

Comprehensive Plans as Tools for Enhancing Coastal Community Resilience

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Published: Journal of Environmental Planning and Management

<https://www.tandfonline.com/doi/full/10.1080/09640568.2019.1700943>

Planning for change is critical to ensuring resilient coastal communities. In Maine, USA, the comprehensive planning process provides a platform for communities to articulate policies that address social, economic, and environmental issues. While comprehensive plans were initially required of municipalities to address urban sprawl over thirty years ago, a broad range of challenges face coastal communities today. Here we report on an assessment of 30 comprehensive plans from coastal communities across the state. We analyzed the degree to which plans incorporate principles of social-ecological resilience. Our results reveal significant variability across comprehensive plans with some communities addressing key indicators of resilience and others engaging with them in a limited way. By more explicitly incorporating principles of social-ecological resilience, the next-generation of comprehensive plans can be repurposed to serve as tools for communities to implement strategies that build adaptive capacity as they face unprecedented challenges and plan for a changing world.

Keywords: coastal communities, community planning, comprehensive plans, social-ecological resilience

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1. Introduction

Coastal communities around the world are increasingly recognized as vulnerable places, particularly in the context of climate change (Beatley 2009; Barbier 2014; USGCRP 2014; IPCC 2018; USGCRP 2017). Planning for both social and ecological resilience is key to ensuring the longevity of coastal communities (Berke and Conroy, 2000). In this context, resilience can be understood as the ability of coastal communities to withstand disturbances without fundamentally altering their essential identity, structure, and functions (after Berkes and Folke, 1998; Leslie and Kinzig, 2009). Examples of disturbances include environmental stressors, i.e., flooding, storm surge, sea level rise (USGCRP 2014; Fu et al., 2017; USGCRP 2017; IPCC 2018), as well as socioeconomic stressors, i.e. recession, shifts in market demand (Kashem et al., 2016; Stoll et al., 2016). Resilience planning emphasizes building capacity to anticipate and prepare for crises under uncertainty (Walker and Salt 2012), and reducing both individuals and communities' vulnerability to potential disturbances, thereby increasing adaptive capacity (Beatley, 2009).

Many scholars argue that polycentric governance arrangements are effective at addressing complex natural resource challenges (Ostrom, 2009; McGinnis & Walker, 2010; Sovacool, 2011). Decisions and policies about how to adapt and remain resilient in the face of change need to be implemented at multiple governance levels (Tribbia and Moser, 2008). State and national governments in the US and many other nations have foregrounded resilience planning at the community scale. For example, the US National Oceanic and Atmospheric Administration's Ecosystem-Based Fisheries Management Policy identifies maintaining community resilience and evaluating community well-being as essential parts of the resilient ecosystem guiding principles

of the Policy Implementation Roadmap (NMFSI 01-120-01). Additionally, the 2010 U.S. National Ocean Policy incorporated actions aimed to specifically benefit coastal communities such as enhanced research and communication about the direct and indirect impacts of climate change, ocean acidification, infrastructure, economies, habitats and key species (E. O. 13547).

While these policy frameworks highlight the importance of planning for resilience, they are not necessarily linked with community-scale concerns or strategies (Sievanen et al., 2011). Similarly, adaptation plans are often developed at geographically extensive scales. Yet, drivers of change in coastal systems, such as declining fish stocks, flooding, population decline, and economic disruption are experienced at the local scale –in the social and ecological interactions that people have with one another and the coastal and marine ecosystems of which they are part (Sievanen et al., 2011). Communities are unique and have their own specific needs, experiences, resources, and ideas about preventing and responding to stressors that threaten coastal ecosystems and local economies (Brody, 2003). Comprehensive plans are intended to guide the future actions and direction of a community (Conroy and Berke, 2004). The comprehensive planning process serves as a platform for communities to envision the future and outline objectives and policies that address social, economic, and environmental issues to guide the future direction of the community (Berke and Conroy, 2000).

Critically assessing resilience in comprehensive plans is key to understanding the aspects of resilience that are prioritized by communities. Complementing research on resilience planning at broader scales, our paper focuses on local scale planning efforts and how they align with resilience principles. Maine provides a useful case study as changing ocean conditions, declines in marine fisheries, and the loss of

working waterfront infrastructure threaten the resilience of coastal communities throughout the state. With over 3,000 miles of coastline and a culture and economy deeply tied to marine resources, citizens and municipalities in Maine have important questions and concerns about the capacity of their coastal communities to respond and adapt in the face of mounting social, economic, and environmental pressures.

The goal of our study was to investigate how local planning is addressing resilience principles. To explore this, we investigate the degree to which Maine's coastal communities are incorporating resilience principles into their comprehensive plans. To answer this, first we provide an overview of the history of comprehensive planning in Maine, including the state requirements that guide plan development. Next, we explore the concept of social-ecological resilience in the context of coastal communities. We apply a framework for evaluating the incorporation of resilience principles to analyze 30 comprehensive plans from coastal communities in Maine. We draw on a framework that employs three types of resilience indicators— ecological, social, and economic—which together reflect elements of social-ecological resilience. Finally, we explore the factors that may be influencing the degree to which comprehensive plans incorporate resilience principles and offer recommendations for the use of comprehensive plans as tools to enhance coastal community resilience.

1.1 Exploring Social-Ecological Resilience in a Community Context

In its broadest sense, resilience recognizes social systems and ecosystems as “coupled, interdependent, and co-evolving” (Berkes, 2015 pg. 51). The focus on social-ecological systems emphasizes the complexity that arises from interactions among the biophysical and institutional domains and across spatial and temporal scales (Ensor and Berger, 2009, Berkes and Folke, 1998; Adger and Barnett, 2009).

In a resilient social–ecological system, social and ecological changes create opportunity for innovation and development (Folke, 2006). Folke and colleagues (2010) differentiate between “specific” and “general” resilience. Specific resilience refers to the capacity of the system to withstand one kind of disturbance, whereas general resilience relates to the capacity of a system to withstand all kinds of disturbances (Folke *et al.*, 2010). This is a significant distinction, as general resilience encompasses coping with stressors in all ways, whereas specific resilience only buffers the system against one kind of shock or protects particular components of the system from disturbance (Folke *et al.*, 2010). Efforts to foster specific resilience may not be beneficial long term, as the concentration on individual parts of the system and specific shocks may inadvertently cause the system as a whole to lose resilience in other critical ways (Folke *et al.*, 2010).

Resilience can be cultivated at both the individual and collective level and can occur at multiple spatial and geographic scales (Ross and Berkes, 2014; Beatley 2009). There are a diversity of definitions of resilience from fields such as ecology, engineering, and geography. The concept of ‘community resilience’ similarly has varied definitions. In general, it is viewed as a positive attribute, associated with decreased risk and increased local capacity at the community scale (Patel *et al.*, 2017). A community’s resilience is often described as a function of the community members’ capacity to mobilize, learn, and work towards a common goal (Steiner and Atterton, 2015). For example, after a systematic assessment of definitions of community resilience from the peer reviewed and grey literature, Patel *et al.* (2017) found that the concept is associated with decreasing risk and increasing social support and resources in a community. Additionally, local knowledge, community networks, effective communication, and leadership, among other attributes, emerged as critical elements that can build resilience

within a community before a disaster and can mitigate long-term damages and retain the essential structure and function of a community after a disaster (Patel *et al.* 2017).

