EVALUATING THE READINESS OF THREE STATES IN THE NORTHEASTERN UNITED STATES TO ADAPT IMPORTANT NATURAL RESOURCES SYSTEMS TO CLIMATE CHANGE: PRACTICAL AND THEORETICAL CONSIDERATIONS

by © Claudia Friedetzky A Thesis submitted

to the School of Graduate Studies in partial fulfillment

of the requirements

for the Master's Degree

in the Department Environmental Policy/School of Science and the Environment

Memorial University of Newfoundland
February 2022

Corner Brook Newfoundland and Labrador

TABLE OF CONTENTS

Abstract

In the last decade, governments have made advances in the development and adoption of climate adaptation programs. With the rise of these programs, scholarly efforts have emerged to assess and evaluate their effectiveness and quality. Thus, researchers have developed and applied a range of climate adaptation evaluation approaches to gauge adaptation progress. In this thesis, a climate adaptation evaluation approach developed by Ford and King (2015) — the adaptation readiness framework — was applied to assess the readiness of three Northeastern US States – Massachusetts, New Hampshire, and Maine – to adapt the natural resources systems located within their boundaries to climate change. To enable the adaptation readiness evaluation, the indicators in the adaptation readiness framework were revised to fit the context of this study shaped by scale and governmental system. Systematic reviews of the scholarly and grey literature were pursued. The revised indicators were used for the coding of documents. Indicators were then scored based on ordinal rankings. Results demonstrated that Massachusetts had the highest level of climate adaptation readiness, New Hampshire the second highest and Maine the lowest climate adaptation readiness. It was found that political leadership – one of the factors in the framework – strongly correlates with climate adaptation readiness, and that high levels of climate adaptation readiness are associated with government centralization. The conceptual strengths of the framework include its ability to illuminate adaptation deficits, and adaptation policy patterns and structures. Its weaknesses stem from the vagueness of the underlying definition of adaptation. Rather than measuring adaptation progress, the adaptation readiness framework measures the extent to which governments have established programs that fall under the category of adaptation as "adjustments".

Acknowledgements

I would like to thank Dr. Klinke who served as my thesis advisor. I would also like to extend my profound appreciation to Dr. Garrett Richards for providing in-depth comments on my thesis and serving on my committee. Dr. Richards always made time to respond to my questions and concerns. His comments and feedback encouraged me to wrestle with important questions and ensured that I grew as a scholar. I consider him a mentor. I very much appreciate the contributions of Nick DiPasquale, former Director of the US Environmental Protection Agency (EPA) Chesapeake Bay Program, Annapolis, Maryland; Stephen S. Perkins, Director, Office of Ecosystem Protection, U.S. EPA Region 1, Boston, MA; and Edward Ambrogio, former Manager, U.S. Environmental Protection Agency, Region III, Office of Ecological Assessment and Management, Philadelphia, PA, for reviewing and providing input into the data collection instrument of the first research design for this thesis. I learned tremendously from their comments and insights. I would also like to thank all the faculty members and staff at the Environmental Policy Program and the School of Science and the Environment for their support of students. Finally, I would like to thank my sons Cairo and Marcel for having joined me on this journey to Newfoundland and Labrador.

List of Tables

Introduction

Climate change impacts ecological and human systems across the world. Global mean temperature increases cause severe storms, floods, and droughts (IPCC, 2018) and are associated with a cascading set of consequences that ripple throughout ecosystems and impact communities (IPCC, 2018).

Climate change adaptation, conceptualized as "[...] adaptation or adjustment to climate and its effects" (IPCC, 2014) — long considered a secondary priority to mitigation — has gained progressively more scholarly attention since the late 1990s. Only in the last decade and a half, however, have governments begun to initiate climate adaptation initiatives. Rising governmental interest in climate adaptation is reflected in the emergence of novel planning processes, policy development, and implementation of adaptation interventions (see Massey & Huitema, 2013). This expansion in governmental climate adaptation efforts has been accompanied by a growth in adaptation scholarship, capturing and analyzing the complexities of human responses to climate change.

In the last decade, the concept of adaptation progress has come to the fore in climate adaptation scholarship. Since the goal of adaptation is articulated as harm reduction (Cooper & Pile, 2013) and reduction in vulnerability of human -and ecosystems, it is important that adaptation interventions yield tangible results. Hence, evaluation and tracking of adaptation success has emerged as an important area of investigation (see Bierbaum et al., 2013; Bours, et al., 2014; Ford et al., 2013; Ford & King, 2015; and Preston et al., 2009) to ensure that measurable reductions in vulnerability[1] (see Füssel, 2013) and harm are achieved. In addition,

[1]Vulnerability itself has been conceptualized in a range of ways and is, like climate adaptation, a contested concept (see Füssel, 2013). Delving into the complexities of the understandings and definitions of vulnerability is outside the scope of this thesis.

with organizations and governments committing progressively more funds to adaptation, rigorous evaluation of adaptation progress is needed to guide funding decisions (Ford et al., 2013).

This thesis, too, was inspired by the quest to evaluate adaptation progress, specifically adaptation of natural resources systems in three US states. Climate change emphasizes the dependence of human systems on functioning ecosystems, rendering the adaptation of natural resources systems a priority in climate adaptation efforts (Turner, 1996; Pramova, 2012, Capon et al., 2013).

The difficulties encountered in finding a credible research design for this thesis[2] made clear that capturing progress in the climate adaptation realm faces significant methodological and conceptual challenges. The temporal dimension of adaptation as a project oriented towards an uncertain future is most frequently listed in the literature as a critical methodological barrier to evaluating adaptation success (see Bours et al., 2014; Ford et al., 2013). Thus, there is uncertainty about the extent to which any adaptation interventions measurably reduce vulnerability and harm. Some interventions may reduce vulnerability in the short-term but may turn out to be ineffective in the long-term as temperatures increase and impacts become more unpredictable and severe. Other interventions may turn out to be not only ineffective but increase vulnerability and harm. The consensus in the literature suggests that the long planning horizons involved in climate adaptation mean that the success or failure of some adaptation interventions will not become apparent until decades from now (Ford et al., 2013). In the natural resources sector, the concept of adaptation faces even greater methodological challenges than in the human sectors. Ecosystems already face significant degradation from past human use. They

[2] Iterations of the thesis research design that preceded the design adopted for this thesis are described in Appendix A.

are impacted by both climate and non-climate related stressors. Thus, ecosystems restoration is considered a critical adaptation measure. The notion of restoration, however, draws on past ecosystems functioning for baseline development. Degradation, shifting baselines and the blurring of the distinction between restoration and adaptation make evaluation of adaptation in the natural resources sector difficult.

To address challenges in adaptation evaluation, the field of adaptation scholarship has largely relied on proxy frameworks to assess adaptation progress rather than examining outcomes directly (see Bierbaum et al., 2013; Bours, et al., 2014; Ford et al., 2013; Klostermann et al., 2018). Proxy frameworks explore several adaptation dimensions, including the quality of adaptation processes, whether the policy-related preconditions for pursuing adaptation are in place, and whether governments pursue initiatives that are defined as 'adaptation'.

For this thesis, a proxy concept called the adaptation readiness framework developed by Ford and King (2015) was selected and applied to evaluate the natural resources adaptation progress in the context of the overall adaptation planning and policy development processes of three Northeastern US states. This framework is based on the notion of an adaptation architecture as articulated by Smith et al. (2009), who contend that without certain policy-related components in place, adaptation is unlikely to proceed. According to Ford and King (2015) adaptation is more likely to occur if these components are in place. Best understood as adaptation preconditions, these components have been conceptualized by Ford and King as overarching factors manifesting in the public, political and policy spheres (Ford & King, 2015; Ford et al., 2013; see Smith et al., 2009). These factors include:

- political leadership
- institutional organization

- adaptation decision-making and stakeholder engagement
- availability of usable science for decision-making
- funding for adaptation planning, implementation, and evaluation
- public support for adaptation

The application of the climate adaptation readiness framework enables the evaluation and ranking of the overarching factors/adaptation preconditions and thus paves the way for comparative evaluation of climate adaptation readiness of national and sub-national units (Ford and King, 2015). The objective of this thesis is twofold, to contribute to meeting the gap in the literature on evaluation of climate adaptation progress (Kamperman & Biesbroeck, 2017; Mimura et. al., 2014; Noble et. al., 2014) and to test the adaptation readiness framework as a valid approach for measuring adaptation progress.

In this thesis, the climate adaptation readiness framework as developed by Ford and King (2015) was modified and then applied to evaluate and compare the readiness of three northeastern US states —Massachusetts, New Hampshire, and Maine — to adapt wildlife habitat, forests and estuaries to climate change[3]. The methods employed in this thesis drew on systematic review of research articles and systematic review of government documents, which were coded for themes based on the criteria and indicators recommended by the authors of the adaptation readiness framework (see Ford & King, 2015). In applying the framework, the strengths and weaknesses of the climate adaptation framework were assessed, and its ability to

[3] My choice of natural resources systems was shaped by considerations of comparability (see Ford & Berrang-Ford, 2017). To meet the criterion of comparability, I analyzed adaptation progress via coding state natural resources management plans required by the federal government. For reasons delineated in the thesis in the methods chapter, I chose wildlife habitat, forests, and estuaries despite the fact that there is overlap between the three as forests and estuaries also comprise wildlife habitat.

capture climate adaptation readiness were analyzed. Considering the theoretical complexity of the concept of climate adaptation, this thesis also explores the extent to which climate adaptation readiness is a meaningful proxy measure of climate adaptation progress.

The following research questions guided data collection and analysis:

1. Based on the application of the climate adaptation readiness framework to three US states, what is the readiness of each of the states to pursue climate adaptation of natural resources systems?
    a. To what extent have the states created the preconditions for adaptation?
    b. How does the quality of the adaptation readiness manifest differently in each state?
2. What are the strengths and weaknesses of the climate adaptation readiness framework developed by Ford and King (2015) to evaluate the readiness of three US states to adapt their natural resources systems to climate change in a federated system?
    a. What are the conceptual and theoretical strengths and weaknesses of the climate adaptation readiness framework?
    b. What are the obstacles in evaluating climate adaptation readiness of natural resources systems using the framework?
    c. Are the adaptation framework's overarching factors and indicators appropriate?
    d. Can the adaptation framework be flexibly applied?
3. What are avenues for future research?

This thesis contains five chapters. In Chapter 1 (Literature Review), climate adaptation definitions and typologies are discussed and critically reviewed. In addition, a range of approaches to evaluation and tracking adaptation progress are examined.

In Chapter 2 (Methodology), the climate adaptation readiness framework as developed by Ford and King (2015) is described, and the way it was revised for the research context in this thesis, i.e., natural resources systems adaptation in three US states.

In Chapter 3 (Methods), the methods pursued in this thesis are described in detail, including the approach taken to the systematic review of articles and documents, search strings used, and exclusions and inclusions applied.

Chapter 4 (Narrative Presentation of Results and Discussion) examines how each readiness factor is manifested in each of the U.S. states evaluated in this thesis. Outcomes data from the data collection efforts grounded in the two previous research designs[4] described in Appendix A is interwoven when relevant, pointing towards additional research gaps in the evaluation of climate adaptation progress.

Chapter 5 (Conclusion) discusses the conceptual and practical strengths and limitations of the adaptation readiness framework as developed by King and Ford (2015) and avenues for future research.

[4] See Appendix A.

Chapter 1: Literature Review

1.1 Climate Adaptation as Discourse

Since the late 1990s and early 2000s the concept of adaptation in the climate change context has seen a dramatic increase in scholarly attention. Recognizing that some warming would be inevitable, scholars have seized on the concept of adaptation to conceptualize human responses to climate impacts (Bassett & Fogelman, 2013). A burgeoning body of adaptation literature emerged (see Preston et al, 2015; Bassett & Fogelman, 2013; Berrang-Ford et al, 2010), which culminated into a scholarly discipline in its own right (see Bassett & Fogelman, 2013).

Broadly speaking, adaptation comprises the actions that need to be undertaken for ecosystems and human societies[5] to persist under changing climatic conditions. According to the IPCC (IPCC, TAR, 2001, p. 982), climate adaptation is defined as:

> […] the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. (IPCC, TAR, 2001, p. 982).

The latter phrase in the IPCC's definition, describing an array of adaptation types, is indicative of the emergence of an adaptation language or discourse. Created by adaptation scholars and practitioners, this discourse is conceived of through the articulation of a multiplicity of new concepts, describing processes and activities that seek to reduce the vulnerability of

[5] The term socio-ecological systems is becoming increasingly popular in the research literature to describe the relationship between ecosystems and human systems. However, government planning approaches still distinguish between natural and human systems. The IPCC definition of adaptation distinguishes between human and natural systems. Therefore, it was decided in this thesis to also distinguish between eco-systems and human societies.

human societies and ecosystems to climate impacts. Examples include the expansive glossaries of the IPCC assessments after 2001, which list definitions for adaptation capacity, adaptation deficit, and soft and hard limits to adaptation and other related terms (see IPCC, 2014, p. 118; see also Adger, 2009) and include the discussions of the numerous, conflicting definitions used by a range of national and international bodies concerned with climate change and adaptation (see Levina & Tirpac, 2006)

Critics of the contemporary adaptation discourse have noted both its top-down nature and focus on the technical as opposed to the social and cultural aspects of adaptation (Eriksen et al., 2015; Schulz, 2015; Basset & Fogelman, 2013). This technocratic orientation of the contemporary adaptation discourse stems from the natural hazards literature of the 1970s, which fashioned many of its concepts, including risk, vulnerability, and adaptation (see Bassett & Fogelman, 2013). Hence, the contemporary adaptation discourse can be understood as a successor discipline to the natural hazards literature of the 1970s (see Bassett & Fogelman, 2013). The latter views environmental threats rather than economic and political inequities as imbued with risks (see Bassett & Fogelman, 2013). In the natural hazards literature, human responses to threats comprise adjustments that become more sophisticated over time (see Bassett & Fogelman, 2023). Ideally, communities undertake adjustments to minimize risks proactively. When these adjustments become standard responses to environmental threats, they are considered adaptive responses according to the natural hazards literature (see Bassett & Fogelman, 2013).

Bassett & Fogelman (2013) note that the contemporary adaptation discourse owes much of its theoretical underpinnings to the natural hazards literature, which they find reductive and limiting in managing risks faced by communities. These authors, along with other political

ecologists, have called for a greater focus on analyses of social-economic determinants of vulnerability (Bassett & Fogelman, 2013; Grove, 2014) and an examination of the power relations underlying the economic drivers of processes that compel human communities to adapt to begin with (Bassett & Fogelman, 2013).

Criticisms have come from other quarters of the scholarly field as well, however. In examinations of the peer-reviewed literature used in IPCC assessments, for example, it has been noted that the IPCC prioritizes economics among the social sciences, while "marginal[izing]" (Hulme & Mahoney, 2010) studies from psychology, anthropology, and history that could shed light on adaptive processes in social systems (Hulme & Mahoney, 2010, see also Pelling, 2010, p. 9). In fact, the prioritization of the natural sciences and the orthodox application of science hierarchies has been a longstanding feature of scientific assessments conducted by international research bodies (Hulme & Mahoney, 2010), possibly hampering both mitigation and adaptation progress (see Sarewitz, 2011; Beck, 2011, Hulme & Mahoney, 2010).

This study, while acknowledging the importance of the social sciences in climate adaptation research and the need for analyzing and considering the social construction of vulnerability, is situated at the intersection of natural resources management and policy analysis. This disciplinary intersection has conceptualized itself in the West, especially since the 70s and 80s, as grounded in technocratic approaches that seek technical and scientific solutions to its problems (Raik, Wilson & Decker, 2008).

Thus, while this thesis assumes a critical stance towards climate adaptation literature as a successor to the natural hazards literature (see Bassett & Fogelman, 2013), it is centered in the scholarly tradition of the natural hazards and public policy literatures. This tradition understands itself as a field of applied scholarship that supports and shapes public policy decision-making.

1.2 Climate Adaptation Progress

This thesis is concerned with the evaluation of adaptation progress. It seeks to provide answers to questions, such as 'are we adapting?' (see Lukasiewicz et al., 2016; Berrang-Ford, 2011; Preston et al., 2009) and 'how are we adapting?' (see Lesnikowski, et al., 2015) and 'how do we know that we are adapting?' (Berrang-Ford, 2013). To lay the groundwork for a discussion of the research literature on climate adaptation evaluation, definitions and typologies of adaptation generated by the adaptation literature need to be reviewed. Definitions and typologies shed light on how adaptation is understood by researchers interested in public policy applications. They illustrate which dimensions of adaptation can be considered for both adaptation evaluation and comparing adaptation progress across national and sub-national units.

While this thesis focuses on natural resources systems adaptation, it is important to understand that governmental planning and implementation processes for climate adaptation have been conceptualized as essentially the same independently of sector. Adaptation as a process in developed nations usually involves planning, policy development, capacity building, and implementation of strategies (Lesnikowski et al.2015; Biagini et al., 2014) in each of the sectors that are understood to be under the purview of governments. Thus, several of the typologies reviewed here originate from scholarly explorations of the adaptation process independently of sector.

In the following paragraphs, examples of adaptation definitions and typologies are critically reviewed from a range of different scholarly perspectives to demonstrate the breadth of definitions and typologies in the research literature.

1.3 Adaptation Definitions and Typologies[6]

Climate adaptation is a methodologically and conceptually complex and dynamic notion. To capture the various dimensions of adaptation, the climate adaptation literature has generated a wide range of both definitions and typologies. Researchers from a multiplicity of disciplines have contributed to the discussion by promulgating climate adaptation definitions and typologies including the successor to the natural hazards literature of the 1970s (see Bassett & Fogelman, 2013; see Smit et al, 1999; Smit & Wandel, 2006) policy analysis and public policy studies (Pelling, 2011; Smit et al., 2000; Eakin et al, 2009) political ecology (Bassett & Vogelman, 2013), and natural resources management (see Cooper & Pile, 2014; Bijlsma et al.,1996)

Consequently, the climate adaptation literature is characterized by a lack of consensus on definitions and concepts (Brooks, 2003). To begin to explore concepts that have shaped the scholarly understanding of climate adaptation, Smit et al.'s *An anatomy of adaptation to climate change and variability* (2000), which offers both a definition and typology of climate adaptation, is discussed in detail. With 1916 citations in google scholar, this article is considered a foundational text in the climate adaptation literature.

According to Smit et al. (2000) and Smit, et al. (1999), adaptation can be defined by asking three questions: "Adaptation to what?", "Who adapts?", and "How does the adaptation occur?" (Smit, et al, 2000, pp. 223 -251). Secondarily, they suggest that "we must ask, how good is the adaptation?" (Smit, et al, 2000, p. 229). The first question "adaptation to what?" refers to the range of climate stimuli that prompt adaptation. These stimuli include the stresses, perturbations and shocks caused by climate variability (Smit, et al, 2000). Climate stimuli also encompass impacts that unfold in a more predictable fashion in relation to temperature increases

[6] My section on adaptation typologies was inspired by Biagini et al. (2014). They review several typologies in the 2014 articles, several of which I explore in this thesis as well, albeit making different arguments.

over longer timeframes, such as sea level rise (SLR). The question "who adapts?" elicits answers targeting the systems and sectors that adapt (Smit, et al, 2000). It also refers to the jurisdictional scales at which these systems and sectors operate (Smit et al., 2000). Thus, answers to this question generate knowledge about the jurisdictional levels at which adaptation unfolds, such as the national, sub-national, local, community or individual level, and which sector adapts, such as, for example, the natural resources, transportation, or water sector (Smit, et al, 2000). Answers to the question 'how does adaptation occur?' provide insights into the nature of the adaptive response (Smit et al., 2000). Is the response planned or autonomous, anticipatory as opposed to reactive, longer term or shorter-term, widespread, or localized (Smit et al., 2000). Finally, the question that explores "how good is adaptation?" addresses the quality of the selected adaptation strategies and whether these strategies are indeed designed to reduce vulnerability (Smit et al., 2000).

In considering Smit et al.'s (2000) foundational text in the climate adaptation literature, one must inquire whether the three questions posed to define climate adaptation are essentially the same questions one might ask about any arbitrarily chosen public policy or governmental problem. In fact, what, who and how questions apply to virtually any public policy topic considered by governments. Furthermore, human societies always adjust in one form or another to existing and emerging problems. Ideally, adjustments by governments, businesses and individuals happen when policy problems emerge. For example, the problem of mass homelessness in the US ideally requires adjustments. Adjustments to the emergence of mass homelessness can happen at different governmental scales and by different sectors, such as transportation or health and human services, or on the municipal, family and the individual level. Scholars can ask questions about how the policy response to homelessness, or predicted

homelessness, unfolds. Thus, increases in rents and stagnating wages are likely to cause increases in homelessness. As in the case of climate adaptation, one can inquire whether the policy response is proactive or reactive, planned or autonomous. One can explore the dimension of scale when considering policy responses to homelessness.

Accordingly, the three questions are "adaptation to what?", "who adapts?" and "how does the adaptation occur?" can be asked about many policy problems and therefore may not be suitable in specifically defining climate adaptation to distinguish it from other policy problems or problems facing humanity in general. Instead, from among the questions posed by Smit et al. (2000) two should be foregrounded, which are "adaptation to what?" and "how good is the adaptation?". The question "adaptation to what" defines the governmental or policy response as one that specifically targets climate impacts as a relatively new set of threats. "How good is the adaptation?" defines whether the response can be authentically considered adaptation. Any response to climate stimuli by itself cannot necessarily be considered adaptation. In fact, some responses to climate change may fail to meet the definition of adaptation or are considered maladaptation (see Juhola et al., 2016). For example, grey infrastructure projects, such as dams and sea walls to reduce flooding caused by climate change, are understood to generate long term negative impacts on important ecosystems. Other responses to climate change may address the short-term impacts of climate change but may be maladaptive in the long run (Eakin et al., 2009).

Hence, it is the quality of the response to climate change at any scale that determines whether harm to human and ecosystem is avoided, and vulnerability reduced over the long term or whether 'quick fixes' dominate the policy response that may increase vulnerability over the long term and may be viewed as maladaptive in the future. One can argue that the question that

is considered of secondary importance in Smit et al. (2000) *An anatomy of adaptation to climate change and variability*, that asks "how good is the adaptation" is more central to defining adaptation than questions centered on "who adapts?", and "how does the adaptation occur?". The quality of the policy response to climate impacts is the element that authentically distinguishes climate change adaptation from any other policy problem considered by governments.

The importance of qualitative factors in considering climate adaptation strategies has been considered in the larger field of adaptation literature, resulting in additional typologies. Thus, trade-offs between short-term solutions and policy responses focused on longer time horizons have been explored. Eakin et al. (2009, pp. 212 -224), in their typology, distinguish between three approaches to addressing climate impacts: 1/Vulnerability-based, 2/adaptation-based, and 3/resilience- focused strategies. Vulnerability-based approaches target population groups that are vulnerable to climate change as a result of their disadvantaged economic and educational status. Thus, vulnerability-based approaches address material and power inequities that render population groups vulnerable to loss and harm (Eakin et al., 2009, p. 215). Adaptation-based approaches, according to Eakin et al. (2009, p. 216) are focused on the present. They target a particular problem through risk evaluation and a cost-benefit analysis to achieve cost-effective solutions (Eakin et al., 2009, p. 216). Resilience-based approaches involve mechanisms that enable a natural or other system to recover from stresses and perturbations. The relative consequences of each approach must be compared by governments to assess the immediate and long-term implications and potential costs of each approach (Eakin et al., 2009, p.216). Adaptation based on risk assessments prioritizes efficiency and effectiveness but may lack considerations of equity and long-term resiliency (Eakin et al., 2009, p.215-216).

Vulnerability-based approaches address the immediate needs of vulnerable populations and focus on urgent harm reduction but may unfold at the expense of efficiency and effectiveness and of reduced ecosystems functioning in the long term (Eakin et al., 2009, p. 216). Resiliency approaches build long-term resilience into systems - an approach that is responsive to the needs and rights of future generations - but may undermine addressing immediate needs of vulnerable populations (Eakin et al., 2009, p. 215). For example, restoration of ecosystems whose declining resilience has been caused by engineered alterations to enable human use may cause economic hardship among the human users, if ecological restoration requires decreasing the use of the ecosystem (Eakin et al., 2009, p.219). By considering the nexus between qualitative, temporal, and social factors, Eakin et al. (2009) center the quality of the adaptation response in their adaptation typology and consider the potential consequences and costs of different adaptation approaches.

Other climate adaptation typologies have been developed based on empirical studies of climate adaptation, which claim to improve our understanding of adaptation in practice. Lesnikowski et al. (2011& 2016) crafted a typology grounded in studies of climate adaptation in the health sector of developed nations. This adaptation typology distinguishes among "groundwork level actions", which are actions considered critical for informing and preparing for adaptation and "adaptation level actions" (Lesnikowski, et al, 2011, pp., 1-9).

Actions considered to be part of the groundwork level include "1/Impact and vulnerability assessments, 2/ adaptation research, 3/Conceptual tools, 4/Climate change scenarios, 5/Stakeholder networking, and 6/Policy recommendations" (Lesnikowski et al., 2016, p. 281). These actions are understood as conveying the commitment to act as opposed to manifest actions (Lesnikowski, et al, 2016). Adaptation level actions are understood as

initiatives that are implemented to tangibly improve the adaptive capacity/resilience of human and natural systems, and include:"1/Organizational developments, 2/regulations, 3/infrastructure/technology innovation, 4/public awareness and outreach, 5/surveillance and monitoring, 6/and financial support" (Lesnikowski et al., 2016, p. 281). The distinction between groundwork level and adaptation level actions usefully captures the temporal dimension of adaptation as a process or as the unfolding of adaptation in stages. It suggests correctly that intent to act does not necessarily reflect evidence of adaptation implementation. However, it is noteworthy that among the actions designated as groundwork level adaptation by Lesnikowski et al. (2016) planning is absent. The planning aspect of adaptation, however, has been widely discussed in the literature (see Bednar et al., 2019; Stults & Larsen, 2020; Miao, 2019; Mimura et al., 2015; Abunnasr et al., 2015; Poyar & Beller-Simms, 2010). In fact, one can argue that the simplest adaptation typology used in the public policy realm distinguishes between two elements: planning and implementation.

Attempts to understand adaptation at the national and international levels, as reflected in Lesnikowski et al. (2016), have been described as fraught by methodological challenges, which derive from the "indistinctness" of adaptation as a concept (Dupuis & Biesbrock, 2013, p.1476), raising again, among others, questions about the qualitative dimensions of climate adaptation. Thus, comparisons of adaptation actions in national units so far have not included an analysis of whether actions described as adaptation by government representatives are effectively adaptive. Like much research on climate adaptation evaluation, international and sub-national comparisons hinge on proxy concepts, which measure climate adaptation progress indirectly rather than by examining adaptation outcomes. While limited in assessing concrete adaptation gains, considering the nature of adaptation as oriented towards an uncertain future, proxy concepts

necessarily play an important role in adaptation evaluation.

In another attempt at developing an adaptation typology that is grounded in an examination of adaptation in practice, Biagini et al. (2014) pursued an empirical study of adaptation projects supported by the Least Developed Nations Fund (Biagini, et al., 2014). This typology resulted in ten categories that include:

> 1/Capacity Building; 2/Management and Planning; 3/Changes in or Expansion of Practice or Behavior 4/ Governance and Institutional Policy Reform, 5/Information and Communications Technology, 6/Climate-Resilient Physical Infrastructure Adaptations, 7/Warning or Observing Systems 8/Climate-Resilient Biophysical or "Green" Infrastructure, 8/Adaptation-Related Financial Strategies, 9/Expansion or Introduction of Climate Adaptation-Related Technology. (p.103)

According to the authors, the strength of this typology lies in its centeredness in on-the-ground actions while the majority of existing typologies are based in theoretical speculations: "In general, the adaptation typology literature has so far relied primarily on theoretical approaches more than on empirical data." (Biagini et al., 2014, p. 103). However, this study shares the same conceptual problems as Lesnikowki's approach. While Biagini et al.'s (2014) stated goal is to "ground-truth theoretical assumptions with empirical research" (p. 99), its analysis is based on a proxy concept. This proxy concept comprises actions that are funded 'as adaptation' by the Least Developed Nations Fund. Moreover, this article aligns the results of the empirical study with theoretical concepts developed in the technocratically-oriented adaptation literature (see Biagini et al., 2014) with the effect of reinforcing the notion of climate adaptation as a technocratic project (see Pelling, 2011).

In the latter two typologies, the quality of adaptation or "how good it is" (Smit, et al, 2000) remains undefined. In fact, the two examples of concrete adaptation projects listed in the Biagini study are installations of grey infrastructure to address flooding and sea level rise. The adaptation literature shares a consensus, however, that grey infrastructure is likely associated

with increases in vulnerability (see Noble et al, 2014, p. 858; Ford et al, 2013; Brooks, 2003; Reilly and Schimmelpfennig, 2000; Smit et al., 2000) and is therefore likely maladaptive in the long run. Thus, the two projects mentioned in Biagini et al. (2014) may reduce vulnerability in the short term but turn out to be maladaptive in the future (see Lamhauge et al., 2012, p.11).

It has become clear that climate adaptation definitions and typologies as discussed in the research literature are often characterized by either an absence of definitions of desirable adaptation or rank qualitative standards for adaptation secondarily. Furthermore, social and political dynamics, such as may manifest in stakeholder and decision-making processes and conflicts that determine what is defined as desirable adaptation or adaptation success, is frequently not taken into consideration in the establishment of these typologies (see Eriksen et al., 2015). Thus, according to Pelling (2011) "growing evidence suggests that too often adaptation is imagined as a non-political, technological domain and enacted in a defensive rather than a progressive spirit." He argues that:

> Dominant development discourses put the economy as first to be preserved, above cultural flourishing or ecological health. There is a danger that adaptation policy and practice will be reduced to seeking the preservation of an economic core, rather than allowing it to foster the flourishing of cultural and social as well as economic development, or of improved governance that seeks to incorporate the interests of future generations, non-human entities and the marginalised. (p.3)

In the preceding paragraphs, it was argued that the quality and effectiveness of climate change adaptation, or as articulated in Smit et al. (2000) typology, "how good is climate adaptation?" ought to be considered as a primary factor in shaping the definition of adaptation. Questions targeting "who adapts?" and "how does the adaptation occur?" are also important in defining adaptation but should be considered secondarily.

