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Planning for green infrastructure along the Gulf Coast: an evaluation of comprehensive plans and planning practices in the Mississippi-Alabama coastal region

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Rapid expansion and development of urban areas in coastal communities degrades ecosystems and increases vulnerability to natural disasters and the effects of climate change. To minimize these negative impacts, some municipalities have adopted "green infrastructure" planning to protect their cities through greenways, wetlands, and open spaces. This research identifies communities that have engaged in green infrastructure planning in the Mississippi-Alabama coastal region and the roles that plans, planning activities and capacity, and plan implementation play in the process, with the goal of creating more resilient cities. Comprehensive plans are analyzed to assess whether, and the degree to which, they incorporate green infrastructure planning, and a survey and interviews with planners were conducted to understand their planning capacity and experiences. Findings suggest that while green infrastructure planning is integrated into Mississippi-Alabama coastal cities' comprehensive plans and practices, there are several barriers related to leadership, plan oversight and implementation, collaboration, and resources.

Keywords: green infrastructure; urban planning; plan evaluation; coastal cities; resilient cities

1. Introduction

Growth and development can threaten the ecosystems of a city and its surrounding areas, as undeveloped land is converted into impervious surfaces. This growth and land development, in turn, can lead to degraded ecosystem services, landscape fragmentation, and increased flooding and potential damage (Arnold and Gibbons 1996; Kim and Park 2016; Shuster *et al*. 2005). This is an issue particularly for coastal cities as their location makes them susceptible to natural disasters, such as flooding and hurricanes. When coastal cities' locational vulnerability is coupled with land development and the expansion of urban areas, their vulnerability and risk of damages increases while making them less resilient to natural disasters (Kim, Woosnam, and Aleshinloye 2014; Gill *et al*. 2007; Liu, Chen, and Peng 2014; Reguero *et al*. 2018).

The concept of "green infrastructure" has emerged as a tool for minimizing the negative impacts of growth and development on a city and its ecosystems. Green infrastructure broadly refers to multifunctional networks of open space and nature-based

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multi-scalar stormwater management projects that are planned, created, and preserved with the goal of creating communities that can respond quickly and effectively to flooding events (Alabama Department of Environmental Management 2013; Benedict and McMahon 2012; Cameron and Blanuša 2016; Eaton 2018; Lee 2018; Lynch 2016; McDonald *et al*. 2005; Rouse and Bunster-Ossa 2013). Green infrastructure practices range from connecting greenways and protecting wetlands to creating bio-retention ponds, green roofs, and rain gardens. The overall goals of green infrastructure planning are to create the conditions for cities to plan for and to respond to flooding events rapidly and efficiently and, when a natural disaster occurs, to temper the physical impacts and damage from stormwater hazards (Kim and Park 2016; Lee 2018; Lynch 2016). The US Environmental Protection Agency (EPA) and National Oceanic and Atmospheric Administration (NOAA) both promote green infrastructure as a best practice (EPA 2021; NOAA websites 2021).

While green infrastructure is gaining traction in planning practice and research continues to document its effectiveness, the question remains if coastal cities are incorporating green infrastructure planning and practices into their comprehensive plan's goals and policies, and if there are strategic action steps for implementing them based on best practices. It is at this juncture that this research endeavor intervenes, focusing on nine cities along the Mississippi-Alabama coastal region – Biloxi, Gulfport, Oceans Springs, D'Iberville, and Pascagoula in Mississippi, and Mobile, Gulf Shores, Orange Beach, and Prichard in Alabama. This research aims to help communities become more resilient to the impacts of climate change by identifying the roles that plans, planning activities and capacity, and plan implementation play in this process.

2. Green infrastructure as a planning strategy

The concept of green infrastructure is not new to the planning discipline. For example, many trace its origins back to the Garden City movement and the more general environmental conservation movement (Eisenman 2013; Lee 2018; McMahon and Benedict 2000). The term green infrastructure, however, is somewhat new (Lennon 2015). As with most concepts and planning practices, there are variances in how green infrastructure is defined, as both a concept and a practice (Eaton 2018; Sussams, Sheate, and Eales 2015). For this research, green infrastructure refers to multifunctional networks of open space and nature-based multi-scalar stormwater management projects that are planned, created, and preserved with the goal of creating more resilient communities that can respond quickly and effectively to flooding events (Alabama Department of Environmental Management 2013; Benedict and McMahon 2012; Cameron and Blanuša 2016; Eaton 2018; Lee 2018; Lynch 2016; McDonald *et al*. 2005; Rouse and Bunster-Ossa 2013). Macro-level strategies are often implemented at the city or regional level (i.e. preserving and creating additional green spaces, open spaces, stormwater wetlands). Private property owners and neighborhood groups tend toward micro-level strategies (i.e. rain gardens, rainwater barrels, and green roofs). Meso-level strategies (i.e. bio-retention ponds, vegetated buffers, permeable pavement, vegetated swales) are found at all levels (Alabama Department of Environmental Management 2013). Lynch (2016) notes two factors that distinguish green infrastructure planning from more general environmental planning – 1) "a broad focus on natural systems, ecological function, and associated ecosystem services;" and 2) "planning and land development strategies that emphasize green space characteristics that support those

services" (91). Similarly, Lee (2018) notes the difference between green infrastructure planning and more general open space planning – "green infrastructure addresses issues related to land development, growth management, and built infrastructure planning" (372). Thus, "the primary objective of green infrastructure planning is to protect and maintain green spaces that provide critical ecosystem services" (Lynch 2016, 94).