In assessing coastal community resilience, themes of flexibility, adaptability, opportunity, and durability are prominent in the literature (Beatley 2009). Paton (2006) advocates for a bottom-up, community-based approach to effectively plan for resilience. Walker and Salt (2012) identify a number of characteristics of a ‘resilient world,’ including ecological variability, diversity, innovation, modularity, and overlaps in governance. Buckle (2006) additionally identifies several elements that support resilience at the community scale, such as robust social networks, connected information channels, and community knowledge of hazards. Communities are also influenced by both internal and external economic forces such as economic growth opportunities, stability and diversity of livelihoods, and equitable distribution of income (Norris *et al.*, 2008).

Community resilience is supported by a resilient local economy with diverse businesses and employment opportunities (Steiner and Atterton, 2015). Building community resilience requires the development of a community’s social capital (Putnam, 1995; Magis, 2010). Resilient communities promote human well-being by creating common objectives to strive for and encouraging citizens to work together for the greater good (Patel *et al.*, 2017). Many definitions of community resilience focus on enhancing adaptive capacity, or the ability of social actors to make deliberate changes that influence the resilience of the complex social-ecological systems in which they are embedded (Ensor *et al.*, 2014; Walker *et al.*, 2014). Although communities do not control all of the conditions that affect them, they do have the ability to anticipate, plan for, and change many of the conditions that can increase their overall resilience and adaptive capacity in the face of disturbances. Adaptive capacity is defined by the ability

of systems to modify their structure in response to changing socioeconomic and environmental conditions in order to adjust and cope with these changes, moderate potential damage, and take advantage of opportunities that arise from change (Adger and Vincent, 2005; Folke, 2002). Advancing adaptive capacity in coastal communities requires holistic planning efforts and the principles of social-ecological resilience provide critical insight to sound coastal management in the future.

Through this analysis, we seek to understand the degree to which comprehensive plans in Maine are currently incorporating principles of social-ecological resilience. Answers to this question highlight the general challenges of enhancing the resilience of communities in Maine. Plan evaluation is a critical component of the comprehensive planning process as the quality of the plan affects its implementation. Information gained from a systematic review of comprehensive plans is vital to determine strengths and weaknesses in Maine's local planning approaches and will provide valuable insight into planning for resiliency in coastal communities in the future.

1.2 A history of comprehensive planning in Maine

Municipalities in Maine began writing comprehensive plans as early as 1918 (Richert and Most, 2005). The development of these initial plans across the country was primarily driven by the interest in adopting zoning ordinances to direct population growth and developmental sprawl. Comprehensive plans are the legal underpinning of zoning ordinances and are intended to ensure that zoning is conducted fairly and with careful consideration to community needs (Conroy and Berke, 2004). In keeping with planning conversations nationwide, sprawl became a major concern in Maine in the 1970s and 1980s, as rapid population growth shifted from urban centers to rural communities. Rural municipalities did not have the appropriate infrastructure, ordinances, or facilities to support the rapidly increasing populations. As a result,

residents across the state were concerned that the rural character of their communities would decline as roads became increasingly congested, forests were cleared for housing development, and taxes began to rise (Richert and Most, 2005).

In 1988, Maine adopted the Comprehensive Planning and Land Use Act, also known as the Growth Management Law. This law initially established local comprehensive planning and land use management in each municipality of the state (30-A M.R.S.A. §§ 4312 - 4350). The Act requires that municipalities appoint a planning committee to prepare a comprehensive plan, which must consider a broad range of public review and comment from the community. As planning for population increase was a pressing issue in the state during 1970s and 1980s, a central goal of the Act is preventing developmental sprawl (Dolan and Walker, 2004). To achieve this, comprehensive plans were designed to direct anticipated growth to specific designated growth areas, and away from rural areas in each municipality (Richert and Most, 2005).

The Act details 11 goals that promote the 'health, safety, and welfare of citizens of the state.' These goals include the protection of the state's natural resources such as agricultural, forest, and marine resources, the preservation of historic and archaeological resources, the promotion of recreational opportunities, and the promotion of affordable housing. Additionally, it calls for a three-stage analysis as part of each plan: inventory and analysis of existing conditions, policies to address the issues identified in the inventory section, and implementation strategies to address these issues. Towns are asked to address 13 topics as part of the inventory and analysis section: topography (soils, geology, and water resources), habitat and other significant natural resources, historical and archaeological resources, agriculture/forestry and marine resources, local and regional economy, population and demographics, land use patterns, housing, transportation, recreation and open space, public facilities and services, and fiscal

capacity. In addition to inventorying these topic areas, comprehensive plans are required to include policies that address specific issues raised in the inventory section, in addition to strategies to achieve these goals (30-A M.R.S.A. §§ 4312 - 4350).

In the late 1990s and early 2000s, many Maine communities began to update their comprehensive plans. Most municipalities had plans that were over 10 years old. At the same time, the Maine State Planning Office (SPO), as part of ongoing efforts to curb sprawl and promote smart growth, began advocating for bolder comprehensive plans that were more effective at guiding growth and addressing other pressing local and regional issues. By 2003, 47% of Maine's organized municipalities developed comprehensive plans that were compliant with the goals of the Comprehensive Planning and Land Use Act (Richert and Most, 2005). That same year, the SPO developed a handbook of 50 recommendations to help guide towns in strategies to address sustainable growth patterns (Richert and Most, 2005). The handbook served as an opportunity for the SPO to reflect on some of the lessons learned from the collective experience of over 10 years of comprehensive planning in Maine under the Planning and Land Use Regulation Act.

The handbook accompanied an updated comprehensive plan grant program that the SPO launched in 2001. This new grant program provided state funding for comprehensive plan development for the first time. The grants were geared towards a new generation of comprehensive plans that incorporated stronger policies and implementation strategies to address pressing issues facing Maine's communities. This shift was largely in response to the earlier generation of comprehensive plans that were effective at inventorying community resources, but less successful at guiding growth and meeting other planning objectives. In many cases, these early comprehensive plans

were quite vague, resulting in ineffective strategies to implement policies (Richert and Most, 2005).

In 2005, the Maine State Planning Office released a manual to guide Maine's communities in developing comprehensive plans. The manual called for communities to tackle a broad range of community issues and encouraged them to take a critical look at their growth patterns and to develop a stronger next generation of plans. It emphasized the importance of citizen involvement as a continuous process in the development of comprehensive plans and calls for realistic, specific, and directive policies. The manual states that the State Planning Office recognizes that comprehensive plans that are consistent with state laws may not necessarily fulfil the local goals and policies of a community, and thus encouraged municipalities to go beyond state laws and develop strategies to meet local needs as well as the requirements of the state (Richert & Most, 2005).