Further, it has been shown that adaptation can comprise a wide range of actions and initiatives and in all governmental sectors. Long planning horizons obscure whether adaptation

interventions will have the projected adaptive impacts or increase vulnerabilities in the future. Thus, the nature, scope, quality, and goals of climate adaptation need to be clearly defined in measurable terms when discussing adaptation progress. For example, the construction of sea walls may be preferred by coastal homeowners to protect their properties from flooding but have destructive impacts on important coastal ecosystems. Both the sea wall and relocation of homes are captured by a definition of adaptation as 'adjustments', with the building of the sea wall resulting likely in long-term maladaptive impacts on ecosystems.

As a result of the indistinctness of adaptation (see Biesbroeck & Dupuis, 2013), adaptation research such as in Lesnikowski et al (2016) and Biagini et al., (2014) draw on proxy indicators. They are based on government and funding initiatives that have been categorized 'as adaptation', independently of a close analysis of whether the projects funded as adaptation meet certain definitions and standards that ensure that these projects are indeed adaptive over the long term.

1.4 Adaptation Typologies in Coastal Systems

The examples of adaptation definitions and typologies discussed above are largely independent of a specific adaptation context or sector, such as urban, rural, agricultural, grey infrastructure, and ecosystems. In the following paragraphs, two typologies are discussed that conceptualize adaptation in the natural resources systems context, specifically pertaining to coastal areas.

While all ecosystem types have been explored in the conservation adaptation literature, coastal adaptation stands out as having attracted particularly high levels of attention because of the population density in coastal areas (National Oceanic and Atmospheric Association (NOAA), n.d.) and the threats caused by SLR to coastal infrastructures and valuable ecosystems.

For coastal areas, a commonly used climate adaptation typology centers on three overarching approaches:"1/planned retreat 2/ accommodate; or 3/protect" (Macintosh, 2013; IPCC CZMS, 1992, p.190; Bijlsma et al.,1996). Planned retreat seeks to limit further development in the coastal zone, and may involve relocation of communities away from the coastal zone; relocation may center on the re-building of coastal infrastructure away from the coast, which can be exceedingly costly (Bijlsma et al.,1996). Planned retreat can be encouraged by governments through the elimination of subsidies for building in the coastal zone (Bijlsma et al.1996). The second approach - accommodation - is grounded in land use planning approaches that are designed to avoid the worst impacts of climate change on human infrastructure while avoiding infrastructure relocation (Bijlsma et al.1996). Accommodation involves land use planning adjustments, including changes to building codes and zoning, ecosystem protection, and hazard insurance. Strategies in the third category, which is 'protect', rely on "hard" engineering structures, which are both costly to construct and maintain" (Bijlsma et al.1996, p. 316). It is understood that the first two approaches allow coastal ecosystems to continue to naturally adapt, and are generally more cost efficient, while the latter, with its focus on hard armoring, leads to the loss of ecosystem function and is high in cost (Bijlsma et al.1996). The reliance on "hard" engineering structures, for example, can make it difficult or impossible for communities to use fishing and hunting grounds, and visit locations that have historical and cultural values (Bijlsma et al.1996).

The adaptation typology that describes coastal adaptation as 1/planned retreat, 2/accommodate and 3/protect has been re-conceptualized by Cooper and Pile (2014) as a spectrum of strategies that is defined as 'resistance to natural processes' on the one end of the spectrum to 'adaptation' – defined as practices that allow natural processes to occur in response

to SLR– on the other end of the spectrum. This typology is based on a critique of prevalent assumptions grounded in the need to protect human settlements from the coast, which have dominated our understanding of managing coastal ecosystems (Cooper & McKenna, 2008). The authors suggest that approaches to sea level rise based on the assumption of the need to protect from the sea, miscomprehend the dynamic nature of coastal ecosystems. Rather than viewing them as static systems harmed by erosion, coastal ecosystems have responded dynamically to rising and declining seas over the course of millennia: "Coastal erosion is a natural process that creates, modifies and destroys coastal landforms through linked processes of erosion, transport and deposition." (Cooper & McKenna, 2008, p.316).

The quality of the adaptive response is central to this typology developed by Cooper and Pile (2014). According to the authors, resistance consists of hard engineering approaches to SLR that protect coastal human infrastructure, such as buildings and roads, raising flood defense structures, dikes, and seawalls, and undertaking beach nourishment[7] (Cooper & Pile, 2014). In contrast, these authors conceptualize climate adaptation as centered on strategies that involve managed retreat and abandonment, which is also defined by them as 'changes in coastal land use' from developed to less or not at all developed (Cooper & Pile, 2014). According to Cooper and Pile, human developments in coastal areas interrupt natural coastal processes and lead to destruction of coastal ecosystems, not sea level rise or storms. Coastal development arrests sediment transport and inhibits migration of coastal ecosystems, leading to the disappearance of coastal landforms (Cooper & Pile, 2014). Hard armoring prevents valuable coastal wetlands, salt marshes and beaches from migrating inland in response to sea level rise - a phenomenon known

[7] Dense development on the coast prevents rivers from transporting sediments to the coast, leading to what is known as coastal squeeze. Beach nourishment comprises the artificial supply of sand to restore beaches that are narrowing and disappearing as a result of coastal development. Sediment transport from rivers nourishes streams naturally.

as “coastal squeeze” (Cooper & Pile, 2014, p. 316). Nonetheless, hard engineering approaches and retreat are often presented to communities as one among a range of equivalent adaptation approaches (Cooper & Pile, 2014). Steeped in a longstanding discourse of the need for ‘protection from the sea’, stakeholders often prefer engineered solutions that come with significant environmental costs. However, according to Cooper and McKenna (2008), it needs to be understood that we either protect valuable ecosystems or maintain human infrastructures; it is impossible to accomplish both.

Concluding this section, a wide range of climate adaptation definitions and typologies have been promulgated, reflecting the specific concerns, knowledge base and interests of the scholars and organizations that have generated these definitions. The multiplicity of understandings of climate adaptation underscores the contested nature of this concept, and associated terms such as risk, hazard, resilience, and vulnerability. In fact, while “there is a need to define what adaptation looks like in practice” as called for by Ford et al. (2013, p.1), without having come to a consensus of what “good adaptation” (see Smit, et al. 2000) is, we cannot determine whether adaptation actions are truly designed to reduce vulnerability of human societies and ecosystems. Projects that receive funding as adaptation may merely serve as economic development projects with adaptive benefits, but may have longer-term negative impacts on ecosystems, which increase the vulnerability of populations and ecosystems rather than reducing it.[8]

1.5 How Do We Know That We Are Adapting to Climate Change?

Climate adaptation is conceptualized as a policy problem (Henstra, 2016), and comprises a relatively novel governmental responsibility. It hinges on specific planning processes, policy

[8] Bours et al. (2014) have made the point that many climate adaptation programs “look similar to other development interventions, they do have specific and distinct characteristics that set them apart.” (p.2).

development, and implementation of adaptation strategies and interventions. As Klosterman, et al., (2018, p.188) suggest:

> With the development of adaptation strategies comes the need for methods to monitor and evaluate the level of implementation and the effectiveness of adaptation policies, measures and actions.

Climate actions are associated with considerable costs to governments, whose offsetting will require the establishment of new funding streams. To meet standards of public accountability and to guide funding decisions, it is important that decision makers and funders understand whether adaptation is successful (Preston, Yuen, Westaway, 2011, Berrang-Ford, 2013; Brooks et al., 2011). However, as a process oriented towards an uncertain future, unfolding at all jurisdictional levels, in all governmental sectors, requiring a range of policy instruments and involving a wide range of implementation strategies, adaptation is complex and thus has been described by scholars as messy (Lorenz et al., 2019, Biesbroek et al., 2013; Berrang-Ford, 2011). These complexities are reflected in researchers grappling with various approaches for evaluating adaptation progress. In the following sections, several different methods for the evaluation of adaptation, their strengths and drawbacks are discussed.

1.5.1 Adaptation Evaluation Approaches[9]

Each aspect of the climate adaptation process can be evaluated, including capacity-building efforts, planning processes, policy development and implementation of interventions, and adaptation governance. Several approaches to evaluating adaptation progress have been noted in the scholarly literature, including process-based, outcomes-based, monitoring and evaluation (M&E), systematic review vulnerability measures, and the adaptation readiness

[9]This section on adaptation evaluation approaches was inspired by the article by Ford et al., (2013) How to Track Adaptation to Climate Change: A typology of approaches for national-level application.

framework that was applied in this thesis (Berrang-Ford, 2013). According to Brooks, et al (2011, p.10):

> Adaptation and climate resilience encompass a wide variety of measures, processes, and actions, operating at different temporal and spatial scales, and this diversity needs to be reflected in any framework for the evaluation of adaptation.

1.5.1.1 Monitoring and Evaluation Approaches

Monitoring and Evaluation (M&E) systems are among the most commonly used methods to evaluate climate adaptation initiatives (Bours et al., 2014; Bours et al, 2013; Ford et al., 2013). M&E systems comprise a combination of both monitoring and evaluation approaches. Monitoring of policy or project progress involves the systematic collection of data illuminating the state of indicators that have been selected to determine the progress or success of the policy, initiative, or project (Kusek & Rist, 2004, p.12). Evaluation comprises the assessment of the extent to which the policy, initiative or project meets delineated goals (Kusek & Rist, 2004, p.12). Monitoring and evaluation approaches pursue these two objectives in parallel. They integrate both on-going monitoring and evaluation of projects and interventions.

A range of adaptation evaluation strategies fall under the umbrella of M&E (Leiter, 2015). No common standards exist in M&E systems used in climate adaptation (Klosterman, et al., 2018). Since the development of these systems is context-dependent (Leiter, 2015), developing common standards and indicators is considered difficult. M&E approaches have been primarily used to generate knowledge concerning the success of individual adaptation interventions or projects rather than adaptation policies or plans. Examples of such projects include adaptation interventions in the agricultural sector, including the adoption of new crops with low water demand or adoption of integrated watershed management approaches (Brooks et

al., 2011). However, M&E approaches have also been used to evaluate adaptation progress at different governmental scales, including the evaluation of progress towards objectives listed in national adaptation plans (see Klosterman, 2018).

Indicator development is critical in M&E approaches. M&E frameworks ideally include input, output, outcome, and process-based indicators. Using the example from agriculture, the adoption of low water demand crops would serve as an output indicator. Enhanced food security during droughts would be an outcome indicator. Inclusion of stakeholders in the decision-making process would be a process indicator. Indicators ideally should follow the SMART framework and be specific, measurable, achievable, relevant and time-bound (Doran, 1981; Glahn et al., 2007). Indicators should be straightforward and uncomplicated so that they can be easily understood. Indicators should also be connected to pertinent science (Bours, et al., 2014; Harley et al. 2008; Spearman and McGray, 2011). In order to assure the credibility of its evaluation program, the monitoring organization should ideally have an independent status (UNDP Evaluation Office, 2002), especially if the evaluation results are expected to be conveyed to the public (Klosterman et al., 2018).

Similar to other adaptation evaluation approaches, M&E approaches also face specific methodological and conceptual challenges. Adaptation is a continuously unfolding process. In adaptation, there is no foreseeable end goal. Long time frames can exist between the implementation of the intervention or strategy and the manifestation of an outcome, which makes evaluation of impacts difficult (Bours et al., 2014). There are considerable questions about the issue of attribution, in other words, the identification of factors that caused the adaptive impact. Determining attribution involves the separation of factors that caused the beneficial impact of an intervention from other contextual factors that may have caused

beneficial impacts but were external to an intervention. (Bours et al. 2014; Brooks et al., 2011; Ford et al., 2013). The attribution problem poses a significant problem for funding agencies.

Despite methodological challenges, M&E approaches are increasingly applied in climate adaptation evaluation, including in the evaluation of national climate adaptation (Klosterman et al, 2018; Bours et al., 2013).

1.5.1.2 Evaluation of 'Macro Adaptation'

According to Ford et al. (2013), outcomes-based approaches are central to the policy evaluation literature and comprise a "gold standard" (p. 3) in the evaluation and monitoring literature. Evaluation of macro adaptation comprises a sub-type in the outcomes-based adaptation evaluation literature (see Kahn, 2003). This type of evaluation centers on avoided impacts over time based on easily accessible, large data sets capturing, for example, avoided deaths from climate-caused disasters. If the trends from these data sets suggest a decline in disaster-related deaths, we can deduce that disaster preparedness has improved (Kahn, 2003). The data analysis underlying macro adaptation hinges on the availability of data sets that provide insights into trends over the course of decades (Kahn, 2003). If collected and analyzed systematically, these data sets reflect evidence of adaptation progress over time (Ford et al., 2013). In the fields of disaster studies or medicine, where data are collected continuously, baselines can be established that allow for the tracking of outcomes over extended time frames (Ford et al., 2013).

The analysis of macro data has drawbacks, however. Evaluation of macro adaptation does not allow for the illumination of causal relationships between factors that lead to a decline in disaster-related deaths over time and the role of individual factors in the decline (Ford et al., 2013). Furthermore, evaluation of macro adaptation fails to provide quantitative data pertaining

to quality-of-life indicators following disasters, and experiences of displacement, and alienation among survivors of disasters. Post-disaster experiences of displacement, alienation, and loss of community connection can lead to additional disaster-related mortality that is not captured by the initial data set.

1.5.1.3 Process-based Evaluation

Process-based evaluation approaches illuminate the quality of the climate adaptation process rather than tangible adaptation outputs and outcomes. They hinge on the assumption that a good process leads to desirable results. They measure progress by evaluating process-based indicators. Thus, these approaches fall into the category of proxy frameworks in the sense that the quality of the process becomes a proxy for desirable outcomes. Proxy indicators are useful when there is a lag time between the implementation of initiatives and the manifestation of outcomes (Ford et al., 2013). Process-based approaches have been primarily used for evaluating individual projects and intervention but can be integrated into national level assessments (see Ford et al., 2013). Process-based indicators may include, but are not limited to effectiveness, efficiency, equity, legitimacy, flexibility, acceptability, mainstreaming, and sustainability (Adger et al, 2005; Yohe & Tol, 2002 as quoted in Ford et al, 2013). It has been noted that sustainability is often excluded as an indicator (Brooks et al., 2011).

The use of process-based indicators has a range of drawbacks. These drawbacks can precede evaluation framework design, arising during the design of the process itself. For example, experts charged with the design and implementation of a process can hold a range of different perspectives about what constitutes a good process (Webler & Tuler, 2001). Once the process has been designed, evaluators may have differences in opinion about which aspects of the process to target for evaluation (Rauschmeyer et al., 2009). Thus, separating the expectations

of the evaluator from the context of evaluation may be difficult or impossible (Rauschmeyer et al., 2009). Finally, there is an assumption underlying process-based evaluation that a good process will lead to the desired outcomes (see Rauschmayer et al., 2009), which may not always be the case. To avoid these pitfalls in climate adaptation evaluation, process-based indicators are often combined with other indicators such as input, output, and outcomes indicators, as is practiced in the application of M&E systems (see Rauschmeyer et al., 2009; see Bours et al., 2014; and Klosterman et al., 2018).

1.5.1.4 The Adaptation Readiness-Based Approach

The adaptation readiness framework was developed by Ford and King (2015) to address several of the conceptual and methodological challenges underlying the evaluation of climate adaptation. These challenges include the temporal disconnect between the implementation of adaptation interventions and climate impacts, which makes outcomes-based evaluation difficult, and the lack of systematic approaches that enable comparison of either national or sub-national units (Ford & King, 2015).

Ford and King's (2015) climate adaptation readiness framework is based on Smith, Vogel, and Cromwell III's article *An Architecture for Government Action on Adaptation to Climate Change: An Editorial Comment* (2009), which lists nine policy-related components or factors that the authors consider preconditions for adaptation success. These factors include political leadership, institutional organization, stakeholder involvement, climate change information, appropriate use of decision-making techniques, explicit consideration of barriers to adaptation, funding for adaptation, technology development, and adaptation research. Ford and King (2015) reduced this list of overarching factors to the following six: political leadership, institutional organization, funding, usable science, stakeholder engagement, and public support

for adaptation. In Ford and King's climate adaptation readiness framework, these factors are assigned indicators, which elucidate the extent to which these factors are present and developed in the policy arena and public realm. Indicators can also be understood as describing the quality of the overarching factors. According to Ford and King (2015, p. 506), "by focusing on what is actually being done to plan and prepare for adaptation, adaptation readiness can provide a measure of the likelihood of adaptation taking place." The climate adaptation readiness framework falls into the category of proxy frameworks for evaluating climate adaptation progress. According to Ford et al., (2013, p.7) "the extent to which a nation is ready to adapt can be used as a proxy for tracking adaptation."

As with other adaptation evaluation frameworks, the adaptation readiness framework has conceptual strengths and drawbacks, which this thesis seeks to explore. One is the notion of the quality of the adaptation already discussed in the first section of the literature review. As in other definitions of adaptation, the authors base their adaptation readiness framework on the definitional shorthand of "adjustments to climate and its effects." (see IPCC, 2001). "How good is the adaptation?" (see Smit et al., 2000) is not considered. Instead, planning, policy, and other adaptation processes are considered to be adaptation because they are defined as such by decision-makers (see Dupuis & Biesbroeck, 2013). The question arises of the ways in which the lack of a more precise definition of the quality of the adaptation hampers the framework's ability to estimate the likelihood that adaptation occurs. This question targets the appropriateness of the indicators and the overarching factors, an issue that is analyzed in this thesis (see Chapter 5). Another question centers on whether the adaptation framework can be flexibly applied to different contexts as Ford and King (2015) claim.

1.5.2 Comment on the Issue of Temporal Disconnect

The notion of a temporal disconnect between interventions or adaptation and adaptation outcomes is mentioned frequently in the adaptation literature as an obstacle to evaluating and tracking adaptation. Accordingly, Ford et al. (2013, p. 4) state that "[adaptation] success may not be apparent for decades" and that there is considerable temporal disconnect between interventions to avert future impacts (see also Bours et al., 2014).

The notion of a temporal disconnect deserves further elucidation. The presupposition that generally adaptation success may not be experienced for decades is likely overstated in the climate adaptation literature. According to attribution science, "confidence in attribution findings of anthropogenic influence is greatest for extreme events that are related to temperature, followed by hydrological drought and heavy precipitation" (Knutson et al., 2017, p.168). The implication of this projection is that droughts and events with heavy precipitation that deviate from the historical means are becoming highly likely. Thus, a range of adaptation actions, especially actions that address heavy precipitation or drought, are unlikely to be characterized by a significant temporal disconnect. For example, the increase in culvert size underneath roads has an immediate adaptive effect. In case of a severe rainstorm, a road crossing a river or stream faces damage with a smaller culvert in place (see Heavy rains, flooding damage roads in Downeast Maine, June 9th, 2020). The adaptation – a larger culvert – therefore is immediately adaptive.

Adaptation targeting more severe impacts to manifest at a greater temporal distance are characterized by greater uncertainty and therefore suffer from temporal disconnect. However, the overarching approach to addressing adaptation by governments in developed nations is one of adaptive management (see Barnett & O'Neill, 2010) which is incremental in nature, in part

driven by cost concerns (see Fletcher, 2013). Except in the cases of sea walls, there are currently no examples of adaptation targeting impacts that will occur half a century from now.

Focusing on uncertainty rather than on our existing expertise pertaining to adaptation may lead to reinforcing institutional inertia and provide fodder for those who seek to avoid trade-offs between economic growth and climate adaptation. Emphasis on uncertainty may provide support for themes that shape much of discussions on adaptation strategies, which includes such heuristics as "no regrets" or "win-win" reinforcing for researchers and policy makers certain framings that fail to capture and address the complexity of climate adaptation (Preston et al., 2015).

1.6 Adaptation in the Natural Resources Systems Sector

In the natural resources systems sector, climate adaptation comprises actions that enable ecological systems to persist under conditions of rapid global environmental change. According to Julius et al. (2008, pp. 2-3):

> The goal of adaptation is to reduce the risk of adverse environmental outcomes through activities that increase the resilience of ecological systems to climate change.

In natural resources management, goals are articulated "in terms of maintaining ecosystem integrity, achieving restoration, preserving ecosystem services, and protecting wildlife and other ecosystem characteristics." (Julius et al., 2008, pp. 2-3). Natural resources systems adaptation is often cited as critical to human adaptation (Spalding et al., 2014; Capon et al., 2013; Munang et al., 2013). However, the concept of natural resources adaptation is methodologically and conceptually even more challenging than adaptation of human systems in developed nations. Adaptation is undertaken in ecological systems that are already highly deteriorated and degraded from human use. Climate change is an additional significant stressor that natural resources managers will have to address to the extent that they can. Significant loss of ecosystems services

is expected as the climate warms (Mooney et al., 2009). In the following section, the complexities of natural resources systems adaptation are discussed.

1.6.1 Climate and Non-Climate Impacts Pose Synergistic Threats to Natural Resources Systems

Maintaining natural systems under climate change is often more complicated than adaptation in human systems in developed nations. Impacts from non-climate related stressors, including habitat fragmentation and destruction, pollution, and over-harvesting of species, have been deteriorating ecosystems for decades. According to Bijlsma et al.'s (1996), assessment of the state of coastal ecosystems:

> For many small islands, population pressure and urbanization, coastal pollution, and overexploitation of resources already are critical problems. For deltas and estuaries, changes in sediment supply and distribution are often already causing significant changes in the coastal zone. This reinforces the message that climate change will act on coastal systems that are already under stress. (p.309)

As Bijlsma et al., (1996) demonstrates, humanity faces climate change with ecosystems that are already considerably threatened. Examples include: hardening of coastlines, which causes erosion, impedes sediment transport, and migration of important coastal habitat in response to sea level rise (see Cooper and Pile, 2014, Cooper & McKenna, 2008); nitrogen and phosphorus pollution in estuaries resulting in dead zones and eutrophication (see Bricker et al., 2008 and Bricker et al., 1999); acidification of lakes from nitrous oxide; the building of canals, and dams of all sizes that alter the natural flow of rivers, impeding fish passage, causing water pollution and habitat destruction (Palmer et al., 2009); destruction of freshwater systems that provide drinking water; residential and commercial development, causing water pollution and resulting and the destruction and fragmentation of habitat (Suskie & Cooke, 2007) and extractive industries that destroy and fragment habitat, leading to the decline of important keystone species;

industrial agriculture that causes pollution of streams, rivers, and estuaries (see Staudt et al., 2013; Suskie & Cooke, 2007).

Thus, adaptation of natural resources systems must take into consideration the impact of a wide range of non-climate related stressors (Julius et al., 2008). Management targeting non-climate-related stressors must be expanded and adjusted to account for new realities under climate change (see Staudt et al., 2013).

1.6.2 The Relationship between Restoration and Adaptation

While ecosystem restoration is a complex field with a long history (see Ehrenfeld, 2000), the goal of conservation broadly speaking has been the restoration of ecosystems to a prior, more pristine, less polluted and more diverse state. As McNeely (2011) suggests:

> For more than a century the collective focus has been on protecting resources as they are, restoring them to what they were at some previous time, or using them based on experience and understanding. Unfortunately, past, and even present conditions are not likely to resemble the future. (p.1)

Hence, restoration involves a wide range of strategies, including the reduction in pollution sources, the elimination of unsustainable uses, and the recovery of species where possible (see Ehrenfeld, 2000). The traditional emphasis on restoration in ecosystems management is also reflected in landmark conservation legislation. For example, the text of the United States Clean Water Act (1972) — which has been declared "one of the most revolutionary statutes ever drafted" (Andreen, 2003, p.537) — begins with an emphasis on restoration: "The objective of this chapter is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." (33 U.S.C. §§1251-1387).

The term restoration as traditionally used, however, has been called into question as the notion of steady baselines against which to measure ecosystems restoration objectives is increasingly undermined by global change processes (see Milly et al., 2008). Concerns have been

raised about whether strictly speaking, restoration of ecosystems is even possible (see Choi, 2007; Ehrenfeld, 2000). Most attempts at restoration confirm that the full scope of ecosystem benefits cannot be restored to baseline conditions once an ecosystem has been degraded (Harris et al., 2006).

Conceptualizing the differences between restoration and adaptation and defining both terms more clearly is one of the challenges of the ecosystem management field. Classifying restoration actions as adaptation — even though restoration may increase ecosystem resilience to expected shocks and perturbations associated with climate change (see Wainger et al., 2017) — can lead to confusion among decision-makers and the public. For example, green stormwater management is often listed as adaptation in data bases of adaptation actions (see US Climate Resiliency Toolkit, n.d.) However, it is understood among stormwater engineers that stormwater management, unless specifically designed for future precipitation scenarios, does not count as climate change adaptation (Thuler & Rhoades, 2016). Calling ecosystems restoration actions 'adaptation' may suggest to the public that governments pursue adaptation when in fact, past impacts are being addressed rather than climate change impacts. The true monetary commitments required to pursue effective climate adaptation may also be obscured by calling restoration actions 'adaptation'.

The question then is how to define the relationship between ecosystems restoration and adaptation. From an evaluation and policy perspective, strictly speaking, any actions defined as adaptation must be based on scientific projections of current and future climate impacts. In relation to nitrogen pollution of estuaries (see Bricker et al., 2008 and Bricker et al., 1999) for example, estuary restoration requires substantial reductions in nitrogen pollution from current

sources, in addition to reductions based on projections of increased precipitation caused by rising temperatures.

However, in the conservation and restoration literature, restoration is currently considered an integral aspect of climate adaptation. Restoration is understood by researchers as an important adaptation strategy among a range of possible strategies (Janowiak et al., 2014; Stein et al., 2013; Seavy et al., 2009; West et al., 2009; Mawdsley et al., 2009). Conservation researchers currently recommend managing ecosystems for both persistence and change (Janowiak et al., 2014; Stein et al., 2013; Seavy et al., 2009; West et al., 2009; Mawdsley et al., 2009). As a result, the notions of restoration and adaptation are currently characterized by a tension that will eventually become increasingly obscured by rising temperatures and altered ecosystems responses.

1.6.3 Expansion of Non-Climate Related Threats

An additional problem in evaluating natural resources adaptation is the continued expansion of non-climate related threats (Aplet & McKinley, 2017; Staudt et al., 2013; Seavy et al., 2009). While adaptation and adaptation-related processes and projects may proceed, increases in non-climate related threats and pressures may outweigh the gains achieved by adaptation efforts. It is understood that non-climate related interventions can be maladaptive (see Jones et al., 2015), and that adaptation designed to protect human infrastructure can have negative consequences for biodiversity and future generations (see Turner et al., 2010). Thus, the expansion of non-climate related actions that degrade ecosystems and increase vulnerability ought to be conceived of as maladaptive, as has been recently suggested by the IPCC (Noble et al., 2014, p. 857).

The question arises whether management and evaluation frameworks have been developed that explain both the impacts of non-climate related and climate-related threats. In fact, at least one framework has been designed — more frequently used in Europe than on the North American continent — called the Driver Pressure State Impact Response model (DPSIR) (see Gari et al., 2015). This model includes pressure indicators that illustrate the impacts of land, resource use, and pollution sources on natural resources management goals. A rare example of the DPSIR framework application in the United States comprises the conceptualization of the expansion of impervious surfaces as a pressure indicator by the Piscataqua Region Estuary Partnership in New Hampshire. This estuary partnership defined the expansion of impervious surface as an indicator of increasing stormwater pollution that is discharged into the estuary (see PREP, 2018, p. 20), thereby articulating the impact of non-climate related threats on estuary health.

A review of the natural resources systems climate adaptation literature reflects the complexities of protecting natural resources under conditions created by climate change. The question poses itself whether the climate adaptation readiness framework can be used to evaluate progress that has been accomplished in the natural resources sector as part of the overall climate adaptation process in US states.

1.7 Summary

As a project oriented towards an uncertain future, climate adaptation is a conceptually complex idea. Climate adaptation is undertaken by a wide range of entities, including in particular, governments, at all jurisdictional levels and pertains to all sectors. Adaptation of natural resources systems is particularly important for humanity since humans depend on ecosystem services for survival.

To theorize the variety of dimensions of adaptation, a multiplicity of definitions and typologies of climate adaptation have been conceptualized, reflecting a range of organizational, political, and scholarly commitments, interests, and traditions. In certain types of typologies, the quality and effectiveness of adaptation has been considered secondarily, while other factors, such as the level at which adaptation occurs — individual, community or jurisdictional — and whether the adaptation is planned or reactive, is considered as more important in defining adaptation. Unless the expected quality and effectiveness of the adaptation project or initiative is foregrounded, however, it is unclear whether adaptation is effective and can therefore be authentically considered adaptation. For example, a grey infrastructure project undertaken by a government entity to reduce flooding caused by climate change could primarily serve as an economic development project with short term adaptive impacts, but maladaptive long-term consequences.

The wide range of responses categorized as adaptation have contributed to the phenomenon being described as "indistinct" by scholars (Dupuis & Biesbroeck, 2013). To address the complexity of adaptation responses and their intended and unintended consequences, a number of scholars have theorized the quality of the adaptation response — providing important parameters for rendering the concept less indistinct and more concrete. Scholars have distinguished between adaptation and resistance (Cooper & Pile, 2014), defined adaptation as manipulation (Thomsen et al., 2012), and finally conceptualized maladaptation in all of its manifestations (Jones et al., 2015).

Definitions and typologies are important for climate adaptation evaluation. They delimit which aspects of the adaptation process are defined as adaptation and are considered for evaluation. Since climate change impacts all aspects of human existence and ecosystems

functioning, evaluation approaches need to reflect the entire range of climate adaptation manifestations (Brooks et al., 2011). A range of approaches for climate change adaptation evaluation have been developed, each characterized by tradeoffs. M&E approaches are among the most widely used adaptation evaluation systems. They can include multiplicity of indicators and thus they provide comprehensive information about adaptation progress. M&E approaches have been primarily used with individual interventions and projects. Scholarship on using M&E for adaptation is evolving, however, and examples of evaluation of national-level adaptation efforts exist (see Klosterman et al., 2018).

Proxy approaches comprise critical evaluation systems for climate adaptation evaluation. Rather than evaluating outputs and outcomes directly, these systems use proxy indicators, such as the existence of policies and programs, to measure adaptation success. These approaches include process-based approaches, approaches that draw on proxy indicators, such as the evaluation of initiatives called 'adaptation' in databases, and the adaptation readiness framework. Proxy approaches can provide insight into policy and program development processes that lead to adaptation outputs and outcomes. Adaptation is, according to the literature, characterized by significant time lags between the initiation of an adaptation program or policy and adaptation outcomes. They can also provide the means to conduct comparisons about adaptation progress on the international level, where output and outcomes data may not yet be available. There are drawbacks to proxy approaches, as well, however. Without considering outcomes and outcomes directly, it remains impossible to determine whether the actions listed as adaptation in a database, or the outcomes from a process called adaptation, are authentically adaptive, i.e., reduce vulnerability to climate impacts, limit harm from severe climate-related events, and are not associated with future maladaptive outcomes.