A considerable amount of technical literature has emerged, and continues to grow, related to the specificities of implementing green infrastructure and its effectiveness. For example, Cameron and Blanuša (2016) highlight how the different types of planting used in green infrastructure projects can have different effects in terms cooling ability, stormwater retention, carbon sequestration, and pollution mitigation. Therefore, the overall impact of green infrastructure is related to what type of planting is used. Similarly, Eaton (2018) demonstrates that different green infrastructure strategies and land uses have differing effects in terms of stormwater runoff reductions and that green infrastructure strategies need to be deliberately aligned with land uses within a given watershed (see also Sarkar *et al*. 2018; Schubert *et al*. 2017). Others note how specific landscape patterns affect runoff, and the effectiveness of various green infrastructure strategies and their integration at reducing flooding (Kim and Park 2016; Mei *et al*. 2018; Xie *et al*. 2017). The overall goal of this existing body of scholarship is to identify the types of green infrastructure practices that will have the greatest effect on reducing flooding and managing the effects of climate change (Gill *et al*. 2007).

Another body of scholarship examines the benefits of green infrastructure as it relates to damage and risks. Gordon *et al*. (2018) claim that the benefits of green infrastructure span beyond reduced flooding and pollution to include greater community resources, such as more recreational space. Ruckelshaus *et al*. (2016) evaluate the strategic location of green infrastructure placement and the value they add to communities (see also Vandermeulen *et al*. 2011). Kim, Woosnam, and Aleshinloye (2014) note that conservation of natural systems, through practices such as green infrastructure planning, is essential to natural disaster recovery. Reguero *et al*. (2018) quantitatively analyze the losses in terms of damage that results from flooding, along with the benefits that green infrastructure can provide to offset this damage, focusing on the Gulf Coast region of the US specifically. In particular, Reguero *et al*. (2018) argue that effective responses to flooding will require an integrated mixing of gray infrastructure (e.g. seawalls, levees), green infrastructure (e.g. wetland restoration and protection), and policy interventions (e.g. building codes, land use planning). Specifically, they predict, "by 2030, flooding will cost $134-176.6 billion (for different economic growth scenarios), but as the effects of climate change, land subsidence and concentration of assets in the coastal zone increase, annualized risk will more than double by 2050 with respect to 2030 … cost-effective adaptation measures [i.e. gray infrastructure, green infrastructure, and policy interventions] … could prevent up to $57-101 billion in losses, which represents 42.8-57.2% of the total risk. Nature-based adaptation options [i.e. green infrastructure] could avert more than $50 billion of these costs" (Reguero *et al*. 2018, 1). They go on to state that "nature-based adaptation, in particular, could be among the most cost-effective options … [and] may help to avert 36.6% of total climate risk ($49-64.6 billion), with an average benefit to cost ratio of 3.7 to 4.9 (at an aggregate cost of $13.2 billion)" (Reguero *et al*. 2018, 15; all figures are in US dollars).

3. Research design and methods

3.1. Overview

US coastal cities' geographic location puts them at risk for flooding events that result from natural disasters, such as hurricanes. As these cities experience population growth and development of the natural environment, this risk is enhanced by all hardscape infrastructure improvements, including population-related development (i.e. rapid expansion of developed land within cities as a response to an increase in population), which often results in an increase in the amount of impervious surfaces (Kim, Woosnam, and Aleshinloye 2014; Liu, Chen, and Peng 2014). The risk of loss and damage is also increased as a larger population and amount of property is concentrated in coastal areas affected by natural disasters (Reguero *et al*. 2018).

The Gulf Coast region of the US is one such area that is vulnerable to natural disasters and is experiencing an increase in population and development. The population of the US Gulf Coast, the area ranging from Texas to Florida along the Gulf of Mexico, has "increased by 109% since 1970, compared to a 52% increase in the US total" (Reguero *et al*. 2018, 7). The Mississippi-Alabama coastal region, specifically, has seen increases in population density and the number of housing units in their coastal counties. Between 1960 and 2008, population density in the Mississippi-Alabama coastal region increased, on average, by approximately 72% (Wilson and Fischetti 2010). In Mississippi, population density increased from 106 people per square mile (41 people per square kilometer) to 197 people per square mile (76 people per square kilometer), an 85% increase (Wilson and Fischetti 2010). In Alabama, population density increased from 128 people per square mile (49 people per square kilometer) to 206 people per square mile (79 people per square kilometer), a 60% increase (Wilson and Fischetti 2010). The number of housing units along the Mississippi-Alabama coastline has also increased from 1960 to 2008. Mississippi added 99,222 housing units to their coastline, and Alabama added 176,372 housing units, representing a 171% and 163% increase, respectively (Wilson and Fischetti 2010). The proportion of Mississippi's total housing units located along the coastline increased from 9% to 12%, while Alabama's increased from 11% to 13% (Wilson and Fischetti 2010).

As such, this research focuses on the Mississippi-Alabama coastal region and includes the cities of Biloxi, Gulfport, Oceans Springs, D'Iberville, and Pascagoula in Mississippi, and Mobile, Gulf Shores, Orange Beach, and Prichard in Alabama (Figure 1). This research examines how green infrastructure planning and practices are integrated into each city's comprehensive plans and the strategic action steps that are in place for ensuring implementation. Working with city planners and leaders and several regional and state-level planning entities, the goal of this research is to help communities become more resilient to the impacts of climate change by identifying the roles that plans, planning activities and capacity, and plan implementation play in this process.

