3: Meeting regulatory requirements and improving economic competitiveness can complement floodplain protection.

There has often been a tension between environmental protection and economic development (Arrow, Bolin, Costanza, Dasgupta, Folke, Holling, Jansson, Simon, Mäler, Perrings, and Pimentel 1995). Increasingly, however, particularly with the advent of environmental economics, this tension has been called into question (Carson 2010). Berry and Berry (2014) posit that competition is one of the routes fostering regional diffusion. When the policies in question are both environmental (water quality regulation) and economic (system development charges and municipal competition), there is the potential for economic goals to foster environmental improvement. The case of Prineville illustrates this complementary relationship. By leveraging the cost-effectiveness of constructed

wetlands versus constructing a new wastewater treatment plant, the community was able to improve water quality and its ability to compete with neighboring communities, while providing recreational opportunities and environmental education.

An earlier, notable example is the protection of the Catskill and Delaware Watersheds for source drinking water protection for New York City. The Safe Drinking Water Act of 1974 requires public water systems to protect drinking water and drinking water sources. There are numerous provisions in the Act, including actions related to minimizing contaminants, as well as cost-benefit analyses of drinking water standards (U.S. Environmental Protection Agency 2016). To meet these regulatory requirements, a memorandum of agreement was negotiated in 1997 between New York City, rural upland communities, New York State, environmental groups, and the Environmental Protection Agency. This agreement created an exemption from having to build a water filtration plant to meet the requirements of the Safe Drinking Water Act in exchange for protecting water quality through watershed protection. The economic benefit was clear: land acquisition for watershed protection was estimated to cost approximately \$500 million, as opposed to the estimated \$3-8 billion (plus annual operating costs) for a water filtration plant (Mehaffey, Nash, Wade, Ebert, Jones, and Rager 2005). Since then, New York has spent more than \$1.6 billion to maintain the necessary watershed protection, rather than build a water filtration plant, now estimated to cost more than \$10 billion, in addition to over \$100 million in annual operating costs (Hu 2018). The Commissioner of New York City's Department of Environmental Protection noted that building such a filtration plant would be "the largest capital project that the city has ever taken on," and water bills would increase significantly to cover the costs (Hu 2018), concerns Prineville later echoed. Similarly, New York City

recognizes the additional benefits this program confers, including flood mitigation and carbon footprint reduction (Lloyd and Licata 2015). New York City now considers their source watershed protection program one piece of a green infrastructure approach to make New York City “the most resilient, equitable, and sustainable city in the world” (New York City 2018).

These communities adopted programs to not only meet Clean Water Act and Safe Drinking Water Act regulatory requirements for water quality, but to do so in a way that was less costly and accrued additional benefits, such as recreation and education in Prineville, or flood mitigation and greenhouse gas reduction in New York. Programs that protect riparian areas, floodplains, and watersheds were largely adopted because of the economic benefits and avoided costs they provided, demonstrating how environmental and economic goals can be complementary rather than oppositional.

Proposition 4: Innovative green infrastructure policy is likely to involve social rationale like community identity in addition to basic stormwater management or floodplain management objectives.

The literature on the use of green infrastructure has emphasized that the barriers to its adoption are not technical, but rather social, political, and institutional in nature (Abhold, Loken, and Grumbles 2011; Brown and Farrelly 2009; Brown 2005; O'Donnell, Lamond, and Thorne 2017). Correspondingly, I propose that social considerations, such as maintaining community identity or preserving natural heritage values, are the linchpin for generating support for the use of green infrastructure.

The connection between community identity and the perception and value of greenspace and other environmental amenities within a community is well documented. Arnberger and Eder (2012) found a significant effect between greenspace and community

attachment. Research in Texas found that community identity is a significant component of quality of life, and greenway trails were one of the major contributors to pride in the community and community identity (Shafer, Lee, and Turner 2000). Swanwick (2009) discussed the positive relationship between sustainable land management and community identity. A review of the connections between green infrastructure, ecosystem health, and human health identified four aspects of public health: socio-economic, community, physical, and psychological (Tzoulas, Korpela, Venn, Yli-Pelkonen, Kaźmierczak, Niemela, and James 2007). In addition to defining terms, this review created a conceptual framework of the interactions between these three aspects of socioecological systems. Green infrastructure was specifically defined to include many functional types of infrastructure at multiple scales, which included green corridors; open, standing water; and running water. Of the four aspects of human health, the importance of community identity in community health was highlighted as a significant contributor to individual well-being (Tzoulas, Korpela, Venn, Yli-Pelkonen, Kaźmierczak, Niemela, and James 2007). In a later review of human interactions with urban outdoor environments, the authors found extensive support for a positive relationship between the physical environment and community attachment, and that the enhancement of urban greenways may not only enhance recreational opportunities, but aesthetic values and community identity, as well (Matsuoka and Kaplan 2008). The common thread between these studies is the directionality: environmental amenities, greenspace, or green infrastructure positively shape community identity. Research by Stewart, Liebert, and Larkin (2004) confirmed those findings of a connection between the environmental landscape and community identity, but also concluded that community identity has the potential to shape the environmental landscape, or a vision for landscape change.

My research expands on this work, illustrating the vital role that social rationales can play in shaping the physical landscape. Sherwood, Oregon illustrates the critical role that a seemingly tangential objective like a desire to maintain a distinct community identity can play in policy processes for flood hazard and floodplain management. Eugene also illustrates the importance of social rationale in determining water resource management objectives. Even within the literal confines of the historical legacy of a concrete flood control channel, the desire to balance economic development with improved environmental protection and community livability led to an innovative project like the West Eugene Wetlands Plan and restoration of sections of the heavily channelized Amazon Creek.

Proposition 5: A community can be a lone wolf and a copycat within the same policy process.

Damanpour (1987) argued that “failure to distinguish between various types of innovations [and] failure to consider adoption of innovations as a multistage process with multiple outcomes” (p. 675) were two of the main reasons for instability in research on the theory of policy innovation. In other words, while my research ostensibly focused on one policy arena—flood hazard and floodplain management—there may be distinctions within the flood hazard and floodplain management policy process that are representative of both a lone wolf and a copycat.

Portland, Oregon exemplifies a city that innovated a green infrastructure policy while simultaneously engineering gray stormwater management infrastructure indicative of a copycat. In 1994, Portland signed an Amended Stipulation and Final Order to decrease the frequency of combined sewer overflow (CSO) events into the Willamette River, the number of which were in violation of the 1987 nonpoint source pollution amendments to the CWA (Oregon Department of Environmental Quality 2010). This ‘Big Pipe’ project, as it was

called, built two pipes, one on either side of the Willamette River, to direct all but the largest CSOs to wastewater treatment plants. Each pipe is several miles long and 14-22 feet in diameter, and additional treatment facilities and pump stations were built to accommodate the increased load. While construction on the Big Pipe was being completed, the City adopted the Cornerstone Projects, the first in their green infrastructure program, to retain stormwater at the source, thereby reducing the amount of stormwater in the combined sewer system (Oregon Department of Environmental Quality 2010). In 2007 Portland expanded its green infrastructure use with its 'Green Streets' program, which promoted and mandated the use of on-site stormwater management facilities in public and private development (City of Portland Bureau of Environmental Services 2018). With capital assets valued at over \$400 million (City of Portland 2015), the City now "has one of the most mature and comprehensive green infrastructure programs in the country" (U.S. Environmental Protection Agency 2010:53). This program includes site-specific green infrastructure (e.g. bioswales and downspout disconnection) as well as a willing seller program that has acquired over 250 acres of the Johnson Creek floodplain (Johnson Creek Watershed Council 2012).

Each community in this research also demonstrate multiple outcomes in their flood hazard and floodplain management policy. While Prineville constructed wetlands, it is also heavily reliant on the upstream Ochoco and Bowman Dams for flood control. Similarly, while Sherwood has protected floodplains within the city, they are also somewhat reliant on the Scoggins Dam upstream of the Tualatin River, which substantially reduces flood stage along the Tualatin River (Linenberger 2000). Milton-Freewater relies extensively on levees for flood control and on its own initiative to leverage multiple funding opportunities for reinvestment in its gray infrastructure. While areas of Amazon Creek in Eugene are

constrained by a built flood control channel, Eugene has introduced green infrastructure design into planning for economic development and habitat protection. In other words, a community may be both a lone wolf and a copycat within their flood hazard and floodplain management policy.

I also discovered that it was not only lone wolf communities that had lone wolves. Each community—regardless of how I initially categorized it—had its own lone wolf, a champion for its floodplain and flood hazard management strategies. Sherwood had a lone wolf that launched a floodplain protection program and collaborative effort to create the Tualatin River National Wildlife Refuge. Prineville and Eugene each had local municipal employees that spearheaded, respectively, the construction of wastewater treatment wetlands or wet prairie and wetland protection. Milton-Freewater had a local volunteer that directed the maintenance of their flood control levees—and focused the community on reinvesting and pursuing a continued relationship with the USACE instead of FEMA.

While different community types and policy processes were evaluated to develop the propositions, there are limitations to the conclusions that can be drawn from this research. One of the primary limitations of this research—and the reason why I frame my interpretation as propositions rather than hypotheses—is not only the limited number of case studies used to develop this research, but the limited number of interviews in each case study. While there were thirteen interviews for Sherwood, there was only one for Eugene. Further, because of my research question, I focused on practitioners for my interviews, but this overlooks the role that local residents and citizen groups may play in the policy process.

Conclusion

I presented five propositions to explain many of the different reasons that local policy processes for flood hazard and floodplain management may vary. First, as was seen in each community, a historical legacy can create a path dependency that constrains future policy decisions. However, communities can circumvent this historical legacy, potentially integrating green infrastructure into the policy process, while still maintaining necessary built infrastructure to protect people and property that rely on it. A community can also circumvent the policy dichotomy of economic development versus environmental protection and improvement, fulfilling both objectives simultaneously with the same project. Developing innovative green infrastructure policy is, however, likely to involve a social rationale, in addition to regulatory or economic reasons for stormwater and floodplain management. Finally, while a community's policy process can be described with the research framework I've developed, policy development and implementation are nuanced processes, and communities can exhibit both lone wolf and copycat properties within the same process. These propositions are a way of framing the character of different policy decisions. The propositions emerged out of the literature and were exhibited in each of four case studies that highlighted different examples of infrastructure use and policy adoption, what I term green and gray wolves or copycats.

I contribute to the body of literature on policy innovation and the adoption of green infrastructure, illustrating successful processes that relied on economic, environmental, and social motives for green infrastructure adoption.

Chapter Two: Green infrastructure for flood hazard and floodplain management: A survey of floodplain administrators in Oregon

Abstract

The high risk and cost of flooding has led to extensive engineering of environmental and social systems as communities attempt to reduce the impacts on those living in the floodplain while still meeting environmental and economic goals. In the United States, there is a historical legacy of using built infrastructure to meet these needs, thereby supporting development in the floodplain and dictating future policy decisions. As this legacy evolves, communities are challenged to adapt approaches that protect people and property from flood hazard while still meeting other planning objectives; green infrastructure is increasingly seen as one solution to meeting these multiple objectives. I used a key informant questionnaire of Oregon floodplain administrators to determine the factors associated with the use of green infrastructure, especially for flood hazard and floodplain management, and to the extent to which regional diffusion may be affecting the use of green infrastructure in these jurisdictions. Through regression and spatial analysis, I was able to elucidate some of these managerial and regional diffusion characteristics, such as knowledge of flood mitigation infrastructure, professional experience with flooding, and how often floodplain administrators talk to their colleagues in other communities.

Key Words

Regional diffusion, green infrastructure, policy adoption, Oregon municipalities, key informant questionnaire, spatial analysis

Introduction

Flooding is widely recognized as the most damaging natural disaster in the world (Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015; Opperman, Galloway, Fargione, Mount, Richter, and Secchi 2009). Recent research assessed the global impacts of flooding over a thirty-year period (1980-2009) and found that, on average, floods killed 17,000, injured 12,000, and affected more than 90 million people every year (Doocy, Daniels, Murray, and Kirsch 2013). Research on the economic impact of flooding over a twenty-year period (1995-2015) found that flooding cost over US\$662 billion (Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015). While countries in Asia are the most impacted by flooding, the United States ranks eighteenth in the world for the average number of people affected by flooding annually (World Resources Institute 2015).

There are two primary types of infrastructure to manage this flood hazard: gray and green. At its simplest, gray infrastructure for flood management is the hard, engineered components of a system such as built flood control channels, weirs, levees, or dams. Gray infrastructure is designed to quickly transport water off the landscape and reduce peak flows during high precipitation events (Opperman, Galloway, Fargione, Mount, Richter, and Secchi 2009). While green infrastructure may also be engineered, it typically uses vegetation, open space, and other mechanisms that mimic a more natural hydrology (Schifman, Herrmann, Shuster, Ossola, Garmestani, and Hopton 2017). Green infrastructure includes small-scale features such as vegetated bioswales for stormwater management and large-scale features such as constructed wetlands and floodplain preservation for flood mitigation

(Benedict and McMahon 2006). In addition, green infrastructure is often implemented to provide benefits beyond stormwater and flood hazard management; these include carbon sequestration, improved air and water quality, increased wildlife habitat and biodiversity, and recreation (Tzoulas, Korpela, Venn, Yli-Pelkonen, Kaźmierczak, Niemela, and James 2007).

United States' policy to address and mitigate flood hazards started in 1917 with the passage of a series of Flood Control Acts (FCA); the majority of these Acts were authorizing specific flood control projects following major flood events. The 1936 FCA was more expansive, however, and granted federal authority to the U.S. Army Corps of Engineers (USACE) for building civil engineering flood control projects such as dams and levees. While this policy largely set the course for infrastructure development used for flood mitigation, there are two other important policies: The National Flood Insurance Act of 1968, which created the National Flood Insurance Program (NFIP), and the Flood Disaster Protection Act of 1973. The latter mandated the purchase of flood insurance for properties located within the special flood hazard area (SFHA) for properties constructed or acquired with federally-backed loans (Federal Emergency Management Agency 2018c).

The NFIP is critically important for flood hazard and floodplain management in the United States because of the dependency between an individual property owner and the Federal Emergency Management Agency (FEMA). The vast majority of flood insurance is underwritten by FEMA through the NFIP, not by private insurers. Flood insurance is only available to an individual, however, if the community in which they reside is part of the NFIP, and to be a part of the NFIP, there are numerous regulatory requirements that the community must meet—building and zoning standards that not only protect property in the SFHA, but also assurance that development does not elevate flood hazard elsewhere.

In 1990, the Community Rating System (CRS) was developed and implemented by FEMA as an incentive for communities to go beyond the NFIP requirements for floodplain management. The CRS is comprised of eighteen floodplain management and public information activities that a community can elect to implement, and each action is worth a number of points. Participating communities are assigned a rank, based on the total number of CRS points awarded, ranging from Class 1 (the highest) to Class 10 (the lowest). NFIP participants in CRS-ranked communities received a discount on their flood insurance premiums as an immediate incentive for community participation. Long-term, however, the entire community benefits from decreased human casualties and property damage (Zahran, Brody, Highfield, and Vedlitz 2010). Many types of activities are eligible for CRS credit, from public information activities, to dam and levee safety programs, with many of these activities focused on nonstructural projects, such as open space preservation (i.e., guaranteeing that currently vacant floodplain parcels will be kept free from development) and the acquisition and relocation of flood-prone buildings out of the floodplain.

As the FCAs demonstrate, many regions rely on gray infrastructure to control flooding and protect people and property. Policies such as the NFIP Act were then crafted with the understanding that communities had developed, and were continuing to develop, in the floodplains. However, as flooding continues to periodically devastate communities and the importance of healthy functioning floodplains has become clearer (Kiedrzyńska, Kiedrzyński, and Zalewski 2015; Opperman, Galloway, Fargione, Mount, Richter, and Secchi 2009; Opperman, Luster, McKenney, Roberts, and Meadows 2010), agencies and communities are looking for other approaches to mitigate flood hazard. As some of the CRS-eligible activities indicate, this includes incorporating green infrastructure into

floodplain and flood hazard management. At a small scale, green infrastructure is principally used for stormwater management. At larger scales, however, green infrastructure may include open space, riparian buffers, or protected floodplain, extending its functionality to flood mitigation and floodplain management. This conception of open space as green infrastructure gained traction with Benedict and McMahon's (2006) definition of green infrastructure as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife" (p. 1). A recent review of green infrastructure typologies reflects these different types and scales of green infrastructure: Koc et al. (2017) identified four main categories of green infrastructure: tree canopy, vertical greenery systems, green roofs, and green open spaces. Amongst other land use types, greenways, vegetated wetlands, ecological buffers, and waterbodies and waterside areas were identified as green open space (Koc, Osmond, and Peters 2017).

Floodplain preservation may be identified and used as green infrastructure because of the numerous ecological and socioeconomic benefits that well-functioning floodplains provide. During periods of high precipitation and snow melt, floodplains store excess water, temporarily slowing its entry into the hydrological system. After these inundations periods, water is slowly released from storage, thereby reducing flooding and simultaneously recharging groundwater (Amoros and Bornette 2002; Brauman, Daily, Duarte, and Mooney 2007). In addition to this flood mitigation and groundwater recharge, floodplains may also improve air quality (Brauman, Daily, Duarte, and Mooney 2007) and water quality (Brauman, Daily, Duarte, and Mooney 2007; Kiedrzyńska, Kiedrzyński, and Zalewski 2015; Tockner and Stanford 2002), provide fish and wildlife habitat (Kiedrzyńska, Kiedrzyński, and

Zalewski 2015; Opperman, Luster, McKenney, Roberts, and Meadows 2010; Postel and Carpenter 1997), increase biodiversity in estuarine systems (Brauman, Daily, Duarte, and Mooney 2007; Kiedrzyńska, Kiedrzyński, and Zalewski 2015; Opperman, Luster, McKenney, Roberts, and Meadows 2010; Tockner and Stanford 2002), provide aesthetic and cultural values (Brauman, Daily, Duarte, and Mooney 2007; Kiedrzyńska, Kiedrzyński, and Zalewski 2015; Tockner and Stanford 2002), and provide areas to recreate (Kiedrzyńska, Kiedrzyński, and Zalewski 2015; Tockner and Stanford 2002). A community may also value floodplains for economic development and transportation and navigation (Jackson, Carpenter, Dahm, McKnight, Naiman, Postel, and Running 2001). How a community selects and prioritizes these values—some of which may conflict—guides the adoption of community policy and management for floodplains and flood hazard.

The efficacy of gray infrastructure for flood control and floodwater retention to protect people and property in the floodplain is often undermined by the “scale of vulnerability and the complexity of flooding causes” (Lennon, Scott, and O'Neill 2014:746). Many communities are therefore integrating flood mitigation and adaptation into their planning—what has been called “Making Room for the River”—to increase community resilience to flooding rather than attempting to prevent flooding (Cho 2011, June 7; Lennon, Scott, and O'Neill 2014; Missouri Coalition for the Environment 2015; Rijke, van Herk, Zevenbergen, and Ashley 2012). A noteworthy example of this is in The Netherlands, which relies on gray infrastructure like dikes and groynes for flood protection. The Room for the River Directive was adopted to improve flood mitigation and floodplain management by removing obstacles from the floodplain (e.g., bridge removal), relocating and setting dikes back, and increasing water storage (Rijke, van Herk, Zevenbergen, and Ashley 2012).

Another example is the willing seller program in Portland Oregon, which acquired and removed properties in the Johnson Creek floodplain to restore and remeander the creek and reconnect the floodplain (City of Portland Bureau of Environmental Services 2008). Through these projects, communities are able to realize multiple benefits from their infrastructure management.

Policy innovation and adoption research provides an excellent framework to analyze how communities choose local policies and infrastructures to use for flood hazard and floodplain management. Berry and Berry adopted Rogers' seminal work on the diffusion of innovation (1962) for policy research to examine the innovation of policy and its diffusion through policy networks (Berry and Berry 1990; Berry and Berry 2014). Within this framework, green infrastructure is considered a policy innovation because of its relative newness when compared to gray infrastructure, and because a policy innovation is understood to mean new to the community in question (Berry and Berry 2014; Lundblad 2003). Empirical research on the paths and barriers to the adoption of green infrastructure as an innovative policy is nascent, but draws heavily on earlier research into the general characteristics of innovation in government planning (Daley and Garand 2005; Damanpour 1991; Damanpour and Schneider 2009; Godwin and Schroedel 2000; Kearney, Feldman, and Scavo 2000; Matisoff 2008; Simmons and Elkins 2004). Drawing heavily on Damanpour's (1991) pioneering work on organization innovation, Kearney et al. (2000) analyze government reinvention by city managers, describing a local willingness to adopt governance innovations as a function of managerial, organizational, fiscal, and community characteristics.

Managerial characteristics such as age, total years of experience, length of tenure in the current position, the amount of formal education, political orientation, and membership in the relevant professional organization may all contribute to the probability of a community adopting an innovation (Damanpour and Schneider 2009; Kearney, Feldman, and Scavo 2000). It is not only these easily-identified managerial characteristics, however, that have predictive power in the adoption of innovations. In their research on the barriers to adopting green infrastructure, Abhold et al. (2011) found that having previous experience with green infrastructure corresponded with a more positive attitude toward its continued use. Carlet (2015) found that managers with a positive attitude toward green stormwater infrastructure may result in a greater likelihood of green stormwater infrastructure being adopted within the community, a finding in line with a broad body of literature on the relationship between attitude and behavior (Ajzen 1991; Ajzen 2002; Frambach and Schillewaert 2002).

Other factors may predict the likelihood of green infrastructure adoption, however. One of the primary organizational characteristics thought to contribute to the willingness of an organization to adopt an innovation is the size of the organization. If an organization has the capacity to invest the necessary resources and tap into the necessary technical expertise, it is more likely to adopt an innovation than a smaller organization without this capacity. A simple way of characterizing this is via the size of the municipal government workforce or the number of full-time employees in the organization (Brudney, Hebert, and Wright 1999; Damanpour and Schneider 2009; Kearney, Feldman, and Scavo 2000).

Fiscal characteristics may relate both to the local municipal government, as well as the community as a whole, which are often tightly coupled. For instance, both per capita

revenue for a community (primarily collected from property taxes, permit sales, and fees), as well as per capita income, have been found to have a positive effect on the likelihood of adopting policy innovation (Damanpour and Schneider 2009; Kearney, Feldman, and Scavo 2000; Krause 2011; Matisoff 2008). These fiscal characteristics also may have a strong correlation with other community characteristics, such as the population size of the community.

Community characteristics have been analyzed extensively as factors contributing to the adoption of innovative policy. Most significant is the size of the community, including characteristics such as population size, population growth, and degree of urbanization (e.g., metropolitan and micropolitan statistical areas) (Burby and May 1998; Damanpour and Schneider 2009; Kearney, Feldman, and Scavo 2000; Krause 2011; Shipan and Volden 2008). Previous research has also found that communities with more liberal citizens tend to be more willing to adopt innovative approaches and policies such as climate change and antismoking policies (Matisoff 2008; Shipan and Volden 2008).

In adapting Rogers' theory of the diffusion of innovation, Berry and Berry not only described the innovation of a policy, but its dissemination to other communities (1990). In Berry and Berry's adaptation framework, the internal determinants model describes policy innovators and frames policy innovation and adoption as a function of internal economic, political, or social factors (2014). In contrast, the regional diffusion model describes those who wait to adopt policy, and frames policy innovation as a clustered, regional phenomenon, in which an innovation spreads through policy networks across communities (Bassett and Shandas 2010; Berry and Berry 2014). In the regional diffusion model, "[communities] view neighboring [communities] as laboratories for policy experimentation" (Matisoff

2008:535)—that is, policy adoption occurs only after observing the effects when a neighboring community adopts the policy. Policy diffusion happens at the regional scale, spreading between communities through policy networks (Berry and Berry 2014). Berry and Berry's (2014) regional diffusion model situates communities within a policy network and describes another potential determinant of the adoption of green infrastructure in a community.

This research aims to expand on the current literature of both policy and green infrastructure adoption at the community level. Specifically, I evaluate the extent to which green infrastructure is being used in the many flood-prone municipal jurisdictions of Oregon, to elucidate my two primary research questions: What factors correlate with the use of green infrastructure, especially for flood hazard and floodplain management, and to what extent is regional diffusion affecting the use of green infrastructure in these jurisdictions? Based on previous research, I formulated three hypotheses incorporating managerial and regional diffusion characteristics that would positively influence the adoption of green infrastructure (Table 2). To test these hypotheses, I conducted a survey of floodplain managers in communities across the state of Oregon. I next describe my data collection and analytical methods before providing results and discussing the nuances the data suggest about my hypotheses.

Table 2. Hypotheses on the characteristics that may positively influence the adoption of green infrastructure adoption for flood risk and floodplain management.

Hypothesis	Variables	Citation
H1: Having more professional experience with 100-year flood events, and being more knowledgeable about the history of flooding in the community will positively correlate with the adoption of green infrastructure.	Flood experience Flood history	(Damanpour 1987; Damanpour and Schneider 2006; Damanpour and Schneider 2009; Kearney, Feldman, and Scavo 2000)
H2: Talking to other communities' floodplain administrator, and reading other communities' flood management plans, will positively correlate with the adoption of green infrastructure.	Frequency Plans	(Berry and Berry 2014; Damanpour and Schneider 2009; Walker 1969)
H3: Being more knowledgeable about flood mitigation infrastructure, and having previous experience as a floodplain administrator will positively correlate with the adoption of green infrastructure.	Infrastructure Previous FPA	(Abhold, Loken, and Grumbles 2011; Carlet 2015; Damanpour 1987; Damanpour and Schneider 2006)

Methods

Study Area

Oregon was selected as the study area because of its topography, flood history, and land use planning. Oregon's topography is heterogeneous, with coastal and inland areas, urban and rural development, and extensive forests and agricultural production, providing an opportunity to examine flood response in communities of differing contexts (Figure 3).

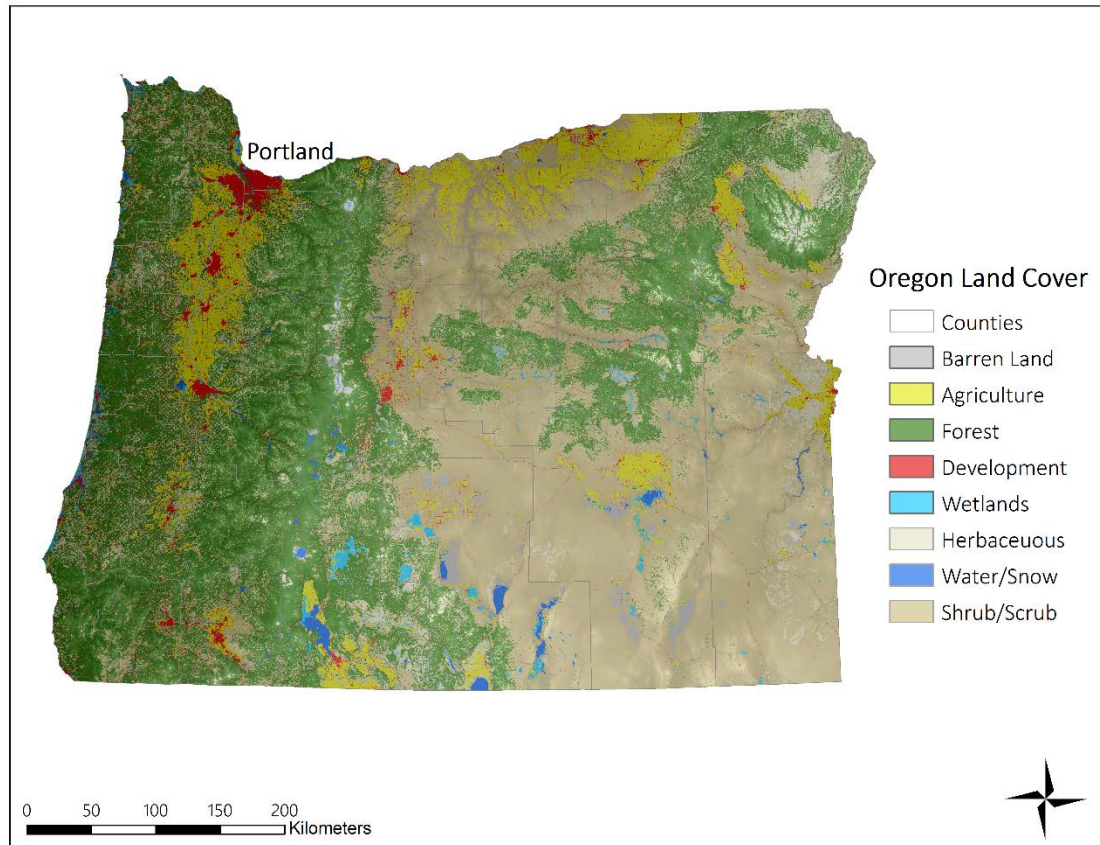


Figure 3. Oregon topography, showing the range of different land covers, including extensive forest, agriculture, and scrublands. The most heavily urbanized areas are in the western and northwestern part of the state; these areas are also heavily agricultural. The darker shades in the western part of the state indicate lower elevations compared to the higher elevations in the eastern part of the state.