Natural resources systems adaptation is fraught with more extensive and different complexities than adaptation of human systems in developed nations. Intact natural resources systems are expected to be more resilient to climate change. Natural resources systems, however, have been already significantly degraded from human use. This degradation renders natural resources systems exceedingly vulnerable to climate change. Hence, restoration — the effort of restoring an ecosystem to baseline conditions — is considered a critical aspect of climate adaptation. For evaluation purposes, strictly speaking, adaptation and restoration are two different approaches, however, the former based on past degradation and the latter based on current and future expected degradation from climate change. There is the potential for confusion in the minds of decision makers and the public, about which actions and funds support restoration vs. adaptation. Furthermore, non-climate related stressors impacting natural resources systems, such as continuing residential and industrial development, need to be taken into consideration in natural resources adaptation.

For this thesis, from among a range of evaluation approaches, a proxy system — the adaptation readiness framework (Ford & King, 2015) — was first revised and then applied to assess the adaptation progress in natural resources management of three US states. In the following chapter, the adaptation readiness framework and its revision are described in detail.

Chapter 2: Methodology

2.1 Research Objectives

This thesis seeks to apply the climate adaptation readiness framework as developed by Ford and King (2013) to evaluate the readiness of three US states — Massachusetts, New Hampshire and Maine — to adapt natural resources systems, including wildlife habitat, forests, and estuaries of high value to climate change. In so doing, a revision of the adaptation framework was undertaken to fit the context of the application (see King and Ford, 2015), which is natural resources adaptation in three sub-national units of a developed nation. Further, this thesis aims to evaluate, rank, and compare the climate adaptation readiness of those sub-national units. The conceptual strengths and weaknesses of the climate adaptation framework are assessed, and the ability of the framework to capture and represent climate adaptation readiness in the natural resources sector is analyzed. Considering the theoretical complexity of the concept of climate adaptation, this thesis also explores the extent to which adaptation readiness is a meaningful proxy measure of climate adaptation progress.

2.2 Scope

Government adaptation plans rank natural resources protection, restoration, and adaptation as critical to enable human societies to persist under conditions of climate change (see for example, Massachusetts State Hazard Mitigation and Adaptation Plan, 2018, pp.7-3; Maine Environmental and Resources Working Group, 2014, p. 3). While ecosystem services are important for the persistence of human systems on this planet, in this thesis, to the extent possible, natural resources systems adaptation were evaluated in their own right. Thus, the

analysis here excludes dimensions of natural resources that are viewed as profit-making endeavors, such as forestry or fisheries as industries.

2.3 Research Questions

1. Based on the application of the climate adaptation readiness framework to three US states, what is the readiness of each of the states to pursue climate adaptation of natural resources systems?
    a. To what extent have these states created the preconditions for adaptation?
    b. How does the quality of the adaptation readiness manifest differently in each state?
2. What are the strengths and weaknesses of the climate adaptation readiness framework developed by Ford and King (2015) to evaluate the readiness of three US states to adapt their natural resources systems to climate change in a federated system?
    a. What are the conceptual and theoretical strengths and weaknesses of the climate adaptation readiness framework?
    b. What are the obstacles in evaluating climate adaptation readiness of natural resources systems using the framework?
    c. Are the adaptation framework's overarching factors and indicators appropriate?
    d. Can the adaptation framework be flexibly applied?
3. What are avenues for future research?

2.4 Analytical Framework

2.4.1 Climate Adaptation Readiness Framework

For this thesis, the climate adaptation readiness framework developed by Ford and King (2015) was applied to evaluate the adaptation readiness of three US states located in New

England. The framework was revised and adapted to fit the context of the evaluation – natural resources adaptation of three Northeastern US states, specifically wildlife habitat, forests and estuaries.

The adaptation readiness framework assumes, grounded in empirical research, that six or more overarching factors need to be present to enable the advancement of new policy initiatives, notwithstanding the specifics of the policy initiative at hand (Ford & King, 2015; Smith et al., 2009). The list of overarching factors selected by King and Ford is not necessarily comprehensive for adaptation policy action to advance (Ford & King, 2015). Rather, the premise underlying this framework is that without the presence of these six specific factors adaptation is unlikely to unfold (King &Ford, 2015, p. 509):

> These factors capture what it means to be ready for adaptation and are concerned with what is actually being undertaken/has been completed with regards to creating an enabling environment for adaptation and recognizes that the actual implementation of adaptations typically represents the culmination of a long chain of processes that make action possible.

The factors, which are considered *over-arching* in the climate adaptation readiness framework, include the following:

- political leadership
- institutional organization
- decision making and stakeholder engagement
- availability of usable science
- funding for climate adaptation planning and implementation
- public support for adaptation.

Each factor is associated with criteria that are used for measuring the extent to which the factors manifest in the public and policy realms of a jurisdiction. Criteria can be understood as the embodiment of each factor in the public policy realm. Thus, the overarching factor of political leadership manifests itself through the following criteria: the presence of visionary or directional leaders, entrepreneurial leaders, collaborative leaders, and adaptation champions (Ford & King, 2015). Furthermore, for each criterium, Ford and King (2015) have defined indicators that enable evaluating the extent to which the criteria are manifest in the public policy realm. For political leadership, for example, the framework includes the following indicators: statements of importance and need for adaptation by leaders, engagement of leaders in adaptation planning exercises, recognition of adaptation as a policy priority, and the existence of adaptation legislation. Finally, the framework suggests potential data collection sources, such as: speeches made by leaders; attendance at CoP meetings for heads of state; adaptation planning documents; and social media engagement on adaptation (Ford & King, 2015). Table 1, as developed by Ford and King (2015), includes the authors' description of overarching factors, criteria, indicators, and sources of information for the indicators.

Table 1: Potential indicators and sources of information for assessing readiness for adaptation (Ford & King, 2015)

Readiness factor	**Criteria**	**Indicators**	**Sources of information**
Political leadership for adaptation	Visionary or directional leaders Entrepreneurial leaders Collaborative leaders Adaptation champions	Statements of importance and need for adaptation by leaders Engagement of leaders in adaptation planning exercises	Speeches made by leaders Attendance at CoP meetings Adaptation planning documents Social media engagement on adaptation

		Recognition of adaptation as a policy priority Adaptation legislation	
Institutional organization for adaptation	Lead department / agency or coordinating body to promote and oversee adaptation Long term planning for climatic risks Multiple problem frames Stakeholder engagement	Existence of a national climate research program Boundary organizations focusing on adaptation Adaptation planning documents Stakeholders involved in decision making Use of adaptation planning frameworks	Lead organization specified for FCCC NCs or NAPAs Adaptation planning documents
Adaptation decision making and stakeholder engagement	Flexible decision making processes (e.g. adaptive management) Stakeholder engagement (informative, consultative, decisional) Multiple problem frames	Stakeholders involved in national climate change assessments and policy consultation Co-authorship on publications Use of decision making frameworks (e.g. UKCIP Framework for Climate Adaptation, UNDP-GEF Adaptation Policy Framework)	National adaptation assessments / plans Stakeholders consultation noted in FCCC NCs; NAPA Boundary organizations (e.g. UKCIP, CCIARN) Consultation documents
Availability of usable science to inform decision making	Knowledge on impacts, adaptation and vulnerability Usable science that is pertinent, timely, and rigorous Identification and prioritization of adaptation options	Stakeholder engagement in science National climate change assessments produced Existence of NAPA Boundary organizations Completion of FCCC NCs Peer-reviewed literature	Peer reviewed and grey literature (e.g. NAPAs, NCs, National Adaptation Strategies)

Funding for adaptation planning, implementation and evaluation	Coordinated multiyear funding for adaptation implementation, monitoring, and evaluation Resources for adaptation research Human resources	Dedicated adaptation funding streams Statutory requirement for adaptation (e.g. UK CCA)	FCCC NCs National Adaptation Strategies Climate change programs / announcements
Public support for adaptation	Public support for climate change and adaptation Adaptation consciousness Recent experience with climate related hazards	Media coverage of adaptation Public perception on the importance climate change Political leadership	Opinion polls on perceptions of climate change

Ford and King (2015) qualify the applicability of the framework. They suggest that the adaptation framework evaluates the readiness of governments to pursue planned adaptation rather than reactive adaptation (Ford & King, 2015; see also Smit et al.,2000;). It is designed to capture adaptation in developed countries as opposed to developing nations (Ford & King, 2015). The framework was created to evaluate adaptation generally rather than adaptation in specific sectors (Ford & King, 2015). There are several aspects of governmental climate adaptation that cannot be evaluated within this framework. The temporal aspect of adaptation as a process, interactions between scales of government, how factors influence each other or their significance in relation to each other are outside the analytical scope of this framework (Ford & King, 2013)

2.4.2 Discussion and Revision of the Overarching Factors

Ford and King (2015) suggest that the adaptation framework is flexible and can be adjusted to fit the context of the application. They also assert that more factors than those listed in the framework possibly play a role in adaptation readiness (Ford & King, 2015).

For this thesis, several of the overarching factors were either revised or removed and replaced with more appropriate factors. These revisions were undertaken to focus the adaptation readiness framework on the context of analysis: the readiness of three US states to adapt their natural resources systems to climate change. Unlike Ford and King (2015) recommend, it was attempted here to focus the framework in a sectoral manner, focused on natural resources systems. The sectoral focus was undertaken because natural resources system adaptation is understood as primary to human adaptation in national and state adaptation plans (see Pramova, 2012).

Initially this thesis was designed as a purely deductive study, seeking to test both the applicability of the adaptation readiness framework overarching factors (See Ford & King, 2015) in a novel context. However, during data collection and analysis, it was found that the existing literature has only partially explained the entire range of manifestations of climate adaptation readiness in US states. A shift was then undertaken to an approach that is alternatively called a combined approach, fuzzy logic, retroductive or abductive (see Graneheim et al., 2017). The abductive approach allows for the refinement of theoretical categories grounded in empirical research. Thus, the framework, its overarching factors and indicators were refined by drawing on two sources, the existing research literature and the results from the data collection. Framework revisions were based both on the existing scholarly literature which informed the articulation of

the overarching adaptation readiness factors, and the actual manifestations of climate adaptation readiness among the three US states based on an inductive approach.

The overarching factors were revised as follows: Stakeholder engagement, sufficient usable science, and public support for adaptation were removed from the framework; state support for local adaptation and adaptation of natural resources systems were added to the framework as overarching factors. Justifications for the inclusion or exclusion of factors are discussed in the next section, which addresses each overarching factor in detail.

2.4.2.1 Political Leadership

The presence of political leadership is a precondition for overcoming the impediment to change that tends to characterize governmental systems (Gupta et al., 2010 as cited in Ford & King, 2015). This resistance inhibits timely responses to new threats (Gupta et al, 2010 as cited in Ford & King, 2015). Governmental resistance is reflected in conflicts over jurisdiction among agencies, bureaucratic stagnation, and dismissal of risk by elected and appointed officials (Smith et.al., 2009; Gupta et al., 2010; Moser & Ekstrom, 2010; Pearce et al., 2011, Meijerink & Stiller 2013 as cited in Ford & King, 2015). Political leadership is particularly important in launching the adaptation process and maintaining impetus over time (Moser and Ekstrom 2010; Isoard 2011 as cited in Ford & King, 2015). Leadership can be delivered by a wide range of persons and groups from many backgrounds (Ford & King, 2015).

For this thesis, political leadership was considered a problematic overarching factor in the adaptation readiness framework. This factor, as described in the framework, has a diffuse and non-specific quality. It is depicted as originating from a range of sources and as influencing all aspects of the adaptation process (Ford & King, 2015). This diffuseness could make data

collection and analysis difficult. For example, a state such as Massachusetts has a 200-member legislature, features many NGOs and private businesses. Collecting data on expressions of political leadership from such a wide range of sources could make a non-biased accounting of the data challenging. Moreover, data analysis may be complicated. How is one to weigh individual manifestations of leadership and their relationship to advancing the adaptation policy process? Further, the factor of political leadership is difficult to differentiate from several of the other overarching factors. For example, funding for climate adaptation – which is described as its own overarching factor in the readiness framework – is inextricably linked to political leadership.

While political leadership can have many sources, executive leadership is more narrowly defined and possibly more important in advancing climate adaptation than other sources of political leadership. According to Ford and King (2015), the role of presidents, premiers, governors, and mayors "in initiating adaptation, building coalitions and overcoming barriers" is critical in the adaptation process (Smith et al. 2009; Bierbaum et al. as cited in Ford & King, 2015, p. 510). Ford and King (2015) underestimate, however, the powers invested in the executive to pass laws, adopt executive orders, and direct executive departments. They suggest that adaptation is an area where laws often do not exist (Ford & King, 2015). In fact, in the three US states examined, key adaptation-related laws and executive orders (EOs) initiating adaptation planning were adopted early in the adaptation process and throughout the process, and in all instances initiated by governors. It was found in this thesis that directing executive agencies and enacting laws comprise a core feature of the kind of leadership that effectively advances adaptation.

In this thesis, the diffuseness characterizing the overarching factor of political leadership was reduced by re-conceptualizing political leadership as executive leadership. The indicators listed for political leadership by King and Ford (2015), including speeches, participation in CoP meetings – which is more likely to happen on the national rather than sub-national level – and social media engagement were replaced with indicators that involve concretely manifest actions, such as the existence of state adaptation legislation, executive orders, and state-wide adaptation plans.

2.4.2.2 Institutional Organization

Institutional organization for adaptation refers to the existence of government departments, agencies and task forces that are charged with leading and coordinating the adaptation process at the national or subnational jurisdictional level (Ford & King, 2015). In the US, state governments have long-standing institutional structures that oversee natural resources management, including fish and game, coastal management, and environmental protection agencies. Representatives of regional offices of US federal agencies often participate in policy planning and development efforts, and provide technical and funding support (see Cohen, 2018). Hence, as discussed by Smith et al. (2009), there is no need for separate agencies charged with overseeing climate adaptation efforts. Instead, mainstreaming climate adaptation into the overall operations of agencies, and coordination across these agencies is of greater importance to climate adaptation success than the establishment of a single entity charged with adaptation (Smith et. al, 2009)

To accomplish climate adaptation mainstreaming and coordination, governments often establish climate adaptation task forces or interagency committees that exist only temporarily until their mission is completed. The role of these temporary structures is to engage

stakeholders, prepare and publish adaptation plans, initiate changes to laws and regulations (Ford & King, 2015). The criteria and indicators for the overarching factor of adaptation readiness include initiatives to establish temporary and permanent task forces and committees' and evidence that these task forces and committees are working committees. For this thesis, institutional organization was retained as an overarching factor in the climate adaptation readiness framework.

2.4.2.3 Adaptation Decision-Making and Stakeholder Engagement

Stakeholder engagement is widely recognized as a critical practice for successful adaptation processes (King & Ford, 2015). In the United States, stakeholder engagement is a pervasive and longstanding practice in public policy planning and development processes. In the US, efforts to craft government plans, new regulations, and laws as a matter of course include listening sessions, town halls, hearings, meetings, and often lengthy comment periods. Comment periods are frequently held for both draft plans and regulations, and final plans and regulations. Descriptions of the scope of stakeholder and public engagement are often included in a separate chapter or section of a final government plan and report. For example, the US Congress mandates that public participation take place in the development of the state Wildlife Action Plans. Public engagement is one of the seven required elements that states have to include in the plans to receive funding for wildlife protection efforts (Yaffe et al., 2008, p. 2).

In practice, however, stakeholder engagement is also recognized as problematic (Layzer, 2012), raising questions about the exclusion of stakeholder groups from comment periods because they lack time or expertise, the extent to which stakeholder comments are taken into consideration in decision-making processes, and conflict of interests of some participants that have strong economic interests in the outcomes (see Furber et al., 2016). While stakeholder

engagement has a long history in the US, the process can be perfunctory (Layzer, 2012). This is especially true in natural resources management planning processes that are dominated by scientific and technical concepts and language, which leads to the exclusion of key stakeholder groups, such as Indigenous Peoples, People of Color, and low income and young people (see Yarbrough, 2015, p.108)

For the purposes of this thesis, it was assumed that stakeholder engagement was pursued in the adaptation policy, planning and implementation processes in each of the three states compared in this thesis. Thus, the decision was made to exclude stakeholder engagement as an overarching factor in determining the three state's readiness for natural resources adaptation because the pervasiveness of the practice in the US makes this factor unsuitable for comparing the three states' adaptation readiness.

2.4.2.4 Availability of Usable Science for Decision-Making

Science meets the definition of usable if the recipients and users have faith in the sources, and the science has topical and temporal relevance. To be considered usable, its production must involve stakeholders (Ford & King, 2013). Availability of usable science, thus, most likely differs from location to location, and its manifestation depends on local culture (Ford, Knight, & Pearce, 2013 as cited in Ford & King, 2015).

For this thesis, 'availability of usable science' was excluded from the framework. There is a plethora of studies and research efforts completed and underway probing and describing climate impacts on natural resources systems at federal and state levels in the US. For example, Maine's report *Maine Prepares for Climate Change (2018)* - a report that is centered on updates of the state's adaptation progress - contains twelve pages filled with descriptions of studies from

the physical and natural sciences designed to improve understanding of natural resources systems' responses to climate impacts (Maine Interagency Climate Adaptation Work Group, 2018, pp.12-24). Each of the three states evaluated in this study features both state and private universities with climate research and science centers, and government-led efforts to advance climate projections, vulnerability and risk assessments (see University Of Maine, Climate Change Institute, n.d; Northeast Climate Adaptation Science Center, n.d.).

2.5.2.5 Inclusion of Climate Adaptation in the Natural Resources Management Sector

Since this study focuses on natural resources adaptation, the adaptation readiness framework was revised to include natural resources management as an over-arching factor. Climate change puts in relief the dependence of human societies on functioning ecosystems. This is reflected in natural resources systems being frequently treated as a priority in climate adaptation planning efforts (Turner, 1996; Pramova, 2012; Capon et al., 2013).

This prioritizing of natural resources protection is palpable in the emphasis on nature-based solutions and prioritizing of green vs. gray infrastructure in both state adaptation plans and the peer reviewed literature (see Seddon, et al., 2019; Morris, 2018; Massachusetts, 2018, p. 7-3). Despite the longstanding scientific consensus on strategies that build eco-systems resilience, however, these strategies' integration in state-wide natural resources plans has only recently emerged in the context of adaptation planning (see Staudinger et al., 2015). The criteria used for this overarching factor are the inclusion of natural resources management strategies in plans for managing the natural resources of each state. Indicators were determined to be the existence of separate chapters dedicated to climate change and the discussion of specific climate adaptation strategies of natural resources systems. Without the clear articulation of these strategies, goals

and objectives that advance ecosystems resilience, and an accounting of the research and funding needs required for implementation, natural resources system adaptation is unlikely to happen.

2.4.2.6 Climate Adaptation Funding

Availability of dedicated funding streams is critical to adaptation success (Ford & King, 2015). While funding requirements differ by sector and intervention (Ford & King, 2015), funding is needed to support each of the components that comprise the adaptation process. These aspects include impact studies, vulnerability assessments, scenario building, mapping, adaptation plan development, design and feasibility studies, and project implementation (Ford and King, 2015). Once an adaptation intervention is completed, costs arise in relation to maintenance, and monitoring and evaluation to ensure the intervention's continued viability (Ford & King, 2015).

Lack of funding is among the most frequently cited barriers to adaptation progress at all jurisdictional levels (Shi, Chu & Debats, 2015 as cited in Ford & King, 2013; Bierbaum, et al, 2013), and specifically in natural resources management (Tribbia & Moser, 2008 as cited in Ford and King, 2015). Since adaptation is a continuous process (Bours et al., 2014) funding needs to be available in multi-year streams (Ford & King, 2015). Adaptation planning, for example, has been shown to be hampered by the absence of targeted multi-year funding streams (O'Brien et al. 2004; O'Brien et al. 2006; Brunner and Nordgren 2012 as cited in Ford & King, 2015). The criteria and indicators developed for framework revision in this thesis included the use of a range of fundraising instruments (Colgan et al., 2016) and the presence of multi-year funding streams. Climate adaptation funding was retained as an overarching factor in the climate adaptation readiness framework.

2.4.2.7 Public Support for Adaptation

According to Ford and King (2015), public risk perception plays an important role in shaping the initiation and implementation of adaptation programs. They also concede that an "adaptation consciousness" has not yet developed (Ford & King, 2015).

In the context of this thesis, indicators of public support for natural resources adaptation specifically in the three states whose climate adaptation readiness was analyzed for this thesis could not be identified. Focus groups and polls lack targeting of adaptation in specific sectors, but rather ask general questions about public acceptance of climate change science (see Yale Program on Climate Communication, September 2nd, 2020). Thus, public support for adaptation as an overarching factor was removed from this analysis.

2.4.2.8 State Support for Municipal Climate Adaptation

State support for municipal adaptation was added to the readiness framework as an overarching factor. The climate adaptation literature has delineated the significance of the local and regional scales in climate adaptation (see Preston, Dow, & Berkhout, 2013; Vogel & Henstra, 2015). A Google Scholar search for "local adaptation" in the title turned up 1690 articles. In fact, it is understood that much of adaptation implementation in the natural resources sector in particular, falls within the jurisdiction of municipalities, especially in the New England states. In these states, municipalities have broad authority to make land use decisions (see Barron, 2003; Looney, 2002), which has significant implications for climate adaptation of natural resources systems. A principle called home rule confers power to municipalities relative to state authority over land use and natural resources management decisions (Costa et. al, 2013, p. 2; Barron, 2003; Looney, 2002). The criteria that were selected for this thesis to delineate the overarching factor of state support for municipal adaptation include funding and technical

assistance for local climate adaptation. Indicators were articulated as funding programs and technical assistance targeted at municipalities (see Nordgren et al., 2016). Enabling and supporting municipalities to pursue climate adaptation is therefore a significant overarching factor in the likelihood that natural resources adaptation occurs.

In Table 2, the adaptation readiness framework's overarching factors, criteria, indicators and data sources as revised for the analysis in this thesis are summarized.

Table 2: Revised adaptation readiness framework as applied in this thesis

Overarching Factors	**Criteria**	**Indicators**	**Data Sources**
Executive leadership	Expressions of gubernatorial leadership in crafting laws, and adopting executive orders (EOs)	Existence of adaptation laws, adaptation EOs, state adaptation plans, and reports	Government websites, adaptation planning documents and reports
Institutional organization for adaptation	Initiatives to establish Interagency task forces and committees charged with adaptation planning and mainstreaming	Existence of temporary and permanent executive, interagency committees and task forces	State government announcements, state government websites and government documents
Adaptation in natural resources management	A thematic focus on adaptation strategies in natural resources management plans	Key adaptation strategies are included in natural resources management plans, Separate chapters dedicated to climate change and adaptation exist	Natural resources conservation plans developed by state, local and federal partnerships
Funding for climate adaptation	Commitment to raising funds for adaptation	Use of a range of approaches to raising funds for adaptation,	Grant announcements, government documents and websites

planning and implementation		multi-year funding streams, funding levels, funding dedicated to natural resources adaptation	
State support for municipal adaptation	Funding for municipal adaptation Resources for climate adaptation planning and implementation	Funding programs targeting adaptation for municipalities Existence of on-line reference libraries, tool kits, clearinghouses, provider networks, and frameworks	Government documents, reports and websites

Chapter 3: Methods

3.1 Data Collection Methods

For a desk-based study, Ford and King (2013) recommend a systematic literature review using a coding sheet or questions that are applied to each of the documents and articles. Systematic reviews have become increasingly popular as a method to investigate policy processes related to climate change adaptation (Berrang-Ford et al., 2011). Systematic reviews are transparent and replicable (Berrang-Ford et al., 2011). They can draw on mixed-methods research that uses both quantitative and qualitative procedures, potentially creating rich accounts of climate adaptation practices (Berrang-Ford et al., 2011).

This thesis draws on three methods for data collection: A systematic literature review of the academic literature relevant to climate adaptation in the designated geographic area; a systematic document review of government plans, and documents that pertain to the six overarching readiness factors; and an analysis of state natural resources management plans that were selected in a targeted manner. Document review was added to the methods because the systematic literature review failed to generate sufficient articles to enable the adaptation readiness evaluation. To support evaluation of natural resources systems adaptation, three natural resources plans were selected from each of the states for comparison. Comparability was a critical factor in the analysis of natural resources plans, which required targeted plan selection rather than a systematic review approach.

The adaptation readiness framework as applied here combined qualitative and quantitative methods. Sources were evaluated based on the presence of qualitative data, which

were then scored based on a continuous scale. The systematic literature review was conducted based on the search string listed in Table 3.

Table 3: Search Terms

Geographic	Massachusetts, New Hampshire, Maine, New England, Northeast
Key words	climate adapt*, resilience, adaptation readiness, adaptation preparedness, adaptation planning, adaptation plans, adaptation implementation, adaptation laws, adaptation policy
Qualifiers	state, municipalities, natural resources, conservation, wildlife, habitat, forests, estuarine, nature-based solutions, green infrastructure

Searches for academic articles were conducted in Web of Science, Scopus and Google Scholar and Google Search. As reflected in Table 3 Search strings included geographical information, key words, and qualifiers. For each research article generated through application of the search string, title and abstract were reviewed. Articles and documents were included in the review based on the inclusion criteria listed in Table 4.

Table 4: Systematic Review Selection Criteria

Included	**De-emphasized/Excluded**
Geographic relevance	Is outside of the designated geographic area
Relating to one or more of the six overarching climate adaptation readiness factors	Relating to bio-physical climate change impacts, vulnerability assessments, and climate change projections grounded in the physical sciences, such as biology, ecology, and physics
Relates to natural resources systems adaptation	Infrastructure, grey infrastructure, buildings, development, roads, human systems, industry

Timeframe: published between 2009 and 2020	Outside of the designated time frame
Completed adaptation plans and reports	Planning exercises and workshops, relating to the mechanics of stakeholder engagement
Scholarly articles, government and NGO websites, government and NGO documents, government plans and reports, chapters and sections of government and NGO reports	Conference papers, media articles
Relating to state-wide issues and three or more municipalities	Articles and documents relating to less than three municipalities

Rather than applying an 'inclusion/exclusion' framework, in this study, criteria were included or de-emphasized/excluded to account for the overlap between governmental sectors, such as transportation and residential infrastructure on the one hand and natural resources on the other hand. For example, culverts that are inappropriately sized compromise stream connectivity, which impedes fish passage and causes additional types of deterioration in aquatic ecosystems (see Schulz, et al., 2017). With increasing precipitation predicted under climate change, culverts that are inappropriately sized also threaten road stability (see Schulz, et al., 2017). Thus, replacing culverts that are too small with newer, updated designs both re-establishes stream connectivity and stabilizes roads (see Maine Department of Environmental Protection, 2014, p. 5). While efforts to replace dams and culverts were included in the data analysis for this thesis,

the objective of this study was to evaluate readiness for re-establishing stream connectivity and thus improving biodiversity rather than enhancing road or dam stability.

By applying the search string, 83 articles were located. Title and abstract were reviewed based on inclusion and exclusion criteria, leaving 74 articles. These articles were read in their entirety. An additional sixty-three articles were excluded based on the inclusion/exclusion criteria, leaving eleven articles for inclusion in the data analysis. Eleven articles were determined to be insufficient for conducting an adaptation readiness evaluation. Document review was then added to the systematic review.

3.1.1 Systematic Document Review

Government and NGO documents were located by conducting searches in on-line databases found through Google Search. This search engine is an important source for grey literature, governmental and institutional reports (Hagstrom et al. 2015) – comprising the majority of sources included in this thesis. Nonetheless, it is important to recognize that Google Scholar and Google Search are of limited efficacy in systematic reviews (Piasecki, Waligora, & Dranseika, 2018). Google has not revealed its algorithm, but it has been established that Google Search feeds information to users based on perceived preferences (Piasecki, Waligora, & Dranseika, 2018). While it should therefore never be used exclusively as a source for systematic reviews, Google Search and Google Scholar are suitable to meet the goals of some types of qualitative systematic reviews (Piasecki, Waligora, & Dranseika, 2018).

Searches were also conducted in two on-line databases: the Georgetown Climate Center (Georgetown Climate Center, n.d.) and the Adaptation Clearinghouse hosted by the Georgetown Climate Center (Adaptation Clearinghouse, n.d.). These databases were selected because they

support geographically specific searches and contain data relating to the overarching adaptation readiness factors.

The Georgetown Climate Center (GCC) is a repository of information managed by Georgetown University (Georgetown Climate Center, n.d.). The GCC features a State Adaptation Progress Tracker, which lists climate adaptation actions by individual US state with links to resources and documents that reflect progress. The State Adaptation Progress Tracker categories include Law and Policy, State Plans, Local and Regional Plans, and Other Resources (GCC, n.d.).

The Adaptation Clearinghouse features a keyword search function and a range of filters (Adaptation Clearinghouse, n.d.). Searches were conducted by entering the name of each of the states and applying filters based on the overarching factors (Adaptation Clearinghouse, n.d.). Searches were conducted individually by state. Filters were applied that reflect each of the overarching factors. The Adaptation Clearinghouse provides titles and summaries for each of the documents that appear in the search results. These summaries were read to include documents in the review or exclude them from the review. The same inclusion and exclusion criteria were

applied as in the systematic literature review.

To ensure that the documents included in the review met the standard of being current, additional documents were located through accessing state government web pages of each of the three states via Google Search. These government websites were found to contain links to documents, plans, legislative websites, with data pertaining to the overarching adaptation readiness factors.

In total, 166 documents were generated from the database searches. One hundred and thirteen documents were excluded based on the exclusion/inclusion criteria. From the included documents, eleven were duplicates, leaving 42 documents to be included in the review. Review of state government websites generated an additional 17 documents, plans and websites. In total, 59 government documents, plans, and websites were included in the review. Adding the eleven academic articles, the entire systematic review included 70 sources.

3.1.2 Scoring Rubric and Adaptation Indicator Scoring Approach

Indicators were scored according to a continuous scale with 0-5 pts assigned per indicator measure. A score of 0 pts was assigned when no action had been taken; a score of 5 pts was assigned when the action had been taken. In addition, measures were scored based on additional qualitative factors, such as timeliness of the action and the quality of the action. Depending on the significance of the action, either 2 or 3 pts were assigned if additional qualitative measures were met.