At the onset of this project, an advisory committee comprised of local and regional planning partners was established to facilitate conversations and information sharing among project partners. The committee also identified best practices in green infrastructure implementation and assessed the degree to which these practices are incorporated in each city's comprehensive plan. Additionally, the partner cities' comprehensive plans were examined to understand the degree to which green infrastructure is planned for and supported via this city council adopted document. A rubric

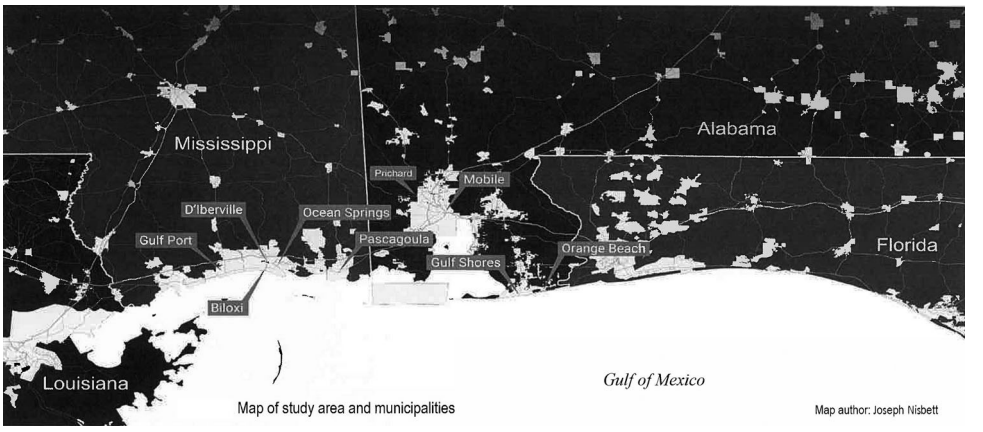

Figure 1. Map of study area and municipalities.

was created, using existing scholarship, to evaluate each city's comprehensive plan and to generate a composite "plan quality score." A survey and interviews with planning leaders in the nine Mississippi and Alabama coastal cities were conducted to collect detailed information on planning practices and capacity, experiences, opportunities, and constraints.

3.2. Plan quality analytical framework

Since the 1990s, the scholarship on plan quality evaluation methods has flourished (Lyles and Stevens 2014). As this scholarship continues to be expanded and refined, there is growing consensus around what indicators determine overall plan quality and what methods should be used in the analyses (Berke and Godschalk 2009). Plan quality analyses can also be used to examine a wide range of specific practices and emerging innovative practices (Lyles and Stevens 2014; Tang 2008). For example, while most of the existing research examines overall plan quality, a growing body examines plan quality as it relates to sustainability and resiliency (e.g. Brody, Highfield, and Carrasco 2004). The research presented here examines plan quality from a green infrastructure perspective. It utilizes existing plan quality scholarship, increasing the reliability of plan quality analysis protocols (Lyles and Stevens 2014), but introduces a specific focus on green infrastructure planning in coastal US cities.

Traditionally, five components of plan quality are assessed: fact base; goals and objectives; policies, tools, and strategies; implementation, monitoring, and evaluation; and inter/intra organizational coordination and capacity (e.g. Brody, Highfield, and Carrasco 2004; Kim and Li 2017). However, as Conroy and Berke (2004) note, public participation in the planning process, a widely accepted best practice in the planning field, increases the public's support for the inclusion of sustainable development policies and strategies within the plan. As such, more recent scholarship on plan quality has incorporated indicators relating to public participation in their analyses (e.g. Stevens 2013; Tang 2008). While existing scholarship on plan quality has examined issues related to green infrastructure, such as stormwater management (Kim and Li 2017), hazard mitigation (Lyles, Berke, and Smith 2014), ecosystem management (Brody, Highfield, and Carrasco 2004), watershed protection (Berke *et al*. 2013), and

coastal zone land use (Tang 2008); none have examined green infrastructure specifically. Meanwhile, the literature on green infrastructure planning evaluation has used an assortment of different plan evaluation criteria, making it difficult to compare the findings across the research. For example, McDonald *et al*. (2005) provide a plan evaluation framework for green infrastructure plans, but not comprehensive plans. They define green infrastructure plan elements, and the framework for evaluating them, as: 1) goal setting, which includes plan foundations, stakeholder involvement, and conservation vision; 2) analysis, which includes network design criteria and network suitability analysis; 3) synthesis, which includes network design model enhancements, identifying priorities, and relationship to plan goals; and 4) implementation, which includes decision support tools, implementation tools, conservation funding, conservation strategies, and defining development opportunities. Meanwhile, Lynch (2016) focuses on seven broad green infrastructure principles, each with its own set of indicators – i.e. "1) create linkages and foster connectivity; 2) value areas of ecological quality and local importance; 3) support a variety of landscapes and ecosystem services; 4) restore and mitigate damage to green infrastructure; 5) manage green infrastructure to support ecosystem services; 6) enact land use planning strategies to protect and retain all scales of green infrastructure; and 7) protect and support green infrastructure through a collaborative and cooperative process" (91).