Across these different landscapes, the state has a long history of flooding, with major riverine or coastal floods occurring regularly since at least the mid-1800s; the deadliest natural disaster in Oregon’s recorded history was a 1903 flood in the town of Heppner, which killed almost 250 people (National Weather Service n.d.). Since 1955, there have been 23 major flood disaster declarations, with over \$135 million in FEMA payouts since 2005 (Federal Emergency Management Agency 2018b; Oregon Department of Land Conservation and Development 2015). The last flood to affect most of the state—27 of 36 counties—was in 1996, when eight people were killed and resulting damages were estimated

at approximately \$280 million (Oregon Department of Land Conservation and Development 2015).

Oregon's land use planning history provides excellent context for examining the use of green infrastructure and open space for flood mitigation. In 1973, Oregon adopted nineteen statewide land use planning goals (Oregon Department of Land Conservation and Development 2010). Cities and counties are required to develop comprehensive plans to meet these planning goals, which include several goals salient to open space and flood hazard and floodplain management: Goal 5 for natural resources, scenic and historic areas, and open spaces; Goal 7 for areas subject to natural disaster and hazards; and Goal 17 for coastal shorelands. Amongst other objectives, Goal 5 mandates the conservation of open spaces for current and future use. This is reiterated in the natural hazards mitigation planning goal, which instructs local government to consider the benefits of preserving "natural hazard areas as open space," including measures similar to CRS activities that exceed NFIP requirements for floodplain management. These objectives are again reiterated in the coastal shorelands planning goal, which explicitly states that as part of the comprehensive planning process, floodplain management "should be expanded beyond the minimal considerations necessary to comply with the [NFIP] and the requirements of the Flood Disaster Protection Act of 1973." These objectives are again reflected in Goal 5, which mandates that "stream flow and water levels should be protected and managed at a level adequate for fish, wildlife, pollution abatement, recreation, aesthetics, and agriculture," all benefits of functioning floodplains (Brauman, Daily, Duarte, and Mooney 2007; Oregon Department of Land Conservation and Development 2010).

Survey Development and Implementation

Survey data for this research were collected through a web-based key informant questionnaire completed by designated floodplain administrators in Oregon. There are 262 communities in Oregon that are part of the NFIP: 223 cities and towns, all 36 counties, and three tribal nations. To be part of the NFIP, a community must have a designated floodplain administrator as a point of contact with FEMA; this may be a municipal government position (e.g., a planner or city recorder) or the community may use an outside contractor. Designated floodplain administrators were the key informants for this survey; because there are questions related to the diffusion of policy between communities, only administrators from the cities and towns were contacted. Recruitment of key informants occurred up to six times between July to December 2017, which included an initial email with a link to the online survey, followed by up to five phone calls, and further emails when requested.

Questions were a mix of open- and closed-ended questions, including yes/no, multiple choice, and Likert-type response questions, grouped into several sections: respondent background, community flood history, beliefs about community flood risk and floodplain policy development, an inventory of community infrastructure and policies, and beliefs and attitudes regarding infrastructure and flood hazard and floodplain management priorities.

Data and Measures

Independent variables were created from publicly-available community data such as population and demographic characteristics. I used two population variables: the 2017 population of the community and population growth between 2000 and 2017 (i.e., Population and PopGrowth) (Portland State University College of Urban & Public Affairs

2017). There were two variables capturing education attainment: the percent of the community that holds a bachelor's degree (Bachelor) and the percent of the community that hold a graduate or professional degree (GradProf). (U.S. Census Bureau 2016b). I also included three employment and economic variables: the percent of the community that work as government employees (Government), community per capita income (Income), and unemployment rate (Unemployment) (U.S. Census Bureau 2016b). The final variable was the degree of urbanization—whether the community was in a Census-designated metropolitan statistical area (greater than 50,000 people), micropolitan statistical area (greater than 10,000 people but fewer than 50,000 people), or neither (U.S. Census Bureau 2018); MMSA, the variable for statistical areas, was coded 2 for metropolitan, 1 for micropolitan, and 0 for neither.

I then performed a Poisson and Ordinary Least Squares (OLS) regression for hypothesis testing, incorporating significant variables from the logistic regression to control for response bias. The dependent variable for the Poisson and OLS regressions was created from the inventory of community infrastructure and policies section of the survey. In this section, respondents were asked a series of yes/no questions regarding the types of green infrastructure, gray infrastructure, planning and preparation activities, risk reduction activities, public awareness activities, and emergency management improvements their community has adopted. Answers were scored 0 (no) or 1 (yes). The dependent variable, green infrastructure, was a sum of the scores from ten of the inventory items specifically related to green infrastructure. Berry and Berry (2014) note that while this approach has limitations, it is appropriate if the focus of the research is specific, rather than a large-scale analysis of adopting innovative policy.

In addition to the significant variables from the logistic regression, six independent variables were created from the key informant questionnaire (Table 3). The respondents' knowledge of and experience with flooding was measured with three variables. The first was labeled Flood Experience and was measured as the number of 100-year flood events the respondent had experienced divided by their length of tenure with as the floodplain administrator. The remaining two variables for knowledge about flooding were created from two Likert-scale questions, including one on the respondent's knowledge of flooding in the community (Flood History) and another regarding flood mitigation infrastructure (Infrastructure); responses ranged from not at all knowledgeable (0) to extremely knowledgeable (4). Previous professional experience with flood hazard and floodplain management planning was measured with a yes (1) / no (0) question to determine if they had previously worked as a floodplain administrator (FPA) in other community (Previous FPA). Regional diffusion potential was measured with two questions. The first asked how often the respondent reported talking to other FPAs, ranging from more than once a week to less than once a year (Frequency). The second question asked respondents to answer yes (1) or no (1) about whether they had read other communities' flood management plans (Plans).

Table 3. Variable names and descriptions for Poisson and OLS regression analysis.

Variable name	Variable description	Source
Bachelor	Percent of population with bachelor degree	U.S. Census
Flood experience	Number of 100-year floods during respondent's tenure, divided by tenure	Survey
Flood history	How knowledgeable respondent is on flooding in their community	Survey
Frequency	How often respondent talks to other floodplain administrators	Survey
GradProf	Percent of population with graduate or professional degree	U.S. Census
Infrastructure	How knowledgeable respondent is on flood mitigation infrastructure	Survey
MMSA	Metropolitan (MMSA=2), micropolitan (MMSA=1), or neither (MMSA=0) designation	U.S. Census
Plans	Respondent has read other communities' flood management plans	Survey
Previous FPA	Respondent previously worked as a floodplain administrator	Survey
Unemployment	Unemployment rate in community	U.S. Census

Spatial Analysis

After testing whether a spatial error model was appropriate, and finding that the residuals did not exhibit spatial autocorrelation, I conducted several other spatial analyses to better understand how green infrastructure was varying through space, and what variables in the regression were correlated with the spatial patterns of use of green infrastructure. To evaluate whether a community is more likely to adopt green infrastructure if its neighbors have already adopted it, and determine if there is correlation between green infrastructure and urbanization (i.e., MMSA), I used GeoDa 1.12.1.131 to calculate Moran's I (I), local Getis-Ord (G_i^*), and bivariate Local Indicators of Spatial Association (LISA). Spatial autocorrelation tests whether a variable (e.g., green infrastructure) is correlated with itself in space—e.g., are similar values clustering together within the study area. Global spatial autocorrelation analyzes whether spatial autocorrelation exists in the study area; local spatial autocorrelation determines where within the study area spatial autocorrelation is occurring. The bivariate LISA, also known as the local Moran's I, is a local analysis of the correlation between two variables across space.

The Moran's I statistic is given as:

$$I = \frac{N \sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^n \sum_{j=1}^n w_{ij}) \sum_{i=1}^n (x_i - \bar{x})^2}$$

where N is the number of observations, \bar{x} is the mean of the variable, x_i is the variable value at a given location i, x_j is the variable value at location j, and w_{ij} is the spatial weights matrix defining the neighbor relation between points i and j. I used an inverse distance weights matrix to define the neighbor relationship (Stakhovych and Bijmolt 2009). Moran's I calculates the extent that a variable covaries across space. If x_i and x_j are on the same side of the mean, then I is positive, denoting positive spatial autocorrelation, or clustering. If x_i and x_j are each on different sides of the mean, then I is negative, denoting negative spatial autocorrelation, or dispersion. I used GeoDa to test for significance using both a z-score and a Monte Carlo simulation with 9,999 permutations. The observed pattern is compared against expected patterns under the null hypothesis that the data are randomly distributed in the study area to generate a pseudo p-value.

I used the local Getis-Ord statistic to determine where clustering occurred in the study area. Getis-Ord can determine not only clustering, but also areas of low values clustering together (cold spots) and areas of high values clustering together (hot spots). The local Getis-Ord statistic is given as:

$$G_i^* = \frac{\sum_j w_{ij} x_j}{\sum_j x_j}$$

where G_i^* is the local Getis-Ord statistic at a given location i, x_j is the variable value at location, j, and w_{ij} is the spatial weights matrix defining the neighbor relation between points

i and j (Getis and Ord 1992). Again, I used an inverse distance weights matrix to define the neighbor relationship (Stakhovych and Bijmolt 2009), and GeoDa to test for significance with a Monte Carlo simulation based on 9,999 permutations. The local Getis-Ord statistic is the ratio of a point and all its neighbor values, as defined by the weights matrix, to the sum of all values in the study area. G_i^* will be high where high values cluster and low where low values cluster.

I used bivariate LISA to evaluate potential correlation between *green infrastructure* and *MMSA*. Previous research has found innovation adoption to be more prevalent in urban areas (Damanpour and Schneider 2009; Godwin and Schroedel 2000; Hwang and Gray 1991; Shipan and Volden 2006; Walker 1969; Yi, Feiock, and Berry 2017); the bivariate LISA will allow me to see to what extent these two variables correlate across space. Bivariate LISA analyzes the correlation between one variable (e.g., adoption of green infrastructure) and the spatial lag of another variable (e.g., MMSA) in neighboring areas; the formula is given as:

$$I_i = z_i \sum_j w_{ij} z_j$$

where I_i is the local Moran's I statistic, z_i is the z-score for the first variable at location i , z_j is the z-score for the second variable at location j , and w_{ij} is the spatial weights matrix (Anselin 1995). Because the bivariate LISA is evaluating the correlation of one variable with the spatial lag of a second variable, it is always the first variable at location i and the second variable at location j . To be consistent, I again used an inverse distance weights matrix. This statistic returns four types of results: High – high, low – low, low – high, and high – low.

The first term refers to the relative value of the first variable (in this case, green infrastructure) in that location, and the second term refers to the relative value of the second

variable (i.e., MMSA) in surrounding locations. Thus, hot – hot, or hot spot, indicates a high value for green infrastructure and a high MMSA value (i.e., an urban area). Low – low, or cold spot, indicates a low green infrastructure value, and a low MMSA value. Low – high indicates a low green infrastructure value and a high MMSA value, while high – low is the reverse.

Regression Modelling

To test for response bias, I first performed a logistic regression predicting differences between respondents and non-respondents. The logistic regression tested to see if there were significant trends describing questionnaire respondent and nonrespondent communities. The dependent variable was categorical—whether or not the community’s floodplain administrator responded to the survey.

I used IBM SPSS 25 to perform both a quasi-Poisson and OLS regression for evaluating which factors correlate with the adoption of green infrastructure. Poisson regression is used when the dependent variable is count data, while OLS assumes the dependent variable is, or approximates, continuous data. The dependent variable in this analysis, green infrastructure, is a sum of the types of green infrastructure being used in a community for flood hazard and floodplain management. I used a quasi-Poisson specification due to the dependent variable being overdispersed; rather than assuming the mean and variance in the dependent variable are equal, as Poisson regression does, quasi-Poisson regression estimates the dispersion parameter from the data. The diagnostics and coefficients remain the same, but the statistical inference is adjusted for overdispersion in quasi-Poisson regression, or what some call Poisson with robust standard errors (Zeileis, Kleiber, and Jackman 2008). To control for response bias, significant variables from the

non-response logistic regression were included. I compared these results to those of an OLS regression. Since the dependent variable was bounded at zero, which is contrary to the assumptions of an OLS model, I also examined the frequency of non-zero predicted values from the OLS to determine its suitability.

Results

I identified 225 flood prone communities in Oregon based on participation in the NFPA. The questionnaire was administered to the municipal floodplain administrator for each community, and was focused on municipal flood hazard and floodplain management. Twenty-four communities were deemed ineligible because the county manages their floodplains; I was also unable to contact floodplain administrators for 43 communities either because I could not find contact information for them or because community staff could not identify their floodplain administrator. Thus, the sample included 158 administrators; 38 of these did not participate, typically stating that flooding was not an issue for their community, that they did not have the resources to complete the survey, or that they were uncomfortable participating. Thirteen completed less than 50% of the questionnaire, the a priori threshold I decided on to define incomplete and unusable responses. The final response rate was 68% and included the 107 responses that were at least 50% complete (Figure 4).

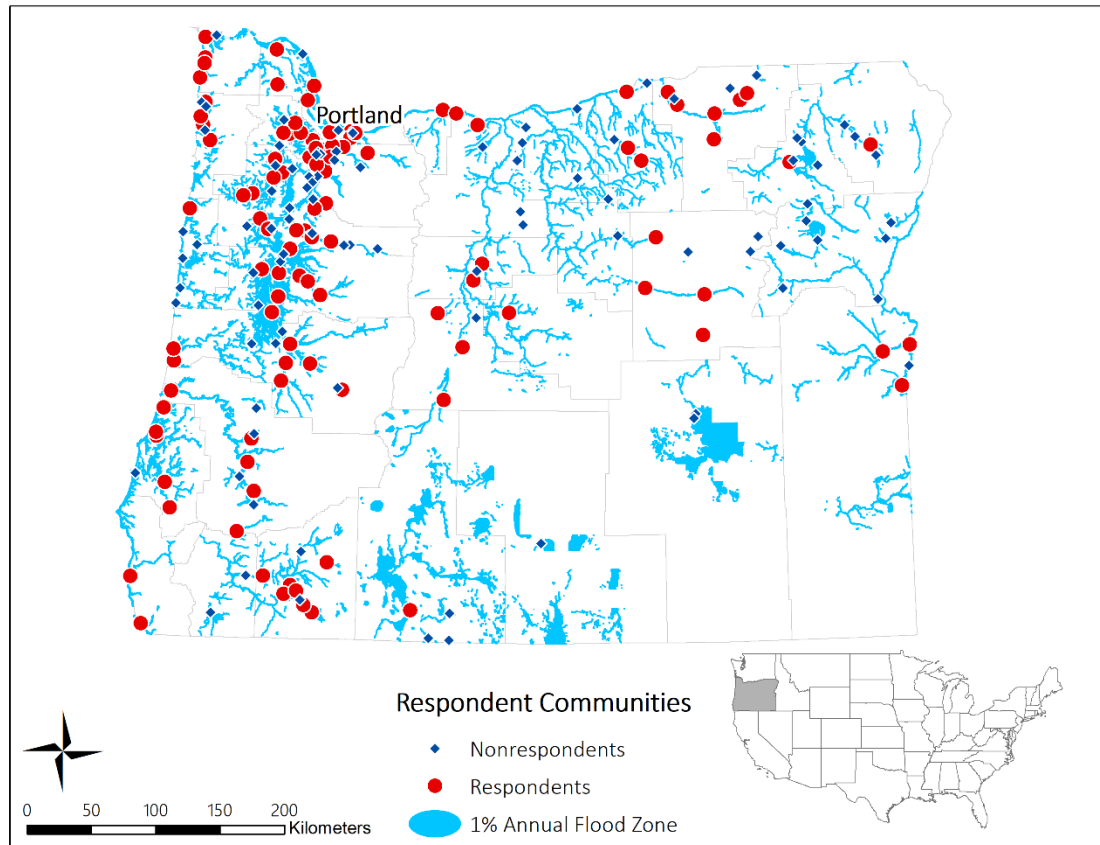


Figure 4. Flood-prone communities and the 1% annual flood zone (formerly called the 100-year floodplain) in Oregon. Survey respondents are noted with red circles, while nonrespondents are noted with dark blue diamonds.

Respondents tended to be from communities with a population greater than 2,500. Over half of the respondents were at least 50 years old (56%) and had completed at least a bachelor degree (bachelor degree = 41%, master degree = 35%). Overall, respondents reported more commonly using green infrastructure than gray infrastructure for flood hazard and floodplain management (Figure 5).

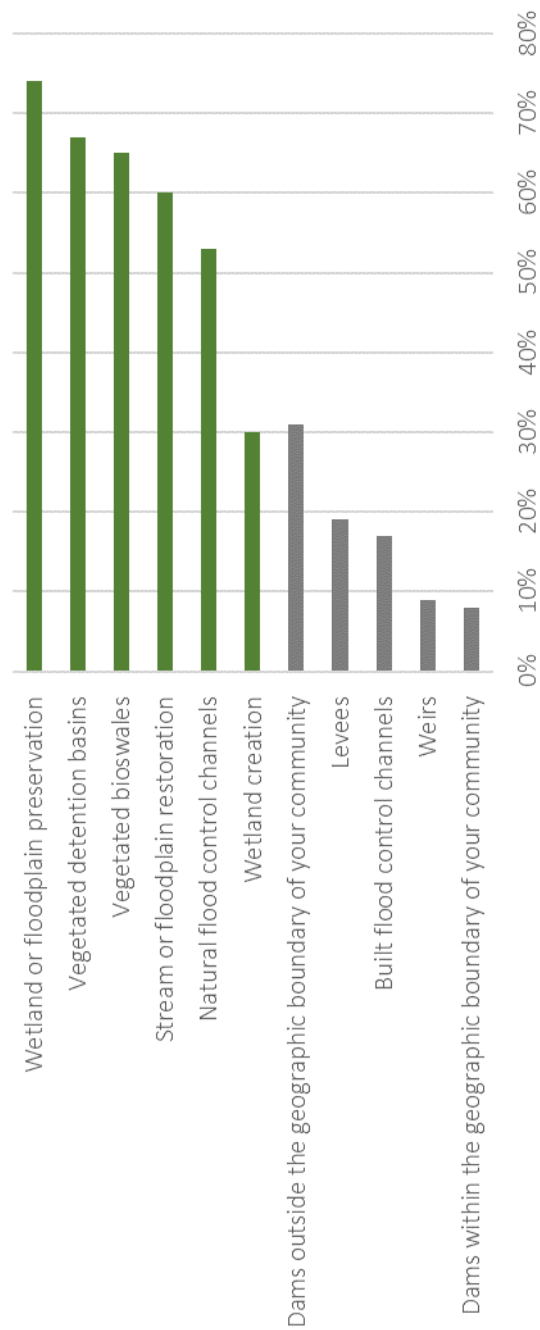


Figure 5. The types of gray and green infrastructure respondent communities are using for flood hazard and floodplain management. This includes large-scale green infrastructure such as wetland or floodplain preservation and stream or floodplain restoration as well as small-scale green infrastructure such as vegetated bioswales, in addition to large-scale gray infrastructure such as dams or levees and smaller gray infrastructures such as built flood control channels. Regardless of scale, green infrastructure was reported as being used more than gray infrastructure for flood hazard and floodplain management.

Non-Respondent Bias

To evaluate whether the final sample was biased towards certain types of communities a logistic regression was performed on whether the community floodplain administrator replied to the questionnaire or not. To evaluate potential response bias across all of the communities, I classified the 43 communities that I was unable to contact and the thirteen incomplete responses as nonrespondents, as well as the 38 nonrespondents. The result was 107 respondents and 93 nonrespondents.

There were three significant variables predicting survey response in the logistic regression ($\alpha = 0.10$): Bachelor, GradProf, and Unemployment; in addition, because MMSA was marginally significant ($p = 0.107$), I decided to control for it in the quasi-Poisson and OLS regressions to ensure that I was addressing response bias. Communities with higher percentages of the population with college degrees and higher unemployment rates were more likely to respond.

Green Infrastructure Composite Index

The dependent variable, green infrastructure, was created as a composite index from the questionnaire data. This variable was the sum of ten yes/no answers from the survey about which types of green infrastructure their community relies on, which meant that values potentially ranged between zero and ten; the mean was 3.87 (standard deviation = 2.60).

Cronbach's alpha was 0.82 for green infrastructure, which denotes good internal consistency (Table 4). Twelve communities reported using no green infrastructure (Figure 6).

Table 4. Survey inventory questions for the dependent variable Green Infrastructure, with percentage of affirmative answers and Cronbach's alpha.

Does your community rely on the following types of infrastructure, or has it undertaken any of the following activities?	Percentage of yes answers	Cronbach's alpha	n
Green Infrastructure variable		0.82	
Wetland or floodplain preservation	74%		97
Vegetated detention basins	67%		93
Vegetated bioswales	65%		97
Stream or floodplain restoration	60%		93
Natural flood control channels	53%		89
Required compensatory storage in the floodplain	33%		88
Wetland creation	30%		83
Established a stream buffer code that exceeds county requirements	28%		89
Acquired and/or relocated flood-prone buildings out of the floodplain	16%		98
Required that currently vacant floodplain parcels will be kept free from development	11%		97

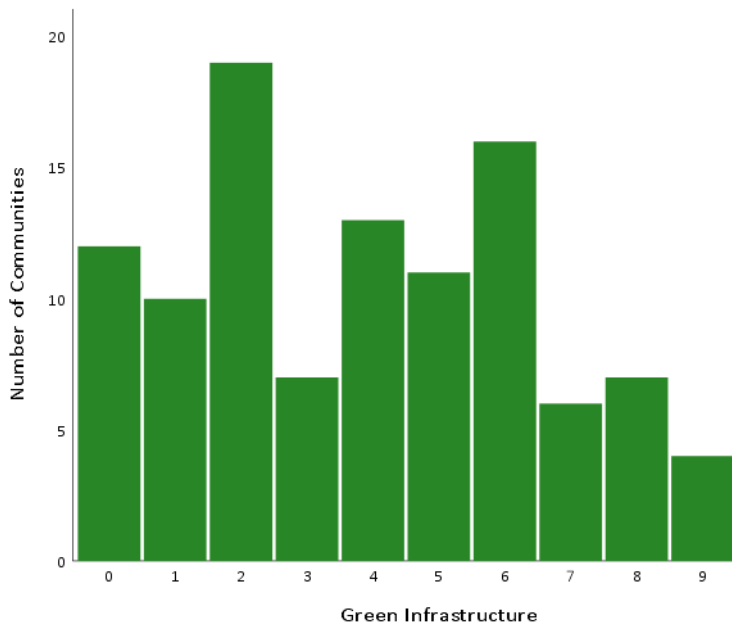


Figure 6. Histogram of the distribution of the dependent variable, *green infrastructure*. Values for this variable range from zero to nine, with approximately 10% of communities reporting that no green infrastructure was being used.

Summary Statistics

Flood experience—that is, the number of 100-year floods during the respondent’s tenure, divided by the length of their tenure, ranged between zero and two with a mean of 0.11 (Table 5). The high score of two would be indicative of a respondent who had experienced, for example, two 100-year flood events within a one-year period, or four 100-year flood events in a two-year period. The mean indicates a respondent who had experienced one 100-year flood in ten years or so. The two knowledge variables—Flood History and Infrastructure—each ranged between one and five, with five being extremely

Table 5. Summary statistics for the dependent and independent variables. The range and mean are presented for integer data, and proportions are presented for categorical data.

	Range	Mean	Proportion
Dependent variable			
Green infrastructure	0 – 9	3.87	
Independent variables			
Flood experience	0 – 2	0.11	
Flood history	1 – 5	3.71	
Frequency	0 – 5	1.83	
Infrastructure	1 – 5	2.76	
Plan			
No			76.9%
Yes			23.1%
Previous FPA			
No			76.6%
Yes			23.4%

knowledgeable. On average, people reported being relatively more knowledgeable of the history of flooding in their community (\bar{x} = 3.71, or somewhat to very knowledgeable) than of flood mitigation infrastructure their community relies on (\bar{x} = 2.76, or slightly to somewhat knowledgeable). Frequency—the frequency respondents spoke with other administrators—ranged from zero to five with a mean of 1.83, indicating that, on average, people talk to other administrators approximately once a year. The majority of respondents

do not read other communities' flood management plans (76.9%), nor have they previously worked as a floodplain administrator in another community (76.6%).

Spatial Analysis

Moran's I for the dependent variable, green infrastructure, was significant ($I = 0.25$, $z = 6.02$ pseudo p -value < 0.001), indicating significant positive spatial autocorrelation. The local Getis-Ord detected clustering throughout the study area. There were hot spots in the northwestern part of the state, primarily in the Portland metropolitan area. There were also cold spots, primarily in the eastern part of the state (Figure 7).

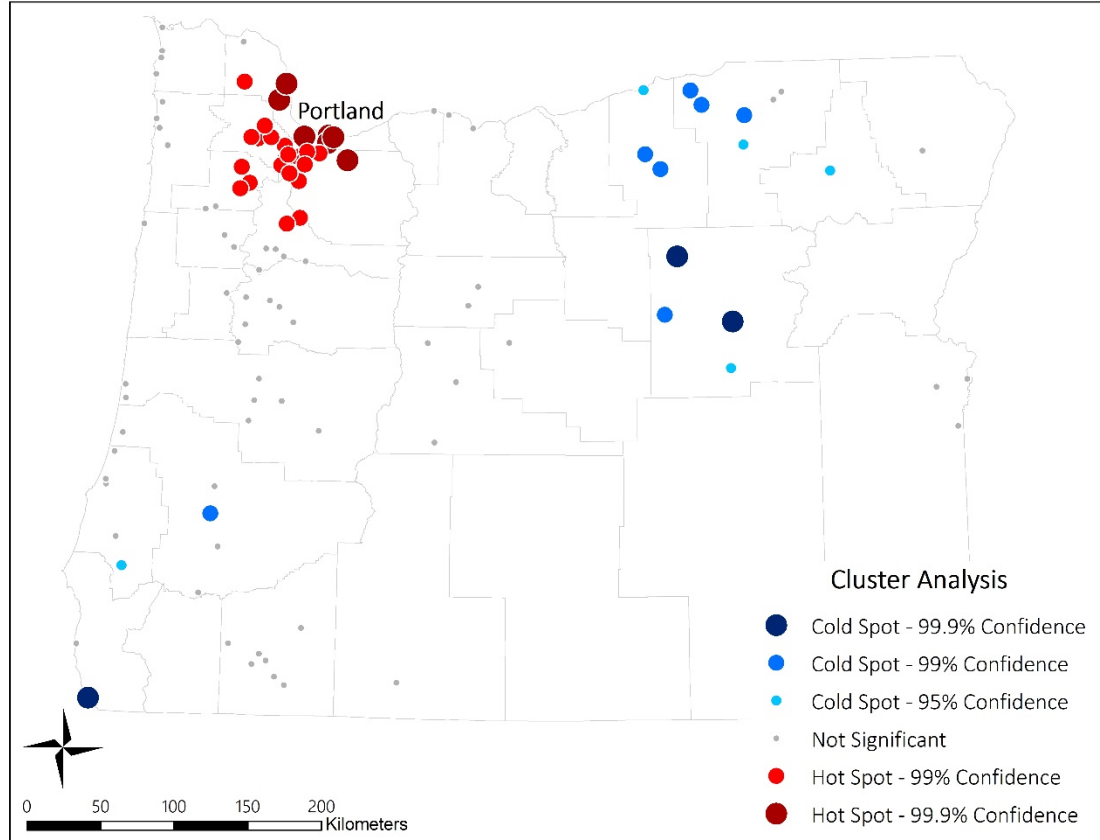


Figure 7. Local Getis-Ord spatial autocorrelation analysis. Hot spots with high values of green infrastructure adoption are found in the Portland metropolitan area. Cold spots with lower values of green infrastructure adoption are primarily in the eastern part of the state.