Table 4: Climate Adaptation Readiness Scoring Rubric

Overarching Readiness Factor	Indicators
1. Executive leadership	**1.a Law (s) Mandating Climate Adaptation Planning:** no law was passed: 0 pts; a law has been passed: 5 pts; laws were passed in a timely manner: 3pts. **1.b Executive Order (s) Mandating Climate Adaptation Planning:** no EO was issued: 0 pts; EOs were issued: 3 pts.; EOs were issued in a timely manner: 3pts. **1.c State Adaptation Reports:** no state adaptation report was issued: 0 pts; a state adaptation report that includes a chapter or section on natural resources adaptation: 3 pts; **1.d State Adaptation Plans:** no state adaptation plan exists: 0 pts; a statewide adaptation plan exists with chapters addressing natural resources adaptation: 5 pts; in the absence of a statewide plan, a partial adaptation plan addressing natural resources management exists; plans were completed in a timely manner: 5 pts; plans are required to be updated regularly: 5 pts. **1.e If no state adaptation plans exist, other concerted state-led efforts, resulting in other climate adaptation-focused reports:** in the absence of statewide plans mandated by legislative or executive action, other statewide climate adaptation reports exist: 2 pts; these other reports are updated regularly: 2 pts; these other reports address key natural resources management themes: 2 pts.

2. Institutional Organization	**2.a Executive office -** Executive office responsible for coordinating environmental affairs does not exist: 0 pts; executive office responsible for coordinating state environmental affairs, including adaptation exists: 5 pts **2.b Interagency workgroups and task forces -** no state government interagency workgroups to pursue adaptation reporting and planning efforts and mainstreaming efforts were established: 0 pts. State government interagency task forces were established: 2 pts. State interagency task forces and workgroups were established to pursue adaptation reporting and planning efforts in a timely manner: 5 pts; state task forces were established recently 1pts.
3. Adaptation in Natural Resources Management Plans[3]	**3.a: Adaptation in state natural resources plans** Critical natural resources adaptation strategies are not covered in the plans: 0 pts. Some critical natural resources adaptation themes are included: 2pts; most critical natural resources adaptation strategies are included: 3pts; the plan addresses climate change and adaptation comprehensively: 5 pts

4.Funding for Adaptation	**4.a Commitment to fund adaptation -** no laws pertaining to funding have been passed: 0 pts; laws have been passed to fund adaptation actions: 5 pts. **4.b Funding mechanism -** no innovative funding mechanisms have been pursued: 0 pts; some innovative funding mechanisms have been pursued: 5pts; innovative funding mechanisms have been pursued: 5pts. **3.c Consistent Availability of Funding -** no targeted funding streams exist: 0 pts. Some funding is available: 2pts; Funding is available in targeted, multi-year streams: 5 pts. **4.b Adaptation Grants -** no adaptation grant funding from charitable foundations and federal agencies has been sought out and secured: 0 pts; adaptation grant funding from charitable foundations and federal agencies has been sought out and secured: 5 pts.
5. State Support for Municipal Adaptation	**5.a Funding;** funding for municipalities to pursue climate adaptation planning and implementation is available: 3 pts; sufficient funding is available: 5 pts; multi-year funding streams have been established; funding opportunities can be accessed at the state level at a central location: 5 pts. **5. b. Technical Assistance -** technical assistance is available: 3 pts.; technical assistance is comprehensive: 5 pts; is made available at a technical assistance hub: 5 pts.

3.1.3 Coding of Natural Resources Systems Plans and Documents

Since natural resources management was added to the adaptation readiness framework as an overarching factor, the natural resources plans included in this factor as sources were coded for natural resources systems adaptation strategies. The adaptation literature describes a range pf natural resources management strategies or best practices that are considered critical for climate adaptation of natural resources systems (Janowiak et al., 2014; West et al., 2009; Blate et al., 2009; Julius et al., 2008). These strategies are reflected in three US states' natural resources management plans whose climate adaptation readiness was evaluated for this thesis. Based on the natural resources adaptation literature, a coding sheet was developed with the following strategies:

- Re-establish aquatic and terrestrial habitat connectivity
- Conserve and restore habitat
- Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).
- Strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots
- Enable retreat of wetlands, marshes, and other habitat in the face of SLR
- Direct development away from sensitive and important habitats.
- Conduct mapping, data collection, studies, and technical assistance to support landowners in climate adaptation and management
- Restore and rehabilitate landscapes damaged from storms
- Land conservation incentives for forest landowners
- Recommends climate smart fire management
- Recommends forest conservation
- Recommends technical assistance on climate change and adaptation for municipalities
- Recommends smart development vs. sprawl growth
- Recommends landscape level restoration work
- Recommends Interagency coordination on climate change
- Supports Low Impact Development (LID)
- should include climate change in their rankings
- Minimize non-climate stressors to species and ecosystems

- Funding (as a theme only, not scored)

Natural resources plans were coded on a binary basis to establish whether the natural resources systems adaptation strategies were discussed in the plan or not.

3.1.4 Natural Resources Plans in Context

3.1.4.1 Natural Resources Management Source Selection

For this thesis, state natural resources management plans were selected in a targeted manner. Plans were selected that met the criterion of comparability. It was found that state plans required by US federal law were more likely to be comparable than any other plans promulgated by the states since the federal government issues guidance on the elements that are must be included in the state plans. Thus, the US federal government conveys a basic set of expectations about the quality that the plans need to meet, which makes the plans more comparable. Plan development and submission is often required by the US federal government as a precondition of funding. In cases where plan funding is contingent on plan submission, US states are required to submit natural resources management plans to the federal government within certain time frames, such as every ten years.

The plans selected for this thesis included: state wildlife conservation plans, forest actions plans and estuary conservation plans. Since there is an overlap between wildlife conservation plans and forest and estuary conservation plans, other natural resources systems were considered for analysis in this thesis, such as freshwater systems, wetlands, and coastal areas. However, the US federal government does not require state-wide action or management plans for freshwater systems, for example. As for wetlands, it was found that states are indeed required to submit plans to the federal government. However, upon reviewing each state wetland

plan, it was found that the Massachusetts plan consisted of two pages of tables and no additional text, and therefore was not deemed suitable for comparison with the more developed plans from New Hampshire and Maine. Estuary management plans are also required by the federal government and were already reviewed for previous iterations of the thesis design so it made sense to include them here. In addition, estuary management overlaps with coastal management, covering an important area for climate adaptation measures. In the following paragraphs, the types of plans selected for this thesis and their legal and regulatory contexts are briefly discussed.

3.6.1.1 Wildlife Action Plans

All states in the US must submit State Wildlife Action Plans (SWAPs) to the federal government to be eligible for the federal state wildlife conservation grants program (Yaffee et al., 2008, p.5). The US federal government mandated the states to complete SWAPS for the first time in 2005 (Yaffee et al., 2008). Updates to the plans are required every ten years (Yaffee, et al, 2008). The actions and strategy recommendations in SWAPs lack regulatory and legal force (Yaffee, et al, 2008). SWAPs must include discussion and analysis of eight elements: "1/distribution and abundance of wildlife species 2/locations and condition of key habitats and community types, 3/wildlife and habitat threats, 4/conservation actions to address these threats, 5/plans for monitoring species, habitats and the effectiveness of conservation actions, 6/plans for review and adaptive management of the strategy, 7/plans to coordinate strategy development, implementation, and review with Federal, state, local agencies and Indian tribes[10], 8/opportunities for broad public participation in plan development and implementation" (see

[10] In the US, in contrast to Canadian language conventions, Indigenous Peoples are referred to and refer to themselves as Indian tribes. See for example, the Noocksack Indian Tribe (https://nooksacktribe.org).

Yaffee, et al, 2008, pp. 7-8). For this thesis, the 2015 SWAPs were reviewed for the presence and absence of critical strategies for climate adaptation of natural resources systems. In addition, keyword searches for climate change and climate adaptation were completed.

3.6.1.2 National Estuary Program Comprehensive Conservation Management Plans

The National Estuary Program was founded in 1987 and codified into law via the Water Quality Act - the 1987 revisions to the US Clean Water Act (Imperial, Hennessey, & Robadue, 1993). The program started with 12 estuaries (Imperial, Hennessey, & Robadue, 1993) and has expanded over time to include 29 estuaries (US EPA, n.d). According to the EPA, the National Estuary Program's (NEP) goal is to protect and restore the water quality and estuarine resources of estuaries and associated watersheds designated by the EPA Administrator as estuaries of national significance. As codified in the Clean Water Act (33 U.S.C. §§1251-1387), NEPs must:

> "1/assess trends in water quality, natural resources, and uses of the estuary; 2/collect, characterize, and assess data on toxics, nutrients, and natural resources within the estuarine zone to identify the causes of environmental problems; 3/ develop the relationship between the in-place loads and point and nonpoint loadings of pollutants to the estuarine zone and the potential uses of the zone, water quality, and natural resources; 4/ develop a comprehensive conservation and management plan that recommends priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the estuary, including restoration and maintenance of water quality, a balanced indigenous population of shellfish, fish, and wildlife, and recreational activities in the estuary, and assure that the designated uses of the estuary are protected; 5/develop plans for the coordinated implementation of the plan by the States as well as federal and local agencies participating in the conference; 6/monitor the effectiveness of actions taken pursuant to the plan."

The 29 National Estuary Program partnerships, or NEPs, use an ecosystem-based management approach to help achieve their protection and restoration goals (Single Audit Resource Center, n.d.). The NEPs receive federal funding to draft Comprehensive Conservation Management Plans (CCMP) that guide the restoration and management of the estuaries included

in the National Estuary Program (Schneider et al., 2003). The plans and the program lack regulatory force (Schneider et al., 2003). The revision and updating of the plans are required to take place every ten years (Schneider et al., 2003). EPA provides comprehensive guidance for the development of the CCMPs (see Massachusetts Bays Estuary Program, 2019, p. 124). The CCMPs reviewed for the climate adaptation readiness framework lack separate chapters addressing climate change and adaptation. Thus, keyword searches were completed for climate change, adaptation, greenhouse gases, ocean acidification, flooding and sea level rise.

3.1.4.2 Forest Action Plans

In 2008, the Farm Bill under Title VIII - Forestry - was amended to mandate that each US state develop a long-term statewide assessment of and strategies for its forest resources (Congressional Research Service, 2008, p.19). Forest Action Plans need to be prepared every ten years (National Association of State Foresters, State Forest Action Plans, n.d.). Federal funding is awarded based on five critical program areas - Forest Health, Forest Fire Assistance, Private Land Stewardship, Urban Forest Assistance, and the Forest Legacy Program (National Association of State Foresters, State Forest Action Plans, n.d.). The plans are also required to address the three USDA Forest Service national priorities: Conserve and manage working forest landscapes for multiple values and uses, protect forests from threats, enhanced public benefits from trees and forests (Northeast-Midwest State Foresters Alliance, United States Department of Agriculture (USDA), Forest Service, Northeastern Area State and Private Forestry, 2018). The state Forest Action Plans were reviewed for this thesis based on the presence or absence of critical strategies for natural resources adaptation.

3.2 State Descriptions

In the following sections, each of the states whose adaptation readiness was compared here is briefly described.

3.2.1 Massachusetts

Massachusetts is the second wealthiest state in the United States by per capita income (Williams, 2021). It is the most populous state among the three states examined in this thesis with 6.89 million residents in an area covering 27,363 km² and an average population density of 339 people per square km (KNOEMA, 2019). Approximately 60% of Massachusetts is forested with 80% of forests privately owned (UMASS Amherst, Masswoods, n.d.). Approximately 20% of open space is protected (UMASS Amherst, Masswoods, n.d.). Roughly, 22% of the state is developed (UMASS Amherst, Masswoods, n.d.). Massachusetts has a coastline of 2,445 km (World Atlas, States with the Longest Coastlines, n.d.) and features several significant estuaries including the Cape Cod Bay, Buzzards Bay, and Massachusetts Bay estuaries (Massachusetts Department of Environmental Protection, n.d.), and several smaller embayments (The Coastal Systems Group, The Estuaries Project, n.d.). Over 50 % of its residents live in coastal counties (Wilson and Fischetti, 2010). In larger coastal urban centers, the population density increases to 1,250 - 2,500 residents per square kilometer (Hinrichsen, 1999). Impervious cover in densely populated coastal communities reaches up to and above 20%, (Massachusetts Bays National Estuary Program, 2016) which is associated with significant water quality impairments.

3.2.2 New Hampshire

New Hampshire is the 9th wealthiest state in the US by per capita income (Williams, 2021). New Hampshire has 1.36 million inhabitants in an area of 24,217 km² with a population

density of 58 per square km (KNOEMA, 2019); the state is 80% forested and 76% is privately owned (NH Timberland Association, Facts about New Hampshire's Forest and Forest Economy, n.d.) Thirty-two (32%) of the land in New Hampshire is protected (St. Concord, 2015). Five point five percent of the state's land cover is developed (NH GRANIT, 2016). New Hampshire has a coastline spanning 235 miles of estuarine coastline with a recessed estuary, but only 20 miles of coastline excluding the recessed estuary, with two significant estuaries, including the Great Bay estuary and the Hampton-Seabrook estuary (Piscataqua Estuary Partnership (PREP), 2010). Approximately 54% of the population live in the state's coastal counties (Crosset, 2005).

3.2.3 Maine

Maine is the 29th wealthiest state in the United States (Williams, 2021). Maine has 1.344 million inhabitants in an area of 91,646 km² with a density of 16.82 inhabitants per square km (KNOEMA, 2019). The state has the longest coast of any US state, featuring 8,400 km of coastline. Coastal counties contain 73% of the state's population (Moser, 2005). Twenty-three percent of the population lives within 1 km of the coast (Lam et al. 2009). Maine has approximately 7.6 million acres of forest land, which covers 89.1 percent of the state's area (Butler, 2018). About 89.1% of the forest land is privately owned (Butler, 2018).

Chapter 4: Results

4.1 Quantitative Results

Based on assessing the readiness of three US states to adapt their natural resources systems to climate change, out of 95 possible points, Massachusetts achieved the highest score of 89 points, New Hampshire received 48 points and Maine received 42 points. It is important to point out that both New Hampshire and Maine pursued climate adaptation readiness actions that ranged just outside of the literature review timeframe. If those actions had been included in the scoring, each state would have gained between 5 - 10 additional points, and thus would have still scored significantly fewer points than Massachusetts.

Table 6: Quantitative Adaptation Readiness Results

Overarching Readiness Factor	**Indicators**				
1. Executive Adaptation Leadership			MA	NH	ME
	1.a Law (s) Mandating Climate Adaptation Planning: no law was passed: 0 pts; a law was passed: 5 pts; law was passed in a timely manner: 3pts		8	8	5
	1.b Executive Order (s) Mandating Climate Adaptation Planning: no E.O. was issued: 0 pts; an E.O. was issued: 3 pts.; executive orders were issued in a timely manner: 3pts.		6	3	0
	1.c State Adaptation Reports: no state adaptation report was issued: 0 pts; a state adaptation report that includes a chapter or section on natural resources adaptation: 3 pts;		3	0	3

	1.d State Adaptation Plans: no state adaptation plan exists: 0 pts; a statewide adaptation plan exists with chapters addressing natural resources adaptation: 5 pts; in the absence of a statewide plan, a partial adaptation plan addressing natural resources management exists: 3 pts; plans address critical natural resources adaptation strategies 5 pts; plans were completed in a timely manner: 5 pts; plans are required to be updated regularly: 5 pts.		18	8	0
	1.e If no state adaptation plans exist, other governmental reporting efforts exist, resulting in other climate adaptation-focused reports: in the absence of statewide plans mandated by legislative or executive action, other statewide climate adaptation reports exist: 2 pts; other reports are updated regularly: 2 pts; other reports address key natural resources management strategies: 2 pts				6
Subtotals			35	22	14
2. Institutional Organization					
	2.a Executive office - Executive office responsible for coordinating environmental affairs does not exist: 0 pts; executive office responsible for coordinating state environmental affairs, including adaptation exists: 5 pts		5	0	0

	2.b Interagency workgroups and task forces - no state government interagency workgroups to pursue adaptation reporting and planning efforts and mainstreaming efforts were established: 0 pts. Informal state government interagency task forces were established: 2 pts. State interagency task forces and workgroups were established to pursue adaptation reporting and planning efforts in a timely manner: 5 pts; state task forces were established recently 1pts		5	5	3
Subtotals			10	5	3
3. Adaptation in Natural Resources Management Plans					
	3.a Mainstreaming - no chapter or section dedicated to natural resources management climate change threats and adaptation strategies is included in state adaptation plans reports: 0 pts.; climate change and adaptation is proactively addressed in state adaptation plans and reports 3pts.;		3	3	3
	3.b Quality of all plans - critical natural resources adaptation strategies are excluded in the state adaptation plans and reports: 0 pts. Some critical natural resources adaptation strategies are included: 2pts; most critical natural resources adaptation strategies are included: 3pts; the plan addresses climate change and adaptation comprehensively: 5 pts		3	5	3

Subtotals			6	8	6
4. Funding for Adaptation					
	4.b Funding mechanism - no innovative funding mechanisms are pursued: 0 pts; Some innovative funding mechanisms have been pursued: 3pts; innovative funding mechanisms have been pursued: 5pts		5	0	3
	4.b Adaptation Grants - no adaptation grant funding from charitable foundations and federal agencies has been sought out and secured: 0 pts; adaptation grant funding from charitable foundations and federal agencies has been sought out and secured:5 pts;		5	5	5
	4.c Capital Budget Allocations - no capital budget allocations have been located: 0 pts.; some capital budget allocations exist: 3pts; significant capital budget allocations exist: 5 pts		5	0	0
Subtotals			15	5	8
5. State Support for Municipal Adaptation					
	5.a Funding; funding for municipalities to pursue climate adaptation planning and implementation is available - 3 pts; sufficient funding is available: 5 pts; multi-year funding streams have been established; funding opportunities can be accessed at the state level at a central location: 5 pts;		13	8	8

	5. b. Technical Assistance - technical assistance is available: 3 pts.; technical assistance is comprehensive: 5 pts; technical assistance is made available at a centralized technical assistance hub: 5 pts;		10	3	3
Subtotals			23	11	11
Totals			89	48	42

The following section includes a detailed narrative description of the results.

4.2 Qualitative Results and Discussion

In the following paragraphs, the results of the systematic review for each of the adaptation readiness overarching factors as manifested in each of the US states analyzed in this thesis are discussed and commented upon in a narrative fashion. In the section on funding, several cases that demonstrate funding need as opposed to funding committed for adaptation are integrated into the narrative. These cases were collected during previous iterations of the research design for this thesis (see Appendix A) and serve illustrative purposes only. These cases raise questions about the extent to which the climate adaptation readiness framework reflects the likelihood that adaptation occurs, which will be explored in detail in the Chapter 5 (Discussion).

4.2.1 State Executive Leadership

In each of the US three states included in this study, laws and executive orders were passed to initiate state adaptation planning. Some adaptation planning was mandated by state legislatures or compelled through executive action. Each state addressed natural resources systems adaptation in its adaptation reports and plans. Each of the three states experienced temporary declines in state commitment to adaptation planning in the timeframe covered in this

thesis, 2009 to 2019. Massachusetts reflects the highest and most sustained levels of state executive leadership to both climate adaptation planning and mainstreaming. While New Hampshire and Maine have published climate adaptation reports and plans, neither state had a state-wide climate adaptation plan when the research for this thesis was conducted.

4.2.2 Laws and Executive Orders Mandating Climate Adaptation Planning[11]

4.2.2.1 Massachusetts

The Massachusetts state legislature passed the Global Warming Solutions Act in 2008 (Massachusetts Legislature, 2011). The law requires the establishment of a Climate Adaptation Advisory Committee charged with the crafting of a state climate adaptation report, including the development of recommendations for adapting government sectors to climate change.

In 2016 Governor Charlie Baker issued Executive Order (EO) 569 - Establishing an Integrated Climate Change Strategy for the Commonwealth (Massachusetts Legislature, 2016) — which mandates the development of a state climate adaptation plan to address climate threats and a timeframe for plan completion. According to EO 569, the state climate adaptation plan must be updated every five years. EO 569 also mandates the creation of a framework to support municipal climate adaptation efforts (Massachusetts, 2016). This framework provides guidance to municipalities on how to conduct vulnerability assessments and develop municipal climate adaptation plans. It also mandates the provision of technical assistance and funding for municipalities to implement climate adaptation interventions (Massachusetts, 2016).

[11] In the scoring rubric, executive orders and adaptation laws are grouped separately. In the narrative results, they are grouped under one category so as to prevent sections that only include two or three lines of text.

4.2.1.2 New Hampshire

In New Hampshire, EO 2007-3 (New Hampshire Department of State, 2007) established the New Hampshire Climate Change Policy Task Force. This Task Force prepared a Climate Action Plan (CAP), which includes one chapter on climate adaptation (New Hampshire Department of Environmental Services (NH DES), 2009, pp.27-33) and two pages on natural resources adaptation (NH DES, 2009, pp. 30-31). Under the category of *Government, Leadership and Action*, one of the actions recommends 'Include Climate Change Adaptation and Mitigation in Programs and Planning' (NH DES, 2009, p. 23).

In the CAP, under the category of Adaptation, Action 8 calls for the *development* of a state adaptation plan (NH DES, 2009, p.24). In 2013, State Bill 163 Chapter 188 established the New Hampshire Coastal Risk and Hazard Commission. The commission was charged with:

> [...] recommend [ing]legislation, rules and other actions to prepare for projected sea-level rise and other coastal watershed hazards such as storms, increased river flooding and stormwater runoff, and the risks such hazards pose to municipalities and state assets in New Hampshire" (New Hampshire Coastal Hazard Commission, 2013, p.iii).

4.2.1.3 Maine

Maine passed *Title 38: Waters and Navigation, Chapter 3-A: Climate Change - An Act to Promote Clean Energy Jobs and to Establish the Maine Climate Council* in 2019 (Maine Legislature, 2019). The Act establishes the Maine Climate Council, which is charged with — in addition to addressing GHG mitigation — to develop climate adaptation strategies (Maine Climate Council, n.d.). A revised *Maine Climate Action Plan*[12] was submitted to the Governor in December of 2020.

[12] Maine adopted a climate action plan in 2008, outside of the time frame delineated in this thesis for document review. The state CAPs focused primarily on mitigation with a brief section dedicated to climate adaptation.

4.2.3 State Climate Adaptation Plans and Reports

Each of the US states examined here issued adaptation reports or plans. The State of Massachusetts issued a state adaptation report and a comprehensive state adaptation plan. New Hampshire completed a partial adaptation plan that applies to the coastal zone. Maine completed a state adaptation report and several adaptation reports generated by interagency workgroups that reflect the state's adaptation needs, progress, and include recommendations. Both New Hampshire and Maine lack comprehensive state-wide adaptation plans and reports.

4.2.3.1 Massachusetts

In 2011, the Massachusetts Secretary of Energy and Environmental Affairs issued the *Massachusetts Climate Adaptation Report* (Massachusetts, 2011). The report is composed of two parts, with Part 2 dedicated to delineating both climate threats and adaptation options for the state's natural resources systems. In 2018, as required by EO 569, Massachusetts delivered the *Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan* (*SHMCAP*) (Massachusetts, 2018). The plan's strategy seeks to mainstream climate adaptation into the operations of all Massachusetts state executive agencies rather than delineating adaptation actions for each sector (Massachusetts, 2018, p.2).

4.2.3.2 New Hampshire

New Hampshire published the *New Hampshire Climate Action Plan* (2009), which is primarily focused on mitigation (NH DES, 2009). In relation to climate adaptation, the plan includes recommendation #8 "To mainstream climate adaptation across all government operations and to develop a stand-alone statewide climate adaptation plan for New Hampshire that would address all the sectors impacted by climate change, including natural resources systems." (NH DES, 2009, p. 59). The completion of a stand-alone climate adaptation plan was

estimated to take six months (NH DES, 2009, p. 60). No statewide climate adaptation plan has been completed as of yet.

In 2013, the New Hampshire Coastal Risk and Hazard Commission was created to craft an adaptation plan for New Hampshire's coastal zone. The plan was delivered to the New Hampshire Legislature in 2016. While New Hampshire does not have a state-wide climate adaptation plan, the recommendations in the *Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation* (New Hampshire Coastal Risk and Hazards Commission, 2016) include natural resources management and address critical natural resources management strategies and best practices for coastal areas (New Hampshire Coastal Risk and Hazards Commission, 2016, p.35). Recommendations for adapting coastal natural resources systems emphasize critical natural resources adaptation strategies, such as enabling habitat migration, buffer establishments on waterways and wetlands, re-creation of natural flow regimes in aquatic systems, habitat connectivity (see New Hampshire Coastal Risk and Hazards Commission, 2016, p. 52)

4.2.3.3 Maine

Maine issued a climate adaptation report rather than a plan, entitled *People and Nature Adapting to a Changing Climate: Charting Maine's Course*, in 2010 *(*Maine Department of Environmental Protection, 2010), which was presented to the Joint Standing Committee on Natural Resources of the 124th Maine Legislature. The document understands itself as preliminary (Maine DEP, p.17-18, 2010), but is comprehensive in its recommendations for natural resources system adaptation. It includes a chapter dedicated to natural resources management (Maine DEP, p.52-67, 2010), addressing the key natural resources systems

adaptation strategies. The report calls for the development of a fully-fledged state climate adaptation plan, which the authors project would take two to three years to assemble (Maine DEP, 2010, p.17) This plan was completed in December 2020 (Mannino, December 1st, 2020), and was thus outside the timeframe for this study.

4.1.2.3.1 Other Climate Adaptation Reports

Only in the State of Maine, climate adaptation documents were published that do not fall into the category of plans mandated by executive orders or laws. In 2014, Maine published a report called *Monitoring, Mapping, Modeling, Mitigation and Messaging: Maine Prepares for Climate Change* (Maine Energy and Environment Workgroup, 2014) which was prepared by Maine's Energy and Environment Workgroup - a temporary governmental structure created by Governor LePage. This report comprises an inventory and status update of climate mitigation and adaptation actions in Maine. Shortened to read *Maine Prepares for Climate Change,* this report was updated in 2018 and 2019 (Maine DEP, 2018 & 2019) by an informal governmental interagency structure called Maine Climate Adaptation Workgroup (MICA) (Maine DEP, 2018, p.1). The 2018 and 2019 reports, in addition to listing on-going actions, offer 32 recommendations covering an array of climate adaptation needs, including recommendations pertaining to the natural resources sector, including strategies considered critical for natural resources systems adaptation (Maine DEP, 2018 & 2019) .

4.3 Institutional Organization

Each state has established temporary institutional structures to pursue climate adaptation planning. Massachusetts has created both temporary and permanent institutional structures for adaptation planning and implementation. New Hampshire established two temporary

institutional structures for addressing climate adaptation. Maine features a workgroup not sanctioned by executive legal or regulatory action. Recently, the State of Maine moved to establish the Maine Climate Council (2020) through legislation, which comprises its first permanent structure to address climate adaptation. Overall, Massachusetts features the most developed and advanced permanent structures charged with natural resources management, and also the most developed institutional structures for addressing climate adaptation.

4.3.1 Massachusetts

Massachusetts has longstanding existing institutional structures charged with environmental protection and has established both temporary and permanent institutional structures to advance climate adaptation. In the wake of the passage of the *Global Warming Solutions Act of 2008* (Massachusetts Legislature, 2008) — which includes adaptation mandates — Massachusetts established an Implementation Advisory Committee to help guide the implementation of the 2008 Act. The Implementation Advisory Committee is composed of representatives from business, NGOs and ENGOs (Massachusetts, 2012).

In 2011, the state formed a Climate Adaptation Advisory Committee to craft the Massachusetts Climate Change Adaptation Report (Secretary of Energy and Environmental Affairs, 2011). Massachusetts has also formed an inter-agency team — Resilient Massachusetts Action Team (RMAT) (Massachusetts Executive Office of Energy and Environmental Affairs, 2019) — to implement the *State Hazard Mitigation and Climate Adaptation Plan* (2018) and to mainstream climate adaptation across state government agencies (Massachusetts Executive Office of Energy and Environmental Affairs, 2019). The RMAT is led by the Executive Office of Energy and Environmental Affairs and the Massachusetts Emergency Management Agency (Massachusetts Executive Office of Energy and Environmental Affairs, 2019). It is staffed by

designated Climate Change Coordinators from each of the state's executive offices (Massachusetts Secretary of Energy and Environmental Affairs, 2019). In addition, Massachusetts has an Office of Coastal Management, a Department of Environmental Protection, a Division of Ecological Restoration - charged with coordinating and overseeing the restoration of degraded ecosystems within the Department Environmental Protection — a Department of Fish and Game, and an Environmental Police Force mandated to enforce environmental laws (see Massachusetts State Organizational Chart, 2018).

4.3.2 New Hampshire

In 2007, New Hampshire created the temporary Climate Action Policy Task Force, which drafted the NH Climate Action Plan, primarily focused on mitigation, but with a section dedicated to adaptation (NH Department of State, 2009). It also established the Coastal Hazards Commission — a temporary institutional structure — which concluded the crafting of the *Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation* report in 2016 (Coastal Hazards Commission, 2016). New Hampshire's existing institutional structures to support climate adaptation of natural resources include the Department of Environmental Services, which contains its Coastal Management Program — representing itself as an agency addressing "clean water and protecting coastal habitat." (New Hampshire Department of Environmental Services, n.d.) New Hampshire also has a Department of Fish and Game (New Hampshire Department of Fish and Game, n.d.). For non-coastal natural resources management, the Department of Fish and Game offers technical assistance and funding resources (New Hampshire Department of Environmental Services, n.d.).

4.3.3 Maine

In 2010, a temporary coordinating committee was formed to craft the *People and Nature Adapting to a Changing Climate: Charting Maine's Course* (DEP, p.10, 2010)[13] . In 2014, an government interagency workgroup (Maine DEP, 2018, p.1) was formed — the Maine Climate Adaptation Workgroup (MICA) — that has coordinated climate adaptation across eight government departments (Maine DEP, 2018, p.1). MICA is managed by the Department of Environmental Protection (DEP, 2018, p.1). This workgroup shares information among agencies and works collaboratively on issues related to climate adaptation and resilience (DEP, 2018, p.1).

In 2019, a Maine Climate Council was established by the Maine Legislature and charged with updating the *Maine Climate Action Plan* by December, 2020 (Maine Legislature, 2019). According to the legislation, the Maine Climate Action Plan is to include recommendations for adaptation of coastal watersheds (Maine Legislature, 2019).

Maine's permanent institutional structures for environmental protection include a Coastal Program, Department of Environmental Protection and a Department of Inland Fisheries and Wildlife.

