Article

The Role of Perceived Risk, Uncertainty, and Trust on Coastal Climate Change Adaptation Planning

Environment and Behavior
1–28

DOI: 10.1177/0013916514551049
eab.sagepub.com

Nathan P. Kettle[1,2] and Kirstin Dow[3,4]

Abstract

This study examines support for climate adaptation planning and the role of perceived risk, uncertainty, and trust on adaptation of U.S. coastal communities. This assessment is based on the analysis of web-based questionnaires (*n* = 137) among state, local, and non-government organization (NGO) planners in Alaska, Florida, and Maryland. Ordinal regression and correlation analysis were used to assess which factors are related to support for adaptation during two planning stages. Findings from this study suggest the influence of perceived risk, uncertainty, and trust on support for climate change adaptation (CCA) varies across two stages of adaptation planning (support for the development of plans and willingness to allocate human and financial resources to implement plans). The disaggregation of planning entities into different study areas and levels of management revealed significant differences in the relationship between perceived risk, uncertainty, and trust and support for CCA planning. These findings have implications for the design of communication and engagement strategies.

[1]Alaska Center for Climate Assessment and Policy, Fairbanks, AK, USA
[2]Alaska Climate Science Center, Anchorage, AK, USA
[3]University of South Carolina, Columbia, SC, USA
[4]Carolinas Integrated Sciences and Assessments, Columbia, SC, USA

Corresponding Author:
Nathan P. Kettle, Alaska Center for Climate Assessment and Policy, 930 Koyukuk Drive, Fairbanks, AK 99775, USA.
Email: nkettle@alaska.edu

Keywords
adaptation planning, climate change, ordinal regression, coastal

Understanding barriers and limits to adaptation planning has emerged as a significant element of climate change vulnerability research in the past decade (Adger et al., 2009; Moser & Ekstrom, 2010). This research has deepened our understanding of the adaptation process and the broad range of technological, institutional, financial, psychological, and social barriers and limits to adaptation (Grothmann & Patt, 2005; Klein et al., 2014). Findings report that adaptive capacities vary among different groups and individuals and throughout different stages of the adaptation process–from identifying risks to planning, implementation, and evaluation (Moser & Ekstrom, 2010).

There are also emerging efforts that seek to understand how perceptions of risk and trust in government regulation relate to support for climate change policies, though the majority of these studies focus on mitigation, rather than adaptation (Bord, O'Connor, & Fisher, 2000; O'Connor, Bord, Fisher, Staneva, et al., 1999; Zahran, Brody, Vedlitz, Grover, & Miller, 2008). There is reason to believe that factors influencing adaptation may be different than mitigation because of timescale mismatches between changes in behavior and a change in perceived risk (Stern, 2000). For example, it may take decades before the benefits of changes to the global energy system are realized, whereas "no regret" adaptation strategies (actions that are worthwhile now and are further justified when climate change is considered) may have an immediate effect. Furthermore, adaptation may also be associated with targeting impacts that relate to experience and observation, rather than analytical concepts (Pielke, Prins, Rayner, & Sarewitz, 2007; Slovic, Finucane, Peters, & MacGreg, 2004). Factors influencing support for adaptation must be theorized separately because the magnitude and significance of the relationship is dependent on specific behavioral changes (Stern, 2000). Understanding how the influence of factors, such as perceptions of risk, trust, and uncertainty vary throughout different stages of adaptation planning remains an important, yet less explored area of research.

This study examines how perceptions of risk, uncertainty, and trust are related to support for CCA planning in U.S. coastal communities. These social and psychological factors are relevant because coastal communities are at risk to several climate-related hazards including permanent and episodic flooding, loss of coastal habitat, saltwater intrusion, and coastal erosion (Wong et al., 2014). Furthermore, planning processes are complicated by several uncertainties, such as future changes in population, budgets, political will, the ability to reach consensus on adaptation goals, and the rate, magnitude, and timing of specific climate impacts (Abbott, 2005; Collins et al., 2013; Moser, 2005). These circumstances, characterized by high risk potential, uncertainty, and diverse values, underscore the importance of trust in state government and climate scientists to reduce the complexity of risk management (Laurian, 2009). We focus our analysis on planners, rather than the general public, because planners are at the forefront of decision-making processes that influence the design and review of documents and policies that guide land use, zoning, transportation, and other matters that affect the development of community land and resources (Gore & Robinson, 2009).

This article seeks to understand the following research question: "How do perceptions of risk, uncertainty, and trust relate to support for the development of, and allocation of human and financial resources for, local-level adaptation strategies that consider addressing climate impacts?" Within the scope of planner duties and responsibilities, these three topics influence perceptions of climate change and adaptation strategies. The following sections review how perceived risk, uncertainty, and trust are related to individual beliefs, behavior, and action, discuss the methods used to assess support for CCA planning and each of the above factors, and discuss the theoretical and practical implications of these findings for adaptation planning.

Literature Review

Research in analogous processes suggests that planner support for CCA is likely to be influenced by their perceptions of risk, uncertainty, and trust. The following section reviews key risks, uncertainties, and dimensions of trust related to coastal CCA and discusses how these factors relate to individual behavior and action.

Perceived Risk

Perceptions of risk are linked to behavioral intent in multiple arenas, including public health, disaster preparedness and evacuations, and political activism (N. Brewer, Weinstein, Cuite, & Herrington, 2004; Lindell & Perry, 2000). In the context of climate change, O'Connor, Yarnal, Dow, Jocoy, and Carbone (2005) found that community water system managers were more likely to use climate forecasts in decision making when there was a higher level of perceived risk. Other research has linked perceptions of risk to support for climate change mitigation policies (Bord et al., 2000; O'Connor, Bord, Fisher, Staneva, et al., 1999; Zahran et al., 2008) and adaptation planning (Tam & McDaniels, 2013). These findings suggest that the strength of the relationship between perceived risk and support for action is influenced by the nature and magnitude of the perceived risk and specific type of action intended to reduce potential vulnerabilities.