While there are some shared themes and overlaps between the plan evaluation criteria proposed by the general plan evaluation scholarship and the green infrastructure planning evaluation scholarship, the two bodies of work have not yet been brought together. To address this, this research blends the existing scholarship on plan quality evaluation with the scholarship on green infrastructure planning to offer a framework for assessing the quality of comprehensive plans from a green infrastructure perspective. The indicators for this research's plan quality evaluation were developed based on existing plan quality research, specifically Berke and Godschalk (2009), Brody, Highfield, and Carrasco (2004), Kim and Li (2017), Lyles, Berke, and Smith (2014), Lyles and Stevens (2014), and Stevens (2013). However, it positions the indicators to focus on green infrastructure-related plan components. Namely, it relies on the peer-reviewed plan evaluation methods research but introduces an explicit focus on green infrastructure planning. As such, this research evaluates six plan components, standard in the plan evaluation literature, and draws from the definitions articulated by Stevens (2013), with a deliberate focus on green infrastructure-related planning interventions (Table 1).

The *fact base* provides a description, supported by data, of the community's current conditions and projections for the future in the absence of planning interventions. This description includes providing information on current and future trends related to population, economic conditions, housing, land use, and public infrastructure. This information is essential for understanding where current development is, where development will likely happen in the future, and to inform decisions about where development should take place going forward. This information, in turn, allows planners to assess reductions in green space and increased stormwater runoff from impervious surfaces, for example, which are related to the need for green infrastructure. The purpose of the fact base is to provide a foundation, or rationale, for the plan's goals and strategies.

The *goals and objectives* component details the overarching intentions and priorities of the plan and the specific actions, with measurable outcomes, that need to be taken to actualize them. Goals and objectives related to green infrastructure could

Table 1. Plan quality score components and indicators.

Fact base	Current population
	Population growth projection
	Current economic conditions
	Anticipated future economic conditions
	Map or inventory of current housing
	Map or inventory of future demand/needs for housing
	Map or inventory of current land use
	Map or inventory of future land use
	Existing capacity of public infrastructure (including transportation)
	Future demand for public infrastructure (including transportation)
	Current stormwater infrastructure and services*
	Future needs for stormwater infrastructure and services*
	Map or inventory of existing natural resources (e.g. greenways and spaces, forests, parks, wetlands, woodlands, and open spaces)*
	Map or inventory of future demand/needs for natural resources (e.g. parks, open spaces)*
	Map or inventory of existing green infrastructure projects*
	Map or inventory of future demand/needs for green infrastructure*
	Classification/description of vegetation and forests*
	Classification/description of soils*
	Impervious surface area density*
	Map or inventory of areas subject to flood hazards or stormwater runoff*
Goals and objectives	Clearly specified goals that seek to promote resiliency and reduce flooding (e.g. protect natural functions and processes; encourage open spaces/recreation actions; maintain stormwater management facilities; control/reduce stormwater runoff and/or flooding; minimize impervious surfaces from development; promote green infrastructure and low impact development; and overall placement strategy for green infrastructure sites)*
	Measurable objectives
Policies, tools, and strategies	Regulatory policies, tools, and strategies that seek to promote resiliency and reduce flooding (e.g. development regulations aimed at protecting coastal and hazard prone areas by improving existing ordinances, such as the erosion and sediment control ordinances, zoning ordinances, subdivision ordinances, flood plain regulations and other development regulations; urban service/growth boundaries; restrictions on local vegetation and forest removal; stormwater impact fees; limits on impervious surface densities; and land use guidelines aimed at reducing vulnerability for new development and redevelopment in coastal and hazard prone areas)*
	Incentive-based policies, tools, and strategies that seek to promote resiliency and reduce flooding (e.g. density bonuses; transfer of development rights; clustered development; stormwater fee discounts; and incentives for innovative practices, such as using water efficient

(*Continued*)

	landscaping, low impact design interventions, green infrastructure, and LEED certifications)*
	Public land preservation and/or land acquisition policies, tools, and strategies that seek to promote resiliency and reduce flooding (e.g. open space preservation; conservation easements; constructed wetlands; setbacks and buffer zones; and ensuring that publicly owned lands will be used at their highest and best use, except for those public lands that are in environmentally sensitive locations, where conservation should be the objective)*
	Capital improvements and funding policies, tools, and strategies that seek to promote resiliency and reduce flooding (e.g. directing funding to projects that support these goals; and adequately funding stormwater management)*
Implementation, monitoring, and evaluation	Plan for implementation, including actions, designation of responsibilities for actions, financial and technical resources needed, and a timeline for implementation
	Plan for monitoring progress on implementation, including mechanisms for measuring objectives, designation of responsibility for measuring and reporting on implementation, and timetable for measuring and reporting
	Implementation includes the monitoring of ecological health and human impacts, including stormwater runoff impacts*
	Process and timetable for updating plan based on monitoring of changing conditions
Inter/intra organizational coordination and capacity	Identification of coordination efforts within the jurisdiction specified
	Identification of coordination needs within the jurisdiction specified
	Identification of coordination efforts with other jurisdictions/organizations/ stakeholders
	Identification of coordination needs with other jurisdictions/ organizations/ stakeholders
	Identification of coordination efforts with higher levels of governments (state/federal)
	Identification of coordination needs with higher levels of governments (state/federal)
	Identification of coordination efforts with private sectors
	Identification of coordination needs with private sectors
	Integration with other environmental plans/programs in the region*
Public participation	Public participated in the plan creation
	Identification of organizations and individuals involved in plan creation
	Description of the role of public participation during plan creation
	Description of the process in which the public was involved, and which techniques were used
	Description of how the public will be involved in implementation, monitoring, and evaluation
	Description of ongoing efforts to involve the public in planning decisions

*Green infrastructure specific indicators.

include encouraging open green spaces, controlling or reducing stormwater runoff and flooding, minimizing impervious surfaces resulting from development, or promoting green infrastructure and low impact development.