4.4 Climate Adaptation in State Natural Resources Management

In each of the three states' natural resources management plans, climate change data, threats, strategies, and actions were integrated. Differences among the plans exist in the frequency and depth with which climate adaptation is discussed and addressed. In the state with the lowest scores for state executive leadership - New Hampshire - natural resources

13 Maine published a Climate Action Plan in 2004 and 2008, both of which primarily focused on mitigation. The Maine climate action plan of 2008 contained a short section on adaptation.

management plans have been crafted that proactively and thoroughly address climate change threats, including comprehensive delineations of important climate adaptation strategies, and discussions of the ways in which proposed restoration actions can address climate change threats. Massachusetts' and Maine's natural resources plans generally address climate change and adaptation. Several plans from these two states lack the depth present in New Hampshire's natural resources management plans.

4.4.1 State Wildlife Action Plans

All SWAPs include and discuss key climate adaptation strategies. While important themes in natural resources adaptation were included in the three state plans, implementation frameworks are weak. [1] Concern over lack of funding as a barrier to implementation runs throughout all three SWAPs (see New Hampshire Fish and Game, 2015, pp. 7-1, Maine Department of Inland Fisheries and Wildlife, 2015, pp.9-12; Massachusetts Division of Fisheries and Wildlife, 2015, pp. 368-374)

4.4.1.1 Massachusetts

Massachusetts' SWAP includes a chapter on climate impacts and adaptation strategies. The principles listed in the SWPA as guiding habitat conservation were lifted from the state's Climate Adaptation Report (Massachusetts Division of Fisheries and Wildlife, 2015, p. 359). They are drawn from the natural resources climate adaptation literature. Compared to the other state SWPAs goals and objectives, however, Massachusetts SWAP lacked the finely grained, and specific strategies. Instead, it highlighted the higher-level principles. In addition, the Massachusetts SWAP features a weak implementation framework, which was found to be true

for all of the state SWAPs[14]. Rather than articulating SMART goals (Specific, Measurable, Achievable, Relevant and Timely), the plan includes goal setting among its list of conservation actions. The authors of the plan reflected on the challenges involved in goal setting:

> The most difficult part of constructing any truly useful conservation plan is setting goals: How many populations of Blanding's Turtles or Chain Dot Geometer or Purple Clematis should be conserved, and which ones? How many acres of early successional habitat should be created each year, and exactly where? (Massachusetts DWF, 2015, p.377).

The plan also states that "the second conservation planning task we will undertake is to incorporate landscape-scale planning into our conservation actions" (Massachusetts DWF, 2015, p.377). Since the first SWAP was required by Congress in 2005, comments suggesting that goal setting is needed and landscape-level planning is called for, suggests that implementation deficits arose during attempts at implementing the first SWAP [15].

Table 7: Massachusetts State Wildlife Action Plan Results

Massachusetts State Wildlife Action Plan	Yes/No
Re-establish aquatic and terrestrial habitat connectivity	√
Conserve and restore habitat	√

[14] It is likely that Massachusetts internal state agency work plans feature more detailed implementation plans.

[15] The quality of government plans does not necessarily always correspond to restoration or adaptation success, as was reflected in the research conducted for the second research design of this thesis to quantify adaptation outcomes in three US estuary watersheds. This research indicated that the presence of a strong ENGO was likely as predictive of restoration and adaptation success as the existence of a highly structured conservation plan crafted with robust stakeholder engagement and featuring a strong implementation framework. The authors of the Massachusetts SWAP may have approached plan development as a bureaucratic requirement mandated by the US Congress in exchange for funding. Rather than writing an ambitious plan, time may be more effectively spent pursuing actions enabled under Massachusetts comparatively more far-reaching natural resources protection laws and regulations and working in partnerships with ENGOs. Accordingly, Massachusetts' SWAP states that "The Commonwealth of Massachusetts has strong and effective environmental laws and regulations (see Chapter 2, Section C). While occasional modifications are needed, no major changes to environmental laws are needed." (Massachusetts Division of Fisheries and Wildlife, p.382). Questions about the relationship between the quality of adaptation plans in the natural resources sector and the likelihood that adaptation occurs cannot be answered in a desk study and is outside the scope of the climate adaptation readiness framework. Answering these types of questions would require semi-structured interviews with state agency staff, NGOs and other stakeholders involved in the crafting and implementation of natural resources management plans.

Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).	√
Strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots	√
Enable retreat of wetlands, marshes and other habitat in the face of SLR	√
Direct development away from sensitive and important habitats	√
Conduct mapping, data collection, studies and technical assistance to support landowners in climate adaptation and management	√
Restore and rehabilitate landscapes damaged from storms	
Land conservation incentives for forest landowners	
Recommends climate smart fire management	
Recommends forest conservation	
Recommends technical assistance on climate change and adaptation for municipalities	
Recommends smart development vs. sprawl growth	
Recommends landscape level restoration work	
Recommends Interagency coordination on climate change	
Supports Low Impact Development (LID)	
Recommends revising rankings of scoring criteria of grants and funding opportunities should include climate change in their rankings	
Minimize non-climate stressors to species and ecosystems	√
Use nature-based solutions, prioritize NBS over grey infrastructure	√

4.4.1.2 New Hampshire

In 2013, New Hampshire published an addendum - *Ecosystems and Wildlife: Climate Change Adaptation Plan* (New Hampshire Fish and Game Department 2013) - to its 2005 Wildlife Action Plan. The plan describes eleven overarching strategies with each strategy further divided into up to twelve individual sub-strategies (New Hampshire Fish and Game Department 2013). From among the Wildlife Actions Plans, the New Hampshire plan was rated as the strongest plan, anticipating the need to respond to climate change by two years. It also includes a comprehensive list of critical natural resources adaptation strategies. The implementation framework was deemed relatively weak, featuring coarsely grained time frames (2-4 years, 3-5 years), no intermediate objectives and benchmarks (New Hampshire Fish and Game Department 2015, p.7-1, 7-2). Like the Massachusetts SWAP, New Hampshire's plan reflects on the state of its implementation framework by including as an implementation goal to develop specific, measurable targets:

> NHFG will work with lead implementation organizations and personnel to develop specific, measurable targets to monitor achievement of Wildlife Action Plan goals. While some performance indicators were developed as a part of the Wildlife Action Plan, additional detail is needed. Working groups may be organized to develop specific work plans and performance monitoring strategies. Work plans for top priorities will be developed in Year 1, while lower priority work plans may not be developed until Years 2-3. (New Hampshire, pp. 7-1, 7-2)

This paragraph reflects a lack of specificity and concreteness, and a sense of 're-inventing the wheel', considering that the first iteration of the SWAPs was published in 2005.

Table 8: New Hampshire State Wildlife Action Plan Results

New Hampshire State Wildlife Action Plan	Yes/No

Re-establish aquatic and terrestrial habitat connectivity	√
Conserve and restore habitat	√
Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).	√
Recommends strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots	√
Enable retreat of wetlands, marshes and other habitat in the face of SLR	√
Direct development away from sensitive and important habitats	√
Conduct mapping, data collection, studies and technical assistance to support landowners in climate adaptation and management	
Recommends technical assistance on climate change and adaptation for municipalities	
Recommends smart development vs. sprawl growth	
Recommends landscape level restoration work	
Recommends Interagency coordination on climate change	√
Supports Low Impact Development (LID)	√
Minimize non-climate stressors to species and ecosystems	√

4.4.1.3 Maine

Maine's Wildlife Action Plan defines three "super themes" (Maine Department of Inland Fisheries and Wildlife, 2015, p.26): "Connectivity, Invasive Species, and Mapping and

Outreach". The plan describes climate change as a secondary theme (Maine Department of Inland Fisheries and Wildlife, 2015, p.26) and lacks a chapter dedicated to climate threats and adaptations. The Maine SWAP featured a wide range of finely grained and detailed strategies to address natural resources systems management and adaptation. While the Maine SWAP declared climate adaptation a secondary theme, the key climate adaptation strategies listed in the natural resources adaptation literature were discussed and addressed.

Table 9: Maine State Wildlife Action Plan Results

Maine State Wildlife Action Plan	Yes/No
Re-establish aquatic and terrestrial habitat connectivity	√
Conserve and restore habitat	√
Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).	√
Strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots	√
Enable retreat of wetlands, marshes and other habitat in the face of SLR	√
Direct development away from sensitive and important habitats	√
Conduct mapping, data collection, studies and technical assistance to support landowners in climate adaptation and management	√
Restore and rehabilitate landscapes damaged from storms	√

Recommends technical assistance on climate change and adaptation for municipalities	√
Recommends smart development vs. sprawl growth	√
Recommends landscape level restoration work	√
Recommends Interagency coordination on climate change	√
Supports Low Impact Development (LID)	√
Minimize non-climate stressors to species and ecosystems	√

4.4.2 Estuaries of National Significance

The planning documents for three of the estuary watersheds - Buzzards Bay (Massachusetts), Piscataqua Region estuary (New Hampshire) and Casco Bay (Maine) - were reviewed for this thesis. Each of the Comprehensive Conservation Management Plans (CCMPs) lists climate change as a threat and climate adaptation as an important goal. The emphasis on climate change and adaptation in the CCMPs ranges from prominent discussions and considerations of climate change to a few mentions of climate change, adaptation and resilience. The estuary management plan for the Piscataqua estuaries in New Hampshire treated climate change most comprehensively, while the plan for Buzzards Bay in Massachusetts was the least comprehensive.

4.4.2.1 Massachusetts

The Buzzards Bay Estuary 2013 CCMP is least focused on climate change and adaptation from among the three CCMPs. Climate change is listed in the 2013 update to the CCMP twelve times. Greenhouse gases are mentioned eight times. Climate change adaptation is referenced to

four times. Climate change adaptation is highlighted in the CCMP under Action Plan 18 *Planning for a Shifting Shoreline and Coastal Storms*, which addresses sea level rise (Costa, et al, 2013, p. 263) and a section discussing stormwater management (Costa, et al, 2013, p.100). The CCMP explains that stormwater runoff is expected to increase under current climate projections. As an adaptation strategy, the CCMP recommends that stormwater management structures be designed and constructed in such a way as to account for the expected increase in stormwater runoff as precipitation increases (Costa, et al., 2013, p. 100). Climate change is also mentioned in the CCMP action plan that relates to changing shorelines. There is no mention of climate adaptation in any of the other 21 CCMP action plans.

4.4.2.2 New Hampshire

The Piscataqua Region Estuary Partnership (PREP) 2010 CCMP prominently addresses climate change impacts throughout the plan. It features climate change as one of twelve critical conservation and restoration 'issues' (PREP, 2010, p. 20). The CCMP lists climate change 60 times, adaptation six times, resiliency seven times and resilience six times. Climate change is addressed by five estuary management objectives out of 32 and eleven action plans out of over 70. Climate impacts and objectives are comprehensively described as they relate to sea level rise, coastal erosion, land use, stormwater runoff, changing salinity, increased land and water-based temperatures, marsh migration, corridors for species migration, invasive species, hydrological changes in river flows. (PREP, 2010, p. 21). The PREP CCMP features the strongest implementation framework from among all the natural resources management plans reviewed for this thesis, with goals, objectives, metrics, timelines clearly defined, and implementation teams assigned to each of the goals (PREP, 2010, p.10). Finally, PREP has completed a climate change vulnerability assessment (PREP, 2019), which reviews all objectives

listed in the CCMP and determines the extent to which achievements of objectives are at risk because of climate change impacts. The climate change vulnerability assessment includes priority actions to reduce risk (see PREP, 2019).

4.4.2.3 Maine

The Casco Bay 2016-2021 CCMP (CBEP, 2016) features climate change prominently throughout its pages. It mentions resilience 15 times, adaptation 13 times, and climate change 15 times. The introductory pages[16] feature climate change under the heading of Facing *Unprecedented Change* and explains the implications of three main climate stressors on the Bay, including rising temperatures, ocean acidification, intensifying precipitation (CBEP, 2016, introduction). The CBEP includes climate adaptation as *resilience* in its guiding vision as one among six principles:

> Adapt as conditions change: foster regional resilience—the capacity for ecosystems and economies to adapt as climate and other variables shift, and to bounce back from unexpected disruptions. (CBEP, 2016, introduction)

The CCMP features four main goals with two-four strategies each and up to twelve actions. The action that articulates CBEP's approach to climate adaptation is entitled *Promote Climate Change Adaptation Best Practices that Incorporate Sound Climate Science* (CBEP, 2016, p.52). In addition, the CCMP integrates climate change impacts with other goals. Thus, Goal 1 — *Protect, Restore and Enhance Key Habitats that Sustain Ecological Health* (CBEP, 2016, p.3) — includes Strategy 1.2 that addresses the establishment and protection of habitat connectivity and

[16] The introductory pages of the Casco Bay CCMP lack page numbers.

calls for "the strengthening the Casco Bay ecosystems to withstand change", which denotes the kind of changes the ecosystem is expected to face under rising temperatures (CBEP, 2016, p.3) . In addition, the CCMP's Goal 2: *Reduce Nutrient Pollution and Its Impacts, Including Coastal Acidification* is based on the connection between increasing nitrogen pollution and increasing ocean acidification and climate change, which is covered by Strategy 2.3 articulated in the CCMP (CBEP, 2016, p.18). The implementation framework was considered robust with timelines, partners, and measurable metrics identified for each of the actions (see for example, CBEP, 2016, p.52).

4.4.3 State Forest Action Plans[17]

Each state considered climate change prominently in their draft Forest Action Plan. Massachusetts' and New Hampshire's Forest Action Plans were more developed than Maine's. The latter state's plan comprised a draft that was submitted to the federal government for review and was therefore in a more preliminary state than the other two states' plans. Climate change was featured prominently in each of the state plans with the most important themes - habitat connectivity, managing for both resistance and transition, strategic conservation, and protecting large, contiguous forest tracts - listed and discussed. While all the Forest Action Plans featured goals, strategies and actions, none of the plans had discernible implementation frameworks that included metrics, implementation timeframes or partner agencies and organizations.

[17] The state Forest Action Plan documents reviewed for this thesis were all drafts submitted to the federal government in December of 2020. Drafts will be revised upon input by the federal government. Following revision, final state Forest Action Plans will be re-submitted to USDA.

4.4.3.1 Massachusetts

Massachusetts' Forest Action Plan foregrounds climate change as a top threat and key management issue (Massachusetts Department of Conservation and Recreation (DCR), 2020). The plan acknowledges the role of forests in climate resilience (p. iii). In the chapter entitled *Forest Ecosystems and Health* (DCR, 2015, p. 21), the plan features a separate section that discusses climate impacts (DCR, 2015, p. 38).

The Plan emphasizes climate change by dedicating its Goal 1 to the "issue" of climate change (DCR, 2020, p ii). This goal seeks to increase the resiliency of trees and forests in the face of climate change (DCR, 2020, p.ii). Seven strategies are articulated to achieve this goal (DCR, 2020, p.15). In the section entitled *Resilient and Connected Landscapes* the Plan lists strategic conservation through preserving habitat connectivity and landscapes most likely to remain resilient (DCR, 2020, pp.37-38). Climate change is also prominently incorporated into the section on disturbances that address wildfires, floods and storms (DCR, 2020, p. 48). The Massachusetts Forest Action Plan lacks any discernible implementation framework.

Table10: Massachusetts State Forest Action Plan Results

Massachusetts State Forest Action Plan	Yes/No
Re-establish aquatic and terrestrial habitat connectivity	√
Conserve and restore habitat	√
Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).	√

Strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots	√
Enable retreat of wetlands, marshes and other habitat in the face of SLR	√
Direct development away from sensitive and important habitats	√
Conduct mapping, data collection, studies and technical assistance to support landowners in climate adaptation and management	√
Restore and rehabilitate landscapes damaged from storms	√
Land conservation incentives for forest landowners	
Recommends climate smart fire management	√
Recommends forest conservation	√
Recommends technical assistance on climate change and adaptation for municipalities	√
Recommends landscape level restoration work	√
Supports Low Impact Development (LID)	√
Recommends revising rankings of scoring criteria of grants and funding opportunities should include climate change in their rankings	
Minimize non-climate stressors to species and ecosystems	√

Use nature-based solutions, prioritize NBS over grey infrastructure	√

4.4.3.2 New Hampshire

The New Hampshire draft Forest Action Plan (2020) emphasizes climate change and adaptation as important management and conservation challenges (New Hampshire Division of Forest and Lands, 2020). The Plan includes a separate and extensive section discussing climate change impacts under the heading of *Forest Resources Assessment* (DFL, 2020, p.55-62). In the section entitled *Goals, Strategies, Actions* the plan includes a separate focus area on climate change. This focus area contains one overarching goal dedicated to climate change:

> New Hampshire forests contribute to mitigation of climate change and are managed with an objective that they can best maintain resilience and adapt to climate change with minimal adverse social, environmental and economic impacts. (DFL, 2020, pp. 141-143)

Two strategies are associated with the goal, one that focuses specifically on adaptation actions: "Incorporate adaptation strategies for climate change in forest management plans that include resistance, resilience and transition" (DFL, 2020, p. 143). In addition, climate change concerns are also addressed in a range of other strategies that are listed under non-climate-targeted focus areas. Climate change concerns are integrated throughout the plan, for example in discussions of invasive species (DFL, 2020, p. 47), plant pests (DFL, 2020, p. 42), wildfires and extreme weather (DFL, 2020, p. 56).

Table 11: New Hampshire Forest Action Plan Results

New Hampshire Forest Action Plan	Yes/No
Re-establish aquatic and terrestrial habitat connectivity	√
Conserve and restore habitat	√

Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).	
Recommends strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots	√
Conduct mapping, data collection, studies and technical assistance to support landowners in climate adaptation and management	√
Direct development away from sensitive and important habitats	
Restore and rehabilitate landscapes damaged from storms	
Climate smart fire management	√
Recommends technical assistance on climate change and adaptation for municipalities	
Recommends landscape level restoration work	
Recommends Interagency coordination on climate change	√
Supports Low Impact Development (LID)	
Minimize non-climate stressors to species and ecosystems	√

4.4.3.3 Maine

Maine's Forest Action Plan foregrounds climate change as a critical management and conservation challenge (Mansius, 2020). It features a section dedicated to discussing climate

impacts on forests under the heading of Issues, Threats and Opportunities, which delineates, one goal articulated as *Address climate change and its impacts on Maine's forest* (Mansius, 2020, p.43) and five strategies to promote climate adaptation of forest resources (Mansius, 2020, pp. 43-46).

Maine's Forest Action Plan includes additional goals that address climate adaptation implicitly, such as Goal 5 - *Maintain the health and resiliency of Maine's forests in the face of threats from biotic and abiotic agents* (Mansius, 2020, p. 48). This goal features twenty (20) strategies, including one that addresses climate adaptation expressly:

> Promote efforts to allow forests to adapt to climate change: 1/Maintain large contiguous areas as forests; 2/ Reduce other stressors; 3/Encourage species suited to future climates. (Mansius, 2020, p.96)

The Plan also integrates climate change concerns in a range of other management concerns, such as fires and biodiversity (Mansius, 2020, p.62).

Table 12: Maine State Forest Action Plan Results

Maine State Forest Action Plan	Yes/No
Re-establish aquatic and terrestrial habitat connectivity	√
Conserve and restore habitat	√
Restore natural flow regimes in aquatic ecosystems (i.e., dam removal, improved hydropower regulation, culvert removal or updating).	√

Strategic conservation: Prioritize habitats, natural communities, and ecosystems of sufficient size; protect large, unfragmented landscape mosaics; protect resilient sites and biodiversity hotspots	√
Enable retreat of wetlands, marshes and other habitat in the face of SLR	
Direct development away from sensitive and important habitats	√
Conduct mapping, data collection, studies and technical assistance to support landowners in climate adaptation and management	√
Restore and rehabilitate landscapes damaged from storms	√
Recommends climate smart fire management	√
Recommends forest conservation	√
Recommends technical assistance on climate change and adaptation for municipalities	√
Recommends smart development vs. sprawl growth	√
Recommends landscape level restoration work	
Recommends Interagency coordination on climate change	
Supports Low Impact Development (LID)	
Minimize non-climate stressors to species and ecosystems	√

4.4.1 Relationship Between state Adaptation Plans and Natural Resources Plans

The relationship between the treatment of climate adaptation in state-wide adaptation plans, sector-specific plans and adaptation progress has not been evaluated in the scholarly literature and comprises an area for further research. Research for this thesis, however, demonstrated that there is not necessarily a positive relationship between executive leadership in adaptation planning and mainstreaming, and the quality of state natural resources plans issued by natural resources sector bureaucratic agencies. In the three states evaluated in this thesis, climate change impacts have been incorporated into natural resources plans in two of the three states independently of executive leadership, which suggests a parallel, and non-hierarchical pattern of plan development rather than a top-down pattern of adaptation planning progress. This pattern suggests a certain independence among agency bureaucrats from the state executive leadership. Thus, in the absence of executive leadership, planning is pursued by agency bureaucrats independently from the state executive, possibly supported by federal agency representatives and NGOs (see Schulz, et al., 2017). Thus, in New Hampshire, which has the second lowest scores for state executive leadership, its Fish and Game Department finished a high-scoring climate adaptation addendum to its Wildlife Action Plan in 2013 - two years prior to the Wildlife Action Plan submission date as required by the US Congress. New Hampshire's National Estuary Program - PREP - crafted the highest scoring plan and features the highest scoring implementation framework of any natural resources management plan reviewed for this thesis

4.5 Funding for Adaptation

Each of the states have generated some funding for climate adaptation. Nonetheless, the need for additional funding is a pervasive theme in state adaptation, wildlife and habitat conservation plans and non-sector specific government reports and plans that address climate

adaptation (see Johnson, et al., 2019; Bierbaum et al., 2013; Schulz, et al., 2017; Mesquita-Emlinger, 2018; see Maine Dept. of Inland Fisheries and Wildlife, 2015, p. 21). According to the government documents and peer reviewed articles analyzed for this study, additional funding is needed for the entire suite of natural resources systems climate adaptation processes and actions to improve the resilience of natural resources systems, including 'climate smart' restoration, conservation, and management, research, and targeted programs, such as removal of dams and culverts impeding wildlife passage and stream connectivity (Mansius, 2020, p. 47; Bierbaum et al., 2013; Schulz, et al., 2017; Mesquita-Emlinger, 2018; Maine Dept. of Inland Fisheries and Wildlife, 2015, p. 21).

Based on the documents reviewed for this study, none of the three states have established estimates or projections of the funds needed to accomplish state-wide adaptation objectives neither for all governmental sectors nor for individual natural resources adaptation programs. Development of cost estimates and projections is also not listed in any adaptation plans or adaptation chapters or section as an objective. These projections may exist on the state level but could not be located through a systematic document search.

Massachusetts has made greater amounts of funding available than Maine and New Hampshire for adaptation planning and implementation. This state has implemented a range of novel funding approaches compared to New Hampshire and Maine. The latter two states have cultivated less diverse funding approaches than Massachusetts.

4.5.1 Massachusetts

Massachusetts has developed a proactive, concerted funding strategy, including the issuance of Green Bonds, an increase in the real estate transfer tax, securing federal grants, and

allocating funds from the state capital budget. In 2013, Massachusetts was the first state in the US to issue Green Bonds (Merill, et al., 2016). In the first year of the Green Bonds program, the state raised $100 million for a range of municipal natural resources conservation projects, including land remediation, river restoration, and open space preservation (Innovation for Sustainable Development Network, n.d.). In 2014, $350 million were raised from Green Bonds. Of these $104 million were allocated to habitat restoration and conservation, river and estuary restoration (Massachusetts, 2016). In 2018, the Massachusetts legislature passed H. 4835, an *Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection and Investment in Recreational Assets and Opportunity* (Massachusetts Legislature, 2017-18). This act allocates $2.4 billion from the state capital fund to support implementation of the state's *Integrated Hazard Mitigation and Climate Adaptation Plan* (Massachusetts, 2017-18) and to fund the Municipal Vulnerability Preparedness Program (MVP), whose goal is described as assisting communities with adapting to climate change and to become resilient (Municipal Vulnerability Preparedness, n.d.). From the document analysis, it was not possible to determine how much funding from the $2.4 billion allocated to climate adaptation in bill H. 4835 was dedicated to adaptation of natural resources systems specifically. It was only possible to glean that natural resources protection was *also* to be funded.

In 2019, the Executive Office of Energy and Environmental Affairs' (EEA) Dam and Seawall Program issued $10,293,414 in grants from the annual capital budget to fund 14 projects for dam removal and repair (Massachusetts, 2019). Fourteen projects were funded in 2019, which included five dam removal projects designed to re-establish stream connectivity and natural flow regimes in rivers and streams, which are critical natural resources adaptation

strategies (Massachusetts, 2019). The remaining nine projects involved dam and seawall repair. Dams and seawalls are grey infrastructure, which is not adaptive in natural resources systems. Since 2013, the year of its founding (Massachusetts, 2019), the Dam and Seawall Program has awarded over $77 million in grants and loans (Massachusetts, 2019). However, precisely establishing the amount of funding that was spent on dam repair as opposed to re-establishing stream connectivity and natural stream flow, was outside the scope of this thesis. To contextualize the Massachusetts dam repair and removal effort, while Massachusetts has removed over 40 dams since 2005 (Division of Ecological Restoration (DER), n.d.), there are approximately 3000 dams in the state causing altered flow regimes, impeding fish passage, and contributing to pollution and flooding (Massachusetts DER, n.d.).

In 2019, Governor Baker filed the Resilient MA legislation, or Senate Bill 10 (Massachusetts Legislature, n.d.), to raise funds for climate adaptation efforts through an increase in the excise tax on real estate transfers. This proposal was projected to generate $1.3 billion over 10 years. The expected funds would be managed by the Massachusetts Global Warming Solutions Trust Fund (Massachusetts, 2019). It appears that this latest gubernatorial funding initiative was not passed by the Massachusetts Legislature in 2020.

In April of 2020, a partnership of Massachusetts governmental agencies and ENGOs in secured a $10 million grant from the US Department of Agriculture Natural Resources Conservation Service (NRCS) - the restoration arm of the US Department of Agriculture - to protect open space and restore streams and wetlands on former cranberry bog farmland in southeastern Massachusetts (Massachusetts, 2019). According to the announcement “The

proposed work will restore habitat for fish and wildlife, help communities adapt to climate change, and benefit cranberry growers." (Massachusetts, 2019).

4.5.1.1 Funding Needs: Two Case Studies

Output and outcomes are not included in the climate adaptation readiness framework as indicators. In Chapter 5 — (Discussion) —, it is argued that the climate adaptation readiness framework would be more meaningful, if outputs/outcomes data, to the extent available, were included as indicators. Alternatively, there is the need for additional evaluation frameworks based on outputs and outcomes. Since several outcomes-based data were collected for the two previous iterations of the research design (see Appendix A), they are presented and discussed here for illustrative purposes only.

4.5.1.1.2 Cranberry Bogs

To consider the potential gap between available funding for climate adaptation in comparison to the projected funding need, it is important to consider the case study of a 'climate smart' restoration project in Massachusetts that restored 250 acres of retired cranberry bog (Galbraith, 2013). According to the final project report, such projects are estimated to cost between $1 - 2 million for 250 acres restored (Galbraith, 2013, p.26) and take 2-4 years to be completed (Galbraith, 2013, p. 26). Currently, there are 13,250 acres of cranberry farms located in Massachusetts (DER, n.d.). Many of these farms are slated for retirement because of falling cranberry demand (DER, n.d.). A Massachusetts partnership secured a $10 million grant from the NRCS that aims to restore 900 acres of wetlands and permanently protect 1,800 acres of open space (DER, n.d.). This example demonstrates that $10 million would enable the restoration of a

small number of acres compared to the number of cranberry bog acres that could qualify for climate smart restoration.[18]

4.5.1.1.3 Restoration Costs of Buzzards Bay

In Massachusetts alone, the cost of ecosystem restoration-rather than adaptation — ranges in the billions of dollars. For example, the Buzzards Bay estuary partnership estimates that "the cost to Buzzards Bay towns to remediate existing (pollution) discharges to comply with bacteria TMDLs and stormwater MS4 permits may exceed $1 billion dollars and take decades to achieve". (Costa, et al., 2013, p.105). One billion is the estimated cost for remediating the impacts of past and current residential and industrial development and population growth in one of two estuaries of national significance in Massachusetts with many smaller estuaries located along the Massachusetts shoreline. Restoration is considered to be an important climate adaptation strategy in the natural resources management literature. If one were to strictly distinguish between restoration/remediation and adaptation, authentic adaptation rather than remediation would likely require meeting pollution reduction targets (TMDLs) above currently established targets. Since studies suggest that climate impacts in the Northeast of the United States could worsen nitrogen levels in estuaries (Williamson et al., 2017), this increase in nitrogen pollution would have to be accounted for and remediated, adding to the cost of restoration and adaptation efforts.

18 Not all cranberry bogs qualify for restoration. Bogs are selected based on their ability to provide ecosystem services.

4.5.2 New Hampshire

New Hampshire lacks a strategic and concerted climate adaptation funding strategy. In contrast to Massachusetts, no green bonds have been offered. Capital fund expenditures could not be identified during document analysis for this thesis.

The New Hampshire Coastal Adaptation Workgroup (NH CAW) asserts that its partner organizations have raised more than $6 million since 2009 (NH CAW, n.d.). Projects that were funded, however, in addition to restoration projects, include scientific studies, school curricula, role-play simulations. Since the projects listed in CAW's grant viewer do not amount to 100 projects at $6 million (NH CAW, n.d.), it is difficult to analyze funding information by expenditure per project type per year since 2009 without conducting interviews.

Since 2014, the NH Department of Environmental Services' Coastal Program has operated a *Coastal Resilience Grant Program* that offers $150,000 annually in federal funds to the 17 communities located in New Hampshire's coastal zone (New Hampshire, 2020). Since 2014, 16 projects were funded throughout the NH coast amounting to about $700,000 in federal grant funds. The purpose of the program is to fund and support decision capacity-building, assessment, planning, and design projects to increase resilience to coastal hazards (New Hampshire, 2020).

The New Hampshire example illustrates the challenges underlying evaluating the funding of sector-specific adaptation in federated systems based on document review alone. Funding in such systems originates often from several sources, including federal and state agencies and charitable foundations. Federal funding is often secured through partnerships, which makes it challenging identify the organization or organizations that led the effort to secure the funds.