I used a bivariate LISA to evaluate spatial correlation between green infrastructure and MMSA. By definition, MMSA should be spatially autocorrelated, because these are areas with a high population density surrounded by closely-integrated, populous areas (U.S. Census Bureau and Federal Register 2010); this supposition was confirmed by the global Moran's I ($I = 0.61$, pseudo p-value < 0.001). While there are hot spots in northwestern Oregon, there are also numerous low – high values, that is, urban areas with low amounts of green infrastructure. Eastern Oregon, as well as the northern coast, has several low spots—low amounts of green infrastructure in rural areas. There are a few high – low spots in these areas too, indicating rural areas using more green infrastructure than neighboring communities (Figure 8).

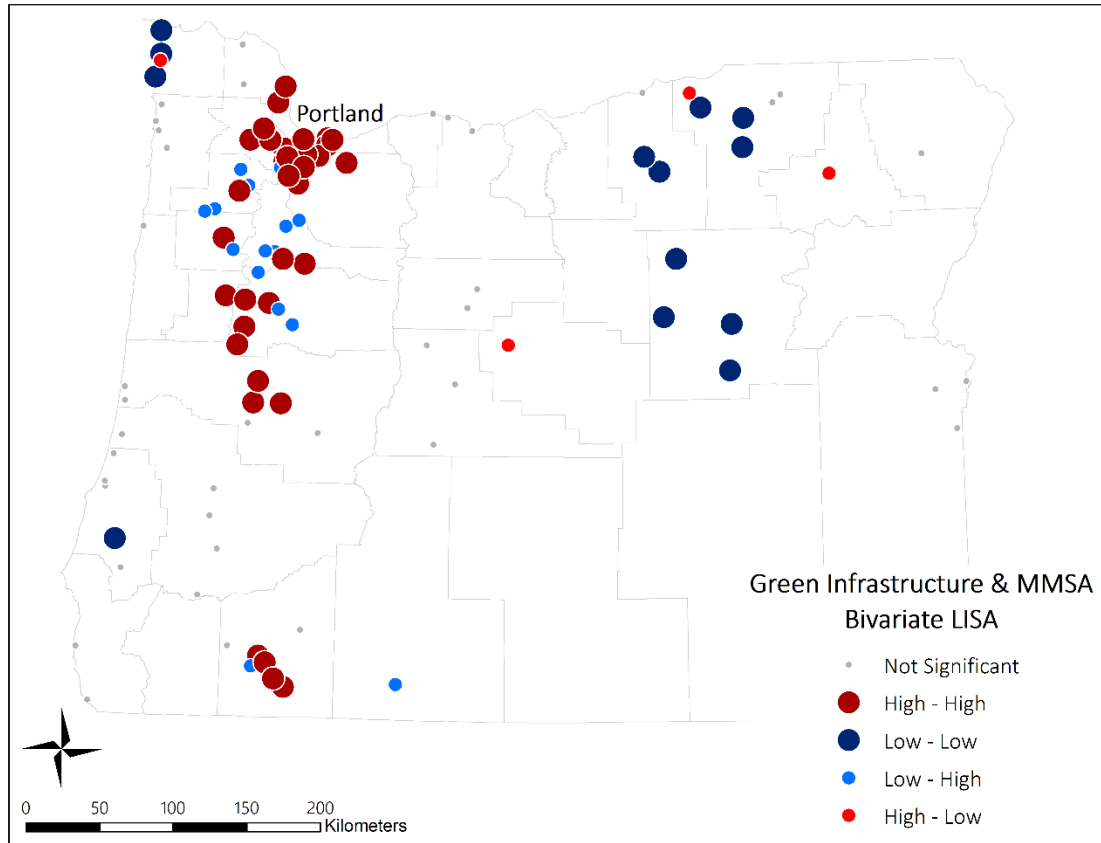


Figure 8. Bivariate Local Indicators of Spatial Association analysis of green infrastructure and MMSA. High – high values found primarily in northwestern Oregon indicate high values of green infrastructure in urban areas. The low – high values interspersed with these indicate urban areas with low amounts of green infrastructure. Low – low areas, found primarily in eastern Oregon, indicate rural areas with low values for green infrastructure, while a couple of high – low spots show rural areas with higher amounts of green infrastructure.

Regression Analysis

I first ran a quasi-Poisson regression (i.e., Poisson with robust standard errors) to account for the overdispersion in the Pearson chi-square diagnostic ($\chi^2 = 1.31$) (Table 6). Quasi-Poisson estimates a dispersion parameter used to improve coefficient standard errors and improve statistical inference. Three variables were significant ($\alpha = 0.05$): Flood Experience, Infrastructure, and MMSA. A fourth variable, Plans, was borderline significant, but did not meet the alpha cutoff value ($\alpha = 0.107$). The model was significant, with a

likelihood ratio χ^2 of approximately 71 ($p < 0.001$) and Akaike Information Criterion (AIC) of approximately 370.

Before analyzing the OLS model, I used GeoDa to analyze the regression model for spatial autocorrelation that would be better addressed with a spatial regression model. The goal was to examine whether there was spatial variation in the Poisson regression error term in order to identify potential omitted variables that may be commonly associated with communities in specific areas. This is done by using Moran's I to test for significant spatial autocorrelation in the error term; a significant Moran's I indicates that spatial regression would fit the data with less bias. Moran's I was not significant, however, so I did not use spatial regression ($I = 0.17$, $p > 0.10$).

I then completed an OLS model, and diagnostics indicated that the model was significant ($F = 5.46$, $p < 0.001$) and explained approximately 35% of the variance ($R^2 = 0.35$) (Table 6). The AIC was approximately 140. All but one of the predicted values for the OLS were positive, ranging from 0.04 to 7.60 (the exception was one value of -0.55), indicating that the OLS regression results were suitable for interpreting the data. Like the quasi-Poisson, the model included four variables to account for response bias, two variables address the regional diffusion theory, and four variables address factors other than regional diffusion that may correlate with the use of green infrastructure. Of these ten variables, the same three variables that were significant in the Quasi-Poisson regression were significant in the OLS regression: Flood Experience, Infrastructure, and MMSA. Frequency was also marginally significant ($\alpha=0.10$) with a positive coefficient. Flood experience was the number of 100-year flood events the respondent had experienced during their tenure divided by their tenure. The coefficient on Flood Experience was positive and highly significant ($p < 0.01$),

indicating that if the administrator experienced more 100-year floods during their tenure, there also tended to be more green infrastructure in that community. Knowledge of infrastructure (the infrastructure variable) was also positive and highly significant, indicating that respondents who considered themselves highly knowledgeable about flood mitigation infrastructure tended to be in communities with higher amounts of green infrastructure. Urbanization (i.e., MMSA—whether a community is in a metropolitan, micropolitan, or rural area) was also highly significant, with the largest standardized coefficient (standardized $\beta = 0.40$, $p < 0.001$). This positive coefficient indicates a correlation between increasing urbanization and an increased amount of green infrastructure being used. Two factors I hypothesized would be correlated with the use of green infrastructure in a community—knowledge of flood history in the community, and previous experience as a floodplain administrator—were not significant.

Table 6. Model coefficients and diagnostics for the Quasi-Poisson and OLS regressions. The control variables are those variables that had a significant effect in the logistic regression evaluating response bias. Hypothesized variables were created from the questionnaire to evaluate which characteristics correlate with the adoption of green infrastructure. Standardized coefficients are in parentheses.

	Quasi-Poisson model coefficients	OLS model coefficients
	Wald χ^2	B
Control variables		
Bachelor	1.70	7.57 (0.22)
GradProf	1.63	-9.40 (-0.22)
MMSA	32.02***	1.56 (0.40)***
Unemployment	0.53	12.30 (0.10)
Hypothesized variables		
Flood experience	16.64***	2.60 (0.28)**
Flood history	0.55	-0.370 (-0.11)
Frequency	2.32	0.43 (0.18) [‡]
Infrastructure	7.18**	0.96 (0.34)**
Plans	2.60	0.81 (0.13)
Previous FPA	0.02	-0.08 (-0.13)
Likelihood ratio χ^2	71.02***	
F		5.46***
AIC	370.04	139.28
Adjusted R ²		0.35

Significance levels: [‡](<0.10), *(<0.05), **(<0.01), ***(<0.001).

Communities in which administrators talk to other administrators more frequently also have more green infrastructure. My second research question focused on the role of regional diffusion in the use of green infrastructure across Oregon municipalities, so I used two variables that I thought would best capture those mechanisms: the frequency floodplain administrators talk to other administrators (frequency variable), as well as whether or not an administrator has read other communities' flood management plans (plans variable). The richness of community use of green infrastructure may be influenced by the frequency administrators talk to other administrators or the likelihood that administrators read other communities' plans and obtain knowledge from other communities. The relationship was positive, indicating that communities in which administrators talk to other administrators more frequently also have more green infrastructure.

Discussion

I had two primary research questions: First, what factors correlate with the use of green infrastructure, especially for flood hazard and floodplain management, and, second, to what extent is regional diffusion affecting the use of green infrastructure in these jurisdictions? This research contributes to, and expands on, the literature assessing the adoption of innovative policy and practice for green infrastructure development. Recent research in this area has largely focused on small-scale green infrastructure, such as for stormwater management (e.g., Abhold, Loken, and Grumbles 2011; Carlet 2015), and I sought to build on this earlier work in two ways. First, applying other definitions of green infrastructure (e.g., Benedict and McMahon 2006; Tayouga and Gagné 2016) to include features such as open space and floodplains sheds light on the ways in which planners and policymakers are conceiving of both green infrastructure and flood hazard and floodplain management. Second, I further explored the applicability of the regional diffusion model not only with spatial analysis but also by including variables that identified how often FPAs talk to other administrators or read other flood management plans.

Prior to these analyses, I performed logistic regression to determine response bias in the questionnaire, which I could then control for in the quasi-Poisson and OLS regression. There were 81 communities that were nonrespondents or that I was simply unable to contact, and I wanted to determine (and control for) any significant differences between nonrespondents and respondents in the quasi-Poisson and OLS regressions. The logistic regression identified three significant community demographic characteristics influencing the likelihood of responding to the survey, including the percent of the population with a bachelor's or graduate/professional degree and the unemployment rate in the community.

Previous research has found that education can be a significant contributor to response bias in surveys (Sills and Song 2002); these results indicate that the education level of the community itself may be influencing the likelihood of a key informant responding to a survey. Unexpectedly, however, the attainment of a bachelor's degree had a negative influence on the likelihood of responding to the survey, while communities with greater proportions of residents that had attained graduate or professional degrees had a positive effect—more research is needed before making such a conclusion. Community unemployment rate had a negative effect on survey responses, which may indicate that hard times within the community translates to a lack of resources for community administrators to participate in a voluntary survey. Although the degree of urbanization was only marginally significant to response bias; I opted to control for urbanization in the regressions based on previous research that indicated its importance (Damanpour and Schneider 2009; Hwang and Gray 1991; Ormrod 1990; Sharp, Daley, and Lynch 2011; Walker 1969).

The dependent variable, green infrastructure, was structured as a count variable (a sum of 1s and 0s); for this reason, I performed a Poisson regression with robust standard errors to account for overdispersion in the model. However, I was not ultimately interested in an exact determination of the number of green infrastructures being used, but more in relative richness of green infrastructure strategies within a community. Further, while this variable consists of discrete, non-negative integers, I propose that, similar to sales price or income, it approximates a continuous variable for this analysis. Moreover, the two models provided very similar results. The same variables were significant with the same directionality, and the AIC diagnostic for model comparison indicated that the OLS model fit the data better than the Poisson model (Poisson AIC = 370 vs. OLS AIC = 139). Lastly,

the OLS model performed well: fewer than one percent of predictions are outside the range of the observed data, and it is more interpretable in determining the marginal effect of an independent variable on the dependent variables. For these reasons, I focus my interpretation on the OLS model.

There were two factors that, in practice, would likely be tightly coupled: previous experience with flooding and knowledge of infrastructure; i.e., experience with the problem, and solutions for addressing it. The former—in which a manager has more extensive experience with flooding—had a positive effect on the adoption of green infrastructure. Including this factor was somewhat novel—previous research has largely focused on a managers' expertise with the policy innovation itself, not the impetus for developing such a policy. Typically, managerial tenure is included to address experience, and is frequently found to be a significant factor in innovation adoption (Damanpour and Schneider 2006; Damanpour and Schneider 2009; Kearney, Feldman, and Scavo 2000). Tenure is often included as one of several managerial characteristics such as age and formal education as an approach to capture experience, insight, and professional judgment (Baldridge and Burnham 1975). However, for the purpose of understanding disaster policy innovation, the frequency of experience with the disaster over one's tenure may be an important predictor. The latter—knowledge of flood mitigation infrastructures—is more in line with previous research, which has included variables regarding a manager's attitudes and perceptions of an innovation such as green infrastructure. For instance, Carlet (2015) used several theoretical frameworks, including the technological acceptance model, as well as the diffusion of innovation model, to analyze the effect of managerial perspectives and attitudes on the adoption of green stormwater infrastructure. In her analysis, she discussed the positive

influence that knowledge of green infrastructure would likely have on the perceived ease of use of green infrastructure, thereby increasing the likelihood of adoption (Carlet 2015). More recently, O'Donnell et al. (2017) analyzed the barriers to adopting blue-green infrastructure and found the second most important barrier to be a lack of knowledge. This research differed, however, in that I asked not about green infrastructure, but about flood mitigation infrastructure, implying that this knowledge, which may include both gray and green infrastructure, is correlated with the adoption of green infrastructure adoption in a community.

Communities in which administrators talk to other administrators more frequently and that have read other community plans were also somewhat more likely to employ more green infrastructure strategies. This finding supports the occurrence of regional diffusion, as well as earlier research by Damanpour and Schneider (2006). A positive correlation between the frequency with which managers are talking to each other and the number of types of green infrastructure used in itself is not conclusive of a causal relationship, but it does support the notion of regional diffusion where communities look to other communities to be laboratories for policy innovation. Additionally, Damanpour and Schneider's (2006) work included nine different models exploring the phases of innovation adoption in organizations; external communication was highly significant in each model. The authors hypothesized that communicating with other managers can improve their knowledge not only of environmental events, but of potential solutions for addressing these events. In effect, talking to other managers allows a manager to explore what Matisoff (2008) referred to as a "policy laboratory."

Urbanization is an important factor in policy diffusion research, and may be included as a hypothesis in its own right (e.g., Walker 1969), or as a control (e.g., Damanpour and Schneider 2006; Damanpour and Schneider 2009). In this research, while urbanization was an extremely important factor in the OLS—a finding with extensive support in the literature—it was also important in the spatial analysis. Urbanization has frequently been found to strongly correlate with the adoption of innovative policies because those communities may have more capacity and resources, as well as a “higher density of information linkages” especially in dense metropolitan areas (Damanpour and Schneider 2006:218). This was borne out in the local spatial analysis to determine if urbanization and use of green infrastructure had a strong spatial association with each other, which they did. High values of green infrastructure were found in the Portland metropolitan area, with lower values observed in rural eastern Oregon. Notably, I also performed local spatial analysis with green infrastructure and factors other than urbanization and did not observe the robust pattern that was observed when green infrastructure was coupled with urbanization. Because of the strong association between urbanization and green infrastructure use, I included urbanization in the regression analysis, which not only controlled for that bias among survey respondents, but also controlled for the spatial variation in green infrastructure, giving me spatially-independent residuals. In other words, I captured variation in the dependent variable that was both managerially related and spatially related.

Policy diffuses through a network to neighboring communities, likely after observing successful implementation and outcomes elsewhere. This is supported not only by the local spatial analysis, finding hotspots of green infrastructure in the Portland metropolitan area, but also because of the positive correlation between green infrastructure use and how often

managers talk to other managers, a mechanism of regional diffusion. The regional diffusion model as developed by Berry and Berry (2014) is inherently spatial—the authors reference proximity being one of the factors that influences the diffusion of policy through networks to neighboring communities. Because frequency of communication between policymakers is an obvious mechanism for policy to diffuse, leveraging this could be an important institutional strategy for encouraging the use of green infrastructure. Currently, the EPA strongly encourages the use of green infrastructure to meet requirements of the CWA, and in 2014 created the Green Infrastructure Collaborative with other federal agencies, nongovernmental organizations, academic institutions, and the private sector to support this mission (U.S. Environmental Protection Agency 2018a). Recreating this at a smaller scale, perhaps at the state or regional level, is one way to reach smaller, more rural communities that, while perhaps interested in implementing more green infrastructure, lack the resources or knowledge represented by a larger collaborative.

My research findings largely support previous research in the fields of policy adoption and green infrastructure use. Increased knowledge regarding flood mitigation infrastructure positively correlated with the use of green infrastructure. Recent research by Carlet (2015), found a strong correlation between manager beliefs and green infrastructure adoption for stormwater management. In her research, perceptions related to the ease of use, usefulness, and internal readiness were strong predictors of whether green infrastructure was being adopted by the community or not. Some of these attitudes and perceptions may very well be captured by the infrastructure variable in this analysis. Future research using a similar questionnaire to elucidate the use of green infrastructure for flood hazard and floodplain management could parse this question to get at these nuances; for example, what

personal experience does the respondent have with gray infrastructure or green infrastructure, and when was their flood mitigation infrastructure constructed?

There are, however, some caveats to these findings. For example, I developed an overall index of the types of green infrastructure used in different communities. However, some communities may employ certain types of green infrastructure (e.g., small-scale stormwater features) for different reasons than attempting large-scale floodplain restoration. Disaggregating the green infrastructure concept may help to highlight motivations for employing different strategies. For instance, this variable contains all questionnaire inventory items that describe green infrastructure (see Appendices A and B). Factor analysis or principal components analysis could separate this variable to determine if the size, scale, or function of the infrastructure affects the degree to which it is implemented and the rationale for doing so, a critical need for future research. My questionnaire also did not address the extensiveness of green infrastructure in a community; for example, if a community has one bioswale, that would be treated the same as a community that had a bioswale on every block. My results therefore focus on the diversity of different approaches to green infrastructure a community employs rather than the richness of green infrastructure in the community.

Conclusion

Through the use of a key informant questionnaire, and regression and spatial analysis, my research uncovered several factors that positively influenced the use of green infrastructure for stormwater, flood hazard, and floodplain management in municipalities across Oregon. Confirming previous research, new policy like green infrastructure development was strongly associated with urbanization, and was a source of respondent bias potentially due to the higher salience of the topic in municipalities that were more likely to

have experience with green infrastructure. Professional experience with 100-year floods, a high degree of knowledge regarding flood mitigation infrastructure, and the frequency a floodplain administrator speaks to other administrators also positively correlated with the use of green infrastructure in a community. It is these last two factors that create the opportunity for intervention to increase the use of green infrastructure within a community. Creating an open forum for administrators to increase their awareness not only about flood hazard, but also about flood mitigation infrastructure, as well as share policy successes (and failures) with colleagues would create an excellent opportunity to further advance the use of green infrastructure for stormwater and flood hazard and floodplain management.

Chapter Three: Community identity, green infrastructure, and flood hazard mitigation: The novel case of the nation's first urban National Wildlife Refuge

Abstract

In the early 1990s, Sherwood, Oregon, was a small town on the outskirts of the Portland metropolitan area. Expecting increasing population pressure from Portland, and wanting to protect what they felt was a unique community identity, Sherwood started taking steps to mitigate the impacts of population growth. To protect the many natural features of the community, the city of Sherwood codified planning objectives that included goals to “achieve the maximum preservation of natural features” and to “minimize the adverse effects of human activity on the natural environment.” The city identified 476 acres as open space (what was then 19% of the city); 424 of those acres were designated as wetlands, floodplains, and other significant natural areas. The town implemented a policy to protect those natural areas and maintain their unique identity by using three different economic and regulatory incentives: outright purchase, density transfer, and system development charges (SDC) credits. Within a five-year period, ~335 acres of floodplain had been protected. Sherwood's floodplain protection program laid the groundwork for the creation of the first urban wildlife refuge, the Tualatin River National Wildlife Refuge. With this case study, I was able to explore the rationale for both the protection of these greenways, as well as the creation of the Refuge, and how these lessons may be applied elsewhere.

Key Words

Floodplain protection, internal determinants, green infrastructure, urban wildlife refuge, Tualatin River National Wildlife Refuge

Introduction

Sherwood, Oregon, is a historically agricultural community located on the periphery of the greater Portland Metropolitan Area (Figure 10). In the early 1990s, pressure from urban growth and increased population from neighboring Portland challenged Sherwood's leaders to consider how the city could shape growth and minimize the negative impacts of building in the city's undeveloped floodplain. Doing so would help meet 1970s regulatory

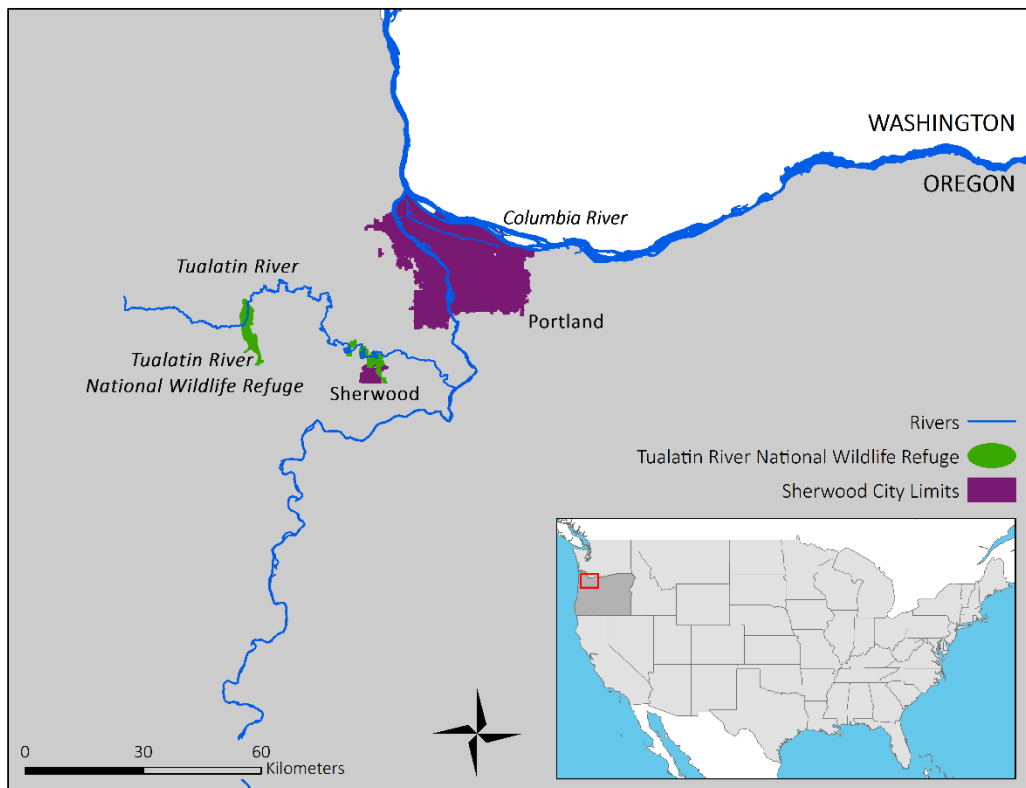


Figure 9. The City of Sherwood and the Tualatin River National Wildlife Refuge in the southwestern Portland metropolitan area.

requirements designed by the state of Oregon to manage growth cohesively through comprehensive plans. In the course of developing Sherwood's comprehensive plan, an unexpected outcome emerged—Sherwood leaders helped create one of the nation's first urban wildlife refuges while simultaneously minimizing future risks to the built environment

from flood hazard. The question underlying this chapter is how Oregon's two decades-old land use planning law resulted in the recognition of Sherwood's natural green infrastructure and the creation of a nationally-protected wildlife refuge. In doing so, I explore how cities adopt natural resource policies and protect resources like urban floodplains, an increasingly important topic as cities around the country and globe struggle to manage imperiled and fragmented floodplain habitat. This paper presents a case study of an Oregon community leveraging coordination across different scales of government and stakeholders to meet local objectives and state-mandated planning goals, in an open space and floodplain preservation program.

Communities that are intersected by streams, rivers, and floodplains rely on policy to balance local planning objectives with state, federal, and other priorities. Local objectives typically include issues like hazard mitigation, economic development, water quality and habitat protection, and open space preservation, which are supported or constrained by federal policies such as the Clean Water Act and National Flood Insurance Program (Freitag, Bolton, Westerlund, and Clark 2009). Observing the difficulties of meeting these federal regulations related to clean water and flood hazards, while also wanting to encourage the growth and vitality of local communities, Oregon developed nineteen statewide planning goals in the early 1970s, focused on land use planning; natural resources, scenic and historic areas, and open spaces; and areas subject to natural hazards, among others. Cities and counties are required to develop comprehensive plans addressing these planning goals that are implemented in local policy (Oregon Department of Land Conservation and Development 2010). Doing so requires not only coordinating vertically between local and state government, as well as regional governments, but also horizontally between potentially

conflicting goals within the local community (Miller and Demir 2007). How do cities navigate vertical and horizontal coordination challenges in the context of floodplain and flood hazard management and how is this task resolved when local objectives create relatively few examples of other cities to emulate? These are the questions I ask in my examination of Sherwood, Oregon's pursuit of a floodplain preservation program that resulted in the establishment of the Tualatin River National Wildlife Refuge, hereafter referred to as the Refuge.

To answer these questions, I introduce two complementary themes: (1) The internal determinants model of policy innovation and adoption, and (2) green infrastructure for flood hazard and floodplain management. I use these two themes—which were developed more extensively in Chapter One—throughout the paper to describe the case of Sherwood and develop a framework for assessing similar policy processes in other Oregon cities.

Internal Determinants and Policy Innovation and Adoption

The internal determinants model describes a community that pioneers the innovation and adoption of policy or management strategies to meet their own economic, social, or political needs (Berry and Berry 2014). The internal determinants and regional diffusion models are widely used for analyzing policy making (Berry and Berry 2014). The regional diffusion model is based on earlier research on policy diffusion (Walker 1969), which Berry and Berry (1990) paired with a new model—the internal determinants model—to explain the innovation and spread of a policy between local communities. For simplicity, I use the term *lone-wolf* to depict the internal determinants model.

One driver for policy innovation in flood hazard and floodplain management is a desire to maintain a distinct community identity. Previous research has found that a desire to

protect the natural environment as part of community identity may be a powerful driver in open space protection policy. McMillan and Chavis (1986) defined a sense of community as having four dimensions: membership, influence, integration and fulfillment of needs, and shared emotional connection. As Kim and Kaplan (2004) note, however, this framework defining community identity was not designed to consider or integrate conceptions of the physical or natural environment. Separate research has addressed the phenomenon of attachment to place or community, however, which bridges the gap to a sense of community that is rooted in place (Hummon 1992; Mesch and Manor 1998; Nielsen-Pincus, Hall, Force, and Wulforth 2010; Trentelman 2009). Community identity incorporates these ideas as personal or public identification with a geographically-bounded community that has its own character (Kim and Kaplan 2004).

This geographic-boundedness of community identity is often enhanced by open spaces and natural features, and this embeddedness of open space and natural amenities into community identity often drives a community to preserve these spaces (Kim and Kaplan 2004; Kline 2006; Swim, Zawadzki, Cundiff, and Lord 2014; Tzoulas, Korpela, Venn, Yli-Pelkonen, Kaźmierczak, Niemela, and James 2007). Kline (2006) examined the economic rationale for open space preservation and found that as open space in a community decreases and its marginal value increases, so too does public demand. Swim et al. (2014) found that strong environmental identity (identifying with nature) and place identity (identifying with their township) predicted the willingness to pay more for open space preservation. Furthermore, people with these two identities were more likely to rank open space as important, but especially important to preserving community identity (Swim, Zawadzki, Cundiff, and Lord 2014).