Policies, tools, and strategies allow a community to operationalize their goals and objectives, and to guide public decision-making. Policies, tools, and strategies related to green infrastructure can be categorized into four broad categories – regulatory, incentive-based, public acquisition, and capital improvement strategies (Berke and Conroy 2000; Brody, Highfield, and Carrasco 2004). An example of a regulatory green infrastructure strategy is Ocean Springs, Mississippi's tree preservation ordinance, which prohibits removing certain species of trees without city approval even when on private property (City of Ocean Springs, Mississippi Comprehensive Plan 2010).

Implementation, monitoring, and evaluation refer to a plan's description of how it will carry out its work, monitor its progress, and evaluate whether it is achieving its goals. Implementation details should include specific actions, a designation of responsibilities for the actions, the financial and technical resources needed to carry out the actions, and a timeline for completing the actions. Implementation, then, needs to be monitored for progress. These details include identifying mechanisms for measuring objectives and a designation of responsibility and timetable for measuring and reporting on implementation progress. A process and timetable for evaluation allows communities to monitor changing conditions and update their plans accordingly. From a green infrastructure perspective, implementation, monitoring, and evaluation include a process for focusing on ecological health and human impacts.

The *inter/intra organizational coordination and capacity* component addresses the fact that successful planning requires coordinating with other organizations and departments within a given municipality, with higher level organizations that may set guidelines or provide funding, and with neighboring municipalities that share ecological features. Since environmental and ecological issues do not respect political boundaries and are affected by many interdisciplinary factors (e.g. new housing developments that increase impervious surfaces, reduce green space, and increase stormwater runoff), this coordination, and the capacity of organizations and departments to coordinate, is essential to green infrastructure planning.

Meaningful *public participation* in the planning process is a widely accepted best practice within the planning field. It can also increase community support for a plan (Conroy and Berke 2004). Participation extends beyond just the plan development phase and includes involving the public in ongoing monitoring, evaluation, and planning decisions. The participation process also facilitates sharing of experiences, developing a common understanding of the issues facing a community, and promoting awareness of how decisions and their impacts are interrelated. Such participation is important to green infrastructure planning in that environmental impacts can be addressed from a variety of different stakeholder perspectives and the community can collaboratively develop equitable outcomes.

This research uses the above six plan components, along with the indicators listed in Table 1 and derived from existing scholarship, as the analytical framework to evaluate plan quality from a green infrastructure perspective. The indicators marked with an asterisk are specific to green infrastructure planning (e.g. incentive-based tools that encourage green infrastructure projects), whereas the other indicators support and enhance the effective use and implementation of green infrastructure planning (e.g. assessing future housing demands and their impact on the natural environment).

3.3. Plan evaluation methods

The comprehensive plans from the selected cities along the Mississippi-Alabama coastline were analyzed using the content analysis and plan evaluation methods developed and articulated by Berke and Godschalk (2009), Brody, Highfield, and Carrasco (2004), Kim and Li (2017), Lyles and Stevens (2014), and Tang (2008) (see Table 2). Gulf Shores, Alabama, does not have a comprehensive plan and is excluded from this specific analysis. Measures to maximize the intercoder reliability were implemented (Berke and Godschalk 2009).

The research team collaboratively developed the evaluation protocol and the guidelines for its use. The researchers pretested the evaluation protocol independently, which resulted in two indicators being removed for being too ambiguous. Once independent pretest scoring was complete, the researchers compared their scores and reconciled any disagreements through discussion. The pretesting process also served as a means for normalizing the scoring process among the research team. Once pretesting was complete and the protocols were finalized, the eight cities' comprehensive plans were assigned among the researchers so that each plan was analyzed independently by at least two of the researchers.

Each researcher read the plan in full and assigned scores based on the indicators listed in Table 1. A score of "0" was assigned to an individual indicator if the plan did not mention that specific indicator at all. A score of "1" was assigned to the indicator if it was mentioned but not detailed, described, or explained. A score of "2" was assigned to the indicator if it was mentioned and further details, descriptions, and explanations were provided. A total of 45 indicators were assessed by each researcher in this manner for each of the eight cities' comprehensive plans. Upon completion of the independent scoring, the researchers met, compared scores, and reconciled disagreements until full consensus on all indicator scores was reached. The scores for each plan component were then standardized.

Following the score standardization process set forth by Brody, Highfield, and Carrasco (2004), Kim and Li (2017), and Tang (2008), the scores for each city's plan components were totaled and then divided by the total possible score for that

Table 2. City and comprehensive plan descriptive data (United States Census Bureau 2010).