Funding time frames listed on government and agency websites in the New Hampshire example date back to 2000 and 2009 (NH CAW, n.d.). Thus, these sources lack data illuminating funds spent per year and per project type. From the available documents addressing New Hampshire's climate adaptation funding, it is unclear whether funding adaptation has increased, decreased or remained the same. Clarification of funding sources and amounts would have to be secured via semi-structured interviews with agency officials and ENGO representatives and require fiscal analysis of government and NGO budgets.

Based on the documents analyzed for this thesis, one can conclude that New Hampshire primarily relies on federal grants for adaptation funding, and that state executive leadership has been largely absent in developing novel or innovative funding sources, such as Green Bonds or tax increases.

4.5.3 Maine

Similar to New Hampshire, Maine lacks a strategic and concerted adaptation fundraising strategy. However, there are signs that leadership may be emerging to secure adaptation funding more strategically, as reflected in recent fundraising actions.

In 2014, Maine voters approved a Water Bond that provides $5.4 million annually for upgrading municipal culverts at stream crossings to improve fish and wildlife habitats and increase road safety (Maine DEP, Bureau of Land Resources, n.d). Despite this investment, Maine's Steam Connectivity Working Group - an unfunded, informal group of government and NGO representatives, expressed concern in 2017:

> With tens of thousands of problem road crossings in Maine, and 1,000+ dams with no accommodation for adequate fish passage, the scale of the connectivity problem can seem insurmountable. As Maine slowly rises to organize a comprehensive response to impaired

> stream connectivity, there is recognition among restoration practitioners that as time passes, the cost of initiating and supporting recovery of habitats and species increases, while the likelihood of success becomes less assured (Moore, 2017, p. 2)

The Maine Department of Inland Fisheries and Wildlife, and the Maine Department of Marine Resources announced in early 2020 that Maine was awarded a $30 million grant from the USDA Natural Resources Conservation Service (USDA NRCS) to restore aquatic connectivity and improve water quality in downeast Maine (NRCS Maine, 2020)

Since 2012, the Maine Agriculture Conservation and Forestry (DACF) program has provided $2.03 million in grant funding for 74 projects in coastal Maine (Maine Department of Agriculture, Conservation and Forestry (ACF) n.d.). Annually, the program awards about $157,000 for about five projects (ACF, n.d).

In respect to adaptation funding approaches, the 2018 *Charting Maine's Course* - Maine's annual update of climate adaptation actions - recommends that:

> The state should identify ways to coordinate funding sources across agencies to consolidate separately funded project segments into one larger fund or 'package', or through multiple funding sources, for a single larger project that addresses the totality of a problem, rather than having to approach a situation piecemeal. (Maine DEP, 2018, p.54)

This recommendation possibly reflects a trend towards a greater role of government in coordinating and centralizing climate adaptation funding.

Summarizing the section on adaptation funding, despite the absence of precise adaptation cost estimates and projections, contextualizing available adaptation funding with information about the cost of adaptation interventions shows that the need for 'climate smart' restoration will likely outpace the funding available. While funds in each of the three states have been committed for adaptation planning and implementation, lack of sufficient funding likely

continues to pose significant barriers to adaptation planning and implementation (see Bierbaum, et. al, 2013). A precise evaluation of available funding for natural resources adaptation is difficult without conducting a close analysis of state and local budget documents and interviews with agency staff and budget officials. Doing so was outside the scope of this study. A targeted research effort, narrowly focused on funding sources and expenditures, is likely needed to account for the total funding available in specific states to pursue adaptation implementation in the natural resources protection sector.

4.6. Support for Municipal Climate Adaptation

State governments assist municipalities with climate adaptation principally through two approaches: 1/Funding adaptation planning, design and feasibility studies and implementation of projects; and 2/technical assistance. Each state offers some adaptation funding to municipalities for adaptation with the extent of funding ranging widely.

There is variation among the states in the quality and quantity of technical assistance offered. Massachusetts has created a centralized on-line technical assistance hub with a comprehensive resource database. In New Hampshire and Maine, technical assistance is decentralized. Both states offer limited on-line technical assistance resources with state/NGO partnerships and NGOs providing both general and subject specific technical assistance. Included in each of the states' technical assistance offerings are habitat maps available for municipal planning staff to create overlays (see Penn State College of Earth and Mineral Sciences, n.d.) showing sensitive and valuable habitat that should be conserved.

4.6.1. Massachusetts

4.6.1.1 Funding for Municipal Adaptation

Massachusetts offers two major programs that fund municipal adaptation[12]. Since 2014, the Massachusetts Office of Coastal Zone Management program has administered the Coastal Resilience Grant program that has issued adaptation grants to the municipalities located in the coastal zone. Shoreline restoration is among the target activities of the program (Massachusetts Office of Coastal Zone Management, n.d.): "Shoreline restoration projects support non-structural approaches to restore or enhance natural systems to provide erosion and flood protection provided by public beaches, dunes, coastal banks, salt marshes, shellfish, and other habitat types.". This program has issued between $1.8 to $3.4 million annually since 2014 to the 75 coastal communities for climate adaptation (Massachusetts Office of Coastal Zone Management, n.d.).

The second significant adaptation funding opportunity targeted at Massachusetts cities and towns is the Municipal Vulnerability Preparedness Program (MVP) established in 2017, and available to municipalities from across Massachusetts (Municipal Vulnerability Preparedness, n.d.). Through the MVP program, $11.6 million in planning and so-called action grants were awarded in fiscal year 2020/21 (Municipal Vulnerability Preparedness, n.d.). According to the Massachusetts Government, 82% of communities now participate in the MVP program (Municipal Vulnerability Preparedness, n.d.).

4.6.1.1.1 Case Studies Demonstrating Funding Need

To contextualize Massachusetts's efforts with outcomes data collected during the first iteration of the research design for this thesis (see Appendix A), two municipal case studies are

briefly discussed here. In 2014, the Town of Gosnold - located in the Buzzards Bay watershed- received a Coastal Resilience grant from the State of Massachusetts to develop design studies supporting a beach nourishment, dune restoration, and other green infrastructure options to strengthen the resilience of Barges Beach on Cuttyhunk Island (Massachusetts Office of Coastal Zone Management, n.d.) Engineering plans were completed for a beach and dune restoration project. The State issued the permit for the project. According to the 2018 *Open Space Plan and Recreation Plan of the Town of Gosnold* "funding [for this project], projected to be between $3 million and $4 million, remains prohibitive." (Town of Gosnold, 2018, p.12). The project remains in the design stage. In 2014, the Town of Falmouth also received an MVP grant for the restoration of Chapoquoit Beach (Massachusetts Office of Coastal Management, n.d.). Completion of this project has been estimated to cost $2 million, and, according to the grey literature, is elusive (Gentile, 2016).

These examples demonstrate that current funding allotments for project planning do not necessarily result in the implementation of adaptation projects. It is understood that natural resources restoration projects cost in the millions of dollars per project (see Galbraith, 2013, p.26). Accordingly, even the comparatively large amounts of funds raised and spent by the State of Massachusetts may fall significantly short of the climate adaptation funding needed. In addition, funds may be available and spent on planning, design, and feasibility studies, but project implementation may stall because of lack of funds for implementation.

Significantly more research is needed on adaptation funding needs of national and sub-national units and strategies for meeting these needs.

4.6.1.2 Technical Assistance

Massachusetts hosts an on-line Climate Adaptation Clearinghouse with a wide range of maps, reports and tools available targeted at municipalities (Resilient MA, n.d). The Clearinghouse contains more than 2000 resources that are curated for reliability and relevance (Resilient MA, n.d). The map section of the Clearinghouse features 30 different maps, including Massachusetts-specific, national maps and maps published by NGOs, such as Audubon Society and the Nature Conservancy, that are important for natural resources protection (Resilient MA, n.d). The Clearinghouse has a search engine that enables document searches of its repository with search fields for types of sources, sectors, impacts and strategies (Resilient MA, n.d). Geographic specificity can be achieved through a keyword search (Resilient MA, n.d). Massachusetts has also developed a specific framework for municipal adaptation, which includes technical assistance for a particular type of planning approach (Executive Office of Energy and Environmental Affairs, n.d.) and a certified adaptation providers network (Municipal Vulnerability Preparedness, n.d.) whose members help facilitate adaptation planning activities, stakeholder engagement, and the writing of adaptation plans.

Strategic habitat conservation in Massachusetts is supported through BioMap 2 — a GIS-based mapping project — which was updated to reflect climate change impacts and areas vulnerable to sea level rise. BioMap2 covers 2.1 million acres, about 40% of the state (Resilient MA, n.d.).

4.6.2 New Hampshire

4.6.2.1 Funding for Municipalities

Since 2014, the NH Department of Environmental Services' Coastal Program has offered a *Coastal Resilience Grant Program* that offers $150,000 annually in federal funds to the

seventeen communities located in New Hampshire's coastal zones (NH DEP, Coastal Program, n.d.). Sixteen projects were funded throughout the New Hampshire coast amounting to about $700,000 in federal grant funds (NH DEP, Coastal Program, n.d.). The purpose of the program is to fund support decision capacity-building, assessment, planning, and design projects to increase resilience to coastal hazards (NH DEP, Coastal Program, n.d.).

4.6.2.2 Technical Assistance for Municipalities

New Hampshire's on-line reference library for adaptation, the Climate Adaptation Tool Kit, includes few resources. Several of the links are broken, suggesting that the Tool Kit is not updated and currently defunct. Most of the technical assistance available in New Hampshire is provided through partnerships comprising NGOs, educational organizations and government agencies rather than government alone. For example, the Taking Action for Wildlife program is a partnership that includes an education institution - the New Hampshire University Cooperative Extension – a government agency, the NH Department of Fish and Game – and the NH Association of Conservation Commission - an NGO (Taking Action for Wildlife, n.d). This partnership supports the implementation of the *State Wildlife Action Plan* (New Hampshire Fish and Game Department, 2015) by offering workshops and resources that support the integration of habitat conservation principles and expertise in land management for municipalities and landowners (Taking Action for Wildlife, n.d). This partnership also offers targeted technical assistance for municipalities in the form of in-person facilitation and discussion of municipal goals in relation to habitat conservation (Taking Action for Wildlife, n.d). The *Taking Action for Wildlife* website features an updated page on climate change and adaptation resources with about 20 entries (Taking Action for Wildlife, n.d). The entire website features about 40 resources (Taking Action for Wildlife, n.d).

New Hampshire's Coastal Climate Adaptation Workgroup (CAW) offers technical assistance to municipalities, land and homeowners (CAW, n.d.). The workgroup's partners include state and federal agencies, NOGs, and universities (CAW, Who We Are, n.d.). Its website features several on-line climate adaptation resources, including a listing of completed and on-going climate adaptation projects, a list of funding opportunities, and a reference library for technical and scientific reports (CAW, n.d.). CAW holds an annual one-day climate adaptation summit for municipalities (see CAW, 2019).

4.6.3 Maine

4.6.3.1 Funding for Municipalities

Coastal Community Grants are offered by the Maine Municipal Planning Assistance Program by providing technical and financial assistance to Maine municipalities for increasing resilience. Since 2012, this program has made available $2.03 million for 74 projects in coastal Maine (Maine Department of Agriculture, Conservation and Forestry, n.d.) In addition, the Shore and Harbor Planning Grant Program offers in total $120,000 annually for a range of programs and projects, including natural resources protection, for communities located in the coastal zone (Maine Department of Marine Resources, Coastal Program, n.d.)

4.6.3.2 Technical Assistance

As in New Hampshire, Maine's climate adaptation technical assistance is decentralized. Technical assistance is provided largely by ENGOs and partnerships between NGOs and governments. Maine hosts an online Climate Adaptation Tool Kit featuring about 20 resources that address climate adaptation of natural resources (Maine DEP, Maine Climate Adaptation Toolkit, n.d.). In 2017, a partnership of federal, state and educational institutions in Maine published the *Maine Flood Resilience Checklist: A self-assessment tool for Maine's coastal*

communities to evaluate vulnerability to flood hazards and increase resilience (Sherwin, 2017). Moreover, Maine Audubon, an environmental NGOG, launched the Stream Smart partnership in 2002 (Maine Audubon, Stream Smart, n.d.). Since then, the partnership has delivered workshops and training to over 1,000 people to restore stream connectivity (Maine Audubon, Stream Smart, n.d.). The Casco Bay Estuary Partnership in Maine has created a *Climate Adaptation Resource Guide for Municipalities in Casco Bay*, which comprises a list of links to climate adaptation resources (Schauffler, 2015). There is a Maine Climate Change Adaptation Providers (CCAP) Network that was founded in 2010 but lacks a website. According to a flyer about CCAP, the providers network is pursuing several projects: a climate adaptation project tracking tool (a master list to track adaptation progress); a CCAP website hosted by UMaine Extension and ME Sea Grant, community resilience risk assessment and evaluation ('database' of actions); resource mapping and coordination of technical assistance resources; funding/financing for resilience, legal liabilities for adaptation responses; greenhouse gas inventory methods and strategies; outreach and communications (Maine Climate Adaptation Providers Network, n.d.).

A recommendation from the 2018 *Charting Maine's Course* report centers on" the expansion of the Maine Climate Change Clearinghouse to include targeted information and technical assistance to municipalities pertaining to adaptation." (Maine DEP, 2018, p. 60). Recommendations such as this one suggest that more centralized approaches are considered desirable and may be emerging in response to climate change adaptation in Maine.

Chapter 5: Conclusion

In this thesis, the climate adaptation readiness framework as developed by Ford and King (2015) was revised and applied to evaluate and compare the adaptation readiness of three Northeastern US States — Massachusetts, New Hampshire and Maine —located in New England. The framework assumes that the presence and quality of six overarching factors determines the likelihood that adaptation occurs in developed nations or sub-national units (Ford & King, 2015). Thus, the climate adaptation framework can be understood as a proxy indicator framework designed to measure climate adaptation progress. The climate adaptation readiness framework is grounded in the concept of an adaptation architecture composed of policy components as delineated by Smith et al. (2009). Without these policy components in place, adaptation, it is assumed, is unlikely to occur (Smith et al., 2009; Ford & King, 2015; Ford et al., 2013)

The adaptation readiness framework was developed by Ford and King (2015) to address several of the methodological and conceptual difficulties of evaluating adaptation progress. These difficulties include the temporal disconnect between adaptation interventions and measurable adaptation outcomes, shifting baselines, and uncertainty. The authors contend that the adaptation readiness lends itself to evaluating the likelihood that adaptation occurs (Ford & King, 2015).

5.1 Climate Adaptation Readiness of Three Northeastern US States

It was found that each of the states included in this thesis has pursued some actions and initiatives that fall under the category of climate adaptation. Further, each of these states has pursued some adaptation actions in the natural resources sector. Based on the application of the

adaptation readiness framework, Massachusetts achieved the highest scores of adaptation readiness, followed by New Hampshire and then Maine. Massachusetts showed significant adaptation readiness strengths across all overarching factors. It featured laws and executive orders mandating statewide adaptation planning. State adaptation plans included critical natural resources adaptation strategies. Temporary and permanent institutional structures charged with natural resources management and climate adaptation are highly developed in Massachusetts. The State has also pursued a range of strategies to raise and set aside funds for natural resources adaptation, including Green Bonds, modest tax increases, capital budget allocations, and applications for federal grants. The State's articulation of natural resources adaptation strategies in the natural resources plans analyzed here, were comparatively not as detailed and well developed than in New Hampshire and Maine. New Hampshire's and Maine's State Wildlife Action Plans featured a wide range of finely grained and detailed strategies that were lacking in Massachusetts' plans. The Piscataqua Estuary Partnership located in New Hampshire developed the strongest of any of the state's natural resources plans. It is important to reiterate, however, that the extent to which plans translate into adaptation progress on the ground is not clear and was not explored in this thesis.

In New Hampshire and Maine, laws and executive orders were less often used to advance adaptation action. These two states issued partial adaptation plans in the case of New Hampshire and informal plans in the case of Maine. In each of the two lower scoring states, there were fewer institutional structures found and they were temporary rather than permanent.

As suggested by King and Ford (2015), there was a strong correlation between executive leadership [19] and governmental climate adaptation initiatives. In Massachusetts, strong executive leadership drove the adoption of climate adaptation laws, executive orders, planning efforts, and support for municipal adaptation. Adaptation readiness in Massachusetts was characterized by an approach tending towards government centralization. In Maine and New Hampshire, planning, funding and support for municipalities was shaped by decentralization and public/private partnerships.

5.2 Strengths of the Adaptation Readiness Framework

The adaptation readiness framework lends itself to comparing adaptation programs across jurisdictions. It articulates a minimal standard for the quality of state adaptation programs and policies against which existing adaptation program components can be evaluated. When applied to a group of sub-national units, the framework can generate comparative data that illustrates a jurisdiction's deficits, gaps, strengths, and best practices relative to other sub-national units.

It was determined that the framework can be flexibly applied in different contexts as King and Ford (2015) suggest. For this thesis, two overarching factors were removed, and one overarching factor was added to result in a robust analytical framework for the context examined in this thesis. However, a purely deductive approach to revising the framework for different contexts was found not to be feasible. Since climate adaptation as a discipline is still a relatively new field, existing research was found to be insufficient to capture all aspects of climate adaptation policy developments underway on the US state level. As a result, the overarching

[19] For the context examined in this thesis, the overarching factor of political leadership was re-articulated as executive leadership.

factors, criteria and indicators had to be revised based, in part, on the findings of the empirical research results generated through the data analysis.

Generally, it was found that the framework is more useful for illuminating deficits than strengths in the adaptation architecture since the notion of strengths is more closely aligned with the concept of concrete outcomes, such as measurable reductions in vulnerability. Thus, one can assume that raising more funds is always better than raising less, but the larger amounts of funds raised may still not be sufficient to meet adaptation needs. Unless adaptation goals are articulated in measurable and time-specific terms and funding needs are projected per state or sector, it remains unclear when or whether adaptation goals have been met. To be more meaningful as an adaptation evaluation tool, the adaptation readiness framework ought to be combined with output and outcomes-based factors and indicators. Output and outcomes-based indicators provide additional information about the effectiveness and quality of an adaptation architecture in a particular jurisdictional context, and thus reflect whether adaptation planning, policy development and funding has the potential to translate into decreases in vulnerability and harm on the ground.

5.3 Weaknesses of the Adaptation Readiness Framework

While Ford and King (2015) suggest that the adaptation readiness framework provides a measure of the likelihood that adaptation occurs, it is argued here, that the adaptation readiness framework provides a compelling measure of the extent to which the *adaptation architecture* (see Smith, et al., 2009) has been established in national and sub-national units. The framework enables an analysis of the existence and quality of each of the components in the adaptation architecture. It is proposed in this thesis that the framework does not provide a measure of the

likelihood that adaptation occurs — a determination that would hinge on a precise definition of the meaning of adaptation and articulation of measurable, time specific adaptation goals. Instead, adaptation is defined by Ford and King (2015) using the rather broad IPCC definition of adaptation as 'adjustments to climate and its effects'.

Climate adaptation, unless defined in clear quantitative and qualitative terms based on the recommendations of scientists, is resistant to evaluation. Governments may take a range of legislative, planning, funding and implementation steps, but unless these commitments meet the magnitude of the leadership, funding, and institutional challenges, such as possibly embodied in the term 'transformative adaptation', significant vulnerabilities will persist and magnify as time passes by.

Further, the notion of adaptation readiness as a time-based concept is problematic. Adaptation is not an outcome. It is a continuous process (Bours et al, 2013). In contrast, the term readiness usually refers to a temporally limited situation. Policy systems achieve readiness compared to a baseline of lack of readiness to address climate impacts followed by a state of readiness. The assumption of readiness contrasts with the reality of continuously shifting baselines that governments will have to contend with under rapidly changing conditions caused by climate change. Thus, adaptation plans require regular updating. Funding needs are predicted to increase over time (see Fankhauer, 2010). Leadership may have to rise to unprecedented levels.

Instead, the procedural model that dominates in the governmental realm, is one of adaptive management, continuous optimization, continuous adjustment rather than necessarily readiness. Finally, the term readiness is problematic once jurisdictions have initiated the process

of adaptation. When does readiness end and implementation begin? With a jurisdiction that is in the process of implementing adaptation actions, can adaptation readiness still be evaluated?

In conclusion, limiting the explanatory dimension of the adaptation readiness framework to the adaptation architecture and its quality rather than the likeliness that adaptation occurs would solve several of these methodological problems.

5.4 Adaptation in the Natural Resources Sector

In the natural resources sector, adaptation is complicated because of past and on-going non-climate related degradation of natural resources. To determine the likelihood that adaptation takes place, all aspects impacting on natural resources systems would have to be included in an adaptation evaluation framework. These aspects include the actions governments take to meet restoration needs caused by past or legacy stressors, impacts from on-going non-climate-related stressors, and climate-related threats. A climate adaptation evaluation framework applied to natural resources systems must take account of the complexities of natural resources systems management. Since the climate adaptation readiness only targets factors for evaluation that are called adaptation, and is not centered in measurable adaptation goals, it is of limited efficacy in accounting for the entire spectrum of actions that need to take place to adapt natural resources systems to climate change.

Similar to the overarching adaptation readiness factors as selected by Ford and King (2015), the adaptation readiness framework is suitable for evaluating the extent to which the adaptation architecture pertaining to natural resources systems has been established, not the likelihood whether natural resources systems adaptation actually takes place.

5.5 Appropriateness of the Overarching Factors and Indicators

The overarching adaptation readiness factors and indicators were found to be largely appropriate. Definitions of several overarching factors needed refinement for the US context. For example, political leadership, while critical in the establishment of the governmental adaptation architecture, was determined to be too broadly defined for analysis in the sub-national context. Instead, executive leadership, the powers of governors or heads of sub-national units was found to be more impactful in the establishment of the adaptation architecture than other types of leadership (see King & Ford, 2015). A clear relationship was found between executive leadership and actions that resulted in the development of the adaptation architecture. In fact, contrary to Ford and King (2015) suggestion that laws are often non-existent in the adaptation realm, the passage of laws and adoption of executive orders was determined to be the most important approach for advancing the establishment of an adaptation architecture in the three US states included in this study.

As suggested elsewhere in this thesis, it would be useful to add outputs and outcomes factors and indicators to analyze the extent to which the adaptation architecture in a particular jurisdiction manifest in concrete adaptation projects, initiatives, and interventions. Two case studies that reflect output of the adaptation architecture pertaining to the overarching factor of State Support for Municipalities suggest that funds spent on initial project implementation steps —engineering and implementation plans — failed to lead to full implementation because of lack of funding for full implementation.

The overarching factor of Funding for Planning and Implementation could also be further refined. Multi-year funding streams for adaptation existed in each of the US states evaluated, but the quality of the funding effort, levels of funding raised, and the funding instruments deployed

by each of the three US states varied widely. It would be useful for the adaptation readiness framework to be able to analyze and describe these differences.

5.6 Flexible Application of the Adaptation Framework

Ford and King (2015) suggest that the framework can be flexibly applied depending on the context. It was found that the adaptation readiness framework indeed can be revised to fit the context of the application. For this thesis, the framework was revised to fit the context of sub-national units in the United States. In addition, a sectoral dimension — adaptation of natural resources management — was successfully added as an overarching factor. For this added factor, state adaptation plans, and reports were analyzed to evaluate the presence and quality of natural resources adaptation strategies.

However, it is important to note that in the absence of a plethora of academic research, it is difficult to pursue a purely deductive approach. If the existing research literature is not developed for the selected context or the existing research literature focuses primarily on sub-sectors, such as coastal management rather than adaptation broadly, deductive approaches prevent capturing the nuances and specific manifestation of adaptation readiness in the context selected for framework application.

Thus, the adaptation readiness framework may benefit from a combination deductive/inductive approach, also called an abductive approach as was pursued in this thesis to further match the overarching factors and categories to the context of analysis.

5.7 Additional Findings

The framework lent itself to making several observations that are not reflected in the research questions. In particular, policy patterns and structures were detected that are described in the following paragraphs.

5.8 Policy Patterns and Structures

The readiness framework enables the researcher to identify adaptation policy development patterns, including patterns that have a temporal and a structural dimension. Each of the states experienced temporary declines in the pursuit of a climate adaptation program development that were most likely caused by declines in political leadership as a result of elections (see Schulz, et al., 2017). A pattern emerged that suggested an initial burst of policy attention targeted at climate adaptation, resulting in planning efforts followed by time periods of inattention lasting as long as a decade. This observation has more of a historical than policy significance, but it raises the question whether there are other temporal patterns that can provide greater insight into adaptation processes or policy development processes in general.

One structural pattern that emerged from the analysis possibly suggests a greater trend towards government centralization to address climate adaptation needs. Thus, Massachusetts demonstrated the greatest level of government centralization pertaining to adaptation, which appeared to be correlated with high levels of political leadership, and a well-developed adaptation architecture. In Maine and New Hampshire, the adaptation process was characterized by decentralization with government bureaucratic staff in state adaptation plans and documents expressing preferences towards a more centralized process. Questions arise whether high levels of political leadership are commonly associated with centralization of adaptation processes, and whether centralization leads to greater scores on adaptation progress. Following from this line of investigation, one also wonders whether there are examples of successful decentralized approaches that lead to high scores for adaptation progress.

5.9 Limitations

It was found that the research for and application of the climate adaptation readiness framework is optimally pursued with a team of researchers collecting the greatest number of data points in a short period of time. US federal departments and US states are proceeding rapidly with development of climate change adaptation programs and generating funding opportunities. An informal grey literature survey demonstrates that since the first draft of this thesis was completed, in Massachusetts, additional municipalities have committed to participating in the Municipal Preparedness Program and have been awarded planning and implementation grants. To achieve a snapshot that provides a credible baseline and sound data for decision-makers, adaptation readiness research needs to be completed rapidly and results need to be published soon after. If publication takes months or years to accomplish, the effort will be outdated before it is accessible to other researchers and decision-makers outdated.

5.10 Implications For Future Research

This thesis points towards several additional research opportunities on adaptation policy. Additional research ought to focus on:1/adaptation cost projections in the context of adaptation goal setting on the state level; 2/adding outcomes-based indicators to the readiness framework; and 3/exploring governmental structures, such as centralization vs. decentralization, most designed to advance adaptation; 4/including non-climate related stressor into adaptation evaluation frameworks; and 5/generating a vision of what the adapted society looks like.

1/Adaptation funding, cost and cost projections, and adaptation goal setting are related topics. While the adaptation readiness framework includes funds raised for adaptation as an over-arching factor in determining the likelihood that adaptation occurs, this over-arching factor ought

to be more clearly defined by establishing a relationship between funding need, and fundraising effort and adaptation goals to be met. Sub-national units may raise funding and even generate multi-year funding streams, and yet the funding raised may be less or vastly less than the funding needed. Thus, the presence or absence of funding earmarked for adaptation does not necessarily indicate adaptation progress. Assessments of funding needs and cost projections have to be established on the state level to generate a more comprehensive impression of the funds needed to achieve adaptation progress. However, cost projections for adaptation could not be identified in the document review for this thesis. Further, case studies of individual adaptation interventions as described in this thesis showed that funding fell short of adaptation needs for individual adaptation projects. More research needs to be conducted on how to generate comprehensive adaptation cost projections on the state level based on climate change scenarios and the best available science for a particular timeframe, 10-20 years, for example, rather than assessing cost on a project-by-project basis, in an incremental manner as needs are identified.

2/Another area of research connected to funding and costs, should focus on adding outcomes-based indicators to the adaptation readiness framework. Outcomes-based indicators are more suggestive of actual adaptation progress than indicators that elucidate the presence of the over-arching factors that make up the adaptation readiness framework. One could argue that adding outcomes-based indicators or simply additional indicators would turn the adaptation readiness framework into an M&E framework, which are indeed increasingly used for assessing adaptation progress.

3/An additional area of research would be to explore governmental structures that are most designed to advance adaptation, such as decentralization vs. centralization of government

action. In this thesis, it was found that the state of Massachusetts, which had the highest scores on adaptation readiness, reflected the greatest level of government centralization in advancing adaptation compared to New Hampshire and Maine, which had significantly lower scores, and pursued more decentralized approaches to adaptation. Researchers should consider exploring the extent to which centralization vs. decentralization impacts the rate of climate adaptation progress. In addition, it may be constructive to examine which aspects of centralization, such as, for example, political or executive leadership, the pursuit of a top-down hierarchical approach or centralization of technical assistance, are significant in advancing adaptation progress. Further, it would be useful to examine whether decentralized approaches can also be effective in advancing climate adaptation progress, and if so, which aspects of a decentralized approach are critical for adaptation success.

4/More research needs to be conducted on the impact of non-climate related stressors on adaptation and how to include non-climate related stressors into evaluation frameworks for adaptation. For example, sprawl growth and the expansion of road systems continues unabated in the United States. Impervious surfaces cause water pollution and flooding, which is exacerbated by climate change. Accounting for non-climate related stressors is critical for evaluating adaptation progress. If non-climate related stressors were to be neglected, one can imagine a scenario whereby certain governmental departments work to implement adaptation initiatives, while others pursue actions that would be defined as maladaptive.

Finally, researchers have not yet articulated a positive and comprehensive vision of the adapted or resilient society. Adaptation as conceived of currently is largely designed to protect an "economic core" (Pelling, 2011, p.3) and is based on incremental changes to a changing

climate. Applied to natural resources systems conservation in the US, states have not aspired to conceive of numeric statewide goals for habitat conservation. Even if there were goals, however, these goals would be difficult to implement since most of the land in the states examined here, is owned privately. It is telling that the US has never ratified the Convention on Biodiversity, which includes Aichi Target 11 that posits minimal goals for the protection of nature. Without overall adaptation goals and benchmarks, progress is difficult to define and measure. Without goals, how do we know when have arrived? One might counter this argument by saying that the goal posts in adaptation are always moving. However, even with moving goal posts, it should be possible to describe land conservation goals, for example, in a quantitative manner that indicate when a US state is closer to an adapted or resilient state or farther away.

Bibliography

Abunnasr, Y., Hamin, E. M., & Brabec, E. (2015). Windows of opportunity: addressing climate uncertainty through adaptation plan implementation. Journal of Environmental Planning and Management, 58(1), 135-155.

Adger, W., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. Global Environmental Change, 15(2), 77–86. https://doi.org/10.1016/j.gloenvcha.2004.12.005

Aguiar, F. C., Bentz, J., Silva, J. M. N., Fonseca, A. L., Swart, R., Santos, F. D., & Penha-Lopes, G. (2018). Adaptation to climate change at local level in Europe: An overview. Environmental Science and Policy, 86, 38-63. doi:10.1016/j.envsci.2018.04.010

Andreen, W. L. (2003). Water quality today-has the clean water act been a success. Ala. L. Rev., 55, 537.