Green Infrastructure

Green infrastructure is one type of infrastructure that may be used for flood hazard and floodplain management. Green infrastructure can be used for small-scale stormwater management (e.g., rain gardens, green roofs, bioswales), or for flood hazard and floodplain management utilizing the natural hydrologic values of open space and natural areas (Allen 2012; Benedict and McMahon 2006). The municipal use of large-scale green infrastructure such as open space and natural areas for flood hazard and floodplain management in the US is relatively recent; Brody and Highfield (2013) note that the explicit use of open space protection for flood mitigation wasn't observed until the 1990s.

Green infrastructure, and the protection of open space for flood mitigation can accrue multiple ecological and socioeconomic benefits (Benedict and McMahon 2006; Brauman, Daily, Duarte, and Mooney 2007). Floodplains protected through open space preservation provide fish and wildlife habitat, increased biodiversity, improved water quality, recreational opportunities, and aesthetic and cultural values (Bengston, Fletcher, and Nelson 2004). Floodplains additionally provide flood risk mitigation through natural storage capacity, and groundwater recharge (Brauman, Daily, Duarte, and Mooney 2007; Opperman, Galloway, Fargione, Mount, Richter, and Secchi 2009; Postel and Carpenter 1997).

Merging the two themes (i.e., policy innovation and adoption, and grey and green infrastructure) provides a framework for understanding local policy choices for floodplain and flood hazard management. For example, I use the term green wolf to describe a community that independently pursues green infrastructure (see Chapter 1). In this chapter, I illustrate in depth why the green wolf concept is represented by Sherwood's approach to flood hazard and floodplain management. Further, community identity is an important

factor that drove Sherwood’s independent push to be a green wolf. I rely on two primary observations to support my case: (1) Sherwood’s protection of its open space, greenways, and floodplains through the establishment of a National Wildlife Refuge, and (2) the internal planning objectives and lack of nearby municipalities taking a similar innovative policy approach in the early 1990s. Given these observations, I evaluated what policy decisions Sherwood leaders and stakeholder made, why Sherwood adopted these ‘green wolf’ policies, and what can be generalized from Sherwood’s experience for other communities with similar planning objectives.

Methods

I used an embedded single-case design for this case study (Yin 2014). The case focuses on two primary embedded units of analysis including the City of Sherwood and the Refuge. I used three primary sources of data, which were analyzed using a pattern matching technique (Yin 2014): semi-structured interviews, document analysis, and site visits.

Several supporting documents were examined for a wide range of salient information, including community descriptions, policy objectives and descriptions, mechanisms for policy implementation, and agency and institutional rationale in decision making (Table 6).

Table 6. Documents used for archival analysis of Sherwood’s floodplain protection program and the creation of the Tualatin River National Wildlife Refuge

Document title	Citation
Sherwood Comprehensive Plan, part 2	(City of Sherwood 1991b)
Sherwood Comprehensive Plan, part 3	(City of Sherwood 1995)
Washington County Comprehensive Plan, vol. II	(Washington County Planning Commission 1993)
Metropolitan Greenspaces Master Plan	(Oregon Metro 1992)
Urban National Wildlife Refuge policy	(U.S. Fish and Wildlife Service 1991)
USFWS Environmental Assessment	(Harrison 1992)

Thirteen people were interviewed during two time periods: one person, a retired municipal employee, was interviewed six times between February 2015 and February 2016. During the last interview, this participant suggested other people for possible interviews; these were conducted between October 2016 and February 2017. I continued using the snowball sampling method and solicited recommendations for other interviewees during each interview. Interviewees were selected from several professional organizations from different levels of government and from non-governmental organizations (Table 7).

Table 7. The professional association of each interviewee regarding the Sherwood floodplain protection program and creation of the Tualatin River National Wildlife Refuge. Respondent numbers are included for references within the text.

Respondent association	Interviewee number
Retired Sherwood municipal	1
Retired Sherwood municipal	2
Retired U.S. Fish and Wildlife	3
Retired Tigard municipal	4
Sherwood municipal	5
Metro regional government	6
Metro regional government	7
Clean Water Services	8
U.S. Fish and Wildlife	9
Friends of the Tualatin River National Wildlife Refuge	10
Retired U.S. Fish and Wildlife	11
Retired U.S. Fish and Wildlife	12
Retired U.S. Fish and Wildlife	13

Interviewees were selected because they were either involved with planning Sherwood's open space and floodplain protection program or creating the Refuge. The interviews were semi-structured with open-ended questions, allowing respondents to reply to specific questions while still sharing their own perspective and any other information they considered salient.

Ten of the interviews were recorded and transcribed. I had technical difficulties for two of the interviews, and one interview took place during a site visit, making recording unwieldy; for these interviews, I took field notes and transcribed unrecorded interviews immediately following the interview. The transcriptions were coded using QDA Miner Lite software. The analysis was based on preliminary research that Sherwood's green wolf policy for floodplain and flood hazard management were driven by its internal planning objectives and the lack of relevant nearby examples of similar policy to draw on. Prior to analysis, I created a codebook to capture main themes and patterns in the interviews, documents, and site visits (Table 8).

Table 8. Code tree with main stem and detailed codes used to analyze interview data.

Code Family Main Stem	Code
Flooding	Flood hazard Floodplain management
Policy	Cross jurisdictional governance Infrastructure Tradeoffs
Refuge	Achievements Challenges Creation Friends of the Refuge Funding and acquisition Riverkeepers
Sherwood	Community identity Concerns Floodplain natural area protection Local policy Planning goals Successes
USFWS	Policy and political will Urban refuges Background, policy, and funding
Quotations	Quotation

Case Study Background

In the early 1990s, Sherwood, Oregon, was a rapidly urbanizing satellite of the Portland Metropolitan area in northwestern Oregon. Sherwood remains a relatively small community, at 1,165 ha and approximately 19,350 people (Portland State University College of Urban & Public Affairs 2017), but its population growth rate since 1990 dwarfs that of Oregon as a whole. Between 1990 and 2017, Oregon's population increased by approximately 46 percent, while Sherwood's population growth was approximately 526% (Portland State University College of Urban & Public Affairs 2017; U.S. Census Bureau 1990).

Sherwood's demographics reflect not only a rapidly-growing city, but an economically-disadvantaged city as well. Compared to the City of Portland, Sherwood has substantially lower unemployment (3.5% versus 5.2%) and poverty (3.3% versus 16.9%), in addition to substantially higher median income (\$86,111 versus \$58,423) (U.S. Census Bureau 2016b). Nonetheless, in 2006, the city prioritized economic development with the Economic Development Strategy, and re-prioritized economic development again in 2013 (City of Sherwood n.d.). The vision statement for the Economic Development Strategy declares that the city will:

Provide jobs for our residents by building on our assets and developing the necessary infrastructure to retain existing businesses and support new businesses. Economic development will also be supported by maintaining our livability and character as a clean, healthy, and vibrant suburban community where one can work, play, live, shop, and do business (p. 1; City of Sherwood 2006).

Although increasingly urbanized, Sherwood has significant environmental resources and natural assets that contribute to community livability and character, as well as its community identity. The largest of these is the Tonquin Scabland Geologic Area, a 67-ha

basalt uplift area created by the Glacial Lake Missoula Floods during the last Ice Age (City of Sherwood 2009; Oregon Metro 2013). Sherwood also contains over seven hectares of public parks, a ponderosa pine forest of almost three hectares (relatively rare for western Oregon), portions of the Chehalem Mountains, Cedar and Rock Creeks (tributaries of the Tualatin River), the Onion Flat floodplains, and portions of the 549-ha Tualatin River National Wildlife Refuge (Figure 8; City of Sherwood 2009; Oregon Metro 2013; U.S. Fish and Wildlife Service 2006).

The Refuge is an urban wildlife refuge created in 1992 and managed by the U.S. Fish and Wildlife Service (USFWS). National wildlife refuges are created to protect wildlife habitat (particularly for migrating birds) and to provide specific types of wildlife-dependent recreation: hunting, fishing, wildlife observation, wildlife photography, environmental education, and environmental interpretation (U.S. Fish and Wildlife Service 1997). The Refuge is located in the southwestern portion of the Portland Metropolitan area and, like most wildlife refuges, has two demarcations—the project boundary that has been approved for acquisition, and the actual acquisition. The Refuge is 549 hectares, with another 689 hectares approved for future acquisition (Figure 11; Tualatin River National Wildlife Refuge 2015). The Refuge straddles approximately eight miles of the Tualatin River, mainly to the north and northwest of Sherwood, but also encompassing a large portion of the Rock Creek floodplain within the Sherwood urban growth boundary, as well as the Onion Flat floodplain (Figure 10; Harrison 1992).

As part of the Portland Metropolitan area, Sherwood is subject to multiple levels of governance. In addition to the city, county (Washington County), state, and federal government, the Portland Metropolitan area has a regional governing body, Metro, that

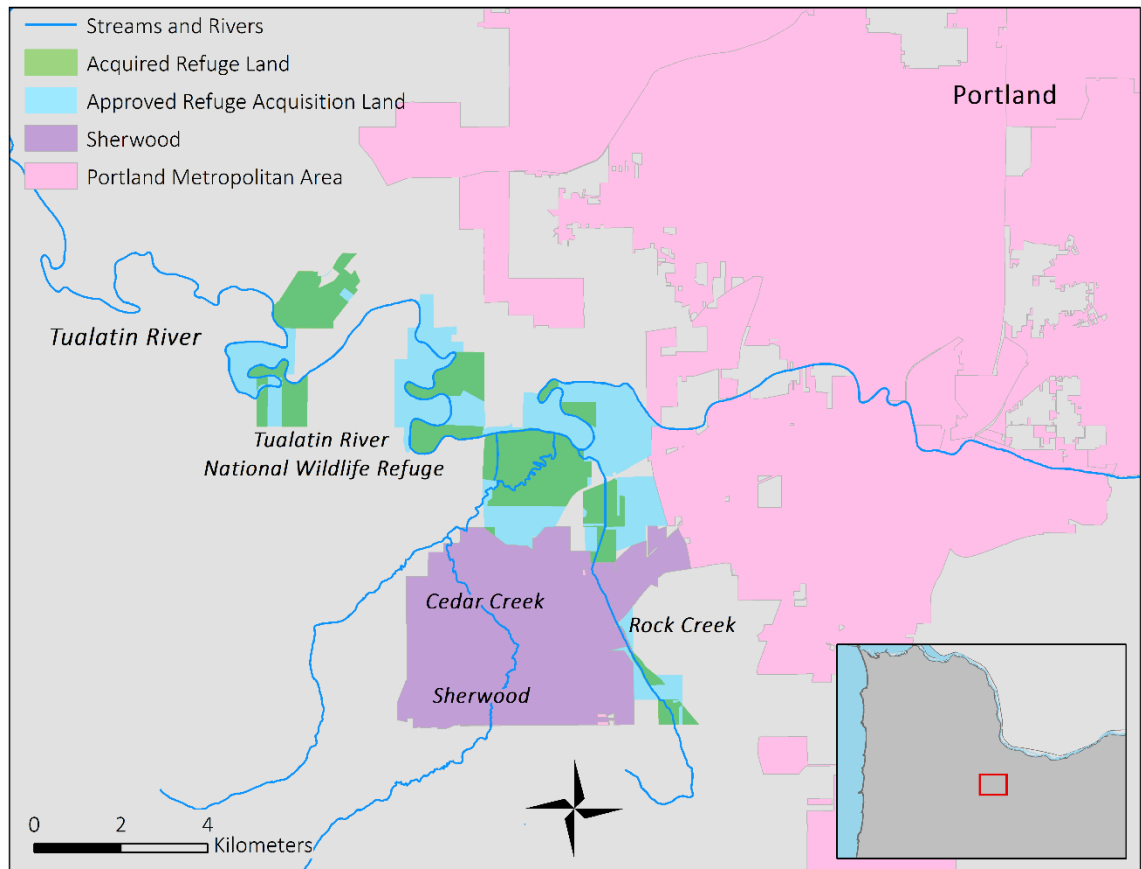


Figure 10. The City of Sherwood and the Portland Metropolitan area. The Tualatin River and its tributaries, Cedar and Rock Creeks are visible, as well as the acquired and approved boundaries of the Tualatin River National Wildlife Refuge.

oversees regional planning and services, particularly related to parks, recreation, and land use for municipalities in the metropolitan area.

Results

Sherwood Floodplain and Open Space Protection Program

In 1991, with the environmental amenities in the community, and the prescient expectation of strong growth pressure—“Everybody knew growth was coming” (Respondent 2)—the city started taking steps in their comprehensive planning to mitigate the pressure. Their first policy goal was “to adopt and implement a growth management policy which will accommodate growth consistent with growth limits, desired population

densities, land carrying capacity, environmental quality, and livability” (p. 3-2; City of Sherwood 1991b). Eight strategies were identified to meet this goal, including a policy objective to “achieve the maximum preservation of natural features” (p. 3-2; City of Sherwood 1991b). Other policies included growth management coordination with Washington County government to ensure the “conservation of a needed amount of open space” (p. 3-8; City of Sherwood 1991b). This policy for growth management translated directly into land management, which included a policy goal to “minimize the adverse effects of human activity on the natural environment” (p. 4-10; City of Sherwood 1991b).

Sherwood’s Parks Master Plan identified 193 ha as open space, greenways, and floodplains—almost 20% of the area within the city’s urban growth boundary—and designated 172 of those hectares for wetlands, greenways, and “significant natural areas” (City of Sherwood 1994). The city used three mechanisms to achieve their policy goals of maximizing the preservation of natural features and open space and minimizing adverse impacts on the natural environment from human activity. To protect and acquire open space, floodplains, and greenways from developers wanting to develop parcels containing a portion of these areas, Sherwood used system development charge (SDC) credits, density transfer, and outright purchase, or a mix of all three. SDCs are fees owed to the city by developers to fund the infrastructure improvements that are needed to meet increased demand. Sherwood originally had three types of SDC credits to offer to developers: parks, stormwater, and water supply. The park SDC credit applied to residential development only—industrial and commercial lands were not eligible for receiving a park SDC credit. In this instance, dedicating a natural area, wetland, or floodplain to the city would make the developer eligible for a park SDC credit (Respondent 1). After the city switched from

groundwater to a regional water supply, the water supply SDC credit was no longer available, leaving the stormwater SDC credit as the main SDC credit mechanism for open space protection (Respondent 1). Stormwater SDC credits were available to developers that met green infrastructure standards developed by the local wastewater treatment utility, Clean Water Services. While Sherwood still relied on a groundwater water supply system, any mechanism that “scrubbed runoff” was eligible for a stormwater SDC credit (Respondent 1). Density transfer was another mechanism used by Sherwood in the protection and acquisition of open spaces. Density transfer was mainly used in planned unit developments by allowing a developer to increase density in a subdivision if the development also protected greenway or floodplain areas; in exchange for the increased density allowance, the developer would transfer ownership for the greenspace to the city. Outright purchase was the third and most used mechanism used by Sherwood to acquire greenspace and floodplains. Sherwood offered \$5,000 per acre of greenspace, and while developers were welcome to get their own appraisal, the incentive was sufficiently powerful that, “no one ever did so” (Respondent 1). With these three mechanisms, the city acquired and protected approximately 90% of the targeted greenways and floodplains in five years (Respondent 1).

At the time, flooding was not a major concern in Sherwood (Respondent 2), although it was in neighboring communities (Respondent 4). Even though there are two creeks running directly through Sherwood and the city is also in close proximity to the Tualatin River, the most recent flood at the time was the Christmas Flood of 1964-1965, which affected large portions of the western United States, although the Tualatin River was affected less than in other areas (Waananen, Harris, and Williams 1971). During Sherwood’s

efforts to protect its floodplain areas, there was a major flood event on the Willamette River that impacted some neighboring communities.

The 1996 flood was a major indicator to [our community] that it, like all other communities, needed to be concerned about flooding.... The 1996 flood...was incredibly high.... There were picnic tables and port-o-potties that were taken downstream from Cook Park. It was totally underwater. That was a wakeup call to the extent of flooding that could take place with a major event like that (Respondent 4).

While neighboring communities downstream on the Tualatin River were severely impacted by the 1996 flood, Sherwood, was not (U.S. Army Corps of Engineers 2017a). Flooding was not a concern: “We really have very few storm issues and a lot of that is because we have such open space. We just don’t have issues with our floodplain. We have a really wide floodplain and it’s pretty good.... There are some little issues and pockets, but for the most part we don’t have flooding issues” (Respondent 5).

While natural hazards are mentioned in the comprehensive plan, as required for state land use planning, hazard reduction was not the primary objective of the city’s greenway and floodplain protection program. As the comprehensive plan stated, protecting open space and natural amenities was done to preserve the natural environment and livability of the community (City of Sherwood 1991b). Further, the comprehensive plan also stated that “The planning process must involve specific steps to identify community design objectives which best enhance community identity and quality of life. Careful attention to site design can result in the protection of natural and man-made features which contribute to the community’s identity” (City of Sherwood 1991b:4-58). The city’s focus on maintaining environmental quality and livability was a natural extension of community concerns. In addition to municipal staff,

Who were trying to preserve wetlands, floodplains, other natural areas, there were other people in the community who were also interested in natural areas, and people who were trying to differentiate Sherwood as a community from the whole rest of the metropolitan area instead of just making it just another neighborhood of a nameless suburb (Respondent 3).

This desire to differentiate and preserve a unique community identity was a consistent theme in the interviews:

The community recognized that Portland was growing outward and [Sherwood] was much more rural. There was quality of life, of value around rural lands, more open spaces, green spaces—if you want to call them green spaces—that they wanted to maintain (Respondent 9).

Sherwood was concerned about maintaining their community identity. At the time, they were still separate from Portland and they wanted to keep a separate community identity. I don't know who the founding fathers were who had this idea, but it stuck (Respondent 13).

I think [Sherwood's floodplain and open space protection program] was really driven by community values more than product line problems or some stormwater requirement or anything like that. I think that's why it was successful. They wanted to create, I hate the term of community distinction, because that is what some people call planning efforts. They wanted to create something different (Respondent 8).

One interviewee stated that Sherwood successfully met this objective:

[Sherwood has] been ranked a number of times in the top most livable communities in various magazines and things like that. Part of that is that open space protection that we have and the trails and all that stuff. I think that kind of creates that community identity. Again, it just is what makes Sherwood, Sherwood. I don't know that people would necessarily associate it with the Refuge, but they associate that open space and natural areas (Respondent 5).

One ramification of this success is that the protected open space and other natural areas are embedded in many peoples' identification with Sherwood, as well as their expectations for future growth. In current planning processes that will likely expand development westward, residents have voiced their expectations of continued preservation of open space and natural amenities, which the municipality may not be able to achieve to

the same extent: “We’ll still be able to protect the floodplains, but I feel like it seems like it’s more than just the floodplain area in Sherwood that’s protected in open space” (Respondent 5). This outcome is not entirely unexpected, given the focus of the planning department and local residents on protecting floodplains, wetlands, and other natural areas. A potential solution to protect greenways and floodplains in such a way as to “provide a green buffer between Sherwood and the rest of the metro area” began gaining municipal and community support in the form of a national wildlife refuge (Respondent 3).

Creation of the Tualatin River National Wildlife Refuge

While Sherwood was pursuing a program of floodplain protection for community identity, the USFWS had drafted an urban wildlife refuge policy prioritizing wildlife habitat protection in urban areas via the creation of wildlife refuges. The mission of the National Wildlife Refuge System at the time was “to provide, preserve, restore, and manage a national network of lands and waters to meet society’s needs for areas where the widest possible spectrum of benefits associated with wildlife and wildlands is enhanced and made available to the public” (U.S. Fish and Wildlife Service 1991). There were six ‘wildlife-dependent’ public uses available for National Wildlife Refuges: hunting, fishing, wildlife observation, wildlife photography, environmental education, and environmental interpretation (Respondent 3). To support the mission of the National Wildlife Refuge System in urban areas, the USFWS chose to acquire land for Refuges in areas that were in or adjacent to metropolitan statistical areas. There were several goals in addition to the mission in this urban refuge policy, including adequacy of habitat corridors and buffer areas, and creating partnerships with local government and citizens (U.S. Fish and Wildlife Service 1991). The Tualatin River National Wildlife Refuge was created in 1992, after the USFWS had looked

throughout the Portland-Vancouver metropolitan area for a suitable site (Respondent 2).

There are currently fourteen wildlife refuges that are considered urban, but many of these became urban as increased development surrounded them; the Tualatin River National Wildlife Refuge was the first refuge created from scratch following the urban wildlife refuge policy (U.S. Fish and Wildlife Service 2015, September 16).

The idea of urban wildlife refuges was not unanimously well received by USFWS staff—"[some staff] said, these dinky refuges and these urban refuges, we don't want them" (Respondent 12), but there were other factors supporting the creation of the Refuge besides the new urban wildlife refuge policy. The idea for the Refuge itself started in Sherwood's planning department and quickly gained traction with Sherwood citizens: "The push did not come from [the] Fish and Wildlife Service.... The push came from the citizenry" (Respondent 2). Indeed, at the time, "The City of Sherwood was trying to do something to distinguish themselves from the rest of the urban sprawl.... They didn't want to get absorbed into [neighboring communities]. [The USFWS] presented the idea about buying a big park there to separate them from [their neighbor]—they thought that was wonderful" (Respondent 11). Further, while Sherwood leaders continued to support the creation of the Refuge, even going to Washington D.C. to lobby for the funding to create the Refuge, it was a local Sherwood couple that donated the first twelve acres of land that would make the Refuge eligible for congressional funding (Respondents 1 and 2). One of the first purchases by the USFWS was from a local citizen who sold a parcel along Rock Creek, on the edge of the urban growth boundary; this purchase resulted in the Refuge continuing into the City of Sherwood (Respondents 12 and 13). The expansion of the Refuge acquisition boundary—the land the USFWS was approved to acquire—into Sherwood's urban growth boundary

aligned with the attitude Sherwood residents had toward the Refuge: “It’s the only refuge I know where we drew the acquisition boundary, opened it up to public comment, and had many people say that it wasn’t big enough. That never happens. So, they went back to the drawing board and expanded the boundary. Almost doubled the size of the Refuge” (Respondent 13).

Neighboring municipalities, however, did not take the same interests as Sherwood in the creation of the Refuge. The Metro charter was being written in the early 1990s, and the Metropolitan Greenspaces Master Plan was adopted in 1992, which laid out a vision for creating a regional system of open space, green space, trails, and natural areas, for people and wildlife in the Portland-Vancouver metropolitan area (Oregon Metro 1992). Without a completed masterplan during the refuge creation, Metro’s involvement in the creation of the Refuge was limited and coordination around the acquisition of open spaces between the USFWS and Metro was causing some challenges. Metro was conducting land acquisition in the area, seeking to fulfill its mission, which created tension with the USFWS, as there was occasionally competition for the same parcel of land. “You don’t want two public agencies competing with one another for land acquisition. The seller loves it because they want to get the best price, but it’s not good for anyone else” (Respondent 13). This tension led to a somewhat adversarial relationship with Metro (Respondents 7,8, and 13). Coordination has since improved (Respondents 7 and 8). No other communities took such a clear interest in the creation and implementation of the Refuge. One downstream neighboring community that is intersected by the floodplain opted to be involved by mostly staying informed, but had limited operational involvement in the creation of the Refuge (Respondent 13). Several other nearby communities, while located in the Tualatin River Watershed, did not have a

vested interest as they were not intersected by the floodplain of the Tualatin River or its tributaries.

In addition to fulfilling the six goals of a national wildlife refuge, downstream communities, especially Sherwood, realized flood mitigation benefits from the establishment of this Refuge:

...Imagine what this [area] would look like if this [Refuge] wasn't here. You just have to look up the hill to see this encroaching [development]—it's suburbanized, all this building. This would all be developed, this would be strip malls, this would be a shopping center, this would be housing, apartments. There would be no place for this water to go. People don't realize [the economic impact the Refuge] has—how much money these areas, this catch basin of water, has saved the City of Sherwood (Respondent 9).

Sherwood's protected floodplains and the nation's first urban wildlife refuge were a culmination of internal social, environmental, and political motivations within the City of Sherwood, coupled with vertical coordination across local, regional, and federal agencies. "I also think for Sherwood, and the Friends of the Refuge, and this floodplain here, there's just so much of the story as a case study right here, but thinking about what it's growing into, it's a pilot for the country now" (Respondent 9).

Discussion

The City of Sherwood successfully implemented policy to protect open space, greenways, and floodplains within the community, eventually protecting more than 150 hectares—over 15% of the current city area, and contributed to the establishment of a National Wildlife Refuge that further shapes floodplain and flood hazard management in the city. I initially hypothesized that local planning goals around flood mitigation would explain Sherwood's adoption of this green infrastructure approach to flood hazard and floodplain management. My findings, however, point to a more complex policy landscape. Many

interviewees reported that the primary catalyst for preserving open space was the preservation of a distinct community identity. Sherwood's Comprehensive Plan highlights the importance of maintaining its identity for planning and growth.: "Sherwood is more than an assemblage of buildings, street and utilities, and places of work, residence, leisure, and meeting. The identity of Sherwood is determined by its natural setting, how its land use activities fit into that setting, and what people see, feel, smell, or hear as they participate in the life of the community" (p. 4-58; City of Sherwood 1991b). The importance of community identity to Sherwood was also extremely influential in the creation of the Refuge. Sherwood's investment in creating the first urban national wildlife refuge supported two of the objectives of the USFWS: to not only create an urban wildlife refuge, but to do so through close collaboration with local communities (U.S. Fish and Wildlife Service 1991). This collaboration allowed Sherwood and the USFWS to meet their own goals in part by supporting each other's goals.

The term green wolf applies not just to the City of Sherwood; an individual champion was key to this lone wolf pursuit of green infrastructure. Multiple interviewees commented on the important role of a now retired city planner in driving local planning efforts and coordinating with the USFWS and others—even going to Washington D.C. to lobby Congress—to support the creation of this Refuge. Echoing a point made by many interviewees, while the Refuge was a federal creation, it would not have happened without the work of this green wolf. This importance of a local champion to achieve policy objectives supports earlier research that the lack of leadership and community buy-in are substantial barriers to the adoption of green infrastructure (Thorne, Lawson, Ozawa,

Hamlin, and Smith 2018). My research goes further and supports the inverse—having a local champion and community support encourages the adoption of green infrastructure policies.

Brown and Farrelly (2009) reviewed 53 papers on the use of sustainable integrated urban water management and identified twelve types of barriers to the adoption and implementation of sustainable water management policies, finding that these impediments tend to be socio-institutional, rather than technological. One of the most prevalent barriers the authors identified was limited community engagement, empowerment, and participation (Brown and Farrelly 2009). Sherwood exemplifies the opposite, as a community that did not experience substantial barriers and demonstrated extensive community engagement in the creation of the Refuge and implementing floodplain and open space protection programs. Brown and Farrelly (2009), however, were not able to identify strategies to overcome socio-institutional barriers. More recently, O'Donnell et al. (2017) identified barriers to the adoption of blue-green infrastructure, including a reluctance to support novel approaches for management or to change current practice. To overcome this barrier, local leadership's willingness to support novel policy and management is important for the adoption of green infrastructure. Indeed, respondents to O'Donnell et al.'s (2017) survey identified improved education and awareness, as well as community engagement and communication as the most important strategies for overcoming barriers to the adoption of green infrastructure. By the early 1990s Sherwood had already distinguished itself as a green wolf through its horizontal coordination of a local floodplain and open space protection program. Sherwood's vertical coordination with USFWS and other governments to support the creation of the nation's first urban National Wildlife Refuge further supports that distinction, while creating an

example of the success that may occur from mitigating socio-institutional or socio-political barriers in policy adoption.