There are several climate-related risks relevant to coastal CCA, including increases in temperature, relative sea level rise, extreme precipitation events, and more intense hurricanes and coastal storms (first-order risks; Collins et al., 2013). These environmental changes may lead to increases in the frequency and intensity of flooding events, impacts to public health, economic losses, beach and dune loss, wetland and ecological loss, and damages to infrastructure and property (second-order risks; Moser et al., 2014). However, coastal communities across the United States will face different risks to climate change because of differences in the rate, magnitude, and timing of exposure to changing climate conditions. The impacts of climate change will also vary within and between communities given that individuals and communities experiencing these changes have different sensitivities, coping capacities, and structural and institutional challenges (Adger, 2006; Folke, 2006).

In addition to non-uniform changes in the rate, magnitude, and timing of climate change across the United States, there are often differences in the level of perceived risk, which are mediated by heuristics, socioeconomic and demographic attributes, attitudes, political affiliation, environmental beliefs, and physical vulnerability, values and worldviews, experiential factors, and trust (Leiserowitz, 2006; O'Connor, Bord, & Fisher, 1999; Zahran et al., 2008). The non-uniform nature of climate change impacts, differences in perceptions of risk, and context-specific linkages between perceived risk and behavioral changes underscore the theoretical importance of understanding how perceived risk relates to support for CCA.

Perceived Uncertainty

Despite the high risk potential from climate change impacts, there are multiple uncertainties that may impede adaptation planning. Understanding the influence of these uncertainties on decision-making processes is important as it may affect behavior, timing, and degree of effort. It is therefore not surprising that uncertainty and human action are discussed in a wide range of contexts (McMullen & Shepherd, 2006; von Mises, 1963). Some theories suggest that the "level" of uncertainty (point where uncertainty rests on a continuum from deterministic knowledge and total ignorance) influences behavior and others focus on peoples' willingness to bear uncertainty, which is influenced by differences in motivation and risk tolerance (McMullen & Shepherd, 2006; Walker et al., 2003).

There are several climate and non-climate-related uncertainties relevant to adaptation planning. These uncertainties include projections in the rate, magnitude, and extent of changes in temperature, sea level, hurricanes and severe storms, wave climates, and precipitation regimes remains unknown (first-order impacts), which are often quantified using probabilities and ranges (Collins et al., 2013). The level of uncertainty increases when using these projections to model second-order impacts such as the rate of saltwater intrusion, the frequency and magnitude of flooding, the ability of marshes to transgress, coastal erosion, and loss of public and private infrastructure (Kettle, 2012b). There are also non-climate-related uncertainties that further complicate coastal planning, including knowing what actors and institutions will be involved in coastal management, the predictability of budgets, population growth and development, the political environment, the cost and availability of insurance, stakeholder values and priorities, and changes in state and local coastal polices (Moser, 2005). Other non-climate-related uncertainties are related to policy and decision-making processes, which include reaching a working agreement on how climate is changing, what is considered "dangerous," what are the goals and needs, and how to assess and compare adaptation options that integrate uncertainties in climate science and deliberation (Moser, 2005; Moser & Ekstrom, 2010). Together these uncertainties influence the assessment and interpretation of impact assessments.

Although uncertainties in climate change models are often quantified using probabilities and ranges, the level of uncertainty may be perceived differently in identical situations (Budescu, Por, & Broomell, 2012; Duncan, 1972). There are also differences in the perceived level of uncertainty for expectations of sea-level rise and temperature change among state, local, and non-government organization (NGO) planners (Kettle, 2012a). Although some assessments have measured the perceived level of uncertainty for climate-related uncertainties, our understanding of the level of perceived uncertainty for social and decision-making process and how these perceptions relate to climate-related uncertainties, is not resolved.

Much CCA research on the influence of perceived uncertainty focuses on the impact of information use. Gagnon-Lebrun and Agrawala (2006) suggest that the level of uncertainty in climate change projections is a barrier to planners using such information in adaptation planning efforts. Other research has investigated the type of information coastal planners want regarding uncertainty (Tribbia & Moser, 2008). Lackstrom et al. (2012) suggest that the influence of uncertainty on information use and implementation of adaptation activities varies across different sectors. Understanding what sources of future change are perceived as having the highest level of uncertainty and how the level of uncertainty is related to support CCA will deepen our understanding of what uncertainty means for adaptation planning (G. D. Brewer & Stern, 2005; Dessai, O'Brien, & Hulme, 2007).

Trust

Trust plays an important role in facilitating cooperation among entities, especially when individuals lack direct experience with events and uncertainties are prevalent (Siegrist, Earle, & Gutscher, 2007). In such situations, individuals must trust persons processing the information and governing institutions recommending policy changes. Earle (2010) points out two dimensions of trust in risk management: confidence in abilities (e.g., knowledge, skills, experience) and trust in intentions (e.g., values and intent). Trust and confidence are both critical in mediating social interactions among people, organizations, and institutions, and reducing the complexity in risk management (Laurian, 2009; Luhmann, 1988). In the context of coastal management, higher levels of social and institutional trust are related to greater community support for climate-related coastal policies (Jones & Clark, 2013, 2014).

Several researchers have investigated public trust in scientists and government as it relates to climate change. Their findings generally indicate that scientists, friends, and family are the most trusted sources of climate information and that perceived motivations behind communication influence willingness to engage in climate-related activities (Leiserowitz, Maibach, & Roser-Renouf, 2008; Rabinovich, Morton, & Birney, 2012; Whitmarsh, 2009). Other studies have found low public trust in government regulation (Poortinga & Pidgeon, 2003), linked trust in government to greater support for change mitigation policies (Dietz, Dan, & Swhwom, 2007; O'Connor, Bord, Fisher, Staneva, et al., 1999), and suggested that public resistance to climate change policy is connected to increased concern for government control and regulation (Leiserowitz et al., 2008).

Although the issue of trust is likely to influence planning decisions related to climate change, no studies were identified that evaluated planner trust and confidence in climate scientists and state government, though some research has evaluated trusted sources of information (Tribbia & Moser, 2008). Relevant aspects of planner trust in state government related to CCA include having sufficient state-level staff and financial resources to implement and enforce CCA policies, taking into account multiple perspectives, sharing a similar vision, and providing all available information for decision makers. Aspects of planner trust in climate scientists include the ability to measure historical climate change, predict future change, be transparent with findings, and maintain independence from private interests.