The Growth Management Law was amended in the early 1990s. The mandate for municipalities to develop a plan was removed when the economic boom ended and state budgetary problems resulted in cutbacks that limited funding for local growth management efforts. While state approval of municipal comprehensive plans are no longer required, there is a process for the voluntary review of the plans by the Maine Municipal Planning Assistance Program. If a town's plan is found to be consistent with the Growth Management Act guidelines, there can be benefits for the municipality, including preferential treatment for some state grant programs (MMPAP, 2017). Over \$80 million is awarded annually through 25 state grant and loan programs that include approval of a comprehensive plan as a review criterion. Examples of these programs include the Land and Water Conservation Fund and Community Development Block Grants. In addition, as provided by state law, when a comprehensive plans is adopted by

the municipality, it serves as the basis for updating the town's zoning and land use regulations. In addition to funding opportunities, in order to provide legal support for any local zoning, zoning ordinances must be pursuant to and consistent with a comprehensive plan adopted by the municipality (Richert and Most, 2005).

Comprehensive plans detail many different aspects of a community. These include community goals and policies that address issues identified by the community, a future land use plan that anticipates growth and development, and implementation strategies that describe how the plan objectives will be implemented in the future (Berke and Conroy, 2000).

A review of the evolution of comprehensive planning in Maine highlights a complex history of local governance. Plans were initially intended to address urban sprawl, a pressing issue in Maine in the 1970s and 1980s. While this no longer is a critical issue facing many towns, municipalities are actively developing comprehensive plans throughout the state to be eligible to compete for grant opportunities and to update local zoning ordinances. Although comprehensive planning is no longer mandatory by the state, the local planning process provides a platform for communities to address challenges facing the community and assert a set of priorities and policies to implement a collective vision for the future. Social-ecological resilience offers a flexible, holistic, and robust lens to critically address the multifaceted challenges that coastal communities face and focuses on interactions that are relevant in managing human-environment systems in the context of change (Quinlan et al., 2016).

2. Methods

2.1 Plan selection

We analysed comprehensive plans from coastal communities across the state of Maine to investigate how social-ecological resilience principles have been incorporated in

local planning documents. Comprehensive plans were selected based on a sample from each coastal community county in Maine. Each municipality is located within Maine's coastal zone as designated by the Maine Coastal Program. The plans selected for analysis were identified as consistent with Maine's Growth Management Act by the Maine Municipal Planning Assistance Program. Municipalities closest to the 25th, 50th, and 75th percentile of the county population were selected in order to assure that both small and large municipalities are included in the analysis. Thirty plans out of a total of 49 state-approved coastal plans were analyzed, thereby representing 61% of all possible coastal municipal plans. The goal of this sampling process was to represent the diversity of Maine's coastal communities with active, state-approved comprehensive plans.

2.2 Resilience Assessment

To assess the degree to which Maine's coastal communities are incorporating resilience principles in their local planning efforts, comprehensive plans were evaluated using an assessment framework focused on social-ecological resilience (modified from Boulware et al., 2013). The framework integrates key indicators of resilience from a variety of nationally recognized resilience frameworks such as the National Oceanographic and Atmospheric Administration's Coastal Community Resilience Indicators and Rating System (NOAA Coastal Community Indicator and Rating System) as well as the Federal Emergency Management Agency Community Resilience Indicators (FEMA Community Resilience Indicators), and is consistent with the diversity of resilience principles outlined in the peer-reviewed literature (Godschalk et al., 2000; Chaskin 2001, Beatley 2009; Leslie and Kinzig 2009, Magis et al., 2010; Boulware, 2013). Although indicators are drawn from national frameworks, they are generalizable with the intent to be applied to any community. Downsizing national frameworks to the local scale may not capture the local needs of a community. To address this, indicators were

specifically selected based on the hazards and threats facing the state of Maine.

Resilience principles were divided into three categories for analysis: ecological, social, and economic. Although the resilience indicators were categorized for evaluation purposes, they are interrelated and in many ways overlap and are dependent on each other (See Appendix A for complete indicator list).

Ecological principles address the relationship between physical development and natural processes and include indicators such as conservation and restoration of natural systems, wetland migration, hazardous area acquisition, shoreline protection, and the incorporation of policies related to coastal hazards such as sea level rise, storm surge, erosion, and flooding (Godschalk, et. al. 2000; Beatley 2009; NOAA 2010).

Social aspects of increasing resilience include indicators such as identifying vulnerable populations within the community, enhancing community education of hazards, promoting emotional and physical well-being among residents, and providing opportunities to strengthen social networks (Godshalk 2003; Magis 2010; Beatley 2009). Economic aspects of increasing resiliency include indicators such as promoting a diverse economic base in the community, business owner education related to hazards, and fostering relationships between local businesses and the community (Beatley 2009).

Each comprehensive plan ($n=30$) was coded based on the incorporation of social-ecological resilience indicators outlined in the framework using the qualitative data analysis computer software package NVivo version 11.4.2. Each plan was scored on a scale of 0-2 for the presence or absence of each individual indicator (after Berke 2000). A ranking of 0 indicates that an indicator is not identified in a comprehensive plan. A ranking of 1 indicates that the indicator was suggested or vaguely defined, but not well incorporated throughout the plan. A ranking of 2 indicates that the indicator was well identified in detail, contains directive language and specific guiding policies or

goals addressing the indicator. This method is widely applied in the planning field as a systematic approach to operationalize qualitative planning evaluation measures (Berke et al. 2000; Godshalk et al. 2000; Paton 2006). A complete list of indicators is outlined in Appendix A.

The total score for each of the three resilience categories was calculated by the number of points (raw score) scored divided by the total possible points for that category. Total resilience scores were calculated for each of the 30 plans in addition to individual scores for social, ecological, and economic resilience. The maximum possible score that a plan could receive was 100%. Nonparametric statistical tests were conducted to test whether there are significant differences in resilience category scores. Specifically, a Kruskal-Wallis test was used to investigate if there is a statistically significant difference between ecological, social, and economic resilience category scores for the comprehensive plans analysed. A Wilcoxon signed-rank test was used to determine if plans addressed resiliency differently based on the year they were adopted.

3. Results

3.1 Total Social-Ecological Resilience Score:

Total resilience scores for each plan were calculated and reported based on percentage of the summed values from the ecological, social, and economic scores present in each plan (Figure 1). Portland had the highest total social-ecological resilience score calculated for a municipality, at 80%. Bangor had the lowest score, of 18%. The average total score for the 30 plans evaluated was 40% (Table 1).