While the Sherwood case does present a model for communities interested in pursuing green infrastructure, there are important limitations. Twenty-five years after the designation of the Refuge and Sherwood's acquisition of floodplain properties, I was not able to find key informants that may have provided a contrarian view of Sherwood's approach. Further, the focus on community identity, exemplified in Sherwood, may not be the only pathway to becoming a green wolf in policy process for adopting flood hazard and floodplain management strategies. While previous research has found community identity to be a potent influence in adopting policies to protect floodplains and open space (Kline 2006; Swim, Zawadzki, Cundiff, and Lord 2014), additional models may also be possible. In-depth research addressing other internal determinants of floodplain policy may provide other motivations, and contrast with other approaches based on regional diffusion of policy innovations can further enhance our understanding of policy processes for green infrastructure adoption.

Conclusion

My research clearly articulates how one community fits the distinction as a green wolf—a community that innovatively leveraged horizontal and vertical governance coordination to protect green infrastructure and a distinct community identity. While open space preservation is not new, this is a novel case of the culmination of social motivations, community engagement, and agency cooperation to achieve a unique outcome for floodplain management and flood hazard mitigation. While novel, there are strategies that can be applied in other municipalities: the importance of community education, engagement, and

local leadership, as well as the importance of agency cooperation. Further, Sherwood leveraged a regulatory requirement—Oregon state land use planning and open space protection requirements—to meet their own internal goals focused on maintaining a distinct community identity in the midst of a growing metropolitan region.

Dissertation Conclusion

This research applies policy analysis to flood hazard and floodplain management, creating a framework that is used to inform several case study analyses, as well as a key informant questionnaire of floodplain administrators. Much of the policy for flood hazard and floodplain management occurs at the federal level, via Flood Control Acts, the National Flood Insurance Program, and the Clean Water Act. However, communities are the locus of practice for managing floodplain and flood hazard. Focusing on communities in Oregon allowed me to evaluate management approaches across communities with diverse social, political, and environmental contexts that are still functioning within the same federal and state regulatory environment.

My research framework focused on two interacting dimensions of flood hazard and floodplain management: policy innovation and adoption, and infrastructure. I first explore policy research on the adoption of policy using two complementary models, the internal determinants and regional diffusion models. The internal determinants model, what I came to call the lone wolf model, describes a community that innovates a policy to meet a specific internal need. The regional diffusion model, or copycat model, describes a community that treats other communities as policy laboratories, adopting innovative policy that has been applied in other municipalities before diffusing through policy networks to other municipalities. One of the crucial policies in flood hazard and floodplain management is the type of infrastructure that will be used to not only mitigate flooding, but to meet other community objectives, as well as regulatory requirements. I was therefore able to apply the lone wolf and copycat models to the adoption of a relatively innovative policy—green infrastructure development (Figure 2). This framework allowed me to develop several

models of flood hazard and floodplain management approaches. This includes a gray copycat that continues to rely on gray infrastructure for flood control, as a result of historical legacy from extensive engineering by the USACE; a green copycat that chose to adopt green infrastructure after observing the successful implementation elsewhere; a gray wolf that required innovation to manage its gray infrastructure; and a green wolf that adopted green infrastructure as means of maintaining community identity.

I used this framework in Chapter One to investigate four Oregon communities that I considered as examples of these four models, including Eugene (gray copycat), Prineville (green copycat), Milton-Freewater (gray wolf), and Sherwood (green wolf). I used case study analysis to apply this framework and develop propositions about the rationale driving communities to pursue different management approaches. Briefly, I proposed that while a historical legacy can constrain future policy decisions (Proposition 1), a community may be able to circumvent such a historical legacy to adopt more green infrastructure (Proposition 2). I also proposed that different goals such as meeting regulatory requirements and improving economic competitiveness can complement floodplain protection (Proposition 3). I further proposed that adopting green infrastructure policy is likely to involve a social rationale (e.g., desire to protect a distinct community identity) in addition to water resource management objectives (Proposition 4). My final proposition connected directly back to my research framework, positing that a community can be a lone wolf and a copycat within the same policy process (Proposition 5). Using this conceptual framework grounded and focused my research, creating the structure to focus my analysis on those characteristics that create these archetypes, whether it's a gray or green, copycat or wolf. What I discovered from these case studies was that the policy processes were not only complex, but were frequently

addressing needs and objectives I had not initially accounted for, such as community identity or regulatory relief.

I used what I learned in the first chapter—especially the discovery of those more nuanced objectives—to operationalize my research framework with a key informant questionnaire of floodplain administrators across the state. This questionnaire allowed me to collect data from over 100 communities, evaluating the role not only of managerial and internal community characteristics, but also regional diffusion characteristics, on the adoption of green infrastructure for flood hazard and floodplain management. My findings indicated that administrators that reported being knowledgeable about flood mitigation infrastructure, that had professional experience with flooding, and talked more frequently to other floodplain administrators often worked in communities with a more diverse suite of green infrastructure. Furthermore, while many of these communities were urban—a common finding in the policy adoption literature—this was not a universal trend; there were numerous urban communities that were using very little green infrastructure and some rural communities that used more green infrastructure than expected. This indicates that while urbanization may strongly correlate with the adoption and implementation of innovative policy like green infrastructure, there are other factors to consider, such as managerial or organizational attributes. I evaluated other factors (e.g., knowledge of flood mitigation infrastructure) and their relationship with the adoption of green infrastructure using spatial analysis—a straightforward way of identifying regional diffusion amongst neighbors—but there were no clear spatial trends that would serve to describe the mechanisms of regional diffusion. My research does, however, serve to expand the literature on green infrastructure,

which in regulation is often described solely in terms of stormwater management because of the nonpoint source amendments to the CWA.

After developing my conceptual framework and propositions, which I then operationalized with the key informant questionnaire, I focused on one community to explore what drove it to adopt a substantial green infrastructure approach to flood hazard and floodplain management nearly three decades ago without other examples to look towards and earn itself the distinction of a green wolf. The final chapter used an in-depth case study method to understand what drove the internal determinants model within this community. The City of Sherwood was indicative of a green wolf because of its early adoption of policies that protected extensive natural areas, including floodplains, wetlands, and greenways. While focused on these riparian areas and floodplains, flood mitigation was not the sole or primary motivating objective of these policies—instead the motivation was to maintain a unique community identity. The internal determinants model describes a community that develops a policy to meet a specific internal objective—whether it is economic, environmental, or social. As a lone wolf, Sherwood was developing policy to protect natural assets and environmental amenities to meet other social objectives. Furthermore, it was not only the community itself that could be considered a lone wolf—an individual was critical. In this case, a now retired city planner drove the political will and leadership to implement these policies, and successfully collaborate with a federal agency and other governments to support the development of the first urban national wildlife refuge in the country. The desire of Sherwood to differentiate itself from its neighboring communities—including a physical separation with open space and floodplains—complemented the

needs of the USFWS to collaborate with a local community to create the first urban wildlife refuge.

I began with a precise research framework to define what type of infrastructure was being used for flood hazard and floodplain management, and how that policy was being innovated, diffused, and adopted. I quickly learned that not only is this a more complex endeavor than I had envisioned, but that there was also more ambiguity in the policy process than I had envisioned. Because my research methods such as interview and survey questions were based on this precise conception of floodplain management, policy adoption, and infrastructure, the data I collected sometimes failed to explain the complexities I uncovered. Future research incorporating more explicit exploration of policy objectives and implementation would allow for more stable hypothesis testing in understanding policy.

A final note on a limitation and contribution of this research: while I take care to differentiate between green infrastructure for stormwater management and for flood hazard and floodplain management, this differentiation is sometimes watered down. Regardless of function, green infrastructure includes vegetation and attempts to mimic natural hydrology. However, regulatory requirements are substantially different, as is the scale of these infrastructures. While community objectives (e.g., community identity preservation or improved water quality) may drive many different scales of green infrastructure adoption, space may constrain their use. In the questionnaire, while numerous scales and functions of green infrastructure are included, my analysis aggregated them together. Disaggregating these scales and functions would allow me to more precisely determine what drives a community to adopt green infrastructure for flood hazard and floodplain management versus for stormwater management. Nevertheless, to the best of my knowledge, this is some of the first

research that specifically applies the internal determinants and regional diffusion models to policy for floodplain management and flood mitigation.

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Appendix A: Survey Summary Report

Executive Summary

Flood hazard and floodplain management is a critical governance issue, as communities address increasing flood risks in many areas and attempt to meet numerous objectives in their decision making. The National Flood Insurance Program dictates many of these regulatory requirements, which are often balanced against goals for improved water quality, fish and wildlife habitat, economic development, and recreational opportunities. Communities adopt policies and infrastructure that best help them meet these objectives.

To explore the decision making that goes into meeting these goals, we administered a survey to designated floodplain administrators throughout Oregon. This survey asked about the types of policy, planning, and infrastructures being used in communities, and what goals were being prioritized in decision making. As of January 2018, we received 107 complete responses, yielding a 48% response rate. Most survey respondents were 50-64 years old and have a bachelor's or master's degree. The average amount of time in their current position was approximately six years, and the majority had no previous experience as a floodplain administrator.

There was a clear trend in many responses correlating with the size of the community, such as types of infrastructure used, prioritization of management objectives, and attitudes toward infrastructures. Fifty percent or more of all respondents said that green infrastructure is a necessary component of managing floodplains and flood hazard and will likely be used more in the future.

Key Findings

- Many communities reported having more federal flood disaster declarations than 100-year floods during their tenure.
- The use of both gray and green infrastructure increased with the size of the community, but the majority of communities rely more on green infrastructure for stormwater or floodplain management.
- The two most important benefits from flood hazard and floodplain management were flood control and water quality improvement.
- Fish and wildlife habitat was ranked higher than economic development as a potential benefit of flood hazard and floodplain management.
- Gray infrastructure ranks higher for effectively reducing flood risk.
- More communities, regardless of size, agreed that green infrastructure is more likely to be used in the future than gray infrastructure.
- Increased capacity and education were cited most as necessary for improved flood hazard and floodplain management (e.g., increased staff levels, updated Flood Insurance Rate Maps, and adoption of flood management plans).

“The question ‘are you prepared for a 100-year flood’ - I feel we are but I answered ‘somewhat’ because no flood is the same so there is always something new to understand and our floods are happening so rarely.... We are understaffed to manage this alone.”

– Survey Respondent

Section One: Introduction

Flooding is a concern for the entire state of Oregon. There has been substantial flooding every decade since the mid-1800s (Oregon Department of Land Conservation and Development 2015). Every county in Oregon has at least two flood-prone communities, with several counties—Clackamas, Linn, Marion, and Washington—having fifteen or more flood-prone communities (Federal Emergency Management Agency 2018a).

Each of these communities is tasked with managing flood hazard and floodplains. As part of its land use planning, Oregon has adopted nineteen statewide planning goals; one of these, Goal 7, *Areas Subject to Natural Hazards*, requires that local governments adopt comprehensive plans to reduce the risk from natural hazards (Oregon Department of Land Conservation and Development 2001). At the federal level, the Clean Water Act regulates water quality and fill and discharge from floodplain areas. Moreover, for most people, flood insurance is available only through the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA). To be a part of the NFIP, FEMA requires a community to meet several standards for management and development of the floodplain, making the NFIP one of the biggest drivers of flood hazard and floodplain management decisions in local government.

In a river and floodplain system, there are myriad assets and values that a community might be interested in protecting and enhancing: flood mitigation; water quality; economic development; recreation; transportation and navigation; open space, aesthetic, and natural heritage values; fish and wildlife habitat; and clean drinking water. These (potential) priorities and regulatory framework create numerous opportunities for a community to decide on its priorities and objectives, and how it is going to meet them.

This report is the result of a survey administered to designated floodplain administrators in flood-prone communities across the state (Figure 2). To be part of the NFIP, FEMA requires a community to have a ‘designated floodplain administrator’ to serve as the point of contact; frequently this role is part of the job duties of a planner, but it may be designated to anyone (e.g., another person or department in the local government, county government, or a contractor). We were interested in how communities prioritize objectives and adopt infrastructure and policy to both meet those objectives and meet regulatory requirements.

Section Two: Understanding This Report

Oregon has 241 incorporated communities (Figure A-1); FEMA considers 223 of these communities prone to flooding, and 212 of those communities are part of the National Flood Insurance Program (NFIP) (Figure A-2). FEMA requires that a community have a point of contact, or designated floodplain administrator, to be part of the NFIP. We contacted these designated floodplain administrators, requesting that they take a floodplain infrastructure survey. We received 107 responses, which are summarized in this report (Figure A-3).

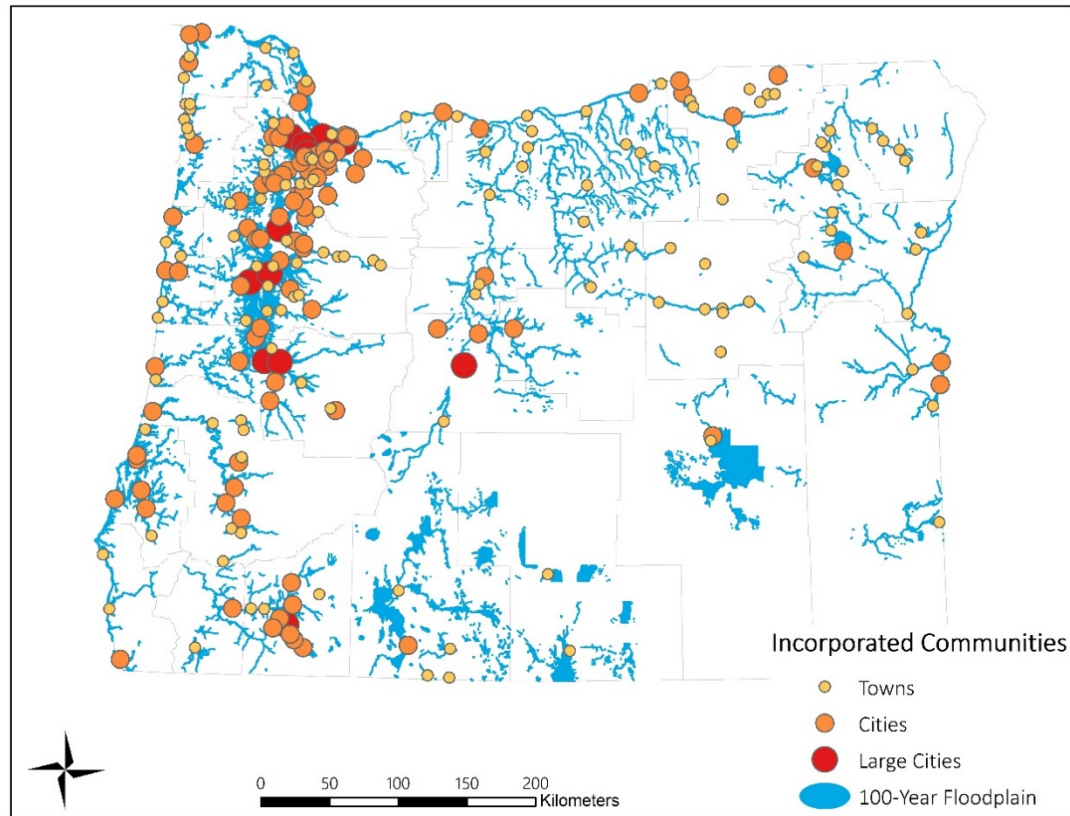


Figure A-1. Incorporated communities in Oregon, categorized population size into towns, cities, and large cities.

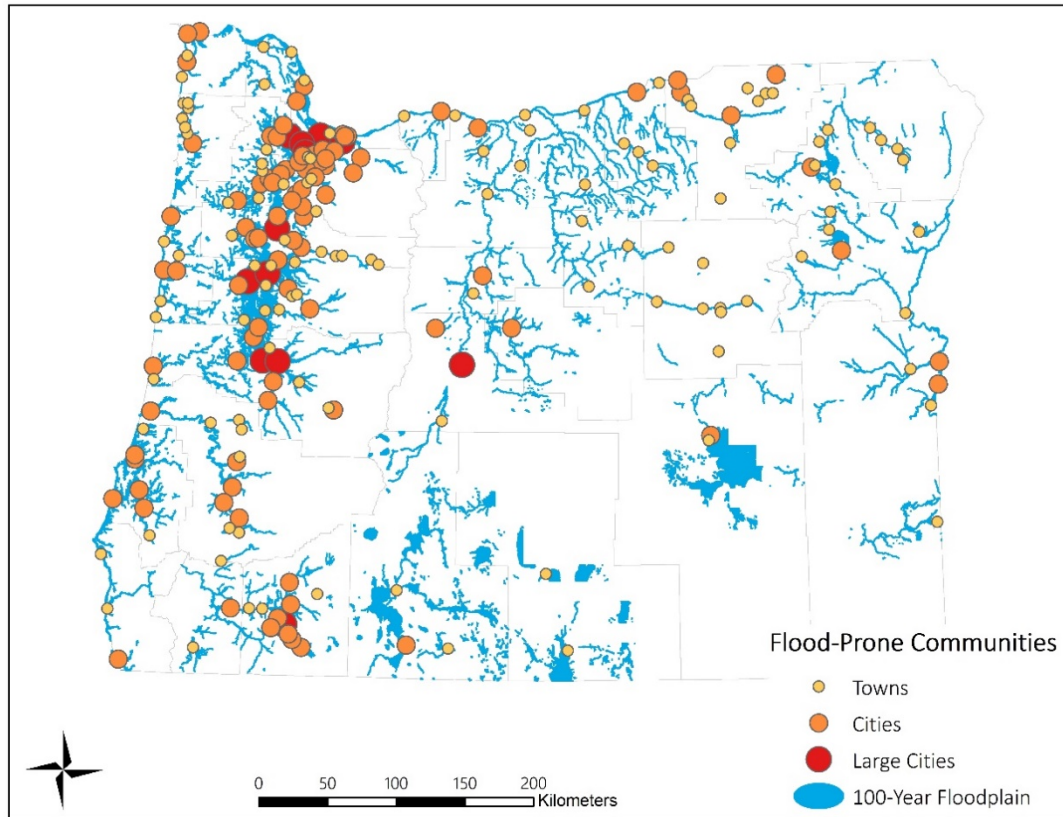


Figure A-2. Flood-prone incorporated communities in Oregon, categorized by population size into towns, cities, and large cities.

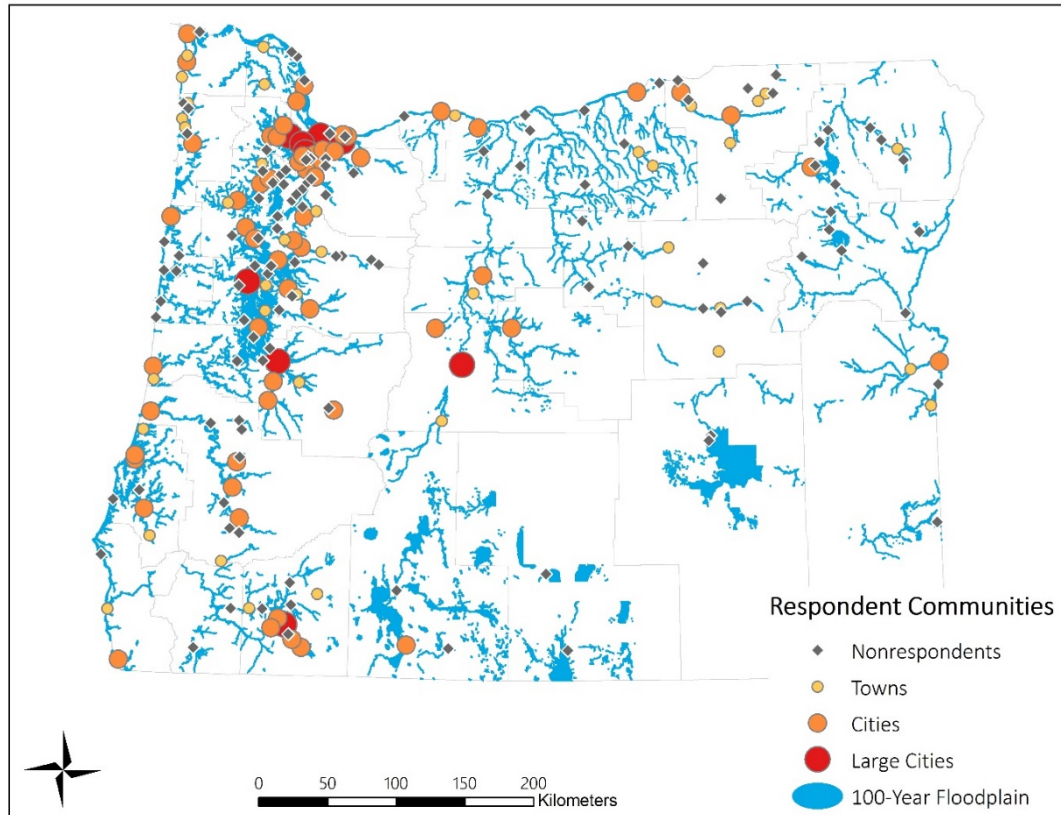


Figure A-3. Communities of survey respondents, categorized population size into towns, cities, and large cities.

For each question, the responses are separated into three groups based on the U.S. Census Bureau's definitions of urban and rural (2015):

1. Town: Communities with a population less than 2,500 people
There are 39 towns represented in this report.
2. City: Communities with populations between 2,500 and 50,000 people
There are 59 cities represented in this report.
3. Large City: Communities of 50,000 people or more
There are nine large cities represented in this report.

Comparing the number of respondents from these groups to the number of these communities in Oregon illustrates that the data are skewed toward larger communities (Figure A-4).

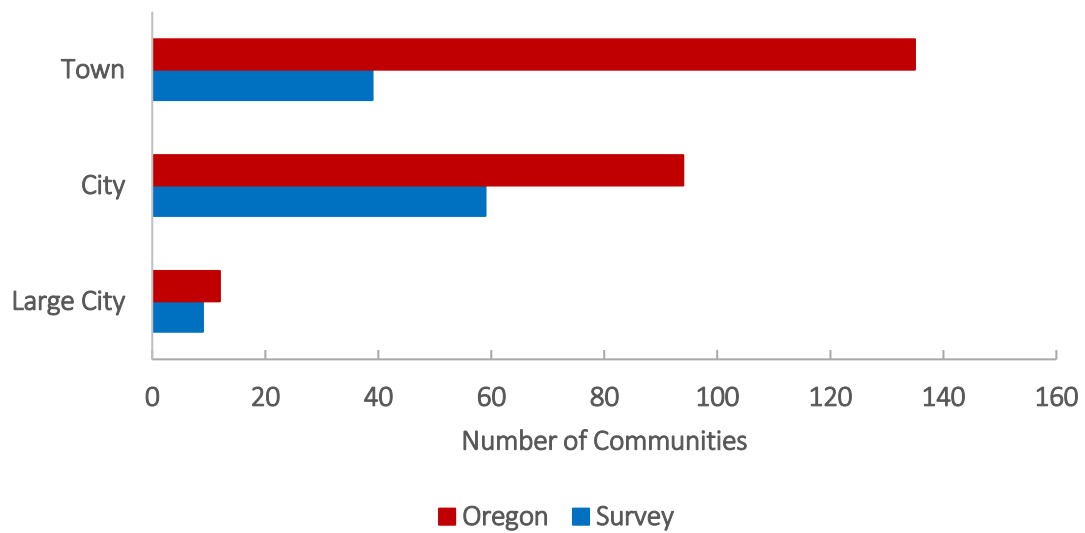


Figure A-4. The number of towns, cities, and large cities that responded to the survey compared to the total number of each in the state of Oregon. A higher proportion of cities and large cities replied to the survey than towns.

Frequently Used Abbreviations

Abbreviation	Meaning
BiOp	NOAA Biological Opinion on the Endangered Species Act and the National Flood Insurance Program
DLCD	Oregon Department of Land Conservation and Development
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
NFIP	National Flood Insurance Program

Section Three: Respondent Background

This section summarizes some basic characteristics of survey respondents such as demographic information (e.g., level of education and age), professional memberships and certification, and experience with flood hazard and floodplain management.

Position and Experience

Designated Floodplain Administrator

To participate in the NFIP, FEMA requires a community to have a designated floodplain administrator to function as a point of contact. Across all community sizes, most respondents identified themselves as the designated floodplain administrator. (79% in towns, 81% in cities, and 67% in large Cities). (n = 106, question 3)

Position Tenure

The number of years in the current position ranged from less than a year to almost 40 years. For all communities, though, the average amount of time in the position was between six and seven years, and the median time was four years. (n = 99, question 5)

Experience

A minority of respondents previously worked as a floodplain administrator in another community: 15% from a town, 32% from a city, and none from a large city. (n = 107, question 6)

Floodplain Manager Certification

The primary professional organization for municipal floodplain managers, the Association of State Floodplain Managers, provides professional certification to floodplain managers that recognizes professional development and continuing education in floodplain management. Fifteen percent of respondents reported being certified floodplain managers, and as population size increases, so does floodplain management certification. (Question 7)

- Town: 8% (n = 38)
- City: 18% (n = 57)
- Large city: 33% (n = 9)

Professional Membership

Like floodplain management certification, the likelihood of membership in a professional organization such as the Association of State Floodplain Managers or its regional branch, the Northwest Regional Floodplain Management Association, increased with the size of the city, with 21% of all respondents holding professional membership. (Question 8)

- Town: 15% (n = 39)
- City: 22% (n = 59)
- Large City: 44% (n = 9)

Education

All respondents completed high school, with most respondents in larger communities possessing a bachelor's or master's degree (Table A-1). (n = 107, question 9)

Table A-1. Highest level of education attained by respondents.

	Town (n = 39)	City (n = 59)	Large City (n = 9)	All
High school diploma	23%	9%	0%	13%
Associate degree	28%	2%	0%	11%
Bachelor degree	21%	56%	33%	41%
Master degree	28%	34%	67%	35%

Age

Respondents range from 25 to over 65 years in age, with most in the smaller communities between 50-64 years old (Table A-2). (n = 107, question 10)

Table A-2. Age ranges of respondents.

Age	Town (n = 39)	City (n = 59)	Large City (n = 9)	All
25 – 34	8%	14%	0%	10%
35 – 49	26%	37%	56%	35%
50 – 64	62%	44%	44%	51%
65 or older	5%	5%	0%	5%

Political Tendency

Most respondents identified as politically moderate (41%), with 21% identifying as conservative and 38% identifying as liberal (Table A-3). (n = 95, question 43)

Table A-3. Political tendency of respondents.

Political Tendency	Town (n = 29)	City (n = 57)	Large City (n = 9)	All
Liberal	38%	33%	67%	38%
Moderate	41%	44%	22%	41%
Conservative	21%	23%	11%	21%

Participation and Knowledge

Flood Hazard and Floodplain Management Activities

There are several activities a floodplain manager may participate in as part of their duties. There are several activities that the majority of respondents participated in (e.g., managing comprehensive planning, hazard mitigation or emergency management planning, and managing stormwater). Other activities respondents were more likely to participate in if they were in cities (e.g., preserving streams, wetlands, or floodplains), or large cities (e.g., restoring streams, wetlands, or floodplains) (Table A-4, Figure A-5). (Question 11)

Table A-4. Flood hazard and floodplain management activities respondents have participated in. Number of responses, n, is indicated in parentheses.

Activities	Town (n = 33 ⁺)	City (n = 56)	Large City (n = 9)	All
Manage comprehensive planning	85%	89%	78%	87%
Hazard mitigation or emergency management planning	76%	75%	89%	77%
Preserving streams, wetlands, or floodplains	46%	75%	78%	65%
Managing stormwater	53%	61%	89%	61%
Restoring streams, wetlands, or floodplains	18%	30%	78%	31%

⁺n = 34 for managing stormwater.