Linking Perceived Risk, Uncertainty, and Trust to Adaptation

The research discussed above enhances our understanding of the diverse risks faced by coastal communities, the major sources of uncertainty in

CCA planning, and the role of trust in risk management. The literature review also provides a foundation for understanding the potential influence of perceived risk, uncertainty, and trust on support for CCA. Yet there are several gaps in the existing literature concerning the ways in which perceptions of risk, uncertainty, and trust are related to support for CCA planning (Dessai et al., 2007; National Research Council [NRC], 2011). First, the influence of the above factors are highly contextual and dependent on the type of specific beliefs, yet most research focuses on climate change mitigation, as opposed to adaptation actions. There is reason to believe that the influence of perceived risk, uncertainty, and trust may be different for adaptation than mitigation because of the mismatch between the timescales of behavioral change and changes in the risk and adaptation may be associated with targeting more observable changes and impacts that relate to experience (Pielke et al., 2007; Slovic et al., 2004; Stern, 2000). Second, the influence of perceived risk, uncertainty, and trust may be different throughout different stages and activities within the adaptation cycle. It is therefore important to consider the influence of these factors during different stages of adaptation (e.g., planning, implementation, evaluation, etc.). Third, most-survey based research focuses on the general public rather than key decision makers such as planning officials, who are at the forefront of the development and assessment of adaptation planning. Fourth, the specific vulnerabilities of, and impacts to, these communities are dependent on local sensitivities, such as physiographic characteristics, levels of development, rates of relative sea level rise, existing infrastructure, as well as adaptive capacities. Priorities, intent, and abilities of planning entities also vary across levels of government. Such differences point to the value of recognizing how the influence of perceived risk, uncertainty, and trust vary across planner groups.

Method

A web-based questionnaire was used to solicit perspectives on the influence of perceived risk, uncertainty, and trust on CCA planning. This approach is used frequently in climate change needs assessments (MRAG Americans, 2009). This section discusses participant selection, questionnaire design, and methods used to measure perceived risk, uncertainty, and trust and parameterize the ordinal regression models used in analysis. The methods used in participant selection, questionnaire design, and analysis (interviews and questionnaire) were pilot tested in South Carolina between March and September 2010.

Participant Selection

CCA planning involves many actors and institutions at multiple scales of governance (Moser, 2009). This study focuses on understanding perspectives from city and county (borough) planners and engineers (local-level), division and section heads of key state agencies (state-level), and non-profit and NGOs. NGOs included both local/grassroots and national-level organizations, whose mission statements or web pages included references to planning. Together, the above planning entities are critical in the design and implementation of comprehensive plans, zoning ordinances, and CCA strategies (American Planning Association [APA], 2011; Cullingworth & Caves, 2009). Alaska, Florida, and Maryland were selected as the study areas because they face diverse coastal management challenges and different projections of climate change, have different political environments related to climate change, and are developing, or are in the process of developing, state-level CCA plans.

An extensive web-based search identified approximately 500 coastal planners whose work-related responsibilities were located within five miles of the coast. This distance was selected to focus on communities whose economies and vulnerabilities are closely tied to the coast. This distance is narrower than the coastal zone for each state as defined by National Oceanic and Atmospheric Administration (2012).

Questionnaire Design

Questionnaire design began with a literature review to identify major risks and sources of uncertainty. Twenty-seven semi-structured interviews were then conducted across Alaska, Florida, and Maryland to verify key risks, uncertainties, and dimensions of trust identified in the literature and develop survey questions to measure perceptions of risk, uncertainty, and trust. A maximum variation purposeful sampling technique was used to identify a wide range of planners across each state. This was achieved by selecting sets of participants within each study area that represented multiple levels of management and diverse regions of the coast.

The final web-based questionnaire was implemented between September and October 2011 based on Dillman's (2000) Tailored Design Method. This questionnaire, which served as the primary data set for analysis, was sent to 463 participants identified in the web-based search. Each participant received a pre-notice letter that described the purpose and voluntary nature of the research. One week later, a link to the questionnaire was emailed to each participant. Two additional reminders were sent to non-respondents at 1-week

Table 1. Questionnaire Sample Population *n* and Response Rate (%).

	Alaska	Florida	Maryland	Total
Local	19 (29)	58 (41)	18 (41)	95 (38)
State	0 (0)	7 (19)	15 (65)	22 (26)
NGO	7 (18)	8 (21)	5 (11)	20 (16)
Total	26 (20)	73 (34)	38 (34)	137 (30)

Note. NGO = non-government organizations.

intervals. The overall response rate was 30% ($n = 137$; Table 1). The response rate was highest for local planners (38%) and lower for state employees (26%) and NGOs (16%). Among the study areas, Florida and Maryland had the highest response rates (34%), and Alaska was considerably lower (20%). The questionnaire received no responses for state-level planners in Alaska. A major factor contributing to non-response among state-level planners was the non-reauthorization of the Alaska Coastal Management Program (ACMP) in July 2011, which occurred before the questionnaire was implemented. Questionnaires were still sent to planners working for ACMP to capture their perspectives; however, a few planners responded that they had new job responsibilities and were not able to complete the survey. The category of state-level planners therefore only includes responses for planners in Florida and Maryland.

Modeling the Relationship Between Perceived Risk, Uncertainty, Trust, and Climate Change Adaptation (CCA)

Two ordinal regression models were used to evaluate the relationship among support for CCA and the influences of perceived risk, types of uncertainty, and trust. The following subsections discuss the survey questions used to measure support for CCA at two different stages of planning (dependent variables) and develop the scales for perceived risk, uncertainty, and trust. Each of these scales is used as a covariate (independent variable) in the ordinal regression model.