[Figure 1. here]

[Table 1. here]

3.2 Resilience Scores by Category

We evaluated the comprehensive plans based on the presence of resilience indicators in three categories: ecological, social, and economic resilience. The scores for each municipality by category are summarized in Table 2 and depicted in Figure 2. The average score for the social resilience category was higher than ecological and economic scores for the comprehensive plans analyzed. The average ecological score for all municipalities analyzed was 40%. The average social score was 55% and the average economic score was 32%. We summarized the variation in total resilience scores, and the relative emphasis different communities place on the social, ecological, and economic elements of resilience in their plans in Figure 3.

[Figure 2. here]

[Table 2. here]

[Figure 3. here]

Results from a Kruskal-Wallis test indicate a statistically significant difference between ecological, social, and economic resilience category scores ($p < 0.05$). Paired contrasts were examined through a Wilcoxon signed-rank test. Results indicate that there is a statistically significant difference between social and economic scores ($p < 0.05$), however there is no statistically significant difference between ecological and social or ecological and economic scores ($p > 0.05$). Statistical analyses revealed that social attributes of resilience were emphasized over ecological and economic aspects of resilience in the comprehensive plans that were assessed.

One criteria that may have influenced overall plan ranking is the year the plan was adopted. This could potentially be significant given that more recent plans should reflect the availability of recent research related to coastal community resilience and hazard mitigation in addition to the 2005 Maine State Planning office directive for comprehensive plans to address a broader range of challenges in communities. A

Wilcoxon signed-rank test was conducted to determine if plans addressed resiliency differently based on the year they were adopted. Results indicate that there is an association between total resilience score and year adopted ($p < 0.05$) such that more recent plans tend to have higher total scores. Figure 4 depicts average total comprehensive plan resilience score by year. Population, land area, and per capita income were not significant drivers of plan score.

[Figure 4. here]

3.3 Resilience Indicator Analysis

Analysis of resilience scores relating to particular indicators in the framework reveal which indicators were well incorporated in comprehensive plans as well as the indicators that were largely not addressed. Thus, this analysis highlights what coastal municipalities prioritize in resilience planning throughout the state. The highest and lowest indicators for each resilience category are outlined in Table 3. Indicators that received an average score greater than or equal to 70% and less than or equal to 30% are reported for each resilience category.

[Table 3. here]

4. Discussion

Our results reveal that social-ecological resilience principles are not well incorporated in Maine's current comprehensive plans in coastal communities overall, but have increased through time. Of the 30 comprehensive plans analyzed, the highest score assigned to a municipality was 80%, the lowest score was 18%, and the average resilience score for municipal comprehensive plans was just 40% out of a possible 100%. Plans that received lower scores failed to address specific indicators, or did not incorporate policies, strategies, or action items that detailed how the community will address the indicators. In comparison, plans that received high scores had a detailed

vision statement, thorough inventory sections, and policies or action items derived from the inventory sections that outline major priorities and delegate specific committees or organizations within a community with oversight and implementation.

We also found heterogeneity in the degree to which municipalities are incorporating indicators of resilience. Although Maine's coastal community comprehensive plans overall do not incorporate social-ecological resilience principles, there is a higher emphasis on social measures relative to ecological and economic measures. Many of the plans emphasized a strong sense of community and a desire to limit development and maintain a rural character of the town. This is exemplified in the Edgecomb town vision to "accommodate and guide Edgecomb's growth while supporting the expressed wishes of the townspeople to retain their individual autonomy, the community spirit and rural environment" (Edgecomb Comprehensive Plan, pg 1). Emotional and physical well-being and an increased quality of life were promoted throughout many of the plans as goals. Mention of community hazard awareness and education as well as policies and goals focused on adaptive capacity were absent in many of the plans.

Priorities in comprehensive plans within the ecological resilience category focused around erosion and flooding and were specifically attentive to infrastructure protection. Some plans encouraged the conservation of natural systems as well as the use of living shorelines for shoreline stabilization. The strong emphasis on erosion and shoreline stabilization in comprehensive plans is likely a reflection of Maine's Mandatory Shoreline Zoning Act (M.R.S.A. sections 435-449), which controls land uses and placement of structures within the shoreland area for the purposes of protecting habitat, wildlife, water quality, historic and archaeological sites, in addition to conserving space and public access. In addition, the Disaster Mitigation Act of 2000

(Public Law 106-390) encourages communities to develop policies that mitigate long-term effects of coastal hazards. The incorporation of these policies in comprehensive plans likely resulted in high scores for indicators related to flooding, erosion, and shoreline stabilization in the ecological resilience category across all the comprehensive plans that were analysed. However, few plans incorporated policies that related to the accommodation or relocation of structures in hazardous area, the prevention of hazardous area acquisition, and redevelopment of structures after hazardous occurrences.

Allusions to climate change impacts were absent from a majority of the plans. Few plans called out sea level rise and storm surge as potential threats. When these threats were identified, objectives and policies addressing these hazards in the community were absent. Results of the ecological resiliency category indicate that many Maine communities are not considering potential impacts of climate change in town planning. The median adoption year of these plans is 2011, however plans developed after this year tend to include more explicit language about climate change impacts and adaptation planning. It is important to note that towns may be planning for and incorporating aspects of resilience in documents other than comprehensive plans. For example, the town of Georgetown has developed a climate adaptation report, which outlines potential climate-related impacts to the community and lists recommendations for the community to prepare for these impacts. Similarly, Lincoln County has prepared a sea level rise plan for the region that projects scenarios of flooding in specific areas in the associated communities. These plans provide valuable information to inform community planning and should be included as part of the comprehensive planning efforts (Baynham and Stevens, 2012).

Components of economic resilience that were highlighted in the plans include policies that encourage coordinated business planning to achieve objectives focused on protecting, sustaining, and enhancing the economic base of the municipality. Many of the plans recognized the relationship between healthy natural systems and a healthy economy, as many coastal municipalities are heavily dependent on commercially harvested marine resources as well as marine tourism. Many municipalities acknowledge this economic dependence in their plans, however few address strategies for economic diversification. Economic recovery options in the face of stressors such as natural disasters or recession were absent from most of the comprehensive plans. Coastal communities in Maine rely on natural resources activities such as fishing, forestry, and agriculture. The future of these resources is threatened by coastal hazards and anthropogenic impacts such as climate change. Greater efforts should be put toward developing policies that address the natural resource dependency of economies in Maine's coastal regions in local planning policies.

Investing in resilience planning can be economically beneficial to municipalities in the long-run. For example, the Maine Coastal Program administers a competitive grant program that provides financial assistance for municipalities to conduct projects related to topics such as storm hazard resiliency, water quality improvement, and public access. In 2013, the town of York used these funds to develop a sea-level rise analysis and adaptation strategy chapter for their comprehensive plan. This work allowed the community to assess inundation areas and identify vulnerable infrastructure to prioritize action strategies to mitigate the costs of replacing infrastructure in the future.