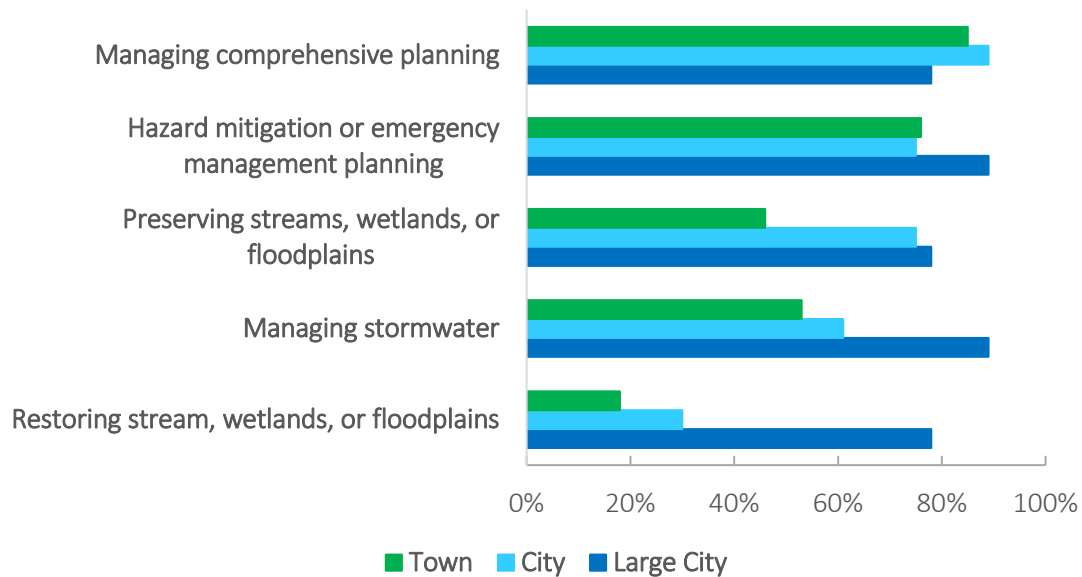


Figure A-5. The flood hazard and floodplain management activities respondents reported participating in.

Flood Hazard and Floodplain Management Knowledge

Managing flood hazard and floodplains requires several areas of knowledge. The majority of respondents reported feeling very or extremely knowledgeable about zoning, but results for other aspects of flood hazard and floodplain management were extremely varied:

respondents in towns and large cities were more knowledgeable about flood mitigation infrastructure and the NFIP biological opinion, while those from cities reported being more knowledgeable about the NFIP itself (Table A-5, Figure A-6). (Question 12)

Table A-5. The percentage of respondents who reported being very or extremely knowledgeable on several aspects of flood hazard and floodplain management.

	Town (n = 39)	City (n = 58 [†])	Large City (n = 9)	All
Zoning	67%	90%	78%	80%
Flooding in your community	46%	74%	78%	64%
National Flood Insurance Program (NFIP)	26%	54%	33%	42%
Flood mitigation infrastructure	44%	28%	33%	20%
NOAA Fisheries Biological Opinion on the National Flood Insurance Program	36%	19%	56%	18%

[†]n = 59 for National Flood Insurance Program (NFIP) and Zoning.

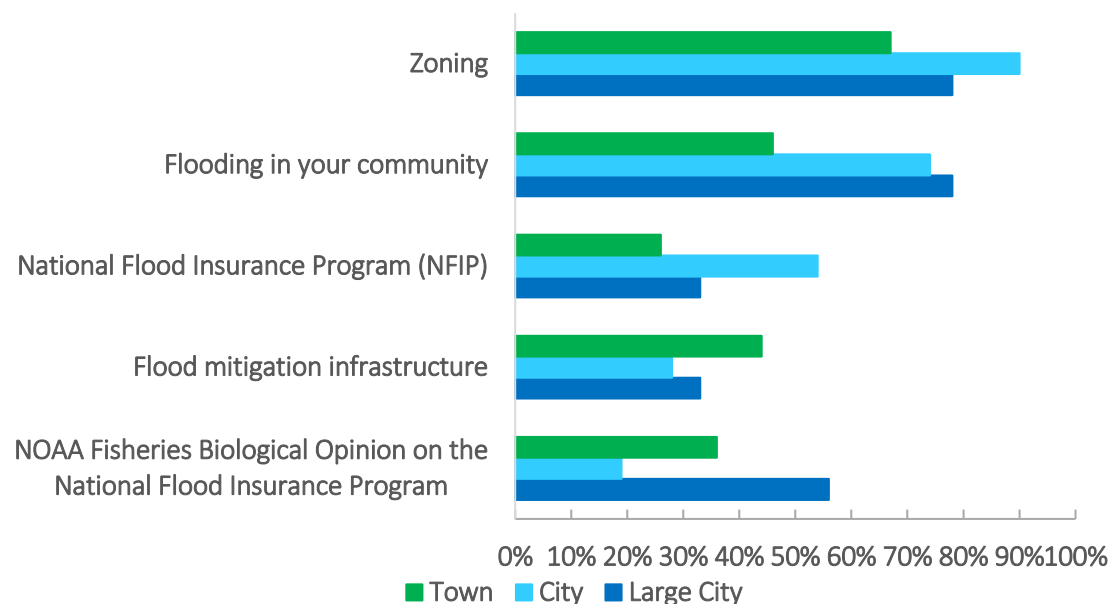


Figure A-6. Areas of flood hazard and floodplain management for which respondents reported being very or extremely knowledgeable.

Section Four: Community History and Experience with Flooding

In this section, we asked people about their experience with flood events in their community: nuisance flooding, 100-year floods, and federal flood disaster declarations. Nuisance flooding is typically reported in a two-year period, and most often using water years, so we asked about the frequency of nuisance flooding between 2014 and 2016. The questions related to 100-year flood events and federal flood disaster declarations were asked in terms of the respondent's tenure in their current position to facilitate recall.

Nuisance Flooding

Nuisance flooding is defined as small events that cause road closures, overwhelmed storm drains, and infrastructure deterioration, such as seen on bridges or roads. Over a two-year period (October 2014 – September 2016), most communities reported a small number of events, but only cities reported have more than ten nuisance flood events (Table A-6, Figure A-7). (Question 14)

Table A-6. The number of nuisance floods communities reported over a two-year period.

Number of Nuisance Flood Events (October 2014 – September 2016)	Town (n = 39)	City (n = 58)	Large City (n = 8)	All
0	46%	28%	0%	32%
1-5	49%	60%	75%	57%
6-10	5%	5%	13%	6%
More than 10	0%	7%	13%	5%

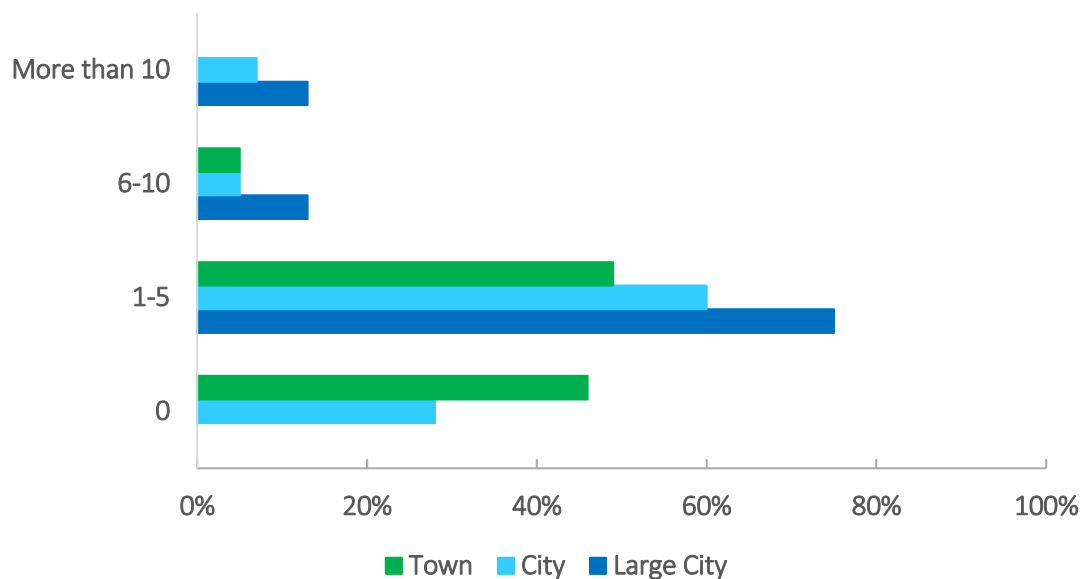


Figure A-7. The number of nuisance floods between October 2014 – September 2016 respondents reported.

100-Year Floods

A 100-year flood is a relatively rare flood event. It is also known as a base flood or a one-percent flood because it has a one percent chance of being equaled or exceeded during any

given year; most flood hazard planning is based on the extent of the 100-year flood. The majority of respondents have not experienced a 100-year flood in their current position (Table A-7, Figure A-8). (Question 15)

Table A-7. The percentage of 100-year floods reported during the respondents' tenure as floodplain administrator for their community.

Number of 100-Year Floods	Town (n = 35)	City (n = 55)	Large City (n = 9)	All
0	80%	80%	89%	81%
1	11%	9%	11%	10%
More than 1	9%	11%	0%	9%

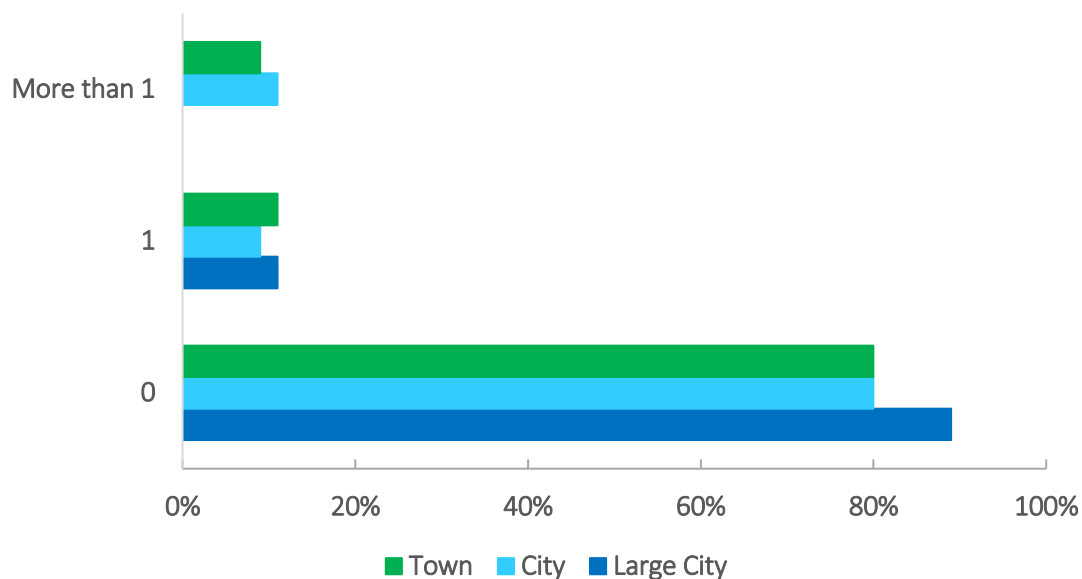


Figure A-8. The number of 100-year floods respondents have experienced during their tenure.

For the respondents who have not experienced a 100-year flood during their tenure, we asked if they knew when the last one occurred; 40% of respondents from towns, 68% of respondents from cities, and 44% of respondents from large cities had an estimated year of the last occurrence. (n = 94, question 16)

Respondents then reported when the most recent 100-year flood occurred; responses ranged from the late 1800s to 2016, with two years, 1964 and 1996, being the most prevalent (Table A-8). (n = 50)

- In December 1964, severe flooding across northern California, Oregon, and western Idaho killed almost 50 people, displaced thousands, and caused approximately 2014\$4 billion in damage (U.S. Geological Survey 2014).
- In 1996, there was extensive flooding in western Oregon: 26 rivers flooded and federal flood disasters were declared in eighteen counties. Eight people died and thousands were displaced (Rose February 5, 2016).

Table A-8. The year of the most recent known 100-year flood, as reported by respondents.

Years	Town (n = 14)	City (n = 32)	Large City (n = 4)	All
~1880 – 1962	29%	6%	0%	12%
1964	14%	19%	25%	18%
1965 – 1986	14%	9%	0%	10%
1996	29%	53%	50%	46%
1997 – 2016	14%	13%	25%	14%

Federal Flood Disaster Declarations

A federal flood disaster is declared by the President following a request by a state governor. A flood is declared a federal disaster when its severity is beyond the combined capabilities of state and local governments to respond. A federal flood disaster declaration provides a wide range of federal assistance programs for individuals and public infrastructure, including funds for both emergency and permanent work. The majority of respondents have not had a federal flood disaster declared while in their position. However, the proportion of respondents from towns and large cities that reported having more federal flood disasters declared while in their position is higher than those who experienced a 100-year flood in the same time period, indicating that a disaster may be declared for less than a 100-year flood. Large cities have experienced more federal flood declarations than 100-year floods (Table A-9, Figure A-9). (n = 98, question 17)

Table 9. The percentage of federal flood disaster declarations reported during the respondents' tenure as floodplain administrator for their community.

Number of Federal Flood Disaster Declarations	Town (n = 34)	City (n = 56)	Large City (n = 9)	All
0	77%	89%	67%	83%
1	18%	7%	22%	12%
More than 1	6%	4%	11%	5%

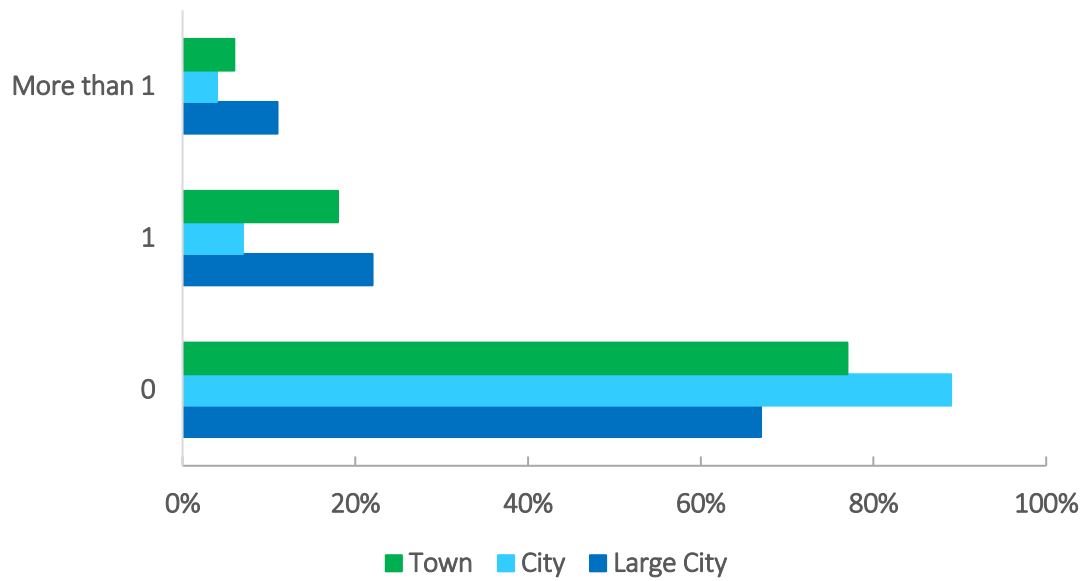


Figure A-9. The number of federal flood disaster declarations reported during respondents' tenure.

For the respondents who have not experienced a federal flood disaster declared during their tenure, we asked if they knew when the last one occurred; 29% of respondents from towns, 32% of respondents from cities, and 14% of respondents from large cities had an estimated year of the last occurrence (Table A-10). (n = 94)

When asked what year the most recent federal flood disaster was declared, the years ranged from 1964 to 2015, with the most declarations occurring during 1996. (n = 25)

Table A-10. The year of the most recent federal flood declaration as reported by respondents.

Years	Town (n = 9)	City (n = 15)	Large City (n = 1)	All
1964 – 1976	11%	20%	0%	16%
1996	33%	33%	0%	32%
1997 – 2015	56%	47%	100%	52%

Section Five: Community Flood Hazard and Floodplain Policy Development

In this section we asked respondents about their sources of information for flood hazard and floodplain management, including the degree of interaction with other communities for information gathering or collaboration. Respondents in towns were slightly more likely to talk to representatives from other communities every few months than those from larger communities. However, respondents from large cities reported talking to other people three times as much as those from smaller communities. This may be correlated with the number of intergovernmental agreements (IGAs): large cities again reported having more than 1 IGA three times more often than smaller communities.

Sources of Information

The majority of communities, regardless of size, reference several pieces of information they rely on for flood hazard and floodplain management, with over half of small and large cities (71% and 78%, respectively) naming three sources of information that are important. The most important sources of information listed include a document, an organization, and a person; to a lesser extent, other communities were also listed (Table A-11). (Question 20)

Table A-11. Number of sources communities cite as important in flood hazard and floodplain management.

	Town (n = 39)	City (n = 59)	Large City (n = 9)	All
Communities listing no sources	26%	10%	26%	14%
Communities listing only one source	8%	7%	14%	8%
Communities listing only two sources	11%	0%	11%	18%
Communities listing three sources	26%	10%	26%	60%

There were four sources of information that were cited repeatedly as important to a community's management efforts:

- Flood Insurance Rate Maps
- Federal Emergency Management Agency
- Oregon Department of Land Conservation and Development
- National Flood Insurance Program Coordinator at Oregon Department of Land Conservation and Development

Flood Management Plans

Communities are not mandated to develop a flood management plan, but may choose to do so to improve management. Of those who responded to the question, smaller communities are more likely to have developed a flood management plan: Over half of towns have developed a plan (59%, n = 27), but less than half of cities (49%, n = 43) and large cities (43%, n = 7) have developed a flood management plan. The majority of these plans were written in the last ten years, but some plans were written in the early 1980s. (Question 23)

A small number of respondents reported reading other communities' flood management plans: eight percent of towns, 19% of cities, and 11% of large cities. The flood management plans of Portland and Salem were named most by respondents (three times and twice, respectively). (n = 106)

Talking to Other Communities

Most respondents reported talking to representatives from other communities about their approach to flood hazard and floodplain management less than once a year. Respondents in large cities talk to others more often; these respondents reported talking to others at least one a month over three times as much as smaller communities (Table A-12, Figure A-10). (n = 100, question 24)

Table A-12. The frequency respondents reported talking to representatives from other communities about their approach to flood hazard and floodplain management.

Frequency	Town (n = 34)	City (n = 57)	Large City (n = 9)	All
Less than once a year	44%	44%	44%	44%
Once a year	26%	26%	11%	25%
Every few months	26%	23%	22%	24%
Once a month or more	3%	7%	22%	7%

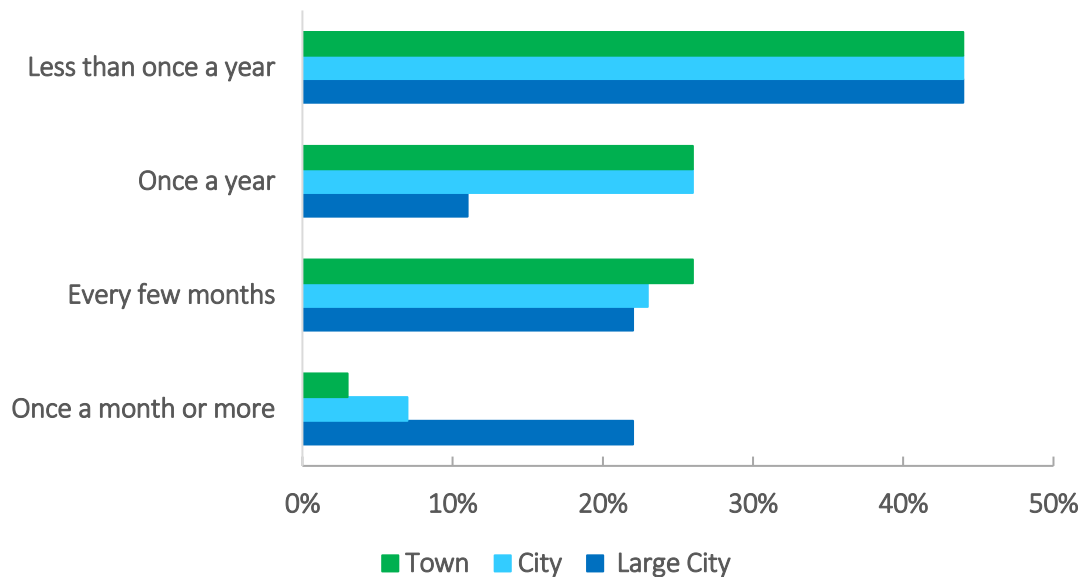


Figure A-10. The frequency respondents reported talking to representatives from other communities about their approach to flood hazard and floodplain management.

Intergovernmental Agreements

Communities often have intergovernmental agreements (IGAs) with different entities such as private companies, neighboring communities, or government agencies to support mandated activities. IGAs related to flood hazard and floodplain management activities are most commonly to provide services such as emergency assistance and equipment.

Approximately one-quarter of respondents (27%) were unsure if their community had IGAs related to flood hazard and floodplain management. Of the remaining responses, the majority reported not having these types of IGAs; if they did have an IGA, though, it was most often only one IGA (Table A-13). (n = 78, question 25)

Table A-13. Number of IGAs respondents reported. Some numbers don't total 100% because some respondents reported having IGAs but didn't provide information about how many.

Frequency	Town (n = 27)	City (n = 43)	Large City (n = 8)	All
No IGAs	56%	72%	50%	64%
Listed 1 IGA	33%	19%	25%	24%
Listed more than 1 IGA	7%	5%	25%	8%

Respondents were asked what entities their intergovernmental agreements (IGAs) for flood hazard and floodplain management were with, and the primary focus of those agreements. Twenty-six respondents provided these details, which were then categorized.

IGAs are primarily held with:

- City government
- County government
- FEMA
- Local business
- Regional government
- State government
- U.S. Army Corps of Engineers
- Utility company

The purposes of these IGAs are:

- Emergency management
- Emergency response
- Mutual aid
- Planning
- Stormwater management

Decision Making

There are numerous factors communities consider when making decisions about how to manage flood hazard and floodplains. Respondents reported the following factors as very or extremely important in decision making (Table A-14, Figure A-11). (Question 27)

Table A-14. The percentage of respondents who reported the following factors being very or extremely important in flood hazard and floodplain management decision making.

	Town (n = 34-36)	City (n = 55-57)	Large City (n = 9)	All
Risk reduction	89%	89%	78%	88%
Effectiveness	72%	89%	88%	86%
Cost effectiveness	78%	86%	89%	83%
Meeting regulatory requirements	72%	79%	100%	78%
Maintenance requirements	67%	78%	78%	74%
Minimize potential exposure to flooding (e.g., through zoning)	67%	74%	67%	70%
Providing multiple benefits	57%	60%	67%	59%
Project lifespan	60%	57%	44%	57%
Meeting environmental goals	50%	50%	67%	51%

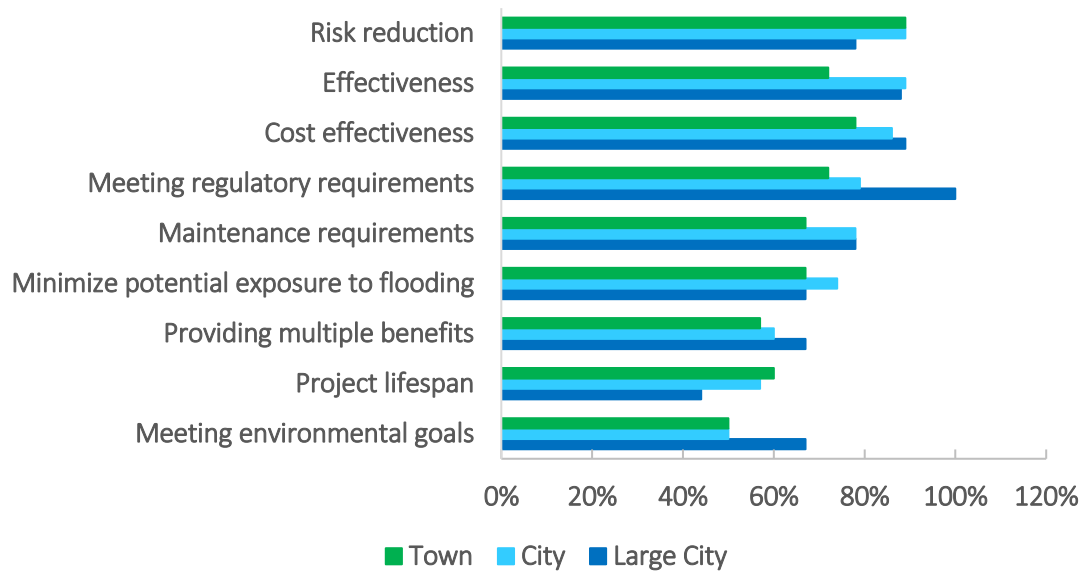


Figure A-11. The factors respondents reported as being very or extremely important in decision making.

Section Six: Community Infrastructure and Policy

This section consists of community inventories related to flood hazard and floodplain management, including infrastructures and different governance activities, including those for improved planning and preparation, risk reduction, increased education and public awareness, and emergency management.

Many of the governance activities are suggested by FEMA as methods for improving flood hazard and floodplain management beyond the requirements of the NFIP. Specifically, these activities allow a community to get credit from FEMA to be part of the Community Rating System, a voluntary program that provides discounts on insurance rates for participating communities.

Gray Infrastructure

Communities may use different types of gray, or built, infrastructure to manage flood hazards and floodplains. Dams outside of the geographic boundary of the community are the most prevalent gray infrastructure communities are relying on (Table A-15, Figure A-12). (Question 30)

Table A-15. The types of gray infrastructure respondents reported their communities using for flood hazard and floodplain management.

	Town (n = 35-36)	City (n = 53-56)	Large City (n = 9)	All
Dams outside the geographic boundary of your community	17%	34%	67%	31%
Levees	14%	20%	33%	19%
Built flood control channels	8%	23%	22%	17%
Weirs	3%	11%	22%	9%
Dams within the geographic boundary of your community	0%	11%	22%	8%

Green Infrastructure

Communities may use a range of green infrastructure for stormwater or floodplain management. Large cities use more green infrastructure than towns or cities (Table A-16, Figure A-12). (Question 31)

Table A-16. The types of green infrastructure respondents reported their communities using for stormwater or floodplain management.

	Town (n = 28-33)	City (n = 47-55)	Large City (n = 9)	All
Wetland or floodplain preservation	58%	79%	100%	74%
Vegetated detention basins	39%	77%	100%	67%
Vegetated bioswales	46%	71%	100%	65%
Stream or floodplain restoration	38%	66%	100%	60%
Natural flood control channels	32%	62%	75%	53%
Wetland creation	11%	34%	75%	30%

Green and Gray Infrastructure

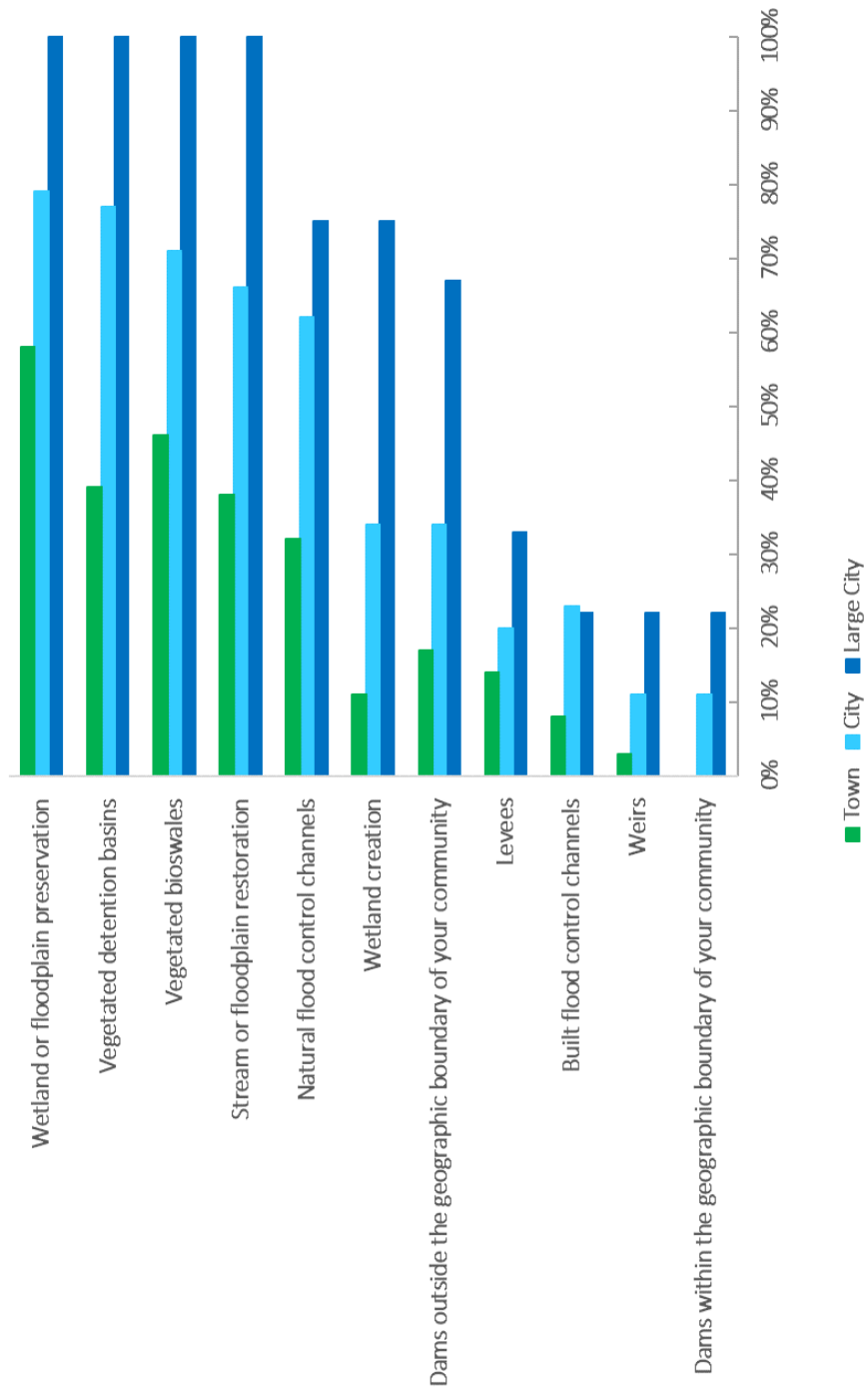


Figure A-12. The types of gray and green infrastructure communities are using for flood hazard and floodplain management.