Dependent variables. Support for CCA was measured at 2 different adaptation cycle stages with the following 6-point Likert-type item questions (see Tables 5 and 6 for response options):

- Development CCA—"Which statement best represents your level of support for the *development* of local-level adaptation strategies in your area that consider addressing the potential impacts of climate change?" [1 question]

- Resources CCA—"Which statement best represents your level of support for the *allocation of financial and human resources to implement* local-level adaptation strategies in your area that address potential impacts of climate change?" [1 question]

Scales (covariates). Perceived risk and uncertainty were assessed with 40 Likert-type items and trust was assessed using 13 bipolar response options based on the following questions:

- Perceived Risk—"Please rate your level of concern that the following [*environmental changes or climate change impacts*] will occur in your community over the next 15-20 years (approximately 2030)." [14 questions]
- Uncertainty—"Please rate the extent of the level of uncertainty associated with changes in [*environmental conditions, social conditions, climate change impacts, or decision making processes*] over the next 15 to 20 years (approximately 2030)." [26 questions]
- Trust—"Please rate your level of agreement for the following statements related to trust in [*publically funded climate scientists or state government*]." [13 questions]

This set of questions captures the key risks, types of uncertainty, and dimensions of trust discussed in the literature and semi-structured interviews (Table 2). The number inside the brackets (above) represent the number of questions used to create each scale. Each question was calibrated to the year 2030 because the time frame aligns with decision-making processes for coastal planners (comprehensive plans, land use management documents, hazard mitigation plans; APA, 2006). The above scales were created on a conceptual basis, justified by an extensive review of the literatures on risk perception, uncertainty, and trust, rather than statistically derived.

Participant responses were combined into eight scales by averaging (mean) Likert-type item and bipolar response questions. There were two scales for perceptions of risk, four scales for uncertainty, and two scales for trust. Cronbach's alpha (α) indicated that each scale exhibited high internal reliability, suggesting that items within each scale were measuring a similar construct (Table 2).

The aggregation of multiple items into a single scale was treated as interval data for regression analysis and will be treated this way throughout the article. Although strictly speaking Likert-type item response format

Table 2. Likert-Type Item Questions and Bipolar Response Options Used to Create Perceived Risk, Uncertainty, and Trust Scales.

Perceived risk first order (α = .76): Perceived risk to environmental changes

A local increase in (a) sea level, (b) land subsidence, (c) the number of extreme precipitation events, (d) the strength of hurricanes and coastal storms, (e) surface temperature, (f) permafrost melt[a]

Perceived risk second order (α = .89): Perceived risk to climate impacts

(a) An increase in the intensity of flooding events, (b) an increase in the number of flooding events, (c) public health and safety issues, (d) saltwater intrusion, (e) economic losses (jobs, businesses, tourism), (f) beach and dune loss, (g) loss of wetland and marsh habitat, (h) infrastructure and property damage

Trust in government (α = .65): Confidence in the abilities and trust in intentions of state government

(a) The state has sufficient financial resources to implement CCA policies, (b) the state has sufficient financial resources to enforce CCA policies, (c) the state has sufficient staff expertise to implement CCA policies, (d) the state is too influenced by industry and private interests to address CCA[b], (e) the state takes into account many perspectives when making a decision, (f) the state provides all of the available information to the public when making a decision, (g) the state has similar options and ideas as I do regarding CCA

Trust in climate scientists (α = .83): Confidence in the abilities and trust in intentions of climate scientists

(a) Scientists have the necessary skills to measure historical changes in climate, (b) scientists have the necessary skills to predict how climate will change, (c) scientists have the necessary skills to measure land subsidence and rebound, (d) the values of scientists studying climate change are similar to mine, (e) climate scientists are influenced by industry and private interests[b], (f) climate change–related data and findings are distorted by scientists[b]

Uncertainty—Environment first order (α = .83): Uncertainty in environmental conditions

A local increase in (a) sea level, (b) land subsidence, (c) the number of extreme precipitation events, (d) the strength of hurricanes and coastal storms, (e) surface temperature, (f) permafrost melt[a]

Uncertainty—Environment second order (α = .89): Uncertainty in climate impacts

(a) An increase in the intensity of flooding events, (b) an increase in the number of flooding events, (c) public health and safety issues, (d) saltwater intrusion, (e) economic losses (jobs, businesses, tourism), (f) beach and dune loss, (g) loss of wetland and marsh habitat, (h) infrastructure and property damage

Uncertainty—Social (α = .84): Uncertainty in social conditions

(a) Knowing which people and organizations will be involved in coastal management, (b) predictability of budgets, (c) population growth and development, (d) the political environment (re: support for environmental policies), (e) cost of insurance for homeowners, (f) stakeholder priorities and values, (g) changes in local coastal policies (zoning, planning, and regulations), (h) changes in state coastal policies (zoning, planning, and regulations)

Uncertainty—Decision processes (α = .95): Uncertainty in decision-making processes

Reaching a working agreement on (a) the level that a change in climate is dangerous, (b) adaptation goals and needs, (c) how to assess and compare adaptation options, (d) how the climate is changing

Note. Response format for Likert-type item questions: *Risk* (not concerned, slightly concerned, somewhat concerned, moderately concerned, very concerned, extremely concerned); *Uncertainty* (certain, slightly uncertain, somewhat uncertain, moderately uncertain, very uncertain, extremely uncertain, not aware of); *Trust* (strongly agree, agree, slightly agree, slightly disagree, disagree, strongly disagree). For each question, participants were given the option to select "not aware of." CCA = climate change adaptation.
[a]Questions were only asked to participants in Alaska.
[b]Inverse response values were used for calculating each scale.

questions produce ordinal data, studies have shown empirically that 5- to 7-point response format questions produce data that are not significantly different than continuous data (Cicchetti, Showalter, & Tyrer, 1985; Rasmussen, 1989).

Table 3. Spearman's Rho Correlation Coefficients for the Covariants.

	Perceived Risk	Uncertainty Env1	Uncertainty Env2	Uncertainty Social	Uncertainty Dec. Pro.	Trust Scientists	Trust Gov.
Perceived Risk							
Uncertainty Env1	−.30***						
Uncertainty Env2	−.40***	.60***					
Uncertainty Social	−.08	.36***	.45***				
Uncertainty Dec. Pro.	−.27***	.31***	.5***	.39***			
Trust Scientists	.32***	−.47***	−.32***	−.11	−.15*		
Trust Gov.	.05	−.11	−.09	−.32***	−.38***	.06	

Note. Env1 = first order impacts; Env2 = second order impacts; Dec. Pro. = decision making processes; Trust Gov. = Trust in state government.
*$p \leq .05$, two-tailed test. ***$p \leq .001$, two-tailed test.