Incorporating social-ecological resilience measures into comprehensive plans is an important step toward fostering resilience in coastal communities (Beatley 2009). In addition to the focus on social aspects of resilience, many of the comprehensive plans in

Maine focus on specific resilience by prioritizing actions and policies that mitigate disturbances related exclusively to infrastructure. While prioritizing specific hazards can help communities prepare for particular disturbances, a social-ecological resilience approach that emphasizes general resilience by encompassing components of social, ecological, and economic resilience has a greater capacity to prepare communities to adapt to a broad range of disturbances long-term (Folke 2010; Boulware, 2013).

Communities face social, ecological, and economic challenges, thus a holistic prioritization of resilience that moves beyond a focus on infrastructure alone may help communities in Maine prepare for extreme, novel, or unexpected disturbances.

Comprehensive plans cover a variety of topics such as housing, natural resources, transportation, and the local economy. These sections and related policies are often written in isolation, however the multifaceted nature of the plans can facilitate a general resilience approach with a prioritization of feedbacks and connectivity between the different components of a community plan.

There are numerous social, political, and economic barriers to building resilience that are specific to the context of each community. Increasing resilience at the community scale requires financial investments, time, and human resources. Some of the major obstacles that have been identified in the coastal planning literature include low prioritization of hazards, limited ability or willingness to confront big issues, short decision-making time-frames, political impediments, as well as limited financial resources and staff capacity (Beatley 2009; Picketts et al., 2013). There are many tradeoffs associated with resilience planning, as building resilience at the community scale may compete with other local objectives. Thus, increasing resilience in one area may be at the expense of another. For example, development of land may increase economic productivity in a community, but may negatively impact critical habitats such

as wetlands, which provide extensive ecosystem services that contribute to human well-being. Communities in Maine are faced with addressing these tradeoffs. The town of Stonington, Maine's leading port for commercial fisheries landings, is confronted with the need to adjust infrastructure to address storm surge and sea level rise hazards while maintaining the working waterfront infrastructure that is necessary for its viability as a fishing port. The development of effective local and regional planning strategies to enhance resilience and increase adaptive capacity among coastal communities necessitates a deep and multifaceted understanding of these obstacles to inform efforts to address them (Beatley 2009).

There is no panacea to overcome the complex barriers to building resilience in coastal communities. However, comprehensive plans can be repurposed to serve as a tool to address and plan for challenges around resilience and adaptive capacity at the community level. Climate change impacts such as sea level rise, ocean acidification, and increased storm severity are already being experienced in coastal communities in the US Northeast (Moser et al., 2008; Lyles et al., 2014; Hare et al., 2016). Policy-makers and resource managers must prepare and plan for the impacts of climate change to coastal communities and implement plans on the ground to address these stressors. We envision the next generation of comprehensive plans as iterative, adaptive planning documents that not only identify resource challenges in communities, but also articulate goals and management strategies across the ecological, social, and economic domains that can support resilient coastal communities.

5. Conclusion

Coastal communities worldwide face an extensive set of threats from a myriad of ecological, economic, and social stressors. Many high-level international and national policies acknowledge the importance of resilient coastal communities, however they do

not touch the ground on the community level, where people are closely connected to the coast and are vulnerable to such stressors. Coastal communities may be better able to prepare for the impacts from socioeconomic and environmental change if they began preparing for them now. Planning for resilience is integral to ensuring the longevity of coastal communities and building local adaptive capacity in the face of ecological and socio-economic change.

Comprehensive plans serve as a platform for communities to develop policies that encourage responsible use of coastal resources and acknowledging the connections of the natural and human systems in order to foster social-ecological resilience. The emphasis on social-ecological resilience focuses on interactions that are relevant in managing human-environment systems in the face of change (Quinlan et al., 2016). Several key planning dimensions are critical to advance social-ecological resilience in coastal communities: resilience of ecosystems and coastal environments, social resilience, and economic resilience (Beatley 2009). These categories of resilience are not independent but are intricately related.

A key step in moving communities toward resilience is to monitor, assess, and evaluate the degree to which local communities are integrating resilience in local planning documents. A review of 30 active comprehensive plans from coastal communities in Maine among these three categories of resilience revealed that coastal municipalities are not incorporating social-ecological resilience principles in their comprehensive plans. The results of the comprehensive plan analysis demonstrate a gap between the academic development of resilience indicators, frameworks, and policies and the integration of key aspects of resilience into coastal community comprehensive plans. Further, there is heterogeneity in the extent to which components of resilience are

addressed in comprehensive plans, with social characteristics outweighing ecological and economic components.

Anticipating potential disturbances through the early implementation of resilience principles can be cost effective and can provide current and future benefits to communities. The comprehensive planning process provides a platform for communities to envision the future and outline objectives and policies that address social, economic, and environmental issues to guide the future direction of the community. Comprehensive plans along Maine's coast have largely not altered from the original requirements of the Comprehensive Planning and Land Use Act. This act was written in the 1988 to encourage towns to address the pressing issue of urban sprawl. Thirty years later, sprawl no longer remains the central challenge facing municipalities. Comprehensive plans are no longer a requirement of municipalities in Maine, however grant based incentives and local zoning ordinances motivate municipalities to keep updated comprehensive plans. New, expansive directions beyond inventorying community resources and directing sprawl are required to reform how comprehensive plans are made.

Climate change is already and will continue to impact every aspect of municipalities including infrastructure, but also public health, housing and biodiversity. Building resilience requires significant structural shifts to address the root causes of challenges in the community as well as a paradigm shift in planning to move towards a more proactive approach and a holistic consideration of resilience. Resilience building is an ongoing process and comprehensive plans are living documents that foster a platform for coastal communities to articulate their vision for the future and implement strategies to build adaptive capacity as we face unprecedented challenges and plan for a changing world.

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[Removed for Review]

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Figure Caption List

Figure 1. Total resilience score for each municipality. Total scores calculated for each municipality out of a maximum score of 100%.

Figure 2. Comprehensive plan total scores for each municipality by resilience category.