Cities	Population 2010 (US Census, Decennial)	Year of comp plan adoption	Year of comp plan update	# of pages in comp plan	Involvement of consultants in comp plan development
Biloxi, MS	44,054	2009	–	236	Yes
D'Iberville, MS	9,486	2010	2015	87 (2010); 83 (2015)	Yes
Gulfport, MS	67,793	2004	–	177	Yes
Mobile, AL	195,111	2015	–	102	Yes
Ocean Springs, MS	17,442	2010	–	111	Yes
Orange Beach, AL	5,441	2006	–	118	No
Pascagoula, MS	22,392	2010	–	233	No
Prichard, AL	22,659	2006	2016	132 (2006); 75 (2016)	Yes

component. Standardized component scores were then multiplied by 10, making the range of each plan component score to be between 0 and 10. All six standardized plan component scores for each city were then totaled, making the range of each city's total score between 0 and 60. Breadth and depth scores were calculated for just the green infrastructure-specific indicators to understand the numerical range of different green infrastructure approaches noted in each cities' comprehensive plans and the level of description given to them. Breadth scores were calculated by totaling the number of green infrastructure-specific indicators that were present (i.e. the number of indicators that had a score of 1 or 2) in each city's comprehensive plan (see asterisked indicators in Table 1). This number was divided by the total number of green infrastructure indicators available (i.e. 17), and then multiplied by 100 in order to give each breadth score a range of 0% to 100%. Depth scores were calculated by totaling the scores (i.e. 0, 1, or 2) for the green infrastructure specific indicators for each city. This number was then divided by the total possible score a plan could receive on the green infrastructure-specific indicators (i.e. 34), and then multiplied by 100 in order to give each city's depth score a range of 0% to 100%.

3.4. Survey and interview methods

A survey and interviews with planning leaders in the selected Mississippi and Alabama coastal cities were conducted to gather detailed data on their planning practices and capacity, experiences, opportunities, and constraints related to green infrastructure planning. Survey and interview questions were developed based on existing scholarship on coastal and environmental plan quality and planning capacity, which highlights planning capacity as a key factor influencing plan quality and planning effectiveness, especially in coastal areas (Brody, Highfield, and Carrasco 2004; Conroy and Berke 2004; Tang 2008; and Tang and Brody 2009). The data collected through this research's survey and interviews extend this literature further by also collecting data on planning leaders' experiences, their perceived level of support for green infrastructure projects, barriers and constraints to their work, and the best practices that they have found most effective in achieving green infrastructure planning goals.

The web-based survey, which was emailed to planning leaders in the selected cities, specifically gathered information on organizational planning capacity, including leadership and collaboration, planning responsibility and oversight, and resources, as well as participants' experiences planning in the coastal areas of Mississippi and Alabama (Table 3).

Planning leaders were also invited to participate in an interview, which gathered data on the detailed planning processes, outcomes, and experiences of planners in this region (Table 4).

4. Results

4.1. Plan quality scores

Overall, the eight cities' comprehensive plans have an average score of 43.99, out of a possible score of 60, indicating that the plans collectively represent a high level of quality and green infrastructure engagement. However, the scores have a wide spread with scores ranging from 32.92 on the low end to 55.83 on the high end. The "implementation, monitoring, and evaluation" and "public participation" components are the lowest scoring components across all plans. The "goals and objectives" and

Table 3. Data collected through self-administered web-based survey.

Organizational information	Organization name
	Organization type (e.g. a regional planning commission, city government, etc.)
	Organization location (i.e. city physically located in)
	Organizational reach (i.e. physical area served)
	Organizational department
	Departmental green infrastructure engagement (i.e. planning, stormwater, etc.)
	Departmental annual budget
	Sources of funding for department
	No. of staff within department
	No. of staff with GIS expertise within the department
Leadership and collaboration	Presence of a state or local mandate that requires some use of green infrastructure or a focus on sustainability/environmental issues as it relates to planning
	Level of political support within organization for using green infrastructure
	Level of political support within the larger community for using green infrastructure
	Current collaboration with other groups around environmental and hazard mitigation issues (e.g. other governmental departments and offices, advocacy groups, community members, etc.) and at various scales (e.g. local, regional, or national)
	Desired collaboration with other groups around environmental and hazard mitigation issues (e.g. other governmental departments and offices, advocacy groups, community members, etc.) and at various scales (e.g. local, regional, or national)
	Adequacy and effectiveness of current collaborations
	Opportunities for public participation in planning decisions
	Plans, maps, etc. are publicly available on a website or other forum
Comprehensive plan responsibly and oversight	Date last comprehensive plan was completed
	Date last comprehensive plan was updated
	Frequency of updates
	Entity responsible for monitoring plan's implementation and progress
	Plan has sustainability as an overarching goal
	Plan proposes the use of green infrastructure
Resources	Resources committed to the comprehensive plan preparation, implementation, and monitoring
	Adequacy of resources
	Departmental staff receive training in green infrastructure or environmental planning
	Departmental staff receive ongoing training and professional development in GIS applications and skills
Personal information	Position/job title
	Highest level of education and degree discipline
	Gender
	Race

Table 4. Data collected through interviews.