Analysis of Spearman's ρ indicated that both perceived risk scales were highly correlated ($r = .824$) and were thus combined into a single scale ($\alpha = .90$). The risk scales were combined by averaging individual responses for all of the 14 perceived risk Likert-type items. The other six scales were related, but not highly enough that multicollinearity would likely be an issue (Table 3).[1]

Model parameters for ordinal regression. Two ordinal regression models were developed to understand how perceived risk, uncertainty, and trust are related to support for CCA strategies. Model 1 regressed support for the development of local-level CCA plans and strategies (Development CCA) and Model 2 regressed support for the allocation of human and financial resources to implement local-level CCA strategies (Resources CCA). The seven covariates used in both of these models represent the scales discussed in Table 3. Both models used the logit link function, 0.00000001 singularity tolerance, 0.000001 parameter convergence, 20 half steppings, and 100 iterations. These parameters specify the transformation applied to the dependent variable, values used to check for correlations among predictors, and the iterations used to estimate effect parameters, respectively.

Research Findings

Research findings are discussed in four sections. The first section addresses the scales used as covariates in the ordinal regression models and the second section reports on support for CCA, the dependent variable. The third section analyzes the results from the ordinal regression models of scales and support for CCA. The final section focuses on correlations between the each of the scales (perceived risk, uncertainty, and trust) and support for CCA at a finer

Table 4. Mean Response Values for Perceived Risk, Uncertainty, and Trust Scales.

	Study area			Level of management			
	Alaska	Florida	Maryland	Local	State^	NGO	Total^
Perceived Risk	3.23[a*]	3.55	3.91[a*]	3.43[b*]	3.73[b*]	3.59	3.59
Uncertainty Env1	2.61	3.16[c*]	2.58[c*]	3.08[d**]	2.89[d**]	2.93	2.89
Uncertainty Env2	2.98	3.17[e*]	2.58[e*]	3.09	2.93	3.01	2.97
Uncertainty Social	3.68	3.94[f**]	3.27[f**]	3.77	3.69	3.73	3.71
Uncertainty Decision Processes	3.26	3.82[g**]	2.70[g**]	3.66[h**]	3.21[h**]	3.53	3.33
Trust Scientists	5.00	4.76	4.96	4.72[i*,j**]	4.85[i*]	4.83[j**]	4.86
Trust Government	3.38[k**]	2.78[k**,l**]	3.51[l**]	3.03	3.08	2.94	3.10

Note. Mean responses range from 1 to 6, with low values representing low levels of perceived risk, uncertainty, and trust. Superscripts indicate significant differences between scales (*$p \leq .05$. **$p \leq .01$). Significant differences in median values are based on Kruskal-Wallis and Mann-Whitney *U* tests. NGO = non-government organizations; Env1 = first order impacts; Env2 = second order impacts.
^The "State" and "Total" categories do not include data for state-level planners from Alaska (no data).

resolution (across states and level of management) to assess which factors are stable across scale.

The Scales: Perceived Risk, Uncertainty, and Trust

Risk research has identified perceived risk, uncertainty, and trust as significant influences on the responses of different groups to a variety of risks. Although these factors are all relevant to adaptation issues facing planners, little is known about how they might influence the motivations of this influential group. Analysis of planners' responses on these factors, as they relate to climate change, revealed differences in their broad perspectives on scales of perceived risk, uncertainty, and trust (Tables 2 and 4). For example, risk perceptions were significantly higher in Maryland than in Florida and for state planners compared with local planners ($p \leq .05$).

Analysis of the four uncertainty scales confirmed that coastal planners face a diversity of climate and non-climate uncertainties in planning processes (Tribbia & Moser, 2008). Overall, planners perceived that social uncertainties had the highest level of uncertainty and first- and second-order uncertainties were perceived to have the lowest level of uncertainty. However, there were significant differences in the perceived level of uncertainty within and across scales. For example, for all uncertainty scales, the perceived level of uncertainty was significantly higher in Florida than in Maryland ($p \leq .05$). Local planners perceived a significantly higher level of uncertainty than state planners for first-order environmental and decision-making process uncertainties ($p \leq .01$; no data for state planners in Alaska).

The trust scale addresses issues of trust in competence and intention with respect to several key groups and aspects of their work. Overall, participants expressed high levels of trust in climate scientists and moderate levels of trust in state government. This lower level of trust in government may affect support for CCA because planners may perceive that the state does not have the resources or ability to act, or share the values of their communities. Trust in scientists was significantly lower for local-level planners than for state-level planners ($p \leq .05$) and NGOs ($p \leq .01$), and trust in government was significantly lower for planners in Florida than in Maryland and Alaska ($p \leq .01$). The three types of scales discussed above (perceptions of risk, uncertainty, and trust) represent factors that may influence support for CCA.

Support for CCA

Research on CCA planning has revealed an increasing level of engagement across the United States and internationally, especially in coastal environments (Bierbaum et al., 2013; Mimura et al., 2014). Analysis of planners' responses for the level of support for CCA revealed differences at two different points in the adaptation process and across scales.

Overall, coastal planners indicated greater support for the development of local-level CCA strategies that consider addressing potential impacts of climate change than for allocating human and financial resources to such strategies (Tables 5 and 6). The majority of planners (62%) believed that their community *must immediately* or *should begin* integrating climate change into planning strategies soon, but few of the same respondents (51%) believed that their community *must immediately* or *should begin* allocating financial and human resources to implement local-level adaptation strategies. Few planners indicated that communities *should not* begin developing plans or allocating resources to implement adaptation planning. For a detailed analysis of cross-scale differences in support for CCA planning among planning entities, see (Kettle & Dow, in press).

The Influence of Perceived Risk, Uncertainty, and Trust on Support for CCA

The relationship between the seven scales of perceived risk, uncertainty, and trust developed in this study and the measures of support for CCA reported above were analyzed with two ordinal regression models (Development CCA and Resources CCA). This subsection describes the model fit and outputs related to the influence of perceived risk, uncertainty, and trust on support for

Table 5. Support for the Development of CCA Strategies (Development CCA) Strategies: *n* (%).