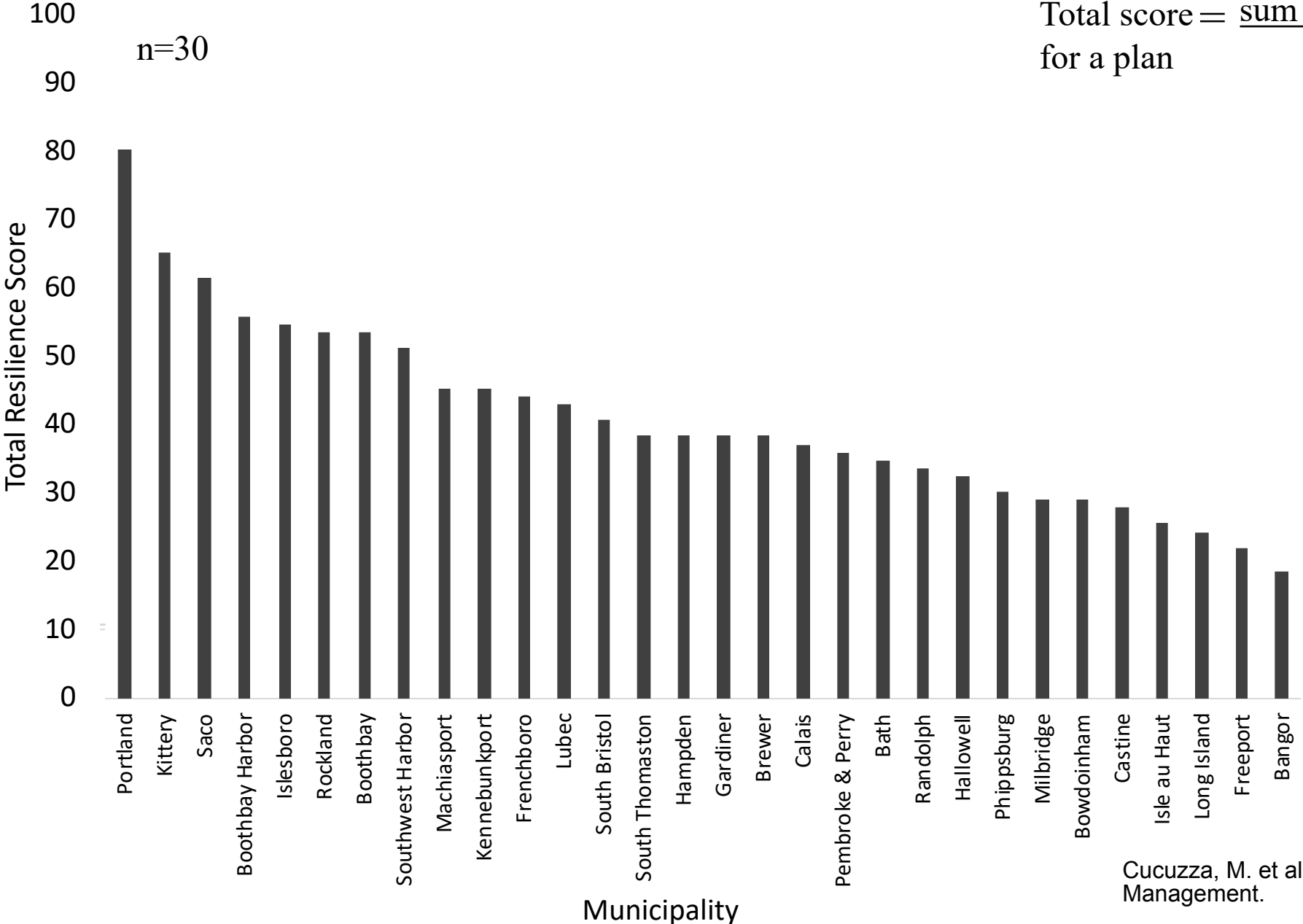
Figure 3. Comprehensive plan analysis scores by resilience category and mapped by municipality.

Figure 4. Total comprehensive plan resilience score and the year each plan was adopted.

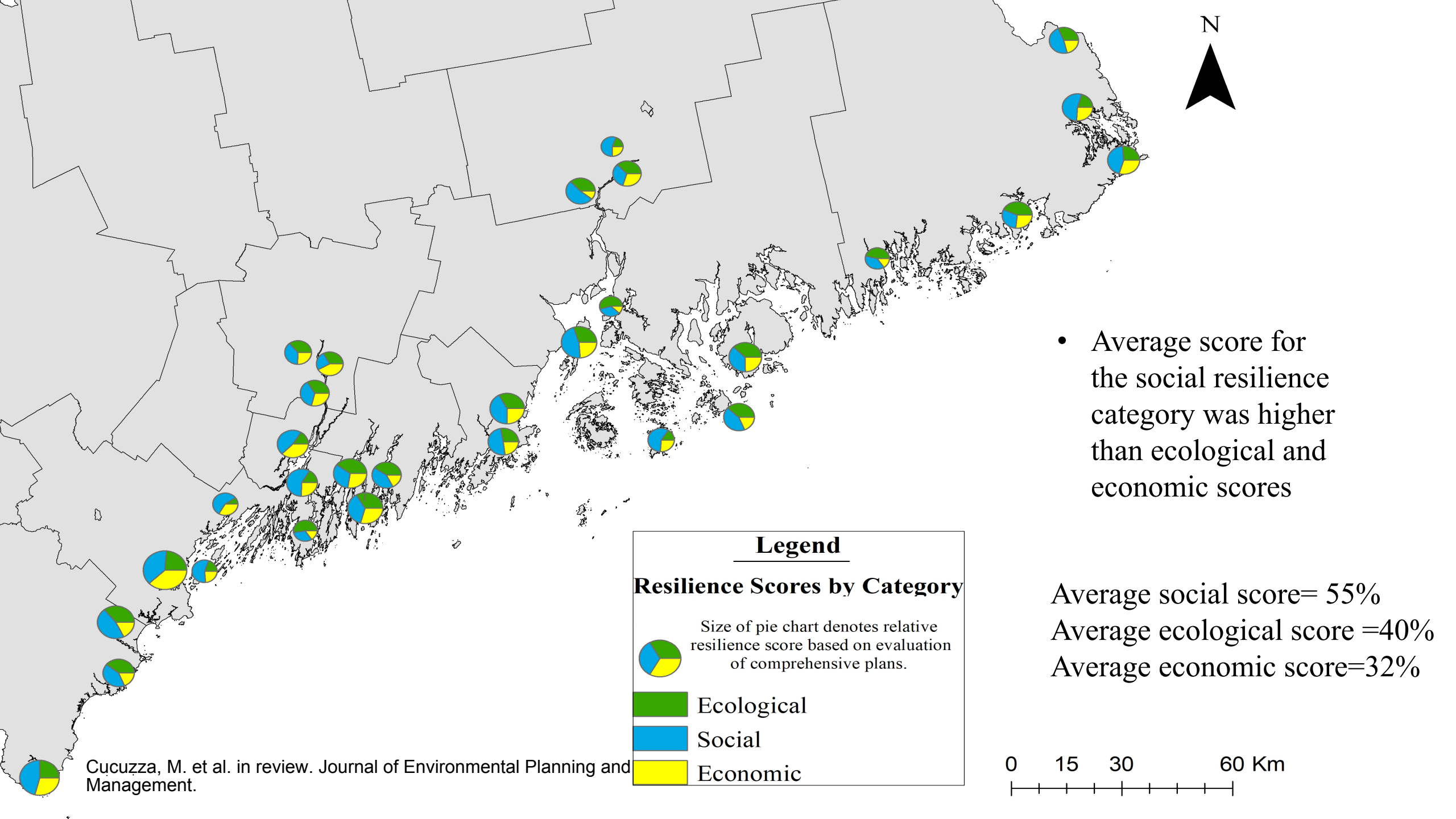
Total Resilience Score

Total score = $\frac{\text{sum of resilience component scores}}{\text{total possible score}} \times 100$
for a plan

n=30




- Average resilience score was 40%
- Lowest score was 18%
- Highest score assigned to a municipality was just 80% out of 100%





Legend

Resilience Scores by Category

Size of pie chart denotes relative resilience score based on evaluation of comprehensive plans.