Engagement with green infrastructure	Describe the work that your department does as it relates to environmental planning, hazard mitigation, and green infrastructure planning.
	How well do you think your department does in terms of environmental planning, hazard mitigation, and green infrastructure planning? Meaning, is it robust, adequate, or would you like to see things improved? How so?
	What barriers or constraints are there (if any) to implementing green infrastructure in your city? Ideas on how you could remove these barriers or constraints?
	What factors have positively contributed to your city implementing green infrastructure? Are there opportunities to expand these efforts?
	Are staff within your department given opportunities for training in green infrastructure? If so, what types and how often?
	Does your (or your department's) knowledge of climate change and the use of green infrastructure as a climate adaption response affect your opinion toward implementing of green infrastructure?
	Does the socio-demographic characteristics of green-space users play a role in your (or your department's) attitude toward implementing green infrastructure?
Collaboration between stakeholders (including other government departments, community-based or advocacy groups, etc.; at the local, regional, or national level)	Does your department share information with other stakeholder groups, or vice versa? Who shares information? What information is shared? How effective is this transfer of information? What are the strong and weak points?
	Does your department collaborate with other stakeholder groups in terms of decision making and plan implementation, or vice versa? Who do you collaborate with? What issues do you collaborate on? How does this collaboration take place (i.e. through what mechanisms)? How effective are these collaborations?
	What barriers or constraints are there (if any) to collaboration? Ideas on how you could remove these barriers or constraints?
	What factors have positively contributed to collaboration? Are there opportunities to expand these efforts? How would you improve collaboration? What is needed for new collaboration expectations?
Planning processes	Describe the process that your department went through to create its last

(*Continued*)

	comprehensive plan. How is its implementation monitored? By who? How frequently? What is the process for updating it? When was the plan last updated? When will it be updated again?
	Are there opportunities for public participation (in the comprehensive plan development, as well as in planning decisions in general)? What are they? Do you think more should be done to involve the public? What?
	When was the last time your community responded to localized flooding or a stormwater damaging event? What did that response look like in terms of process and outcomes? What did you learn from the event and response? Do you feel your city's comprehensive plan adequately addresses these issues?

"policies, tools, and strategies" components are the highest scoring components, with "fact base" and "inter/intra organizational coordination and capacity" falling in the middle, overall. This suggests that, while goals and policies are well supported with data and clearly articulated, there are limited processes for ensuring that the plan's actions will be executed in practice and that there are systems of accountability in place. The low overall score in "public participation" is concerning, suggesting that these cities' plans were created with limited input from the community. On average, the green infrastructure breadth score (79%) is higher than the green infrastructure depth score (68%), indicating that plans are more likely to mention an aspect of green infrastructure in their plans but not to provide detail about it or its implementation (Table 5).

The existing scholarship that applies plan quality evaluation to specific cities and regions' plans has provided mixed results, and the findings from this research further complicate the picture. For example, Brody, Highfield, and Carrasco (2004) found that, in an evaluation of plans from cities in southern Florida, the "fact base" component was the lowest scoring component and the "inter/intra organizational coordination and capacity" component was the highest scoring. Whereas, in analyzing the plans of cities in the Chesapeake Bay watershed region, Kim and Li (2017) found that the "fact base" and the "inter/intra organizational coordination and capacity" components scored the highest, while the "policies, tools, and strategies" component scored the lowest. Similar to this research's findings, Stevens (2013) found that an emphasis on "implementation, monitoring, and evaluation" was lacking in the southern cities of British Columbia. These findings suggest that plans, and the planning process, are context specific, and that there will be regional differences found in the results.

4.2. Survey and interviews

A number of noteworthy themes emerged from the survey and interviews around issues of leadership, comprehensive plan oversight, collaboration, and resources, which align with the trends from the plan evaluation findings.

Table 5. Plan quality scores.

	Indicators								
Cities	Fact base	Goals and objectives	Policies, tools, and strategies	Implementation, monitoring, and evaluation	Inter/intra organizational coordination and capacity	Public participation	Total	GI breadth score	GI depth score
Biloxi, MS	8.75	10	10	8.75	10	8.33	55.83	88%	88%
D'Iberville, MS	8	10	10	5	8.89	2.50	44.39	82%	68%
Gulfport, MS	7.75	10	8.75	3.75	6.67	3.33	40.25	82%	65%
Mobile, AL	5.5	7.5	7.5	8.75	8.89	8.33	46.47	71%	59%
Ocean Springs, MS	9.5	10	6.25	7.5	7.78	5.83	46.86	76%	74%
Orange Beach, AL	7.5	7.5	6.25	2.5	6.67	2.5	32.92	76%	56%
Pascagoula, MS	8.5	10	8.75	5	8.33	2.5	43.08	88%	79%
Prichard, AL	7	10	7.5	3.75	5.56	8.33	42.14	65%	53%
Mean Score	7.81	9.38	8.13	5.63	7.85	5.21	43.99	79%	68%

Note: Gulf Shores, AL, one of the project partners, does not have a comprehensive plan and was, therefore, excluded from the plan quality analysis.

The average ranking of political support within one's larger community/city for implementing green infrastructure projects was 4.89, on a scale of 0 to 10 with 0 representing very weak, 5 neutral, and 10 very strong (with responses ranging from 2 to 7). By comparison, the average ranking of political support within one's organization for implementing green infrastructure projects was 5.67, on the same scale (with responses ranging from 3 to 8). This suggests that the overall political climate for green infrastructure is lukewarm, but is stronger among planning entities. Common concerns that were noted were that there is limited political leadership to enact/enforce environmental protections and create new green infrastructure projects; preservation ordinances, when they exist, and permitting processes are not uniformly or evenly enforced or applied within cities; and changing political leaders and administrations result in changing priorities, including not supporting or undoing past environmental planning efforts in the name of development. It was also noted that there is very limited accountability and oversight for ensuring that what is in a city's comprehensive plan, and its other related plans, gets implemented. Despite this, all survey respondents indicated that their organizations have implemented and/or use some form of green infrastructure planning. Two respondents (22%) noted the presence of local mandates in their cities that require some use of green infrastructure or a focus on sustainability/environmental issues as it relates to planning. Five respondents (56%) reported that their city/region's comprehensive plan has sustainability as an overarching goal. Six (67%) respondents reported that their city/region's comprehensive plan proposes the use of green infrastructure.