	Study area			Management level			
	Alaska	Florida	Maryland	Local	NGO	State^	Total^
Communities in my area *must immediately integrate* climate change into planning strategies to address future impacts, no matter what happens	6 (23)	10 (14)	10 (26)	9 (9)	10 (50)	7 (32)	26 (19)
Communities in my area *should begin integrating* climate change into planning strategies soon to address potential impacts	6 (23)	33 (45)	20 (53)	40 (42)	7 (35)	12 (55)	59 (43)
Communities in my area *should start thinking about how to integrate* climate change into planning strategies, but should not begin developing these strategies until they know more about what to prepare for	8 (31)	17 (23)	7 (18)	28 (29)	2 (10)	2 (9)	32 (23)
At some point communities in my area *may need to start thinking about integrating* climate change into planning strategies, but they don't need to until they know more about what to plan for	4 (15)	11 (15)	1 (3)	15 (16)	0 (0)	1 (5)	16 (12)
Communities in my area *should not integrate* climate change into planning strategies right now. They have *too many other more important challenges* to address	1 (4)	1 (1)	0 (0)	1 (1)	1 (5)	0 (0)	2 (1)
Communities in my area *should not integrate* climate change into planning strategies because *climate change will not impact coastal planning and management* where I work	1 (4)	1 (1)	0 (0)	2 (2)	0 (0)	0 (0)	2 (1)
Total	26	73	38	95	20	22	137

Note. CCA = climate change adaptation; NGO = non-government organizations.
^The "State" and "Total" categories do not include data for state-level planners for Alaska (no data).

Table 6. Support for the Allocation of Human and Financial Resources to Implement CCA Strategies (Resources CCA): *n* (%).

	Study area			Management level			
	Alaska	Florida	Maryland	Local	NGO	State^	Total^
Communities in my area *must immediately* allocate financial and human resources to implement local-level adaptation strategies that address climate change impacts in my area	4 (15)	8 (11)	3 (8)	7 (7)	6 (30)	2 (9)	15 (11)
Communities in my areas *should begin allocating financial and human resources* soon to implement local-level climate change planning strategies that address potential impacts	7 (27)	25 (34)	23 (61)	30 (32)	8 (40)	17 (77)	55 (40)
Communities in my area *should start thinking about allocating financial and human resources* soon to implement local-level climate change planning strategies, but should not begin allocating resources until they know more about what to prepare for	6 (24)	21 (29)	9 (24)	31 (33)	3 (15)	2 (9)	36 (26)
At some point communities in my area may need to *start thinking about allocating financial and human resources* to implement CCA strategies, but they don't need to until they know more about what to plan for	9 (35)	13 (18)	2 (5)	21 (22)	2 (10)	1 (5)	24 (18)
Communities in my area *should not allocate financial and human resources* to implement CCA planning strategies right now. They have *too many other more important challenges* to address	0 (0)	4 (5)	1 (3)	5 (5)	0 (0)	0 (0)	5 (4)
Communities in my area *should not allocate financial and human resources* to implement CCA planning strategies because climate change *will not impact coastal planning and management where I work*	0 (0)	2 (3)	0 (0)	1 (1)	1 (5)	0 (0)	2 (1)
Total	26	73	38	95	20	22	137

Note. CCA = climate change adaptation; NGO = non-government organizations.
^The "State" and "Total" categories do not include data for state-level planners for Alaska (no data).

the development of, and allocation of human and financial resources for, local-level adaptation strategies that consider addressing climate impacts.

Analysis of the ordinal regression models revealed that perceived risk and trust in climate scientists are significant in support for local-level adaptation strategies that consider climate change impacts during two substages of adaptation planning (Table 7). An increase of one ordinal level in either perceived risk (e.g., increase from "slightly concerned" to "somewhat concerned") or the level of trust in climate scientists raises the odds of having a higher level of support for the development of CCA by 2.47 (perceived risk) and 1.92 (trust in scientists). An ordinal-level increase also raises the odds of having a higher level of support for the allocation of resources for CCA by 2.48 (perceived risk) and 1.82 (trust in scientists). These findings are consistent with previous research findings, both within the United States and internationally, that identifies risk perceptions as the strongest explanatory variable related to support for climate change mitigation policy (Bord et al., 2000; O'Connor, Bord, Fisher, Staneva, et al., 1999; Zahran, Brody, Grover, & Vedlitz, 2006). The findings are also consistent with research that emphasize the importance of trust in climate scientists' on willingness to engage with climate science messages (Rabinovich et al., 2012).

The model fit was carefully evaluated using four tests—threshold estimates, proportionality of odds, Pearson, and Deviance Goodness of Fit. Threshold estimates in both models contained values that were not significant ($p \geq .05$), indicating that some ordinal levels of the dependent variable did not have significant cut points (some levels have equations that are not significantly different). Ordinal levels 4 to 6 were therefore combined within both models such that the ordinal interval of the dependent's variables had statistically significant cut points (e.g., responses for bottom three statements in Table 5 were combined into a single measure). Both models passed the proportionality of odds assumption (parallel lines test), indicating that the slopes of the predictor variables are the same for each ordinal level of the dependent variable. Pearson and Deviance Goodness of Fit tests were both non-significant, indicating that the data were a good fit to the model, and likelihood ratio tests for both models were significant, indicating that both models were more effective than their respective null models.

Three of four uncertainty scales are not significantly related to CCA support (Table 7). These findings run counter to the debate over uncertainty on climate change, which suggest that uncertainties in the magnitude of climate change and potential impacts are a significant barrier to planning (Fussel, 2007). Only the scale focusing on uncertainty in decision-making processes is significant (e.g., reaching a working agreement on [a] the level that a change in climate is dangerous, [b] adaptation goals and needs, [c] how to

Table 7. Parameter Estimates and Odds Ratios for the Influence of Perceived Risk, Trust, and Uncertainty on Support for CCA.