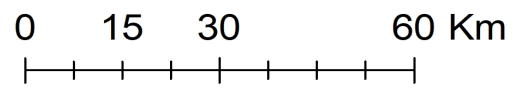
 Ecological

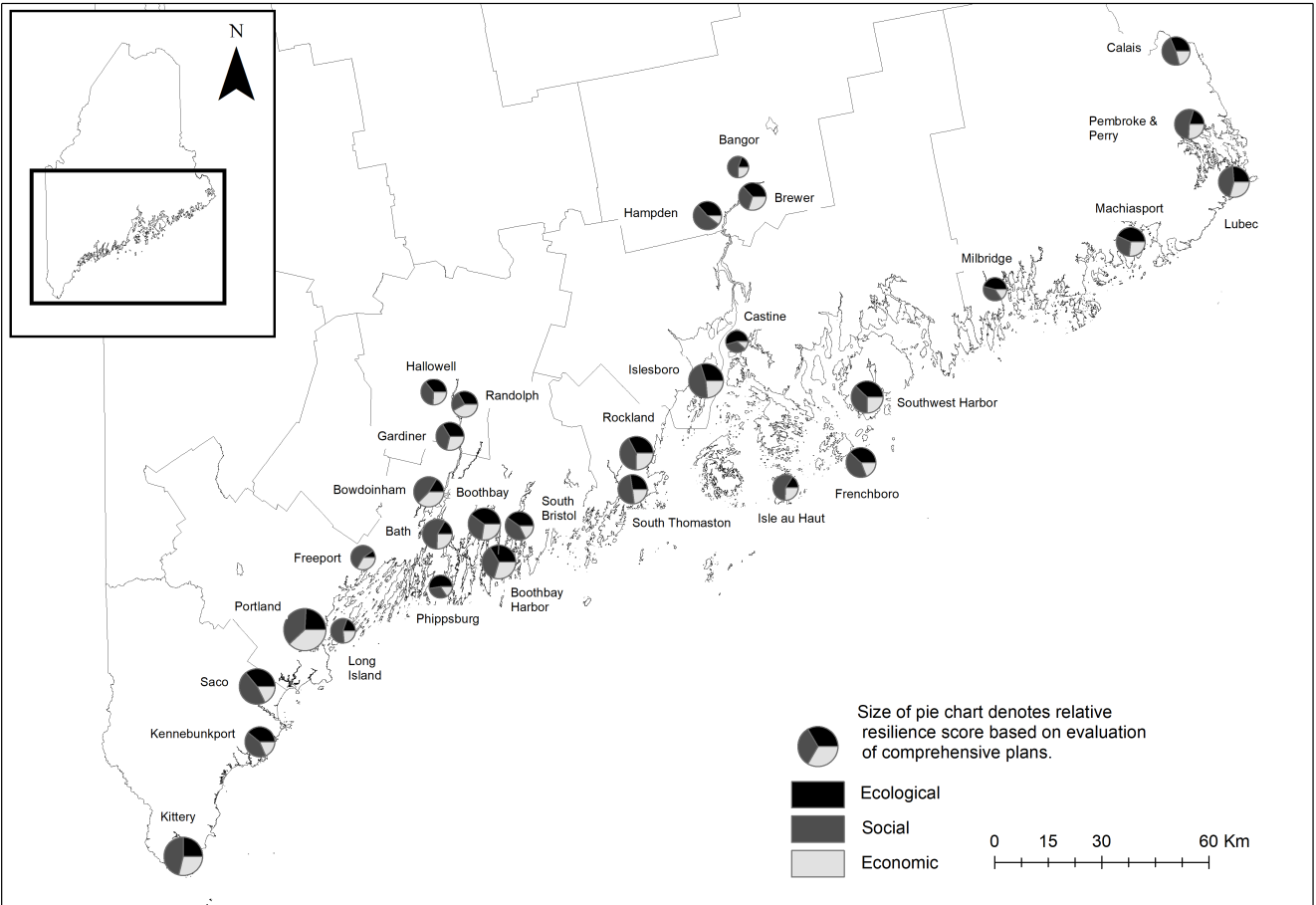
 Social

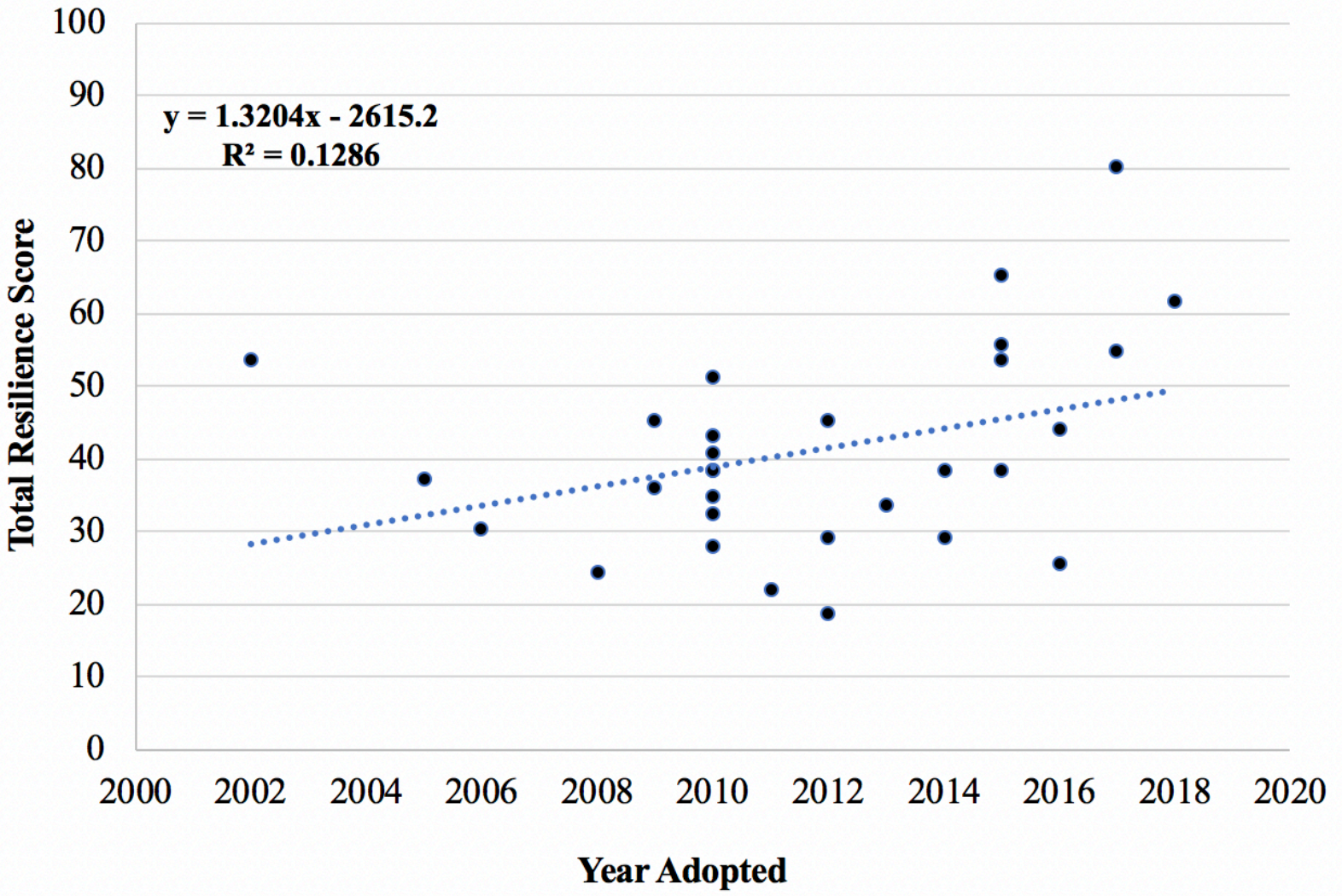
 Economic

- Average score for the social resilience category was higher than ecological and economic scores

Average social score= 55%
 Average ecological score =40%
 Average economic score=32%







Municipality	Year Established	Total Resilience Score
<i>Bangor</i>	2012	18.6
<i>Bath</i>	2010	34.88
<i>Boothbay</i>	2015	53.48
<i>Boothbay Harbor</i>	2015	55.81
<i>Bowdoinham</i>	2014	29.06
<i>Brewer</i>	2015	38.37
<i>Calais</i>	2005	37.2
<i>Castine</i>	2010	27.9
<i>Freeport</i>	2011	22.09
<i>Frenchboro</i>	2016	44.18
<i>Gardiner</i>	2014	38.37
<i>Hallowell</i>	2010	32.55
<i>Hampden</i>	2010	38.37
<i>Isle au Haut</i>	2016	25.58
<i>Islesboro</i>	2017	54.65
<i>Kennebunkport</i>	2012	45.34
<i>Kittery</i>	2015	65.11
<i>Long Island</i>	2008	24.41
<i>Lubec</i>	2010	43.02
<i>Machiasport</i>	2009	45.34
<i>Milbridge</i>	2012	29.06
<i>Pembroke & Perry</i>	2009	36.04
<i>Phippsburg</i>	2006	30.23
<i>Portland</i>	2017	80.23
<i>Randolph</i>	2013	33.72
<i>Rockland</i>	2002	53.48
<i>Saco</i>	2018	61.62
<i>South Bristol</i>	2010	40.69
<i>South Thomaston</i>	2010	38.37
<i>Southwest Harbor</i>	2010	51.16

Table 1. Total scores for each municipality are depicted along with the year each plan was completed. Each total social-ecological resilience score is based on the summed values of the plan’s ecological, social, and economic scores, which was then converted into a percentage.

MUNICIPALITY	ECOLOGICAL		SOCIAL		ECONOMIC	
	Raw Score	Total Score	Raw Score	Total Score	Raw Score	Total Score
BANGOR	6	13.04	6	37.5	4	16.67
BATH	10	21.74	12	75	8	33.33
BOOTHBAY	28	60.87	8	50	10	41.67
BOOTHBAY HARBOR	26	56.52	10	62.5	12	50.00
BOWDOINHAM	10	21.74	10	62.5	5	20.83
BREWER	19	41.30	6	37.5	8	33.33
CALAIS	17	36.96	9	56.25	6	25.00
CASTINE	18	39.13	4	25	2	8.33
FREEPORT	4	8.70	8	50	7	29.17
FRENCHBORO	23	50.00	9	56.25	6	25.00
GARDINER	18	39.13	7	43.75	8	33.33
HALLOWELL	16	34.78	6	37.5	6	25.00
HAMPDEN	20	43.48	10	62.5	3	12.50
ISLE AU HAUT	7	15.22	9	56.25	6	25.00
ISLESBORO	24	52.17	13	81.25	10	41.67
KENNEBUNKPORT	24	52.17	9	56.25	6	25.00
KITTERY	25	54.35	16	100	15	62.50
LONG ISLAND	8	17.39	8	50	5	20.83
LUBEC	17	36.96	10	62.5	10	41.67
MACHIASPORT	25	54.35	6	37.5	8	33.33