Aplet, G. H., & McKinley, P. S. (2017). A portfolio approach to managing ecological risks of global change. Ecosystem Health and Sustainability, 3(2), e01261.

Araos, M., Berrang-Ford, L., Ford, J. D., Austin, S. E., Biesbroek, R., & Lesnikowski, A. (2016). Climate change adaptation planning in large cities: A systematic global assessment. Environmental Science & Policy, 66, 375–382.

Baker, I., Peterson, A., Brown, G., & McAlpine, C. (2012). Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. Landscape and urban planning, 107(2), 127-136.

Barnett, J., & O'Neill, S. (2010). Maladaptation. Pergamon.

Barron, D. J. (2003). Reclaiming Home Rule. *Harvard Law Review*, *116*(8), 2255–2386. https://doi.org/10.2307/1342767

Beck, S., & Mahony, M. (2017). The IPCC and the politics of anticipation. Nature Climate Change, 7(5), 311–313.

Beck, S., & Mahony, M. (2018a). The IPCC and the new map of science and politics. Wiley Interdisciplinary Reviews: Climate Change, 9(6), e547. GAIA-Ecological Perspectives for Science and Society, 23(2), 80–87.

Beck, S. (2011). Moving beyond the linear model of expertise? IPCC and the test of adaptation. Regional Environmental Change, 11(2), 297–306.

Bednar, D., Henstra, D., & McBean, G. (2019). The governance of climate change adaptation: Are networks to blame for the implementation deficit? Journal of Environmental Policy & Planning, 21(6), 702–717. https://doi.org/10.1080/1523908X.2019.1670050

Berrang-Ford, L., Biesbroek, R., Ford, J. D., Lesnikowski, A., Tanabe, A., Wang, F. M., ... & Grecequet, M. (2019). Tracking global climate change adaptation among governments. Nature Climate Change, 9(6), 440-449.

Berrang-Ford, L., Ford, J. D., & Paterson, J. (2011). Are we adapting to climate change? Global Environmental Change, 21(1), 25–33.

Berrang-Ford, L., Pearce, T., & Ford, J. D. (2015). Systematic review approaches for climate change adaptation research. Regional Environmental Change, 15(5), 755-769.Berrang-Ford, L., Pearce, T., & Ford, J. D. (2015). Systematic review approaches for climate change adaptation research. Regional Environmental Change, 15(5), 755-769.

Berrang-Ford, L., Ford, J. D., & Paterson, J. (2011). Are we adapting to climate change? Global Environmental Change, 21(1), 25-33. doi:10.1016/j.gloenvcha.2010.09.012

Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., & McNeeley, S. M. (2014). A typology of adaptation actions: A global look at climate adaptation actions financed through the

Global Environment Facility. Global Environmental Change, 25, 97–108. https://doi.org/10.1016/j.gloenvcha.2014.01.003

Bierbaum, R., & Stults, M. (2013). Adaptation to climate change: Context matters. Michigan Journal of Sustainability, 1.

Bierbaum, R., Smith, J. B., Lee, A., Blair, M., Carter, L., Chapin, F. S., Fleming, P., Ruffo, S., Stults, M., McNeeley, S., Wasley, E., & Verduzco, L. (2013). A comprehensive review of climate adaptation in the United States: More than before, but less than needed. Mitigation and Adaptation Strategies for Global Change, 18(3), 361–406. https://doi.org/10.1007/s11027-012-9423-1

Bierwagen, B., Thomas, J., Pyke, C., Theobald, D., Choate, A., Cohen, J., & Groth, P. (2009). Land-use scenarios: National-scale housing-density scenarios consistent with climate change storylines. Environmental Protection.

Biesbroek, G. R., Termeer, C., Kabat, P., & Klostermann, J. E. M. (2009). Institutional governance barriers for the development and implementation of climate adaptation strategies.

Bijlsma, L., Ehler, C. N., Klein, R. J. T., Kulshrestha, S. M., McLean, R. F., Mimura, N., ... & Turner, R. K. (1996). Coastal zones and small islands. Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, 289-324.

Blate, G. M., Joyce, L. A., Littell, J. S., McNulty, S. G., Millar, C. I., Moser, S. C., Neilson, R. P., O'Halloran, K., & Peterson, D. L. (2009). Adapting to climate change in United States national forests. Unasylva 231/232. 60 (1-2): 57-62., 60, 57–62.

Bours, D., McGinn, C., & Pringle, P. (2013). Monitoring & evaluation for climate change adaptation: A synthesis of tools, frameworks and approaches. Retrieved from: https://ora.ox.ac.uk/objects/uuid:8a5b5ca6-aeb6-494f-98e5-371f08659008

Bours, D., McGinn, C., & Pringle, P. (2014). Guidance note 1: twelve reasons why climate change adaptation MandE is challenging (pp. 2–9). SEA Change CoP and UKCIP.

Bours, D., McGinn, C., & Pringle, P. (2014b). Guidance note 2: Selecting indicators for climate change adaptation programming.

Bours, D., McGinn, C., & Pringle, P. (2014c). Guidance note 3: Theory of Change approach to climate change adaptation programming.

Bours, D., McGinn, C., & Pringle, P. (2015). Monitoring and evaluation of climate change adaptation: A review of the landscape: new directions for evaluation, number 147.

Boyd, J. (2010). Ecosystem services and climate adaptation. Issue Brief, 10–16.

Bricker, S.B., C.G. Clement, D.E. Pirhalla, S.P. Orlando, and D.R.G. Farrow. (1999). National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries. NOAA, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science. Silver Spring, MD: 71 pp.

Bricker, S. B., Longstaff, B., Dennison, W., Jones, A., Boicourt, K., Wicks, C., & Woerner, J. (2008). Effects of nutrient enrichment in the nation's estuaries: A decade of change. Harmful Algae, 8(1), 21–32.

Brooks, N., Anderson, S., Ayers, J., Burton, I., & Tellam, I. (2011). Tracking adaptation and measuring development.

Brooks, N. (2003). Vulnerability, risk and adaptation: A conceptual framework. Tyndall Centre for Climate Change Research Working Paper, 38(38), 1-16.

Brunner. R., Nordgren J (2012) Climate adaptation as an evolutionary process: A white paper. In: Foundation K (ed), http://www.kresge.org/sites/default/files/climate-adaptation-evolutionary-process.pdf

Butler, B. J. (2018). Forests of Maine, 2017. Resource Update FS-160. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. 3 p., 160, 1–3.

Capon, S. J., Chambers, L. E., Mac Nally, R., Naiman, R. J., Davies, P., Marshall, N., Pittock, J., Reid, M., Capon, T., Douglas, M., Catford, J., Baldwin, D. S., Stewardson, M., Roberts, J., Parsons, M., & Williams, S. E. (2013). Riparian Ecosystems in the 21st Century: Hotspots for Climate Change Adaptation? Ecosystems, 16(3), 359–381. https://doi.org/10.1007/s10021-013-9656-1

Casco Bay Estuary Partnership (2016). Climate Adaptation Resource Guide for Casco Bay Communities.https://www.cascobayestuary.org/publication/climate-adaptation-resource-guide-for-casco-bay-communities/

CFDA 66.456 National Estuary Program - Single Audit Resource Center, n.d

Cohen, Steve, (July 16, 2018). *Columbia Climate School: Climate, Earth and Society.* The State and Local Role in Protecting America's Environment. Retrieved from: https://news.climate.columbia.edu/2018/07/16/state-local-role-protecting-americas-environment/

Choi, Y. D. (2007). Restoration Ecology to the Future: A Call for New Paradigm. Restoration Ecology, 15(2), 351–353. https://doi.org/10.1111/j.1526-100X.2007.00224.x

Congressional Research Service (CRS). (2008). The 2008 Farm Bill: Major Provisions and Legislative Action.

Climate Savvy: Adapting Conservation and Resource Management to a Changing World. By , x + 245 pp., Island Press, Washington D.C. ISBN 978-1-59726-685-7 (hbk); 1-59726-685-X (pbk). Oryx, 45(3), 456–457. https://doi.org/10.1017/S0030605311001232

Colgan, C. S., Kartez, J. D., & Sheils, M. P. (2016). Climate Adaptation and Resiliency Planning for New England Communities: First Steps and Next Steps.

Cooper, J. A. G., & Pile, J. (2014). The adaptation-resistance spectrum: A classification of contemporary adaptation approaches to climate-related coastal change. Ocean & Coastal Management, 94, 90–98. https://doi.org/10.1016/j.ocecoaman.2013.09.006

Cooper, J. Andrew G., & McKenna, J. (2008). Working with natural processes: The challenge for coastal protection strategies. Geographical Journal, 174(4), 315–331.

Costa, J. E., ed. 2013. Buzzards Bay Comprehensive Conservation and Management Plan 2013 Update. November 26, 2013. Buzzards Bay National Estuary Program, Massachusetts Executive Office of Energy and Environmental Affairs, Office of Coastal Zone Management. 323 pp.

Crosset, K. M. (2005). Population trends along the coastal United States: 1980-2008. Dessai, S., Lu, X., & Risbey, J. S. (2005). On the role of climate scenarios for adaptation planning. Global Environmental Change, 15(2), 87–97.

Doran, G. T. (1981). There's a SMART way to write management's goals and objectives. Management review, 70(11), 35-36.

Dupuis, J., & Biesbroek, R. (2013). Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. Global Environmental Change, 23(6), 1476–1487. https://doi.org/10.1016/j.gloenvcha.2013.07.022

Eakin, H., Nelson, D. R., & Anderies, J. M. (2009). Hidden costs and disparate uncertainties: trade-offs in approaches to climate policy. Adapting to climate change: Thresholds, values, governance, 212.

Ehrenfeld, J. G. (2000). Defining the Limits of Restoration: The Need for Realistic Goals. Restoration Ecology, 8(1), 2–9. https://doi.org/10.1046/j.1526-100x.2000.80002.x

Eriksen, S. H., Nightingale, A. J., & Eakin, H. (2015). Reframing adaptation: The political nature of climate change adaptation. Global Environmental Change, 35, 523–533. https://doi.org/10.1016/j.gloenvcha.2015.09.014

Facts about New Hampshire's Forests and Forest Economy*. (n.d.). Retrieved March 21, 2021, from https://nhtoa.org/general/61-facts-about-new-hampshire-s-forest-and-forest-economy.html

Field, C. B. (2014). Intergovernmental Panel on Climate Change. Working Group II, issuing body, Canadian Electronic Library (Firm), distributor (Eds.), Climate change 2014 : Impacts, adaptation, and vulnerability : Summary for policymakers Geneva, Switzerland : Intergovernmental Panel on Climate Change.

Fischer, H. W. (2021). Decentralization and the governance of climate adaptation: Situating community-based planning within broader trajectories of political transformation. World Development, 140, 105335.

Fletcher, C. S., Taylor, B. M., Rambaldi, A. N., Harman, B. P., Heyenga, S., Ganegodage, K. R., & McAllister, R. (2013). Costs and coasts: An empirical assessment of physical and institutional climate adaptation pathways. National Climate Change Adaptation Research Facility.

Ford, J. D., & Berrang-Ford, L. (2016). The 4Cs of adaptation tracking: consistency, comparability, comprehensiveness, coherency. Mitigation and Adaptation Strategies for Global Change, 21(6), 839-859

Ford, J. D., Berrang-Ford, L., & Paterson, J. (2011). A systematic review of observed climate change adaptation in developed nations. Climatic Change, 106(2), 327–336.

Ford, J. D., Berrang-Ford, L., Lesnikowski, A., Barrera, M., & Heymann, S. J. (2013). How to track adaptation to climate change: a typology of approaches for national-level application. Ecology and Society, 18(3).

Ford, J. D., Knight, M., & Pearce, T. (2013). Assessing the 'usability of climate change research for decision-making: a case study of the Canadian International Polar Year. Global environmental change, 23(5), 1317-1326.

Forest Society (2015, April 7). New Hampshire Land Conservation Report. https://forestsociety.org/advocacy-issue/nh-land-conservation-report

Foster, J., Lowe, A., & Winkelman, S. (2011). The value of green infrastructure for urban climate adaptation. Center for Clean Air Policy, 750(1), 1–52.

French Environment and Management Agency, (n.d) Monitoring and Evaluating Climate Change at Local and Regional Levels: Learning from International Experience to Develop an M&E Methodology. Angers: France

Füssel, H.-M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. Global Environmental Change, 17(2), 155–167. https://doi.org/10.1016/j.gloenvcha.2006.05.002

Furber, A., Medema, W., Adamowski, J., Clamen, M., & Vijay, M. (2016). Conflict Management in Participatory Approaches to Water Management: A Case Study of Lake

Ontario and the St. Lawrence River Regulation. *Water*, *8*(7), 280. https://doi.org/10.3390/w8070280

Fankhauser, S. (2010). The costs of adaptation. Wiley interdisciplinary reviews: climate change, 1(1), 23-30.

Gari, S. R., Newton, A., & Icely, J. D. (2015). A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. Ocean & Coastal Management, 103, 63–77. https://doi.org/10.1016/j.ocecoaman.2014.11.013

Gentile. C. (June 5th, 2016) Chapoquoit Beach Restoration Feasible But Could Cost $2 Million Retrieved from: https://www.capenews.net/falmouth/news/chapoquoit-beach-restoration-feasible-but-could-cost-2-million/article_545bd582-326c-58ca-8b36-b78a0c28ffa2.html)

Glahn C, Specht M, Koper R (2007). Smart Indicators on Learning Interactions. In: Creating New Learning Experiences on a Global Scale. Lecture Notes in Computer Science Volume 4753, pp 56-70

Graneheim, U. H., Lindgren, B.-M., & Lundman, B. (2017). Methodological challenges in qualitative content analysis: A discussion paper. Nurse Education Today, 56, 29–34.

Grove, K. (2014). Biopolitics and adaptation: Governing socio-ecological contingency through climate change and disaster studies. Geography Compass, 8(3), 198-210.

Guercio, L. D. (2013). Climate change adaptation and coastal property rights: A Massachusetts case study. BC Envtl. Aff. L. Rev., 40, 349.

Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., ... & Bergsma, E. (2010). The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Environmental Science & Policy, 13(6), 459-471.

Haddaway, N. R., Collins, A. M., Coughlin, D., & Kirk, S. (2015). The role of Google Scholar in evidence reviews and its applicability to grey literature searching. PloS one, 10(9), e0138237.

Hagstrom, C., Kendall, S., & Cunningham, H. (2015). Googling for grey: Using Google and Duckduckgo to find grey literature. In Abstracts of the 23rd Cochrane Colloquium. Cochrane database systematic reviews supplements (pp. 1–327).

Hamin, E. M., Gurran, N., & Emlinger, A. M. (2014). Barriers to Municipal Climate Adaptation: Examples From Coastal Massachusetts' Smaller Cities and Towns. Journal of the American Planning Association, 80(2), 110–122. https://doi.org/10.1080/01944363.2014.949590

Harley, Mike, and Jelle van Minnen. "Development of adaptation indicators." ETC./ACC–European Topic Centre on Air and Climate Change Technical Paper 6 (2009).

Harris, J. A., Hobbs, R. J., Higgs, E., & Aronson, J. (2006). Ecological restoration and global climate change. Wiley Online Library.

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global environmental change, 23(2), 485-498.

Henstra, D. (2016). The tools of climate adaptation policy: Analysing instruments and instrument selection. Climate Policy, 16(4), 496–521.

Howlett, M., & Cashore, P. B. (2009). The Dependent Variable Problem in the Study of Policy Change: Understanding Policy Change as a Methodological Problem. Journal of Comparative Policy Analysis: Research and Practice, 11(1), 33–46.

https://doi.org/10.1080/13876980802648144

https://www.maine.gov/dep/sustainability/climate/adaptation-actions.html

Hulme, M., & Mahony, M. (2010). Climate change: What do we know about the IPCC? Progress in Physical Geography, 34(5), 705–718.

Hulme, P. E. (2005). Adapting to climate change: Is there scope for ecological management in the face of a global threat? Journal of Applied Ecology, 42(5), 784–794. https://doi.org/10.1111/j.1365-2664.2005.01082.x

Imperial, M. T., Hennessey, T., & Robadue Jr, D. (1993). The evolution of adaptive management for estuarine ecosystems: The National Estuary Program and its precursors. Ocean & coastal management, 20(2), 147-180.

Implementation Advisory Committee | Mass.gov. (n.d.). Retrieved April 26, 2021, from https://www.mass.gov/service-details/implementation-advisory-committee

Innovation for Sustainable Development Network. (n.d.) *Massachusetts Green Bond*. Retrieved from: https://www.inno4sd.net/massachusetts-green-bond-459

IPCC. (2016). IPCC FIFTH Assessment Report (AR5): Climate Change 2016. Contribution

IPCC. (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W.

Island Institute, Waypoints, Community Indicators for Maine's Coasts and Islands,

Janowiak, M. K., Swanston, C. W., Nagel, L. M., Brandt, L. A., Butler, P. R., Handler, S. D., Shannon, P. D., Iverson, L. R., Matthews, S. N., & Prasad, A. (2014). A practical approach for translating climate change adaptation principles into forest management actions. Journal of Forestry, 112(5), 424–433.

Johnson, E. S., Stancioff, E., Johnson, T., Sabine, S., Maurice, H., & Reboussin, C. (2019). Preparing for a Changing Climate: The State of Adaptation Planning in Maine's Coastal Communities. Maine Policy Review, 28(2), 10–22. https://digitalcommons.library.umaine.edu/mpr/vol28/iss2/3

Jones, L., Carabine, E., & Schipper, L. (2015). (Re) Conceptualising Maladaptation in Policy and Practice: Towards an Evaluative Framework (SSRN Scholarly Paper ID 2643009). Social Science Research Network. https://doi.org/10.2139/ssrn.2643009

Joyce, S. (2000). The Dead Zones: Oxygen-Starved Coastal Waters. Environmental Health Perspectives, 108(3), A120-5.

Juhola, S., Glaas, E., Linnér, B.-O., & Neset, T.-S. (2016a). Redefining maladaptation. Environmental Science & Policy, 55, 135–140.

Julius, S., West, J., Joyce, L. A., Kareiva, P., Keller, B. D., Palmer, M., & Peterson, C. (2008). Preliminary review of adaptation options for climate-sensitive ecosystems and resources. National Parks, 1(6).

Kahn, M. E. (2003). Two measures of progress in adapting to climate change. Global Environmental Change, 13(4), 307–312. https://doi.org/10.1016/S0959-3780(03)00052-9

Klein, R.T. (2016) Discussion Brief 1, Adaptation Future 2016: Practices and Solutions. Retrieved from https://mediamanager.sei.org/documents/Publications/Climate/AF-DB-2017-Research-for-and-on-adaptation.pdf

KNOEMA (2019). Maine - Population density. Retrieved from: https://knoema.com/atlas/United-States-of-America/Maine/Population-density

KNOEMA (2019). Massachusetts - Population density. Retrieved from: https://knoema.com/atlas/United-States-of-America/Massachusetts/Population-density#:~:text=Population%20density%20of%20Massachusetts%20increased,average%20annual%20rate%20of%200.42%25.

KNOEMA (2019). New Hampshire - Population density. Retrieved from: https://knoema.com/atlas/United-States-of-America/New-Hampshire/Population-density

Knutson, T., Kossin J.T., Mears, C. , Perlwitz, J., & Wehner M.F. (2017). Detection and attribution of climate change. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 114-132, doi: 10.7930/J01834ND.

Kusek, J. Z., & Rist, R. C. (2004). Ten steps to a results-based monitoring and evaluation system: a handbook for development practitioners. World Bank Publications.

Lamhauge, N., Lanzi, E., & Agrawala, S. (2012). Monitoring and evaluation for adaptation: lessons from development co-operation agencies.

Lawler, J. J. (2009). Climate change adaptation strategies for resource management and conservation planning. Annals of the New York Academy of Sciences, 1162(1), 79–98.

Layzer, J. A. (2012b). The Purpose and Politics of Ecosystem-Based Management. In M. P. Weinstein & R. E. Turner (Eds.), Sustainability Science: The Emerging Paradigm and the Urban Environment (pp. 177–197). Springer. https://doi.org/10.1007/978-1-4614-3188-6_9

Leiter, T. (2015). Linking monitoring and evaluation of adaptation to climate change across scales: Avenues and practical approaches. New Directions for Evaluation, 2015(147), 117-127.

Lempert, R., J. Arnold, R. Pulwarty, K. Gordon, K. Greig, C. Hawkins Hoffman, D. Sands, and C. Werrell, 2018: Reducing Risks Through Adaptation Actions. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II[Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.CH28. Retrieved from https://nca2018.globalchange.gov/chapter/28/

Lesnikowski, A., Ford, J., Biesbroek, R., Berrang-Ford, L., & Heymann, S. J. (2016). National-level progress on adaptation. Nature Climate Change, 6(3), 261–264.

Lesnikowski, A. C., Ford, J. D., Berrang-Ford, L., Barrera, M., & Heymann, J. (2015). How are we adapting to climate change? A global assessment. Mitigation and Adaptation Strategies for Global Change, 20(2), 277–293.

Levina, E. and Tirpak, D. (2006). Adaptation to Climate Change: Key Terms. Paris, France: OECD/IEA

Lewis, N., Jastremski, M., Aldridge, M., Levy, S., Theriot, J. C., Visser, J., ... & Michael, E. (2008). Analysis of the Priorities, Obstacles, and Opportunities for Implementing US State Wildlife Action Plans.

Lorenz, S., Porter, J. J., & Dessai, S. (2019). Identifying and tracking key climate adaptation actors in the UK. Regional Environmental Change, 19(7), 2125–2138. https://doi.org/10.1007/s10113-019-01551-2

Looney, M. T. (Michael T. (2002). *Knowing no boundaries: Stemming the tide of urban sprawl in several southern Connecticut towns and the lessons for other strong home rule areas* [Thesis, Massachusetts Institute of Technology]. https://dspace.mit.edu/handle/1721.1/68388

Lukasiewicz, A., Pittock, J., & Finlayson, C. M. (2016). Are we adapting to climate change? A catchment-based adaptation assessment tool for freshwater ecosystems. Climatic Change, 138(3), 641–654.

Macintosh, A. (2013a). Coastal climate hazards and urban planning: How planning responses can lead to maladaptation. Mitigation and Adaptation Strategies for Global Change, 18(7), 1035–1055. https://doi.org/10.1007/s11027-012-9406-2

McGuire, C. J. (2018). Examining legal and regulatory barriers to climate change adaptation in the coastal zone of the United States. Cogent Environmental Science, 4(1), 1491096.

Madsen, Andersen, Rygaard, & Mikkelsen. (2018). Definitions of event magnitudes, spatial scales, and goals for climate change adaptation and their importance for innovation and implementation. Water Research, 144, 192-203.

Mansius, D. J., (ed.). (2020). Maine Forest Action Plan 2020. Maine Forest Service, Department of Agriculture, Conservation and Forestry, Augusta.

Maine Legislature. (2020). (SP0163), LD 460, item 1, Resolve, To Evaluate Climate Change Adaptation Options for the State. Retrieved March 9, 2021, from http://www.mainelegislature.org/legis/bills/bills_124th/billtexts/SP016301.asp

Maine Legislature (2019) Title 38, §577-A: Maine Climate Council. Retrieved April 26, 2021, from https://www.mainelegislature.org/legis/statutes/38/title38sec577-A.html

Maine Legislature (2020). Title 38. Waters and Navigation. Chapter 3-A. Climate Change .org/legis/statutes/38/title38sec5https://www.mainelegislature77-A.htm

Maine Climate Adaptation Providers Network (n.d.) Retrieved from: https://www.google.com/search?q=maine+climate+adaptation+providers+network&oq=maine+climate+adaptation+providers+network&aqs=chrome..69i57.7069j0j4&sourceid=chrome&ie=UTF-8

Maine Audubon (n.d.). Stream Smart. Retrieved April 28, 2021, from https://maineaudubon.org/projects/stream-smart/

Maine Climate Action Plan (2008)—Google Scholar. Retrieved March 17, 2021, from https://scholar.google.com/scholar?start=30&q=maine+climate+action+plan+2008&hl=en&as_sdt=0,5

Maine DEP, Bureau of Land Resources (n.d.) Stream Crossing Upgrade Grant, Bureau of Land Resources (Maine DEP). (n.d.). Retrieved March 25, 2021, from https://www.maine.gov/dep/land/grants/stream-crossing-upgrade.html

Maine Climate Council (n.d.) Retrieved from https://climatecouncil.maine.gov/members

Maine Department of Marine Resources. Coastal Program. (n.d.) https://www.maine.gov/dmr/mcp/grants/shore-and-harbor-planning-grants.html

Maine Department of Environmental Protection. Environmental and Resources Working Group (2014). *Monitoring, Mapping, Modeling, Mitigation and Messaging: Maine Prepares for Climate Change.* Augusta, ME: http://www.maine.gov/dep/sustainability/climate/maine_prepares.pdf

Maine DEP. The Maine Interagency Climate Adaptation Work Group (MICA). (2018) *Maine Prepares for Climate Change*. Augusta, ME. Retrieved from:

Maine DEP. MICA. The Maine Interagency Climate Adaptation Work Group. (2019) *Maine Prepares for Climate Change. Augusta,* ME. Retrieved from: https://www.adaptationclearinghouse.org/resources/maine-prepares-for-climate-change-2019-update.html

Maine Department of Agriculture, Conservation and Forestry. (n.d.-a). Municipal Planning Assistance Program. Retrieved April 28, 2021, from https://www.maine.gov/dacf/municipalplanning/index.shtml

Maine DEP. (2010) *People and Nature Adapting to a Changing Climate: Charting Maine's Course*. Retrieved from: https://www.adaptationclearinghouse.org/resources/people-and-nature-adapting-to-a-changing-climate-charting-maine-s-course.html

Maine DEP. (n.d.) Maine Adaptation Toolkit, Climate, Sustainability. Retrieved April 28, 2021, from https://www.maine.gov/dep/sustainability/climate/adaptation-toolkit.html

Maine DEP. (2010). People and Nature Adapting to a Changing Climate: Charting Maine's Course. (summary) Retrieved from: https://digitalcommons.usm.maine.edu/cbep-publications/223/?utm_source=digitalcommons.usm.maine.edu%2Fcbep-publications%2F223&utm_medium=PDF&utm_campaign=PDFCoverPages

Mannino, G. (December 1st, 2020) 'Maine Won't Wait': Four-year climate action plan unveiled. NBC Newscenter Maine. Retrieved from: https://www.newscentermaine.com/article/tech/science/environment/maine-wont-wait-four-year-climate-action-plan-unveiled/97-bb22173a-4143-4dfe-b5ff-ff2cfdd31f27

Massachusetts Bays National Estuary Program. (May 2006) Extreme Rain Event and the Response of the Coastal Waters in the Massachusetts Bays System. Retrieved from:

https://www.mass.gov/doc/may-2006-extreme-rain-event-and-the-response-of-the-coastal-waters-in-the-massachusetts-bays/download

Massachusetts Legislature (2008). The Global Warming Solutions Act. *Session Law - Acts of 2008 Chapter 298*, Retrieved from: https://malegislature.gov/laws/sessionlaws/acts/2008/chapter298

Massachusetts Climate Change Adaptation Report. (2011) Retrieved at: https://www.mass.gov/service-details/2011-massachusetts-climate-change-adaptation-report

Massachusetts Department of Conservation & Recreation. Bureau of Forest Fire Control & Forestry (2015) Massachusetts Forest Action Plan. Retrieved April 27, 2021, from https://www.mass.gov/service-details/massachusetts-forest-action-plan

Massachusetts Department of Fish and Game (2015). Division of Fisheries & Wildlife. State Wildlife Action Plan (SWAP). Retrieved April 27, 2021, from https://www.mass.gov/service-details/state-wildlife-action-plan-swap

Massachusetts (2016). Mass Green Bonds: Final Investor Impact Report (series E).

Massachusetts (2016). Office of Governor Charlie Baker and Lt. Governor Karyn Polito. Executive orders 500 - 599. No. 569: Establishing an Integrated Climate Change Strategy for the Commonwealth. Retrieved April 26, 2021, from https://www.mass.gov/executive-orders/no-569-establishing-an-integrated-climate-change-strategy-for-the-commonwealth

Massachusetts Legislature (2017-2018) Bill H.4835 -190th (2017 - 2018) *An Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection and Investment in Recreational Assets and Opportunity*. Retrieved from: https://malegislature.gov/Bills/190/H4835

Massachusetts (2018). State Government Organizational Chart. Retrieved from: https://budget.digital.mass.gov/bb/gaa/fy2019/app_19/ga_19/hcdefault.htm

Massachusetts Department of Fish and Game (2019). Division of Ecological Restoration. *Cranberry Bog Program*. *Baker-Polito Administration Announces $10 Million in Federal Funds for Ecological Restoration of Former Cranberry Bogs.* Retrieved from: https://www.mass.gov/cranberry-bog-program

Massachusetts Executive Office of Energy and Environmental Affairs. (2019). *Baker-Polito Administration Awards Over $10 Million for Dam and Seawall Projects: Projects Will Protect Public Safety, Increase Resilience to Climate Change*. Retrieved from: https://www.mass.gov/news/baker-polito-administration-awards-over-10-million-for-dam-and-seawall-projects-2

Massachusetts Office of Coastal Zone Management. (n.d.) Coastal Resilience Grant Program. Retrieved from: https://www.mass.gov/service-details/coastal-resilience-grant-program#:~:text=The%20Coastal%20Resilience%20Grant%20Program%20is%20open%20to%20the%2078,within%20the%20Massachusetts%20coastal%20zone.&text=Proposals%20to%20model%20flooding%20and,the%20socioeconomic%20impacts%20are%20encouraged.