		Estimate	*SE*	Wald	*df*	Significance	Odds ratio
Development CCA	**Perceived Risk**	**−0.905**	**.202**	**19.964**	**1**	**.001**	**2.47**
	Uncertainty Env1	0.086	.207	.171	1	.679	0.92
	Uncertainty Env2	0.284	.229	1.546	1	.214	0.75
	Uncertainty Social	−0.262	.232	1.282	1	.257	1.30
	Uncertainty Dec. Pro.	0.195	.151	1.668	1	.197	0.82
	Trust Scientists	**−0.650**	**.237**	**7.512**	**1**	**.006**	**1.92**
	Trust Government	0.020	.238	.007	1	.932	0.98
Resources CCA	**Perceived Risk**	**−0.908**	**.203**	**19.951**	**1**	**.001**	**2.48**
	Uncertainty Env1	0.149	.208	.515	1	.473	0.86
	Uncertainty Env2	0.044	.229	.037	1	.847	0.96
	Uncertainty Social	−0.179	.231	.597	1	.440	1.20
	Uncertainty Dec. Pro.	**0.264**	**.152**	**3.019**	**1**	**.082**	**0.77**
	Trust Scientists	**−0.601**	**.237**	**6.417**	**1**	**.011**	**1.82**
	Trust Government	0.332	.240	1.915	1	.166	0.72

Note. Pseudo *R*-squared values: Development CCA—Cox and Snell .389, Nagelkerke .420, McFadden .190; Resources CCA—Cox and Snell .362; Nagelkerke .392; McFadden .174. CCA = climate change adaptation. Bold face values represent co-variates significantly related to CCA support ($p \leq .011$). Env1 = first order impacts; Env2 = second order impacts; Dec. Pro. = decision making processes.

assess and compare adaptation options, and [d] how the climate is changing) with respect to support for the allocation of human and financial resources for CCA strategies. An increase in one ordinal level in this uncertainty scale significantly decreases the odds of having higher level support for Resources CCA by 0.77 (negative relationship). These findings underscore the growing awareness of the challenges associated with diverse values and priorities when developing working agreements on how the climate will change, what is considered dangerous, and what are the needs and goals of adaptation (Adger et al., 2009; Moser & Ekstrom, 2010; Southeast Florida Regional Climate Change Compact, 2011).

Although uncertainties related to social processes had the highest levels of uncertainty, interpretation of regression analysis indicated that this scale was not related to support for Development CCA or Resources CCA. Such findings suggest that different sources of uncertainty are related to support for CCA in various ways. For example, support for CCA is linked more to peoples' willingness to bear social uncertainties under conditions of high risk potential, rather than the perceived level of social uncertainty. In contrast, support for Resources CCA is linked to the perceived level of uncertainty for decision-making processes. Trust in government is also not significantly related to support for CCA.

Differences in the Correlation Across Study Areas and Level of Management

The potential for social and psychological factors to have different levels of influence and significance across different regions and levels of management has been identified in related work (O'Connor, Bord, Fisher, Staneva, et al., 1999). Outputs from the ordinal regression models (discussed above) were used to detect the influence of risk perceptions, uncertainty, and trust on support for CCA across study participant groups. This section discusses the stability of these findings at a finer scale within each study area and level of management. The relationship between each of these scales on support for CCA for each subset of planners is assessed using Spearman's ρ, rather than ordinal regression. This selection was made because, despite significant effort in developing a list of potential participants and close reliance on the recommended survey techniques (Dillman, 2000), the sample sizes for each of the subgroups (study area and level of management) remained too small for regression analysis (Table 1). The findings from the correlation analysis therefore provide an exploratory analysis of the relationship between each of the covariates and support for CCA, rather than the inferential analysis that might be provided by ordinal regression with a sufficient sample size. A more detailed analysis of how support for CCA varies across study areas and levels of management is presented in Kettle and Dow (in press).

Comparison of Spearman's ρ correlation coefficients revealed that some scales had similar degrees of association with Development CCA and Resources CCA across study areas and level of management (Table 8). For example, the influence of risk perception and trust in scientists on support for CCA was stable across all study areas and levels of management. Specifically, the degrees of association for risk perceptions and trust in climate scientists on support for CCA were relatively high, significant ($p \leq .05$), and positive for all subgroups (except for two subgroups, where the relationship was positive, but not significant).

Other factors were less consistent across subgroups of planners. For example, three of the uncertainty scales (first- and second-order environmental and decision process uncertainties) were significantly correlated to support for CCA in both models at the local-and NGO level, but not significant for state-level planners. Such findings suggest that the availability and accessibility of more precise climate models is more important to local planners, who must live with, and make decisions in the face of uncertainty.

In another example, trust in government was significantly related to support for CCA in Alaska and Maryland, but the sign of the relationship was opposite, and not significantly related in Florida. Some differences in trust in

Table 8. Spearman's Rho Correlation Coefficients for Support for CCA and Scales.

		Study area			Level of management			
		Alaska	Florida	Maryland	Local	State^	NGO	Total^
Development CCA	Perceived Risk	0.59**	0.47**	0.55**	0.51**	0.32	0.48*	0.53**
	Uncertainty Env1	−0.42*	−0.38**	−0.14	−0.30**	−0.14	−0.29	−0.37**
	Uncertainty Env2	−0.46*	−0.38**	−0.35*	−0.40**	−0.22	−0.31	−0.40**
	Uncertainty Social	−0.31	0.01	−0.47	−0.05	−0.15	−0.29	−0.13
	Uncertainty Dec. Pro.	−0.22	−0.16	−0.43**	−0.28**	−0.32	0.11	−0.31**
	Trust Scientists	0.45*	0.40**	0.34*	0.24*	0.43*	0.40	0.41**
	Trust Government	−0.31	0.01	0.40**	−0.02	0.33	−0.24	0.03
Resources CCA	Perceived Risk	0.60**	0.51**	0.42**	0.48**	0.44*	0.58**	0.52**
	Uncertainty Env1	−0.53**	−0.28*	−0.18	−0.26**	−0.30	−0.24	−0.33**
	Uncertainty Env2	−0.36	−0.27*	−0.25	−0.24*	−0.22	−0.28	−0.30**
	Uncertainty Social	−0.20	−0.05	0.12	−0.02	0.05	−0.35	−0.11
	Uncertainty Dec. Pro.	0.03	−0.30**	−0.38*	−0.24*	−0.23	−0.04	−0.28**
	Trust Scientists	0.40*	0.35**	0.38*	0.27**	0.49*	0.41**	0.38**
	Trust Government	−0.45*	−0.12	0.45**	−0.13	0.18	−0.23	−0.05

Note. CCA = climate change adaptation; NGO = non-government organizations. Env1 = first order impacts; Env2 = second order impacts; Dec. Pro. = decision making processes.
^The "State" and "Total" categories do not include data for state-level planners for Alaska (no data).
*$p \le .05$. **$p \le .01$.

government can be illustrated through responses from the semi-structured interviews. A borough-level planner from Alaska stated that "the states' entire coastal zone management program was gutted basically because the oil companies were saying it's hampering development . . . they [the state] didn't care what local governments had to share." This sentiment was voiced by two of the three local planners interviewed in Alaska. In the case of Maryland, where support for CCA strategies is positively correlated to trust in government, a city planner stated that "If you play it right and have a good relationship with the state then you can participate in the process, rather than sit back and wait for the state to tell you what to do." Another local planner in Maryland stated that it "helps to have the people on the state-level, with the expertise they have . . . come up with this adaptation plan." Together, these findings at finer scales of analysis highlight correlations that are consistent across study areas and levels of management and factors that vary at a finer resolution of analysis.