Green / Gray Infrastructure Index

Frequently a community uses a mix of green and gray infrastructure to meet its objectives. To easily compare the amount and types of infrastructures being used, we created a green/gray index from the previous inventories (Table A-17):

- If a respondent answered yes for an item, it was scored 1; if a respondent answered no to an item, it was scored 0
- The scores for both green and gray infrastructure were added together and a one was added to each to prevent issues of dividing by zero
- The mean for each was calculated by dividing the green infrastructure score by six and the gray infrastructure score by five
- To create a ratio, the mean for green infrastructure was divided by the mean for gray infrastructure, as reported below

Table A-17. The minimum, median, mean, and maximum values for the green / gray infrastructure index.

Green / Gray Statistics	Town (n = 36)	City (n = 58)	Large City (n = 9)	All
Minimum	0.2	0.3	1.2	0.2
Median	1.7	2.0	2.5	1.9
Mean	2.0	2.4	2.4	2.3
Maximum	5.0	5.8	4.2	5.8

Planning and Preparation

There are numerous planning and preparation activities communities implement to manage flood hazards and floodplains. The most prevalent planning and preparation activities are the adoption of a stormwater management plan and maintaining elevation certificates for new construction in the floodplain (Table A-18, Figure A-13). (Question 32)

Table A-18. The planning activities respondents reported their communities using for flood hazard and floodplain management.

	Town (n = 29-35)	City (n = 50-59)	Large City (n = 8-9)	All
Maintained elevation certificates for new construction in the floodplain	60%	89%	100%	80%
Adopted a stormwater management plan	56%	85%	89%	75%
Adopted a floodplain management plan	45%	56%	44%	51%
Established a stream buffer code that exceeds county requirements	14%	28%	75%	28%
Required that currently vacant floodplain parcels will be kept free from development	21%	7%	0%	11%
Adopted a more restrictive mapping standard than the National Flood Insurance Program requirements	3%	15%	11%	10%

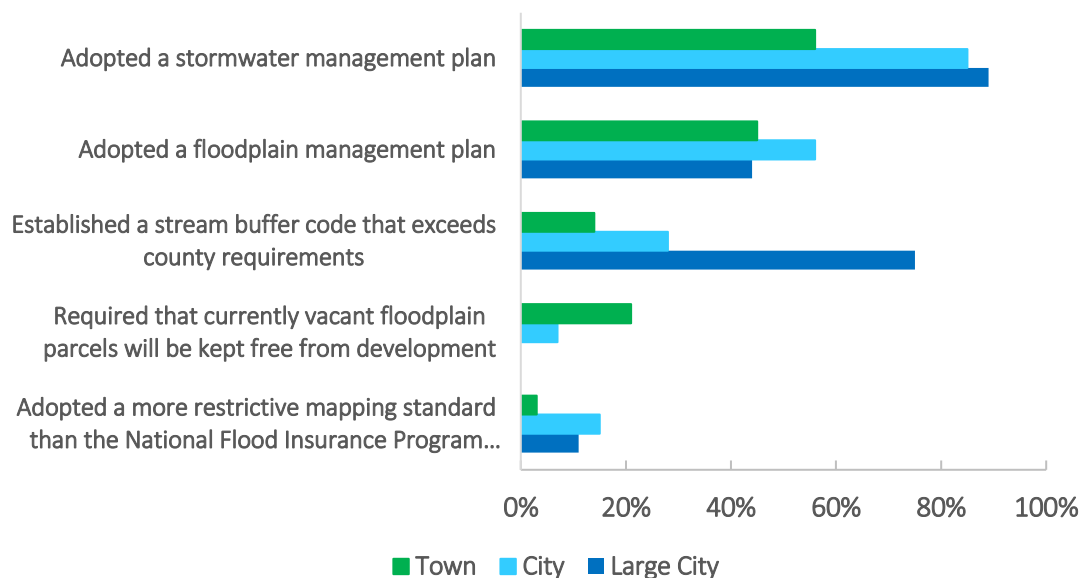


Figure A-13. The planning and preparation activities used by communities to address flood hazard and floodplain management.

Risk Reduction

There are several risk reduction activities a community may undertake. The majority of communities periodically remove debris from drainage systems and retentions basin, in addition to regulating new development for stormwater runoff and to minimize soil erosion and protect or improve water quality (Table A-19, Figure A-14). (Question 33)

Table A-19. The risk reduction activities respondents reported their communities using for flood hazard and floodplain management.

	Town (n = 29-35)	City (n = 48-55)	Large City (n = 9)	All
Regulated new development to ensure that post-development stormwater runoff is no worse than pre-development runoff	59%	94%	100%	82%
Regulated new construction to minimize soil erosion and protect or improve water quality	61%	91%	100%	82%
Periodically removed debris from all drainage systems and retention basins	71%	82%	89%	79%
Required compensatory storage in new developments in the floodplain	13%	40%	67%	33%
Prohibited any fill in the floodplain area	21%	22%	11%	20%
Acquired and/or relocated flood-prone buildings out of the floodplain	9%	15%	56%	16%

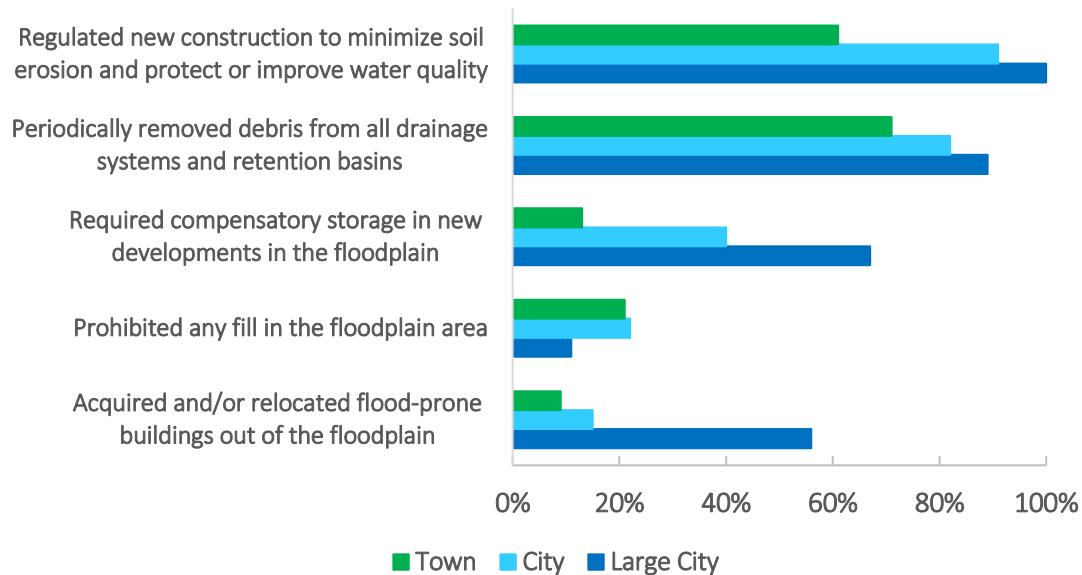


Figure A-14. Activities communities are pursuing to reduce flood hazard risk.

Education and Public Awareness

There are several things communities may do to increase education and public awareness about flood hazard and floodplain management. Most communities provide flood insurance rate maps to those who inquire and also communicate information to residents on flood hazard, flood insurance, or flood protection measures (Table A-20, Figure A-15). (Question 34)

Table A-20. Education and public awareness activities respondents reported their communities using for flood hazard and floodplain management.

	Town (n = 30-35)	City (n = 49-58)	Large City (n = 9)	All
Provide Flood Insurance Rate Maps (FIRMs) to people who inquire	70%	95%	100%	87%
Communicate information on flood hazard, flood insurance, or flood protection measures to residents	60%	82%	100%	76%
Provide technical assistance on protecting buildings to property owners who inquire	40%	76%	78%	63%
Communicate information on the natural and beneficial function of floodplains to residents	29%	63%	89%	54%
Maintain current information on flood insurance and flood protection on our website or at the public library	30%	55%	89%	50%

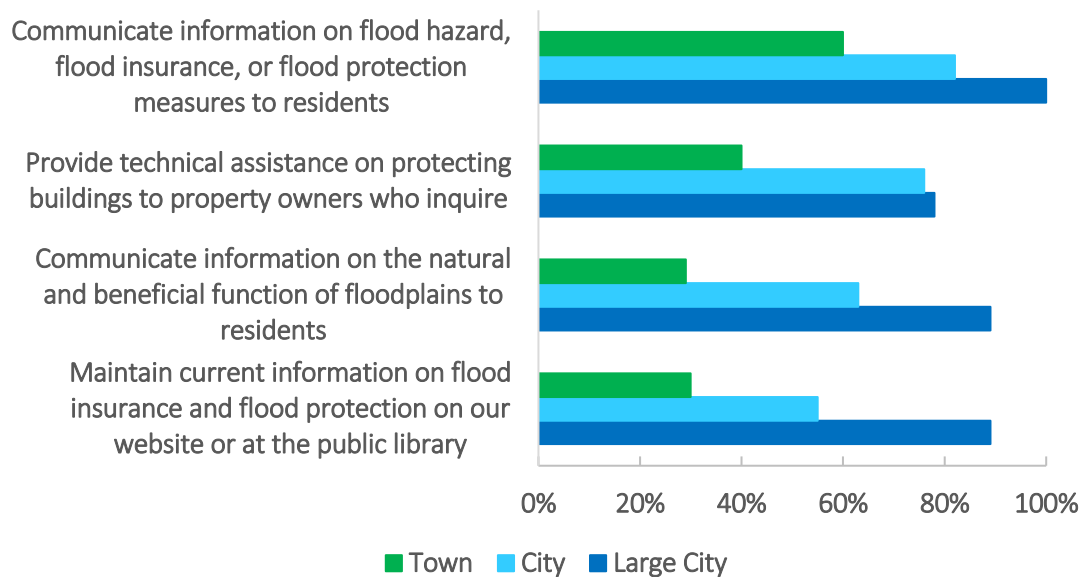


Figure A-15. Activities to increase education and public awareness about flood hazard and floodplain management.

Emergency Management Improvements

A community may implement several emergency management improvements for flood hazard. Providing early flood warning to the public was the most prevalent (Table A-21). (Question 35)

Table A-21. Emergency management improvements implemented for flood hazard.

	Town (n = 34)	City (n = 50, 53)	Large City (n = 6, 7)	All
Provide early flood warning to the public	27%	52%	50%	42%
Post signs in hazardous areas	21%	25%	29%	23%
Created a detailed flood response plan keyed to flood crest predictions	12%	22%	33%	19%

Preparedness

Many respondents felt their community was moderately prepared for a 100-year flood, and only a few respondents in cities felt their community was extremely prepared for a 100-year flood (Figure A-16). (n = 106, question 36)



Figure A-16. How prepared for a 100-year flood respondents reported feeling.

When asked what improvements the respondent feels are necessary for their community to better manage flood hazard and floodplains, there were similarities in many responses; the most common were:

- Education for council members, staff, and residents
- Updated Flood Insurance Rate Maps
- Increased staff levels
- Infrastructure improvements or removal (e.g., too small culverts)
- Adoption of flood management plans

Other responses included:

- “Move our town.”
- “Personal responsibility and common sense.... It’s frustrating when people KNOW they live in flood prone areas and still act surprised when the creeks rise during heavy rains.”
- “Cooperative and informed developers/home builders. The architecture and home builder community [have] no clue and continuously perform a disservice to their clients (the homeowners). They fail to inform their clients of the hazards and additional regulations related to (re)development in the [Special Flood Hazard Area], allowing for projects to reach the permitting stage, only to find out the projects don’t meet the regulatory requirements of floodplain development and must be redesigned. This creates a great financial burden upon the clients and make the community look heavy-handed and onerous.”

Section Seven: Beliefs and Attitudes About Flood Hazard and Floodplain Management

In this section, we asked respondents how they and their communities perceive the practices and consequences of flood hazard and floodplain management.

Flood Hazard and Floodplain Management Benefits

Respondents were asked to assign 100 total points to different benefits flood hazard and floodplain management can provide to a community. Respondents were able to assign as many or as few points as possible to each potential benefit, not to exceed 100 points overall. Overall, flood control and water quality improvement were scored the highest (Table A-22, Figure A-17). (Question 39)

Table A-22. The mean values of potential benefits as reported by respondents.

Potential Benefit	Town (n = 38)	City (n = 59)	Large City (n = 9)	All
Flood control	23	22	23	22
Water quality improvement	17	12	23	15
Fish and wildlife habitat	11	12	12	12
Economic development	10	12	6	11
Recreation	10	9	7	9
Education	8	9	6	8
Regulatory relief	7	9	7	8
Aesthetic and heritage values	6	6	5	6
Adaptation to the risks of climate variability and change	5	5	7	5
Community identity	5	5	5	5

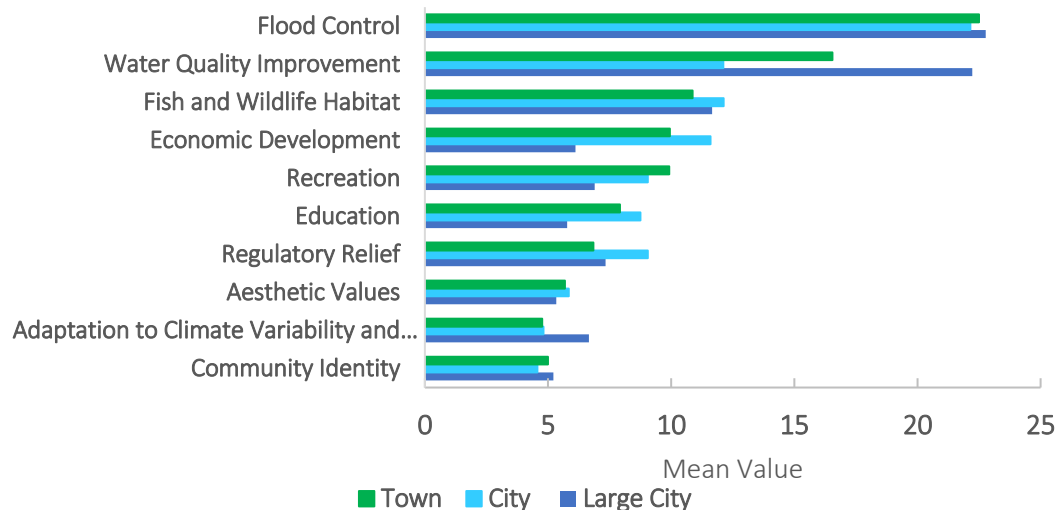


Figure A-17. Mean values for the potential benefits of flood hazard and floodplain management. Flood control, water quality improvement, and fish and wildlife habitat rank the highest for all three community sizes.

Green Infrastructure Beliefs

There are many factors that contribute to the decision-making process on the types of infrastructure to use, from its perceived efficacy to community response to future goals. Within this context, respondents reported either somewhat or strongly agreeing that in their community, green infrastructure effectively reduces flood risk and is a necessary component of managing floodplains and flood hazard (Table A-23, Figure A-18). (Question 40)

Table A-23. The percentage of respondents who reported somewhat or strongly agreeing with the following dimensions of green infrastructure use in their community.

	Town (n = 27-33)	City (n = 56 ⁺)	Large City (n = 9)	All
provides multiple benefits	45%	84%	100%	72%
will likely be used more in the future	50%	77%	89%	69%
effectively manages stormwater	45%	79%	89%	68%
is compatible with local environmental goals	44%	70%	89%	63%
is a necessary component of managing floodplains and flood hazard	50%	63%	100%	62%
effectively reduces flood risk	52%	64%	89%	62%
includes more than stormwater management facilities	45%	63%	78%	58%
is an important strategy for adapting to the risks of climate change and variability	44%	61%	88%	57%
is affordable	31%	52%	67%	46%
includes all vegetated spaces	38%	41%	56%	41%
is the best way to meet regulatory requirements	22%	45%	67%	39%
is designed to benefit salmon and other native fish	22%	44%	67%	39%
is valued by residents	38%	30%	56%	35%
is championed by local leaders	22%	34%	56%	32%
is easily maintained	19%	39%	11%	30%

⁺n = 48 for green infrastructure is designed to benefit salmon and other native fish.

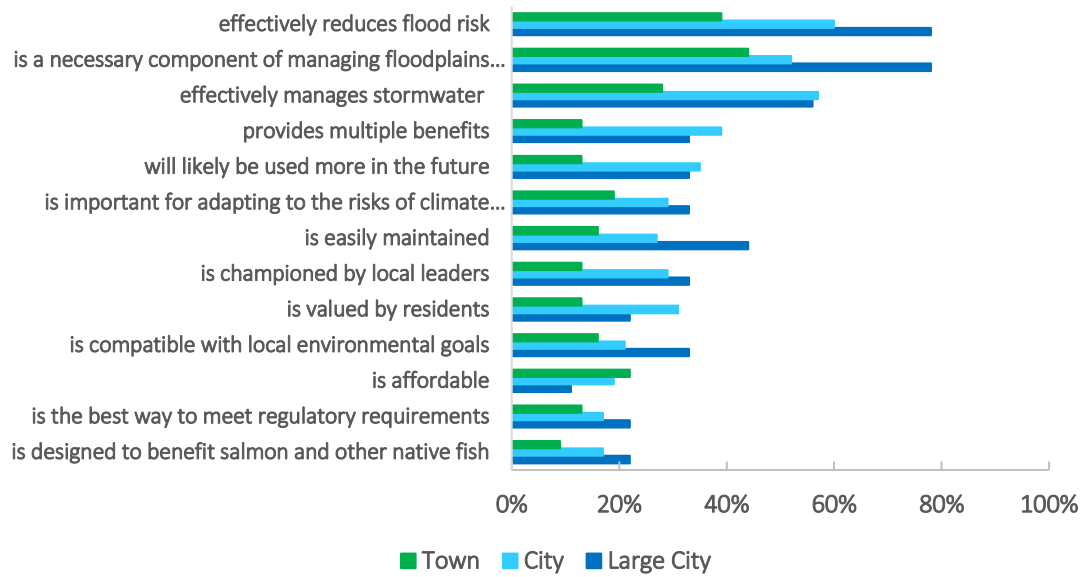


Figure A-18. The percentage of respondents reporting somewhat or strongly agreeing with statements about the use of green infrastructure in their community.

Gray Infrastructure Beliefs

Many of the same factors contribute to the decision to use gray infrastructure. Overall, respondents favored the use of green rather than gray infrastructure for its efficacy in managing stormwater and flood risk, amongst other items. However, large cities in particular still see gray infrastructure as an effective way of reducing flood risk and managing flood hazard and floodplains, albeit not to the extent described with green infrastructure (Table A-24, Figure A-19). (Question 41)

Table A-24. The percentage of respondents who reported somewhat or strongly agreeing with the following dimensions of gray infrastructure use in their community.

	Town (n = 31-32)	City (n = 51-52)	Large City (n = 9)	All
effectively reduces flood risk	39%	60%	78%	54%
is a necessary component of managing floodplains and flood hazard	44%	52%	78%	52%
effectively manages stormwater	28%	57%	56%	47%
provides multiple benefits	13%	39%	33%	29%
will likely be used more in the future	13%	35%	33%	27%
is an important strategy for adapting to the risks of climate change and variability	19%	29%	33%	26%
is easily maintained	16%	27%	44%	25%
is championed by local leaders	13%	29%	33%	24%
is valued by residents	13%	31%	22%	24%
is compatible with local environmental goals	16%	21%	33%	21%
is affordable	22%	19%	11%	19%
is the best way to meet regulatory requirements	13%	17%	22%	16%
is designed to benefit salmon and other native fish	9%	17%	22%	15%

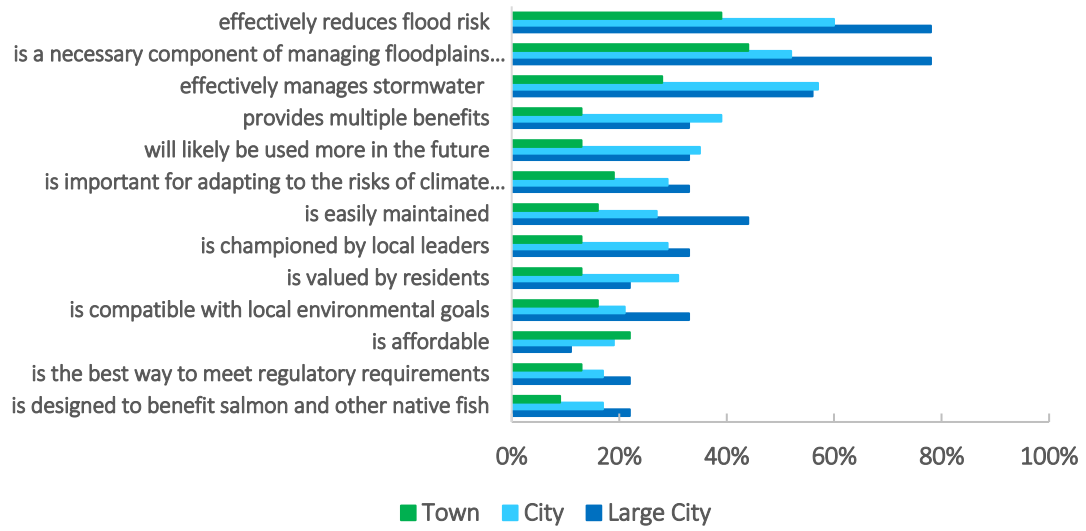


Figure A-19. The percentage of respondents reporting somewhat or strongly agreeing with statements about the use of gray infrastructure in their community.

Appendix B: Community Data

We also accessed other data about each community to provide some context to the survey data, such as city finances and residents' income and education levels.

General Fund

City budgets consist of different funds, such as governmental or general funds. Most operating finances are collected in the general fund; these include revenues such as property taxes and licenses and permits and expenses such as general administration, emergency services, and parks and recreation (Table B-1). (n = 107, Oregon Secretary of State 2018).

Table B-1. The mean general fund ending revenues, expenses, and balances for fiscal year 2016 (in dollars).

	Town	City	Large City	All
General fund revenues	546,387	7,670,885	108,023,167	13,514,952
General fund expenses	539,585	8,141,445	97,037,761	12,847,934
General fund ending balance	249,116	3,060,981	17,536,962	3,253,701

Income and Unemployment

The U.S. Census (2016a) collects income data, including mean, median, and per capita income, as well as employment and unemployment data and poverty levels for a community. In general, each of these increases with the size of the community, with one exception: median income is higher in a smaller city than in a larger city (Table B-2). (n = 107)

Table B-2. Mean values for median, mean, and per capita incomes for each city size (in dollars).

	Town	City	Large City	All
Median income	44,816	49,955	48,499	47,959
Mean income	56,855	61,585	63,434	60,017
Per capita income	23,469	24,460	25,510	24,187
Unemployment rate	5%	6%	5%	5%
Poverty rate	16%	17%	18%	17%
Employees in public administration	6%	5%	4%	6%
Government employees	18%	16%	15%	17%

Education

The U.S. Census also collects education data—the highest level of education attained by community members. People in larger communities were more likely to obtain a bachelor’s or master’s degree than those from smaller communities (Table B-3). Additionally, we compared community education levels with education levels of survey respondents and found that regardless of the size of the community, survey respondents were more likely to have at least a bachelor’s or master’s degree (Figure B-1). (n = 107)

Table B-3. Mean values of highest level of education attained within communities.

	Town	City	Large City	All
High school diploma	32%	28%	20%	29%
Associate degree	9%	9%	9%	9%
Bachelor degree	13%	14%	19%	14%
Graduate or professional degree	7%	9%	11%	8%

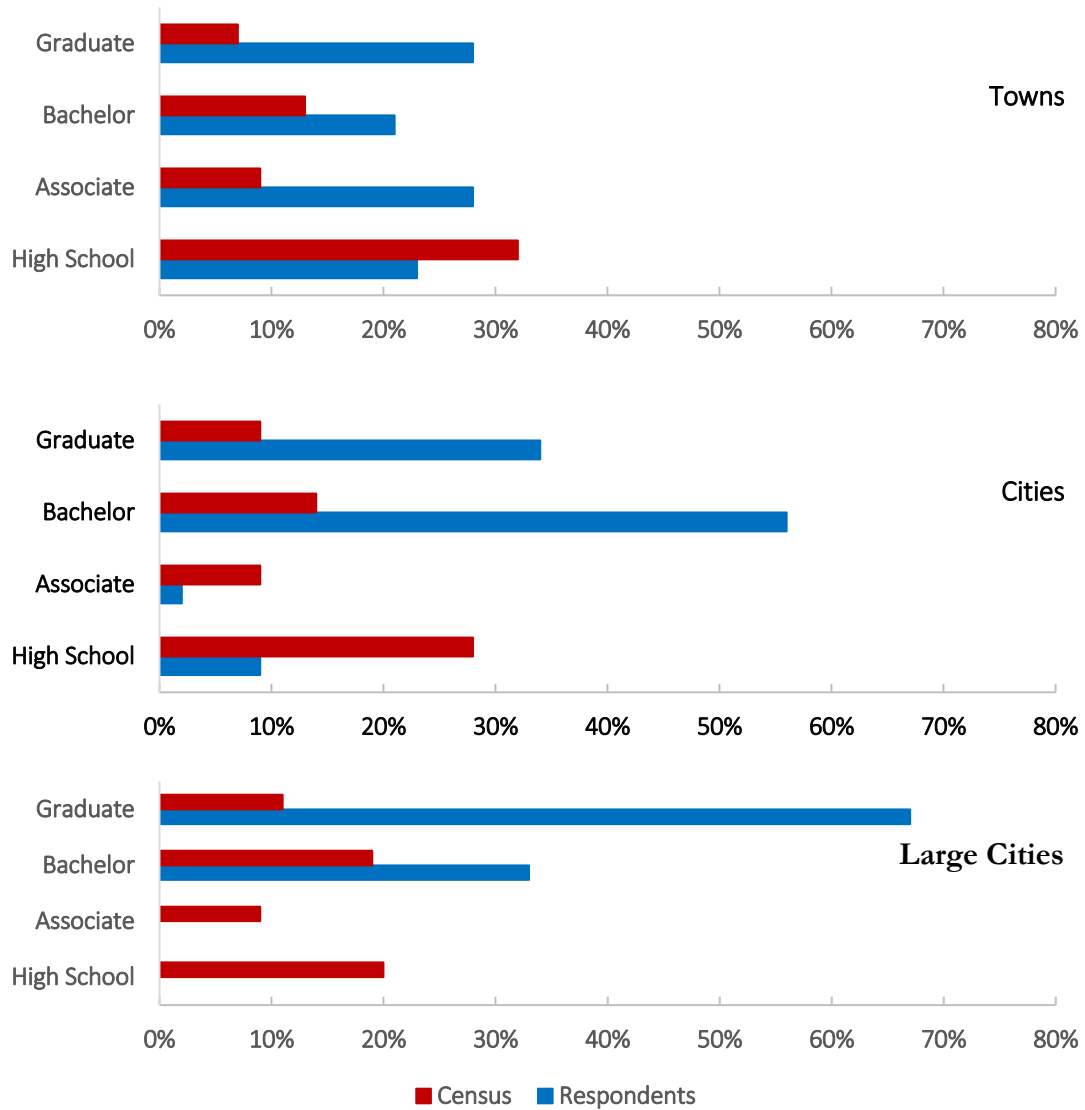


Figure B-1. A comparison of education levels from survey respondents and community members in towns (top), cities (center), and large cities (bottom).