MILBRIDGE	17	36.96	5	31.25	3	12.50
PEMBROKE & PERRY	12	26.09	11	68.75	8	33.33
PHIPPSBURG	19	41.30	4	25	3	12.50
PORTLAND	29	63.04	16	100	24	100.00
RANDOLPH	15	32.61	4	25	10	41.67
ROCKLAND	25	54.35	11	68.75	10	41.67
SACO	31	67.39	14	87.5	8	33.33
SOUTH BRISTOL	22	47.83	8	50	5	20.83
SOUTH THOMASTON	16	34.78	10	62.5	7	29.17
SOUTHWEST HARBOR	26	56.52	9	56.25	9	37.50
TOTAL POSSIBLE SCORE PER CATEGORY	46		16		24	

Table 2. Scores for each municipality by resilience category are reported. Raw scores represent the total number of points for the resilience category from the comprehensive plan analysis. Total scores were calculated based on the raw score divided by the total possible score for each resilience category.

Resilience Category	Indicators Frequently Excluded from Maine's Comprehensive Plans	Indicators Well Incorporated in Maine's Comprehensive Plans
Social	<ul style="list-style-type: none"> • Plan promotes community hazard awareness and education • Plan discusses adaptive capacity 	<ul style="list-style-type: none"> • Plan establishes a sense of community • Plan promotes emotional and physical well-being and increased quality of life
Economic	<ul style="list-style-type: none"> • Plan discusses economic recovery options • Plan encourages a business owner education component related to hazards 	<ul style="list-style-type: none"> • Planning encourages coordinated planning to achieve objectives focused on protecting, sustaining, and enhancing a communities economic base • Plan recognizes the relationship between healthy natural systems and economy
Ecological	<ul style="list-style-type: none"> • Plan addresses sea level rise • Plan addresses storm surge • Plan discourages hazardous area acquisition • Plan promotes the relocation of critical facilities out of hazardous areas 	<ul style="list-style-type: none"> • Plan promotes the conservation of natural systems • Plan promotes living shorelines & wetland protection • Plan addresses erosion • Plan addresses flooding

Table 3. Indicators of social-ecological resilience that scored an average of 30% or below or a score of 70% or above for each resilience category. These thresholds represent indicators that are minimally addressed and integrated in the comprehensive plans as well as indicators that are well integrated into comprehensive plans on average.