While environmental issues do not respect political boundaries or jurisdictions, nor do they align perfectly with the various departments of an organization; decisions related to growth and development, as well as environmental protections, affect all aspects of a city and region. Respondents noted that collaboration, communication, and accountability among city departments at the local level are extremely important since all city departments are interrelated and their decisions impact all the others. On a regional level, the collective goal needs to be focused on helping developers develop properties properly and responsibly, with the entire region benefiting as a result. All but one respondent (89%) noted an array of different groups and organizations that they collaborate and coordinate with, ranging from other departments within their organization to state and federal level entities. The average ranking of adequacy and effectiveness of these collaborations was 5.22, on a scale of 0 to 10 with 0 representing very ineffective, 5 neutral, and 10 very effective (with responses ranging from 1 to 7), indicating that collaboration and coordination are perceived as being limited in its effectiveness.

It was also noted that planning for, and responding to, natural disasters tends to be reactive, especially as it relates to resources. For example, when a natural disaster occurs, like a hurricane, the federal relief money that cities receive needs to be used to replace the damaged infrastructure as it was prior instead of improving it to withstand the next storm. In other words, the funding to support this work tends to be used for mitigation only and not for changing development patterns or standards. Meanwhile, cities are applying for grants to make green infrastructure projects happen – often competing with one another for the same resources and with no guarantee they will get the funding for their projects. Respondents were evenly divided in terms of whether the resources that are committed to their city/region's comprehensive plan preparation, implementation, and monitoring are adequate or not. Six respondents

(67%) reported that staff in their department receive training in green infrastructure or environmental planning. Five respondents (56%) reported that staff in their department receive ongoing training and professional development in GIS applications and skills.

5. Discussion

Based on this research, there are a number of key findings that serve as recommendations. Specifically, there needs to be more of a focus on the implementation, monitoring, and evaluation, as well as public participation, planning processes. There is also a need for greater political leadership, more effective collaborations, and increased resources.

While the selected cities' comprehensive plans' goals and policies are clearly articulated and well supported with data overall, these plans, collectively, do not clearly or robustly detail how the plan will be implemented, who is going to monitor its progress, and how its success will be evaluated. This finding was corroborated in the survey and interviews based on practitioners' experiences on the ground. The majority of research participants reported that their city/region's comprehensive plan has sustainability as an overarching goal and proposes green infrastructure; however, there is very limited accountability and oversight for ensuring that what is in the comprehensive plan gets implemented. A greater focus also needs to be placed on the public participation aspects of planning in these cities. Specifically, the comprehensive plans need to fully describe how the public was involved in the creation or revision of the plan, as well as its ongoing monitoring and evaluation and future planning decisions, expanding on these efforts as needed. As Conroy and Berke (2004) note, meaningful public participation in the planning process can increase community support for a plan, which can work to strengthen implementation and accountability. As such, cities need to create detailed plans for ensuring that the plan's actions will be executed in practice, there are systems of accountability in place, and the public will be involved.

As was apparent from the survey and interviews, there is a low level of perceived political support within the larger community/city for green infrastructure planning, and a low level of perceived political leadership for enforcing environmental protections and creating new green infrastructure projects. This lack of support is coupled with a tension between growth and development on one hand, and environmental protections on the other hand, when it comes to planning in coastal cities where growth and development tends to be prioritized. The regional and interdisciplinary nature of environmental issues, as well as the effects of growth and development, further complicates this, requiring collaboration and coordination. However, there is a low level of perceived adequacy and effectiveness regarding current collaborations, despite the prevalence of collaboration efforts noted in the city's comprehensive plans and by the interviewees. More effective and productive partnerships and collaborations are needed at all scales.

Financial and human resources are limited among the project partners, but adequate funding and support are essential for making planning successful. The US Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) are two federal agencies that provide funding and technical assistance opportunities that advance the implementation of green infrastructure and nature-based solutions. These federal agencies are helping to build vibrant and resilient

communities with programs that support the design, construction, and maintenance of green infrastructure. Some funding is reactive in nature, becoming available only after a natural disaster has happened and funds only activities that restore the existing infrastructure; other funding can be used to proactively address environmental issues and be a catalyst for changing development patterns and standards. Cities and regions need to pursue a diverse portfolio of funding options and invest in their human resources to carry out this work. Specifically, reliable and flexible funding sources are needed to implement and maintain the green infrastructure projects, which are often promoted by the city's comprehensive plan.

6. Conclusion

As the effects of climate change continue to be experienced in coastal cities and as these cities continue to grow and develop, planning has an important role to play. Green infrastructure planning is one tool that planners and cities have to mitigate the associated risks. This research found that while green infrastructure is integrated into Mississippi-Alabama coastal cities' comprehensive plans and planning practice, there are several barriers as they relate to leadership, comprehensive plan oversight and implementation, collaboration, and resources. A focus on these planning aspects is required to create more resilient cities.

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