Appendix C: Additional Survey Responses

In several questions, respondents were given the opportunity to write in comments, providing the opportunity to expand on their answers. These supplementary responses are collected and categorized below.

Flood Hazard and Floodplain Management Activities and Knowledge

Flood Hazard and Floodplain Management Activities

Several respondents wrote in other flood hazard and floodplain management activities they have participated in. These activities are categorized and listed below. (n = 7, question 11)

City Code and Permitting

- Permits and planning for the city in conjunction with contracted City Planner
- Code writing and updating
- Implementation of floodplain overlay district during development review

FEMA Planning

- Prepare and process map revisions through FEMA
- Community Rating System (CRS)
- Letter of Map Amendment (LOMA) analyst for FEMA

Land use planning

- Riparian ordinance adoption

Flood Hazard and Floodplain Management Knowledge

Similarly, several respondents wrote in other flood hazard and floodplain management topics for which they are very or extremely knowledgeable. These topics are categorized and listed below. (n = 3, question 12)

FEMA

- Flood mitigation codes
- Administration of FEMA mapping information and floodplain elevation certificates

Building code and inspection

- Building code and floodplain management; certified one and two family-plans examiner; building inspector

Communities Exemplifying Good Management

Flood Management Plans

Respondents were asked to list the flood management plans from other communities that exemplify good flood hazard and floodplain management. Most of the communities listed were in western Oregon, with the exception of Prineville (in central Oregon) and Payette County, Idaho (Figure C-1). (Question 23)

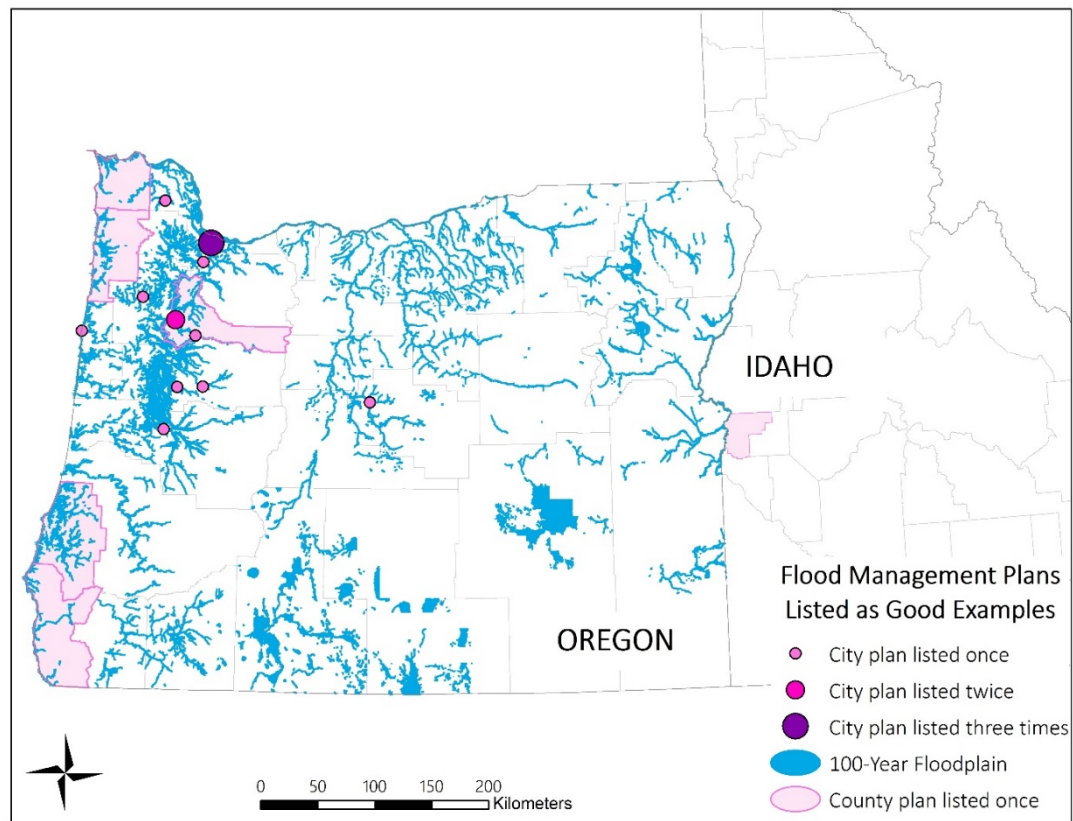


Figure C-1. Map of cities and counties listed by respondents as communities with flood management plans that exemplify good flood hazard and floodplain management.

Best Practices

Respondents were asked to list communities that are good examples of the best practices in flood hazard and floodplain management. In addition to naming several communities in Oregon, respondents also reported three out-of-state communities as being exemplars of best practices in flood hazard and floodplain management; these communities and respondents' descriptions, are reported below (Figure C-2, question 38):

- Skagit County, Washington: "Skagit County has an annual flood awareness week and 'flood fight teams' that train annually so that all staff are prepared when a flood occurs."
- Roseville, California: "[Rated 1] in the CRS." As described earlier, the Community Rating System, or CRS, is a voluntary FEMA program to incentivize flood hazard and floodplain management activities that surpass the NFIP requirements with discounts on flood insurance. Communities that join the CRS are rated from 1 (the highest rating) to ten (entry level); higher ratings indicate increased management activities and higher insurance discounts.
- North Carolina: "[North Carolina] has a great state floodplain mapping program. The state has taken over mapping from FEMA and have tons of data about vulnerability that can be used to automate and inform Hazus runs." Hazus is free spatial software available from FEMA that allows communities to model the estimated potential physical, economic, social, losses from floods, tsunamis, hurricanes, and other natural hazards.

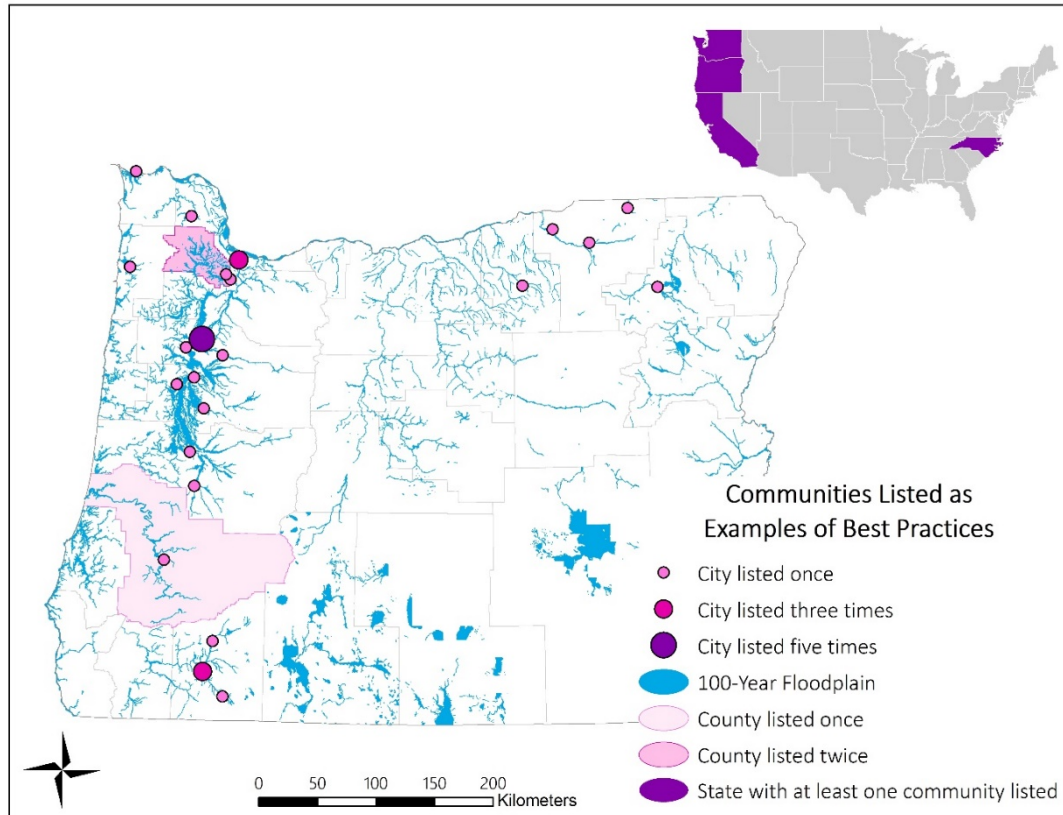


Figure C-2. Communities listed as exemplifying best practices in flood hazard and floodplain management, including communities in Oregon, Washington, California, and the state of North Carolina.

Management Priorities

When asked about their community's priorities for flood hazard and floodplain management decision making, two respondents provided two other priorities: Education and outreach, and protecting property rights. (Question 27)

Respondents were asked how the priorities for this decision making have changed over time. Eleven respondents provided these details, which were then categorized. (Question 28)

Improving Development and Zoning

- “The community is completely built out and most local floodplains are constrained by residential development that predates the floodplain designation. Floodplain management efforts are almost entirely focused upon management of redevelopment (tear-down and rebuild) of older homes. In that sense, the new structures are built to current floodplain development standards and older structures in the floodplain are incrementally being replaced.
- “In the last [seven] years, the city has improved zoning related to flood protections in riparian areas and experienced a leadership change that values public investment in infrastructure projects, ... specifically on their own properties.”

Improving Stormwater Management

- “Current city management has recognized city-wide benefits of hazard management. Supportive floodplain management program, as well as public works projects to improve floodplain natural and beneficial functions through construction of storm overflow areas.”
- “Certainly, this is an important area that I look forward to addressing at some point. I’ve spoken with the mayor about the need to create a storm drainage fund in our budget—not just a line item in the general fund—and to start building funds there to increase the capacity of our storm drainage system. I’m interested in exploring bioswales and some of the other options that might be available to help us manage our stormwater safely. However, we have several pressing infrastructure projects and I wear many hats. This is most likely something we will have capacity to dig into within the next 3-4 years.”

Supporting Multiple Benefits

- “With increasing concern about environmental issues (e.g., [NOAA] NFIP BiOp and [Clean Water Act Stormwater Management] Phase II requirements), there has been increasing emphasis on meeting multiple objectives through floodplain management in partnership with other program areas (e.g., stormwater, hazard mitigation planning, and zoning requirements).”
- “We’ve started incorporating multiple purpose modeling into development of [capital improvement plans] so that we’re ranking each project for its comparative benefits to the natural environment, public safety, infrastructure risk reduction, etc. We’re working closely with DLCD and other Oregon jurisdictions in developing updated model floodplain ordinance language to bring code into compliance with

NOAA BiOp performance standards. [We] may become [an] early adopter community (that's under discussion with DLCD, NOAA Fisheries, and FEMA)."

- "Provide multiple benefits has become more important."
- "More emphasis is being placed on projects that provide multiple benefits; e.g., flood mitigation, habitat restoration, ecological benefits, etc."
- "Meeting multiple benefits and cost effectiveness are guiding principles that include many of the other factors listed [in question 27] (effectiveness, project lifespan, meeting environmental goals, etc.). Priorities are always changing."

Miscellaneous

- "Priorities change with regulation, experience, and known/experienced impacts."
- "Flood [sic] was a Goal 5 and [Goal] 7 issue for Oregon. Our regulations did not consider the close coordination needed with FEMA. FEMA changes in Biggert Waters [Flood Insurance Reform Act] and the recent [NOAA] Biological Opinion have caused impacts to insurance costs and changes in federal actions forcing changes in local activities. It is still evolving."

Green Infrastructure and Native Fish

Respondents were asked about their perceptions of green and gray infrastructure. This included a question about whether green infrastructure is designed to benefit salmon and other native fish—and if so, what specific actions is the community taking. We broadly categorized these responses into seven groups, although there is substantial overlap in several answers (n = 20; 13 of 33 that responded somewhat or strongly agree to the question did not write in an answer, question 40).

Fish ladder

- “Completing installation of a fish ladder in [a local creek].”

Planning

- “Our County has adopted [a] salmon recovery plan.”

Preservation

- “Our City has purchased or [received] donated wetland areas in the past to hold in a protected state instead of them being potential development sites that would take them out of the green system.”
- “We have a riparian corridor overlay along all stream banks which limits development within 50 feet of stream banks. We limit development within the 100-year floodplain and require larger minimum lot sizes for any construction activities, which naturally deters development there.”
- “Willing seller acquisition of structures in the floodplain, then restoration/reconnection, followed by designation as open space in perpetuity.”

Regulation

- “Recently, the City’s design standards have been updated to require post construction BMPs [best management practices] for a development that disturbs more than 1,000 ft².”
- “[Our City] continues to develop regulations and recommendations to ensure a healthy fish population.”
- “Comprehensive update of sensitive lands’ regulations.”

Restoration

- “I think the community has taken large strides in reducing pollution and lowering river temperatures by enhancing river banks and retention ponds.”
- “Worked with ODOT on creek restoration projects.”
- “Removing barriers, restoring habitat, wetlands.”

Riparian

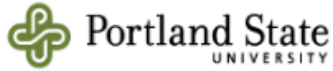
- “Vegetated corridors and stormwater treatment.”
- “Riparian zone is an adopted overlay where only native restoration activities and public uses such as trails [are] allowed.”

- “Code is in place to require water quality features on new stormwater systems and retain native vegetation buffers along riparian and wetland areas. Also partner with the [local] Watershed Council to provide native plants to owners of property along these natural features.”
- “The primary action is to preserve and enhance riparian vegetation along stream corridors.”
- “Required stream buffers and natural resource protections. LID [low impact development] approach to stormwater management is required per adopted Stormwater Management Manual. Adopted and enforced tree protection code.”

Stormwater

- “Our community requires new development to use green infrastructure to manage volume and water quality. This is vital to mitigating impacts from new development as it occurs. The City has also identified several green infrastructure CIP [capital improvement plan] projects that are part of the Stormwater Management Plan. These will improve water quality and start mitigating peak volume discharge during storm events.”
- “Storm drainage improvements along [two local creeks] designed to benefit native fish [were] focus of [the] Capital Improvement Plan over [the] last eight years.”
- “Stormwater does not enter river pathways.”
- “Water quality monitoring is tied to discharges meeting criteria for salmonids. Stormwater [Management Department] works in partnership with Natural Resources [Department] to include stormwater retrofit opportunities in stream and wetland restoration planning.”

Appendix D: Survey Instrument



1. Welcome to FINS, the Floodplain Infrastructure Survey!

Thank you for your interest in this research from Portland State University in Portland, Oregon. Your participation is very valuable to us as it helps ensure that we have a representative sample of communities throughout Oregon.

The questions we are asking have to do with community flood hazard and floodplain management. What we learn will be made available to floodplain managers, community leaders, planners, and policy makers.

Participation is completely voluntary. We estimate that the survey should take between 20 to 30 minutes of your time. **The information you provide is completely confidential and we foresee no risk to you from participating in this study.** Your responses will not be attributed to you in any reports or publications, but instead will be reported as statistical summaries.

To begin taking this survey, please enter your 4 digit access code below, then click on the button on the bottom right marked "Next" to indicate your consent to participate and start the survey. Thank you!

If you have questions about the study, please contact Samantha Hamlin at shamlin@pdx.edu or (971) 801-2636.

If you have concerns or questions about your participation in this study or about your rights as a research participant, please contact the Human Subjects Research Review Committee at:

Portland State University
Office of Research Integrity
1600 SW Fourth Ave., Market Center Building, Suite 620
Portland, OR 97201
(503) 725-2227 or (877) 480-4400

An access code was included in the email you received. Please enter this 4-digit access code below:

2. For a community to be part of the National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) requires that the community has a designated floodplain administrator. While recognizing that there are other people in a community that play a role in flood hazard and floodplain management, we are specifically surveying floodplain administrators.

3. Are you the designated floodplain administrator for your community?

☐ Yes

☐ No. If no, can you provide the name and email address of the person who is?

4. What is your position title?

5. How many years have you been the floodplain administrator for your community?

6. Have you worked as a floodplain administrator in another community?

☐ No

☐ Yes; how many years:

7. Are you a Certified Floodplain Manager?

- ☐ Yes
 - ☐ No
-

8. Are you now, or have you ever been, a member of a floodplain management association?

For example, the Northwest Regional Floodplain Management Association (NORFMA), the Association of State Floodplain Managers (ASFPM), or the Floodplain Management Association (FMA).

- ☐ Yes
 - ☐ No
-

9. What is the highest level of formal education you have completed?

- ☐ Less than high school diploma
 - ☐ High school diploma
 - ☐ Associate degree
 - ☐ Four-year college degree (e.g., BA, BS)
 - ☐ Master's degree (e.g., MS, MPA, MBA)
 - ☐ Doctorate degree (e.g., JD, PhD, or equivalent)
-

10. What is your age?

- ☐ 24 or younger
- ☐ 25-34
- ☐ 35-49
- ☐ 50-64
- ☐ 65 or older

11. Which of the following flood hazard and floodplain management activities have you participated in? Please check all that apply.

- ☐ Hazard mitigation or emergency management planning
- ☐ Managing stormwater
- ☐ Municipal comprehensive planning
- ☐ Preserving streams, wetlands, or floodplains
- ☐ Restoring streams, wetlands, or floodplains
- ☐ Other (Please briefly describe)

12. Please state how knowledgeable you are with respect to the following aspects of flood hazard and floodplain management.

	Not at all knowledgeable	Slightly knowledgeable	Somewhat knowledgeable	Very knowledgeable	Extremely knowledgeable
Flood mitigation infrastructure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flooding in your community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
National Flood Insurance Program (NFIP)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
NOAA Fisheries biological opinion on the National Flood Insurance Program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Zoning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (Please briefly describe)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. In this section, we're going to ask you about your community's experience with flooding. Here are three definitions for questions we ask you:

- Nuisance flooding is defined as small events that cause road closures, overwhelmed storm drains, and infrastructure deterioration, such as seen on bridges or roads.
 - A 100-year flood is a relatively rare flood event. It is also known as a base flood or a one-percent flood because it has a one percent chance of being equaled or exceeded during any given year.
 - A federal flood disaster is declared by the President following a request by a state governor. A flood is declared a federal disaster when its severity is beyond the combined capabilities of state and local governments to respond. A federal flood disaster declaration provides a wide range of federal assistance programs for individuals and public infrastructure, including funds for both emergency and permanent work.
-

14. Please estimate how many nuisance flood events your community has experienced over the previous two water years (from October 2014 to September 2016).

- ☐ 0
 - ☐ 1-5
 - ☐ 6-10
 - ☐ More than 10
 - ☐ Don't know
-

15. During your tenure as the floodplain administrator, how many 100-year floods have there been in your community?

- ☐ 0
 - ☐ 1
 - ☐ 2
 - ☐ 3-5
 - ☐ More than 5
 - ☐ Don't know
-

16. If there haven't been any during your tenure, do you know when the last 100-year flood happened in your community?

- ☐ Yes (If yes, please provide year, if known)

- ☐ No
-

17. During your tenure as the floodplain administrator, how many federal flood disaster declarations have there been in your community?

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3-5
- ☐ More than 5
- ☐ Don't know

18. If there haven't been any during your tenure, do you know when the last federal flood disaster declaration occurred in your community?

- ☐ Yes (If yes, please provide year, if known)

- ☐ No

19. In this section, we're going to ask about shared information or collaborations your community might have with other communities.

20. What are the three most important sources of information for you in flood hazard and floodplain management? For example, this may include (but aren't limited to):

- A person (please include name, job title, and organization)
- A document (please include title)
- An organization (please include organization name)
- Another community (please include community name)

Information source:

Information source:

Information source:

21. Does your community have a flood management plan?

- ☐ Yes. If yes, what year was it written?
- ☐ No
- ☐ Don't know

22. Have you read other communities' flood management plans?

- ☐ Yes
- ☐ Maybe
- ☐ No

23. If yes, please list up to five flood management plans from other communities that you think exemplify good flood hazard and floodplain management.

Plan 1

Plan 2

Plan 3

Plan 4

Plan 5

24. How often do you talk to representatives from other communities about their approach to flood hazard and floodplain management?

- ☐ More than once a week
- ☐ At least weekly
- ☐ At least monthly
- ☐ Every few months
- ☐ At least once a year
- ☐ Less than once a year
- ☐ Not sure

25. Does your community have intergovernmental agreements related to flood hazard or floodplain management (for example, with a neighboring community or state agency)?

- ☐ Yes
- ☐ No
- ☐ Don't know

26. If you answered yes to the previous question, please list up to the five most important agreements. Include the name of the entity and 1-2 sentences describing the purpose of the agreement.

	Entity the agreement is with	Brief description of the agreement
Agreement 1	<input type="text"/>	<input type="text"/>
Agreement 2	<input type="text"/>	<input type="text"/>
Agreement 3	<input type="text"/>	<input type="text"/>
Agreement 4	<input type="text"/>	<input type="text"/>
Agreement 5	<input type="text"/>	<input type="text"/>

27.

Below are 10 factors communities might consider when making decisions about how to manage flood hazard and floodplains. Please state how important each of these is for your community's flood hazard and floodplain management.

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Effectiveness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Project lifespan	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost effectiveness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maintenance requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meeting regulatory requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Risk reduction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Providing multiple benefits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meeting environmental goals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Minimize potential exposure to flooding (e.g., through zoning)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (Please describe in a few words below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

28. During your tenure, have these priorities changed?

☐ Yes (Please describe in 1-2 sentences; drag the lower right corner to expand the text box)

- ☐ No
- ☐ Don't know

29. In this section, we're going to ask you about actions or approaches your community has taken for flood hazard and floodplain management. This includes actions related to stormwater management, which can affect the frequency of nuisance flooding.

30. Does your community rely on any of the following types of gray infrastructure for flood hazard mitigation?

	Yes	No	Don't Know
Built flood control channels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weirs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Levees	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dams within the geographic boundary of your community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dams outside of the geographic boundary of your community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

31. Does your community rely on any of the following types of green infrastructure for stormwater and floodplain management?

	Yes	No	Don't know
Vegetated bioswales	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vegetated detention basins	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Natural flood control channels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stream or floodplain restoration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wetland or floodplain preservation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wetland creation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

32. Has your community undertaken any of the following planning and preparation activities?

	Yes	No	Don't know
Adopted a stormwater management plan	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Adopted a floodplain management plan	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Adopted a more restrictive mapping standard than the National Flood Insurance Program requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Required that currently vacant floodplain parcels will be kept free from development	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Established a stream buffer code that exceeds county requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maintained elevation certificates for new construction in the floodplain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

33. Has your community implemented any of the following flood risk reduction activities?

	Yes	No	Don't know
Prohibited any fill in the floodplain area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Acquired and/or relocated flood-prone buildings out of the floodplain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Periodically removed debris from all drainage systems and retention basins	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulated new development to ensure that post-development stormwater runoff is no worse than pre-development runoff	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulated new construction to minimize soil erosion and protect or improve water quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Required compensatory storage in new developments in the floodplain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

34. Does your community conduct any of the following education and public awareness activities?

	Yes	No	Don't know
Provide Flood Insurance Rate Maps (FIRMs) to people who inquire	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communicate information on flood hazard, flood insurance, or flood protection measures to residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communicate information on the natural and beneficial functions of floodplains to residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maintain current information on flood insurance and flood protection on our website or at the public library	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide technical assistance on protecting buildings to property owners who inquire	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

35. Has your community established or improved any of the following emergency management improvements for flood hazard?

	Yes	No	Don't know
Provide early flood warning to the public	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Created a detailed flood response plan keyed to flood crest predictions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Post signs in hazardous areas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

36. How prepared do you believe your community is for a 100-year flood?

- ☐ Not at all prepared
- ☐ Slightly prepared
- ☐ Somewhat prepared
- ☐ Very prepared
- ☐ Extremely prepared

37. What improvements do you believe are necessary for your community to better manage flood hazard and floodplains?

38. Please list up to 5 communities you think are good examples of the best practices in flood hazard and floodplain management. Provide a 1-3 sentence description for each community.

	Community Name, State	Brief description of what makes this community a good example of best practices in flood hazard and floodplain management
Community 1	<div></div>	<div></div>
Community 2	<div></div>	<div></div>
Community 3	<div></div>	<div></div>
Community 4	<div></div>	<div></div>
Community 5	<div></div>	<div></div>

39. Flood hazard and floodplain management can often provide multiple benefits to a community. Please assign 100 total points to reflect which benefits are provided by your community's approach to flood hazard and floodplain management.

Listed below are 10 potential benefits your community's approach to flood hazard and floodplain management may provide. You may assign as little as 0 points or as many as 100 points to a benefit if that is the only benefit you view as important to your community. If all benefits are valued equally, please assign 10 points to each.

Flood control	<input type="text" value="0"/>
Economic development	<input type="text" value="0"/>
Community identity	<input type="text" value="0"/>
Aesthetic and heritage values	<input type="text" value="0"/>
Adaptation to the risks of a climate variability and change	<input type="text" value="0"/>
Education	<input type="text" value="0"/>
Recreation	<input type="text" value="0"/>
Fish and wildlife habitat	<input type="text" value="0"/>
Water quality improvement	<input type="text" value="0"/>
Regulatory relief	<input type="text" value="0"/>
Total	<input type="text" value="0"/>

40. How much do you agree or disagree with the following statements about using green infrastructure in flood hazard and floodplain management?

In my community, green infrastructure...

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
... effectively reduces flood risk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is championed by local leaders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is valued by residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is a necessary component of managing floodplains and flood hazard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... effectively manages stormwater	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is an important strategy for adapting to the risks of climate variability and change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is designed to benefit salmon and other native fish (If strongly or somewhat agree, what actions is your community taking to preserve or restore floodplain functions?)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="text"/>					
... provides multiple benefits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is affordable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is compatible with local environmental goals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is easily maintained	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is the best way to meet regulatory requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... will likely be used more in the future	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... includes more than stormwater management facilities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... includes all vegetated spaces	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

41. How much do you agree or disagree with the following statements about using gray infrastructure in flood hazard and floodplain management?

In my community, gray infrastructure...

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
... effectively reduces flood risk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is championed by local leaders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is valued by residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is a necessary component of managing floodplains and flood hazard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... effectively manages stormwater	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is an important strategy for adapting to the risks of climate variability and change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is designed to benefit salmon and other native fish	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... provides multiple benefits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is affordable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is compatible with local environmental goals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is easily maintained	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is the best way to meet regulatory requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... will likely be used more in the future	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

42. If there are any other comments you would like to add, please do so below.

43. What is your political tendency?

- ☐ Very liberal
 - ☐ Somewhat liberal
 - ☐ Moderate
 - ☐ Somewhat conservative
 - ☐ Very conservative
-

44. I am compiling a list of people that would like to learn more about our results from this survey of flood-prone communities in Oregon. Would you like to be added to this list?

- ☐ Yes (Please enter email address)

- ☐ No
-

45. Thank you for your time. We really appreciate your contribution to this project.