Massachusetts Executive Office of Energy and Environmental Affairs. Massachusetts Emergency Management Agency (2019). Baker-Polito Administration Launches Resilient MA Action Team: Interagency Team Will Coordinate to Prepare for Impacts of Climate Change. Retrieved April 26, 2021, from: https://www.mass.gov/news/baker-polito-administration-launches-resilient-ma-action-team

Massachusetts Legislature. (2019). An Act Providing for Climate Change Adaptation Infrastructure Investments in the Commonwealth. *Senate Docket, No. 2235 Bill S.10*. Retrieved from: https://malegislature.gov/Bills/191/S10.Html

Massachusetts Executive Office of Energy and Environmental Affairs. (2020) *Baker-Polito Administration Awards $11.6 Million in Climate Change Funding to Cities and Towns 82% of Communities Participating in Municipal Vulnerability Preparedness Program.*Retrieved from: https://www.mass.gov/news/baker-polito-administration-awards-116-million-in-climate-change-funding-to-cities-and-towns

Massachusetts Department of Conservation and Recreation. (2020) *Massachusetts State Forest Action Plan*. Retrieved from: https://www.mass.gov/service-details/massachusetts-forest-action-plan

Massachusetts Executive Office of Energy and Environmental Affairs. (n.d.) *Dam and Seawall Repair or Removal Program.* Retrieved from: https://www.mass.gov/service-details/dam-and-seawall-repair-or-removal-program-grants-and-funds

Massachusetts (n.d.) Division of Ecological Restoration. *Deciding to Remove Your Dam*. Retrieved from: https://www.mass.gov/guides/deciding-to-remove-your-dam#-funding-opportunities-for-dam-removal-

Massachusetts Division of Ecological Restoration. (n.d.) *River Restoration: Dam Removal DER helps dam owners through the dam removal process, providing funding, project management, and technical assistance.* Retrieved from: https://www.mass.gov/river-restoration-dam-removal

Massachusetts Legislature (2017-2018) Bill H.4835 -190th (2017 - 2018) *An Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection and*

Investment in Recreational Assets and Opportunity. Retrieved from: https://malegislature.gov/Bills/190/H4835

Massachusetts (2018). *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*. Retrieved from: https://resilientma.org/shmcap-portal/#/

Massachusetts Executive Office of Energy and Environmental Affairs. (n.d.) *Ensuring Success Webinars -- Municipal Vulnerability Preparedness (MVP) Program's Tool Box.* Retrieved from: https://www.mass.gov/service-details/ensuring-success-webinars-municipal-vulnerability-preparedness-mvp-programs-tool.

Massey, E., & Huitema, D. (2013). The emergence of climate change adaptation as a policy field: the case of England. Regional Environmental Change, 13(2), 341-352.

Matso, K. (2018). Flushing Time Versus Residence Time for the Great Bay Estuary. PREP Reports & Publications. https://scholars.unh.edu/prep/413

Mawdsley, J. R., O'malley, R., & Ojima, D. S. (2009). A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation. Conservation Biology, 23(5), 1080–1089. https://doi.org/10.1111/j.1523-1739.2009.01264.x

McNamara, D. E., Gopalakrishnan, S., Smith, M. D., & Murray, A. B. (2015). Climate adaptation and policy-induced inflation of coastal property value. PloS One, 10(3), e0121278.

McNeely, J. A. (2011). Climate Savvy: Adapting Conservation and Resource Management to a Changing World. By Lara J. Hansen and Jennifer R. Hoffman (2011), x + 245 pp., Island Press, Washington D.C. ISBN 978-1-59726-685-7 (hbk); 1-59726-685-X (pbk). Oryx, 45(3), 456–457. https://doi.org/10.1017/S0030605311001232

Melillo, J. M., T. (T. C. Richmond, and G. W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, Washington, DC, 841 pp. doi:10.7930/J0Z31WJ2.

Meijerink, S., & Stiller, S. (2013). What kind of leadership do we need for climate adaptation? A framework for analyzing leadership objectives, functions, and tasks in climate change adaptation. Environment and Planning C: Government and Policy, 31(2), 240-256.

Mesquita-Emlinger, A. (2018). Challenges to address climate adaptation actions in coastal New England—Insights from a web survey. Revista Geografica De America Central, 61E, 39–55. https://doi.org/10.15359/rgac.61-3.2

Miao, Q. (2019). What affects government planning for climate change adaptation: Evidence from the US states. Environmental Policy and Governance, 29(5), 376–394.

Miller, C. A. (2007). Democratization, international knowledge institutions, and global governance. Governance, 20(2), 325-357.

Miller, C. A. (2004). Climate science and the making of a global political order. States of knowledge: The co-production of science and social order, 317.

Milly, P. C. D., Betancourt, J., Falkenmark, M., Hirsch, R. M., Kundzewicz, Z. W., Lettenmaier, D. P., & Stouffer, R. J. (2008). Stationarity is dead: Whither water management? Earth, 4, 20.

Mimura, N., Pulwarty, R. S., Elshinnawy, I., Redsteer, M. H., Huang, H. Q., Nkem, J. N., Rodriguez, R. A. S., Moss, R., Vergara, W., & Darby, L. S. (2015). Adaptation planning and implementation. In Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects (pp. 869–898). Cambridge University Press.

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. Proceedings of the national academy of sciences, 107(51), 22026-22031.

Morris, R. L., Konlechner, T. M., Ghisalberti, M., & Swearer, S. E. (2018). From grey to green: Efficacy of eco-engineering solutions for nature-based coastal defence. Global change biology, 24(5), 1827-1842.

Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J., & Rivington, M. (2013). Climate change and Ecosystem-based Adaptation: A new pragmatic approach to buffering climate change impacts. Current Opinion in Environmental Sustainability, 5(1), 67–71. https://doi.org/10.1016/j.cosust.2012.12.001

Municipal Vulnerability Preparedness. (n.d.). Municipal Vulnerability Preparedness Program: Supporting Massachusetts cities and towns as they build resilience to climate change. Retrieved from: https://resilientma.org/mvp/

National Association of State Foresters, State Forest Action Plans, n.d., retrieved from: https://www.stateforesters.org/forest-action-plans/keeping-the-plans-current/

Natural Resources Conservation Service Maine. (n.d.) *$30 million aquatic conservation project announced for Downeast Maine.* Retrieved March 25, 2021, from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/me/newsroom/releases/?cid=NRCSEPRD1532037

Nelson, D. R., & Anderies, J. M. (2009). Hidden costs and disparate uncertainties: Trade-offs in approaches to climate policy. Adapting to Climate Change: Thresholds, Values, Governance, 212.

New Hampshire Department of Natural and Cultural. Resources Division of Forests and Lands

2020. New Hampshire Forest Action Plan - 2020. Retrieved from: https://www.nh.gov/nhdfl/natural-heritage/current-projects-and-events/2020-forest-action-plan.htm#:~:text=It%20is%20a%2010%2Dyear,facing%20New%20Hampshire's%20forests%20today.

New Hampshire Coastal Hazards Commission (2016). Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation: Final Report and Recommendations.

New Hampshire Coastal Adaptation Workgroup. (n.d.). Project Portal. Retrieved March 9, 2021, from https://www.nhcaw.org/what/projects/project-portal/

NH Coastal Risk and Hazards Commission (2016). Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise and Extreme Precipitation. http://www.nhcrhc.org/wp-content/uploads/2016-CRHC-final-report.pdf

NH Department of Environmental Services. Coastal Program. (n.d.). Coastal Program Announces Request for Proposals for New Hampshire Coastal Resilience Grants. Retrieved April 27, 2021, from https://www.des.nh.gov/news-and-media/coastal-program-announces-request-proposals-new-hampshire-coastal-resilience-grants

New Hampshire DES (2009). New Hampshire Climate Change Policy Task Force The New Hampshire Climate Action Plan: A Plan for New Hampshire's Energy, Environmental and Economic Development Future. Retrieved from: https://www.adaptationclearinghouse.org/resources/new-hampshire-climate-action-plan-a-plan-for-new-hampshire-s-energy-environmental-and-economic-development-future.html

New Hampshire DES (n.d.). Retrieved from: https://www.des.nh.gov/

NH Department of Fish and Game (n.d.) Retrieved from: https://www.wildlife.state.nh.us/

NH Fish and Game Department. (2015). New Hampshire Wildlife Action Plan. Retrieved from: file:///Users/claudiaf/Zotero/storage/3GEYVL6F/wap.html

NH Department of State. Executive Orders. Governor John H. Lynch. Executive order 2007-3. Retrieved April 26, 2021, from https://sos.nh.gov/administration/miscellaneous/executive-orders/governor-john-h-lynch/

NOAA. National Estuarine Research Reserves. Retrieved at https://oceanservice.noaa.gov/ecosystems/nerrs/

Noble, I.R., Huq, S., Anokhin, Y.A., Carmin, J., Goudou, D., Lansigan, F.P., Osman-Elasha, B. and Villamizar, A. (2014) Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC. Cambridge and New York: Cambridge University Press. - Google Search. (n.d.). Retrieved March 30, 2021, from Noble, I.R., S. Huq, Y.A. Anokhin, J. Carmin, D. Goudou, F.P. Lansigan, B. Osman-Elasha, and A. Villamizar, (2014): Adaptation needs and options. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A:Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R.

Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 833-868.

Northeast Climate Adaptation Science Center (n.d.) Retrieved at: https://necsc.umass.edu/about-us

Northeast-Midwest State Foresters Alliance, United States Department of Agriculture (USDA), Forest Service, Northeastern Area State and Private Forestry (2018).Guide for State Forest Action Plans. Retrieved from: https://www.stateforesters.org/wp-content/uploads/2018/10/NMSFA-NA-StateForestActionPlan-Guide-20180831-1-1.pdf

Nordgren, J., Stults, M., & Meerow, S. (2016). Supporting local climate change adaptation: Where we are and where we need to go. Environmental Science & Policy, 66, 344-352.

NRCS Maine. (n.d.). $30 million aquatic conservation project announced for Downeast Maine. |Retrieved April 27, 2021, from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/me/newsroom/releases/?cid=NRCSEPRD1532037

Olazabal, M., Galarraga, I., Ford, J., Sainz De Murieta, E., & Lesnikowski, A. (2019). Are local climate adaptation policies credible? A conceptual and operational assessment framework. International Journal of Urban Sustainable Development, 11(3), 277–296.

O'Brien, K., Sygna, L., & Haugen, J. E. (2004). Vulnerable or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. Climatic change, 64(1), 193-225.

O'Brien, K., Eriksen, S., Sygna, L., & Naess, L. O. (2006). Questioning complacency: climate change impacts, vulnerability, and adaptation in Norway. AMBIO: A Journal of the Human Environment, 35(2), 50-56.

Palmer, M. A., Lettenmaier, D. P., Poff, N. L., Postel, S. L., Richter, B., & Warner, R. (2009). Climate change and river ecosystems: Protection and adaptation options. Environmental Management, 44(6), 1053–1068.

Pearce, T. D., Ford, J. D., Laidler, G. J., Smit, B., Duerden, F., Allarut, M., ... & Wandel, J. (2009). Community collaboration and climate change research in the Canadian Arctic. Polar Research, 28(1), 10-27.

Pelling, M. (2011). In null (Ed.), *Adaptation to climate change: From resilience to transformation*. Routledge

Pendleton, L. H. (2010). The economic and market value of coasts and estuaries: What's at stake? Arlington: *Restore America's Estuaries.*

Piasecki, J., Waligora, M., & Dranseika, V. (2018). Google search as an additional source in systematic reviews. Science and engineering ethics, 24(2), 809-810.

Piscataqua Region Estuaries Partnership. (2010) Piscataqua Region Comprehensive Conservation and Management Plan " by Retrieved April 27, 2021, from https://scholars.unh.edu/prep/22/

Poteete, A. R., & Ostrom, E. (2008). Fifteen Years of Empirical Research on Collective Action in Natural Resource Management: Struggling to Build Large-N Databases Based on Qualitative Research. *World Development*, *36*(1), 176–195. https://doi.org/10.1016/j.worlddev.2007.02.012

Poyar, K. A., & Beller-Simms, N. (2010). Early Responses to Climate Change: An Analysis of Seven U.S. State and Local Climate Adaptation Planning Initiatives. Weather, Climate, and Society, 2(3), 237–248. https://doi.org/10.1175/2010WCAS1047.1

Pramova, E., Locatelli, B., Brockhaus, M., & Fohlmeister, S. (2012). Ecosystem services in the national adaptation programmes of action. Climate Policy, 12(4), 393-409.

Preston, B., Dow, K., & Berkhout, F. (2013). The Climate Adaptation Frontier. Sustainability, 5(3), 1011–1035. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su5031011)

Preston, B. L., Westaway, R. M., & Yuen, E. J. (2011). Climate adaptation planning in practice: an evaluation of adaptation plans from three developed nations. Mitigation and adaptation strategies for global change, 16(4), 407-438.

Preston, B. L., Westaway, R., Dessai, S., & Smith, T. F. (2009). Are we adapting to climate change? Research and methods for evaluating progress. Greenhouse 2009: Abstracts.

Quevauviller, P. (2011). Adapting to climate change: reducing water-related risks in Europe–EU policy and research considerations. Environmental science & policy, 14(7), 722-729.

Rauken, T., Mydske, P. K., & Winsvold, M. (2015). Mainstreaming climate change adaptation at the local level. Local Environment, 20(4), 408-423.

Raik, D. B., Wilson, A. L., & Decker, D. J. (2008). Power in natural resources management: an application of theory. Society and natural resources, 21(8), 729-739.

Rauschmayer, F., Berghöfer, A., Omann, I., & Zikos, D. (2009). Examining processes or/and outcomes? Evaluation concepts in European governance of natural resources. Environmental policy and governance, 19(3), 159-173.

Ray, A. & Grannis, J. From Planning to Action: Implementation of State Climate Change Adaptation Plans Michigan Journal of Sustainability. Volume 3, Spring 2015 DOI: http://dx.doi.org/10.3998/mjs.12333712.0003.001

Rayner, T. and Jordan, A. (2009) Adaptation to Climate Change: An Emerging EU Policy.

Reilly, J., & Schimmelpfennig, D. (2000). Irreversibility, uncertainty, and learning: portraits of adaptation to long-term climate change. Climatic Change, 45(1), 253-278.

Resilient MA (n.d.) Climate Change Clearinghouse for the Commonwealth. Retrieved from: https://resilientma.org/

Roberts, M. D., Bullard, L., Aflague, S., & Sleet, K. (2015). Coastal Erosion in Cape Cod, Massachusetts: Finding Sustainable Solutions.

Runhaar, H., Wilk, B., Persson, Å., Uittenbroek, C., & Wamsler, C. (2018). Mainstreaming climate adaptation: taking stock about "what works" from empirical research worldwide. Regional environmental change, 18(4), 1201-1210.

Sarewitz, D. (2011). Does climate change knowledge really matter?. Wiley Interdisciplinary Reviews: Climate Change, 2(4), 475-481.

Seddon, N., Turner, B., Berry, P., Chausson, A., & Girardin, C. A. (2019). Grounding nature-based climate solutions in sound biodiversity science. Nature Climate Change, 9(2), 84-87.

Seavy, N. E., Gardali, T., Golet, G. H., Griggs, F. T., Howell, C. A., Kelsey, R., Small, S. L., Viers, J. H., & Weigand, J. F. (2009). Why climate change makes riparian restoration more important than ever: Recommendations for practice and research. Ecological Restoration, 27(3), 330–338.

Schauffler, M. (2015). Climate Adaptation Resource Guide for Casco Bay Communities.

Schneider, M., Scholz, J., Lubell, M., Mindruta, D., & Edwardsen, M. (2003). Building consensual institutions: networks and the National Estuary Program. American journal of political science, 47(1), 143-158.

Schulz, A., Zia, A., & Koliba, C. (2017). Adapting bridge infrastructure to climate change: Institutionalizing resilience in intergovernmental transportation planning processes in the Northeastern USA. Mitigation and Adaptation Strategies for Global Change, 22(1), 175–198. https://doi.org/10.1007/s11027-015-9672-x

Schulz, K., & Siriwardane, R. (2015). Depoliticised and technocratic? Normativity and the politics of transformative adaptation.

Shi, L., Chu, E., & Debats, J. (2015). Explaining progress in climate adaptation planning across 156 US municipalities. Journal of the American Planning Association, 81(3), 191-202.

Smit, B., Burton, I., Klein, R. J. T., & Street, R. (1999). The Science of Adaptation: A Framework for Assessment. Mitigation and Adaptation Strategies for Global Change, 4(3), 199–213. https://doi.org/10.1023/A:1009652531101

Smith, J. B., & Lenhart, S. S. (1996). Climate change adaptation policy options. Climate Research, 6(2), 193–201.

Smith, M. H. (2020). Creating a market for retreat: Transfer of development rights as a climate adaptation tool in coastal Massachusetts [PhD Thesis]. Massachusetts Institute of Technology.

Smith, J. B., Vogel, J. M., & Cromwell III, J. E. (2009). An architecture for government action on adaptation to climate change. An editorial comment. Climatic change, 95(1), 53-61.

Smit, Barry, & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16(3), 282–292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Single Audit Resource Center.(n.d.). United States Environmental Protection Agency (EPA). 66.456 National Estuary Program. Retrieved from: https://singleaudit.org/program/?id=66.456

Spalding, M. D., Ruffo, S., Lacambra, C., Meliane, I., Hale, L. Z., Shepard, C. C., & Beck, M. W. (2014). The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. Ocean & Coastal Management, 90, 50–57. https://doi.org/10.1016/j.ocecoaman.2013.09.007 Springer Full Text PDF. (n.d.). Retrieved March 30, 2021, from https://link.springer.com/content/pdf/10.1023%2FA%3A1009652531101.pdf

Spearman, Margaret, and Heather McGray. "Making adaptation count." (2011).

Staudinger, M. D., Morelli, T. L., & Bryan, A. M. (2015). Integrating climate change into northeast and midwest state wildlife action plans. Department of the Interior Northeast Climate Science Center Report, A mherst, Massachusetts.

Staudt, A., Leidner, A. K., Howard, J., Brauman, K. A., Dukes, J. S., Hansen, L. J., Paukert, C., Sabo, J., & Solórzano, L. A. (2013). The added complications of climate change: Understanding and managing biodiversity and ecosystems. Frontiers in Ecology and the Environment, 11(9), 494–501.

Stein, B. A., Staudt, A., Cross, M. S., Dubois, N. S., Enquist, C., Griffis, R., Hansen, L. J., Hellmann, J. J., Lawler, J. J., Nelson, E. J., & Pairis, A. (2013). Preparing for and managing change: Climate adaptation for biodiversity and ecosystems. Frontiers in Ecology and the Environment, 11(9), 502–510. https://doi.org/10.1890/120277

Stults, Missy, and Larissa Larsen. "Tackling uncertainty in US local climate adaptation planning." Journal of Planning Education and Research 40.4 (2020): 416-431.

Taking Action for Wildlife. (n.d.). Retrieved April 27, 2021, from https://takingactionforwildlife.org/

Tang, Z., Dai, Z., Fu, X., & Li, X. (2013a). Content analysis for the US coastal states' climate action plans in managing the risks of extreme climate events and disasters. Ocean & Coastal Management, 80, 46–54.

The Coastal Systems Group, The Estuaries Project (n.d.) Retrieved from: http://www.smast.umassd.edu/Coastal/research/estuaries/estuaries.html

Thomsen, D. C., Smith, T. F., & Keys, N. (2012). Adaptation or manipulation? Unpacking climate change response strategies. Ecology and Society, 17(3).

Town of Gosnold. (2018). Open Space and Recreation Plan for the Town of Gosnold - Draft.

Tuler, S. P., Webler, T., & Rhoades, J. L. (2016). Stormwater management in a time of climate change: Insights from a series of scenario-building dialogues. Weather, Climate, and Society, 8(2), 163-175. doi:10.1175/WCAS-D-15-0048.1

Webler, T., & Tuler, S. (2006). Four Perspectives on Public Participation Process in Environmental Assessment and Decision Making: Combined Results from 10 Case Studies. *Policy Studies Journal*, *34*(4), 699–722. https://doi.org/10.1111/j.1541-0072.2006.00198.x

Turner, W. R., Bradley, B. A., Estes, L. D., Hole, D. G., Oppenheimer, M., & Wilcove, D. S. (2010a). Climate change: Helping nature survive the human response. Conservation Letters, 3(5), 304–312. https://doi.org/10.1111/j.1755-263X.2010.00128.x

Turner, R. K., Subak, S., & Adger, W. N. (1996). Pressures, trends, and impacts in coastal zones: interactions between socioeconomic and natural systems. Environmental management, 20(2), 159-173.

UMASS Amherst. MassWoods (n.d.). Retrieved from: https://masswoods.org/massachusetts-forests

UNDP Evaluation Office (2002) Handbook on monitoring and evaluating for results. Evaluation Office, United Nations Development Programme, New York. http://web.undp.org/evaluation/guidance.shtml#handbook

University Of Maine (n.d.) Climate Change Institute. Retrieved from: https://climatechange.umaine.edu/

United States Department of Commerce, NOAA. (n.d.). What percentage of the American population lives near the coast? Retrieved March 29, 2021, from https://oceanservice.noaa.gov/facts/population.html

United States Clean Water Act (Federal Water Pollution Control Amendments of 1972) (P.L. 92-500).

US Environmental Protection Agency. Climate Ready Estuaries Program [website], retrieved from https://www.epa.gov/cre

US EPA. National Estuaries Program. [website]https://www.epa.gov/nep/basic-information-about-estuaries#important

Vogel, B., & Henstra, D. (2015). Studying local climate adaptation: A heuristic research framework for comparative policy analysis. Global Environmental Change, 31, 110–120.

Wainger, L. A., Secor, D. H., Gurbisz, C., Kemp, W. M., Glibert, P. M., Houde, E. D., Richkus, J., & Barber, M. C. (2017). Resilience indicators support valuation of estuarine ecosystem restoration under climate change. Ecosystem Health and Sustainability, 3(4), e01268. https://doi.org/10.1002/ehs2.1268

Wake, C. P., Godlewski, S., Howard, K., Labranche, J., Miller, S., Peterson, J., & Ashcraft, C. (2015). Engaging Communities Where They Are: New Hampshire's Coastal Adaptation

Workgroup. AGU Fall Meeting Abstracts, 33, PA33D-07. http://adsabs.harvard.edu/abs/2015AGUFMPA33D..07W

Webler, T., & Tuler, S. (2001). Public Participation in Watershed Management Planning: Views on Process from People in the Field. Human Ecology Review, 8(2), 29–39. https://www.jstor.org/stable/24707126

West, J. M., Julius, S. H., & Weaver, C. P. (2012). Assessing confidence in management adaptation approaches for climate-sensitive ecosystems. Environmental Research Letters, 7(1), 014016.

West, J. M., Julius, S. H., Kareiva, P., Enquist, C., Lawler, J. J., Petersen, B., Johnson, A. E., & Shaw, M. R. (2009). US natural resources and climate change: Concepts and approaches for management adaptation. Environmental Management, 44(6), 1001.

What is an estuary? (2018). Retrieved from https://oceanservice.noaa.gov/facts/estuary.html

Wheeler, S. M. (2008). State and Municipal Climate Change Plans. American Planning Association. Journal of the American Planning Association, 74(4), 481–496. https://search.proquest.com/docview/229737772/abstract/D0B72F3C4E5449A9PQ/1

Williams, W. (April 25, 2021) Investopedia. Median Income by State. Retrieved from:https://www.investopedia.com/median-income-by-state-5070640

Williamson, S. C., Rheuban, J. E., Costa, J. E., Glover, D. M., & Doney, S. C. (2017). Assessing the impact of local and regional influences on nitrogen loads to Buzzards Bay, MA. Frontiers in Marine Science, 3, 279.

Wilson, S.G. & Fischetti, T.R. (2010). Coastline Population Trends in the United States: 1960 to 2008. Retrieved from: www.census.gov

Woodruff, S. C., & Regan, P. (2019). Quality of national adaptation plans and opportunities for improvement. Mitigation and Adaptation Strategies for Global Change, 24(1), 53–71.

Wuebbles, D. J., Fahey, D. W., Hibbard, K. A., Arnold, J. R., DeAngelo, B., Doherty, S., Easterling, D. R., Edmonds, J., Edmonds, T., & Hall, T. (2017). Climate science special report: Fourth national climate assessment (NCA4), Volume I.

Yaffee, S., Visser, J., Michael, E., Jastremski, J.,Lewis, N., Pidot, L., Lowe, A. ,Levy, S., Aldridge, M., Theriot, C.. (2008). StateWildlife Action Plans in the Northeast: A University of Michigan Master's Project. Retrieved from: http://seas.umich.edu/ecomgt/swap/index.html

Yale Program on Climate Communication, (September 2nd, 2020) Yale Climate Opinion Maps 2020. Retrieved from: https://climatecommunication.yale.edu/visualizations-data/ycom-us/

Yarbrough, A. (2015). Species, race, and culture in the space of wildlife management. Critical animal geographies: Politics, intersections and hierarchies in a multispecies world, 108-126.

Yohe, G., & Tol, R. S. (2002). Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity. Global environmental change, 12(1), 25-40

Appendices

Appendix A - Iterations of The Research Design

Previous Thesis Research Designs

The research design for this thesis underwent three iterations, two of which faced feasibility challenges. In the following paragraphs, the first two research designs are described, and their feasibility obstacles are discussed.

The first iteration was based on the application of an M&E framework by collecting input, output, outcomes-based and process-based data. The approach was a large N study (see Poteete & Ostrom, 2008) evaluating the climate adaptation implementation outcomes in 60 US estuary watersheds. To structure the data collection instrument and interpret the data, this research design drew on the climate adaptation Monitoring and Evaluation (M&E) Framework developed by the French Environment and Energy Management Administration (n.d.). A wide range of M&E frameworks exists (Bours, et al., 2013). All M&E frameworks are organized according to similar principles. M&E frameworks measure adaptation progress by assessing inputs, outputs, process-based indicators, and outcomes-based indicators (Bours, et al., 2014b). In the context of these frameworks, inputs are defined as financial, human, and other resources that have been determined to be needed for adaptation. Outputs comprise the actions that increase resilience taken with available financial and human resources (French Environment and Energy Management Administration, n.d.). Outcomes comprise improvements in system resilience and avoided impacts (see French Environment and Energy Management Administration, n.d.). This research design was deductive and grounded in a hypothesis.

To collect the data for the large N study, a comprehensive estuary climate adaptation implementation questionnaire was developed. To refine the questionnaire, comments were sought from this study's academic supervisor and three outside reviewers, who are retired EPA senior level administrators. The first research design included a pilot phase which involved distribution of the questionnaire to five pilot estuary partnerships with a return timeframe of two months. By the deadline, one response was received out of five. The quality of the response was deemed poor by the investigator. Email exchanges took place with three of the pilot study estuary partnerships, in which the estuary managers of two estuaries indicated that they lacked the time and human resources to complete the questionnaire. One pilot study estuary partnership was unresponsive to email inquiries. Another one indicated that they would participate and then became unresponsive. Considering the low response rate and poor quality of the one response received in the pilot phase, an alternative research design was contemplated.

Based on conversations with the supervisor for this thesis, it was decided to attempt a small N approach to evaluating climate adaptation outcomes in three US estuary watersheds that are part of EPAs National Estuary Program (NEP). The analytical framework for the second research design centered on collecting output data in relation to four indicators that are reflective of estuary health. The four indicators selected were impervious surface, nitrogen pollution, habitat conservation, and shoreline stabilization. Impervious surface contributes to flooding and water quality deterioration, which is expected to worsen with the increased precipitation caused by rising global average temperatures. Nitrogen pollution causes eutrophication (declining oxygen levels caused by high algae growth that feed on nitrogen) in estuaries, causing declines in important aquatic species and dead zones devoid of oxygen. Nitrogen pollution is expected to increase as a result of the increased precipitation spurred by climate change. Habitat protection

and shoreline stabilization are considered actions that are important for countering degrading processes in estuary watersheds, including climate change. The data collection method for the second research design was based primarily on collecting secondary data from document analysis. To augment the document analysis, it was decided to attempt to conduct interviews. Email and phone outreach was conducted to estuary managers, local and state government officials, and NGOs. However, the majority of individuals contacted via email were unresponsive despite repeated efforts at contacting them.

During the document analysis phase of this research design, data was lifted from a wide range of documents issued by federal, state and local government agencies, ENGOs organizations, and scientific organizations published for purposes of estuary watershed management, planning, implementation and science. Four different types of documents were reviewed for each estuary: 1. estuary planning documents; 2. updates and progress reports; 3. vulnerability assessments; and scientific studies delineating projected climate impacts; 4. reports and documents by government agencies; and 5.reports and documents generated by outside organizations, such as NGOs, if they were found to have bearing on climate adaptation of these three estuaries. Data collection was conducted in a targeted manner, lifting data from documents that had high probability of containing information about the four estuarine health indicators.

The efforts at collecting adaptation outcomes data from document analysis in the three US estuaries raised problems that illuminate the obstacles of such an effort in decentralized, federated systems generally. In the three states in which the study estuaries are located, estuary management plans are published in different years, progress reports are published for differing time intervals, data for the four indicators selected for this study design are collected for different

time frames and by varying approaches. Regulatory and legal approaches also vary across the three state jurisdictions.

There is considerable variation in the consideration of climate change in the main conservation planning document for each of the estuaries - the Comprehensive Conservation Management Plans (CCMP). Climate change was either mentioned a few times (see Costa, et al, 2013) or a key focus of concern (see PREP, 2010). While each of the CCMPs included climate change in their plans and objectives, each of the CCMPs lacked clearly articulated climate change adaptation baselines and objectives. This is not to say that goals and action plans in the CCMPs omitted climate impacts and adaptation to those impacts. Especially in the Piscataqua Region Estuary (PREP) CCMP, climate change was prominently featured and addressed by a wide range of action plans. Nonetheless, measurable climate adaptation indicators were absent. Without measurable goals, baselines, consistent data sets and indicators, it was impossible to conduct a meaningful evaluation of adaptation outcomes and a comparison of outcomes across estuaries.

In addition, at the estuary scale, adaptation outcomes based on climate change data were nearly non-existent. Estuary restoration outcomes - actions based on historical data rather than climate projections - could have been theoretically evaluated as part of the restoration/climate adaptation spectrum. Such an evaluation, however, would have been based on arbitrarily chosen, non-scientific indicators. Finally, as natural features of the landscape, estuaries are distinguished by a range of unique characteristics, which stand in the way of comparison. For example, the Great Bay estuary in New Hampshire is a recessed estuary with a much slower flushing time (Matso, 2017) than Buzzards Bay.

For the third revision of the research design, the decision was made to apply a proxy concept - climate adaptation readiness (Ford and King, 2015; Ford, 2013, see also Bours et al, 2013, p.10; see Smith, et al., 2009) - to the three US states in which the estuaries selected for the second research design are located - to achieve insights into climate adaptation progress at the state scale rather than the estuary scale. This framework is based on the evaluation of overarching factors that are considered critical for the likelihood that adaptation occurs (Ford & King, 2013). These factors include: political leadership; institutional organization; decision-making and stakeholder engagement; funding for adaptation planning, implementation and evaluation; sufficient available science for decision-making; public support for adaptation; (King & Ford, 2013). For this thesis, the climate adaptation readiness framework was adopted and revised to evaluate adaptation readiness specifically of natural resources systems at the sub-national scale in a longstanding and complex federated system.

***