Discussion and Conclusion

Coastal planners are in the center of decision-making processes that guide the development of community land and resources, including how climate change-related concerns are integrated into planning and management strategies. This study assessed the influence of perceived risk, uncertainty, and trust on support for local-level adaptation strategies that consider addressing the impacts of climate change over a near-term planning horizon (10-15 years) among coastal planners in Alaska, Florida, and Maryland. The findings from this study advance our understanding of how social and psychological factors influence the many dimensions of adaptation planning and the differences among planning stages, types of planners, and states. In the following sections, we discuss the contributions of this study and the additional research needed to advance our understanding of climate adaptation planning. We conclude by discussing the policy implications of the study findings.

First, this study found that the influence of perceived risk, uncertainty, and trust on support for CCA varies across two stages of adaptation planning (Development CCA and Resources CCA). For example, a higher level of perceived risk and trust in scientists both significantly increase the odds of a higher level of support for the development of, and allocation of resources for, CCA strategies. In contrast, uncertainties in decision-making process were significant (negative) for the allocation of human and financial resources to implement CCA plans, but not for the development of a plan. Although this study investigated the influence of three factors during two stages of the adaptation planning cycle, there are several other stages, including problem identification, managing, and evaluating the performance of planning measures, which may be affected differently by the influence of these and other factors. Additional research is needed to investigate the influence and stability of social and psychological factors at different stages of adaptation planning.

Second, the disaggregation of planning entities into different study areas and levels of management revealed significant differences in the relationship between perceived risk, uncertainty, and trust and support for CCA planning. Trust in government and support for CCA differed in magnitude, direction, and significance across each of the study areas. Furthermore, climate change-related uncertainties matter more for local planning officials than for state and NGO planners. Analysis of the total sample showed that a higher level of climate-related uncertainties did not significantly decrease the odds of a higher level of support for CCA; however, disaggregation of planners across levels of management revealed that a higher level of uncertainty is significantly ($p \leq .05$) correlated to a lower level of support for CCA among local planners. Such findings highlight the importance of finer scale comparative studies, rather than national-level surveys, in understanding support for CCA planning and what factors are stable and different across regions (NRC, 2011). Additional research is needed to investigate the role of perceived risk, trust, and uncertainty on adaptation planning across planner groups and study areas. Specifically, a larger sample size within each study area or level of management would allow for the use of inferential statistics, rather than exploratory correlation analysis, thus providing greater insight into differences between planning groups and across states.

Third, although an increase in the perceived level of uncertainty did not significantly alter support for Development CCA or Resources CCA (regression analysis), three of the four uncertainty scales—those concerning first- and second-order environmental impacts and decision-making processes—were significantly, negatively correlated in support for CCA. It is possible that the influence of specific uncertainties may have been masked in creating the scales. It would be important to identify which specific uncertainties have the greatest barrier to planning efforts. Identifying thresholds in these uncertainties remains an important, yet relatively unexplored research area in CCA. There are also additional variables to include in future modeling efforts that may play a critical role in support for CCA. For example, further distinguishing the influence of different dimensions of trust, such as confidence in abilities or trust in intentions or trust among NGOs and local planners, may yield a deeper understanding of the role of trust for CCA planning and governance relations. It would also be useful for modeling efforts to include an explicit consideration of the political context as it influences approaches to climate adaptation (Haywood, Brennan, Dow, Kettle, & Lackstrom, 2014).

These findings have implications for the design of more effective climate adaptation communication, engagement strategies, and policy. First, communication and engagement strategies designed to increase support for CCA should be sensitive to the stage of adaptation planning processes. Although some factors, such as trust in scientists and risk perceptions are critical in support for CCA throughout multiple stages of planning, other factors are more stage specific and could be targeted. Specifically, strategies to facilitate dialog among planning entities to reach working agreements on adaptation goals and needs, adaptation options, and how the climate is changing should target entities that are preparing to implement strategies, rather than increase support for the development of plans. Second, strategies to improve support for the development and implementation of CCA plans must be sensitive to the appropriate level of management. In the case of climate-related environmental uncertainties, efforts to reduce uncertainty may not increase support among state and NGO planners, whereas more targeted efforts to local planners may increase support.

Acknowledgments

The authors wish to thank the planners who participated in this study and members of the dissertation committee (Drs. Gregory Carbone, Michael Hodgson; and Dwayne Porter) for their guidance and insight.

Authors' Note

This research was conducted as part of the lead author's doctoral dissertation research project at the University of South Carolina.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by The National Science Foundation, Doctoral Dissertation Research Improvement Grant (Decision Risk and Management Sciences) [Grant No. SES-1023448]; The Department of Geography at The University of South Carolina; and The Carolinas Integrated Sciences and Assessments.

Note

1. A principal components analysis (with varimax rotation) was conducted for the Likert-type items in the Uncertainty Env1 and Env2 scales. A review of the factor loadings suggests (a) most components load on Factors 1 and 2 (10 of 14), and (b) five of the eight components for first-order uncertainties load on Factor 1 and five of the six components load on Factor 2. This analysis of the statistical distribution of the data suggests that the uncertainty scales do not correlate and may be treated as separate dimensions. Interpretation of Cronbach's alpha suggests there is high internal reliability for the first and second-order uncertainty scales (.83 and .89, respectively).

References

Abbott, J. (2005). Understanding and managing the unknown: The nature of uncertainty in planning. *Journal of Planning Education and Research*, *24*, 237-251.

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*, 268-281.

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., . . .Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change*, *93*, 335-354.

American Planning Association. (2006). *Planning and urban design standards*. Hoboken, NJ: John Wiley.

American Planning Association. (2011). *Policy guide on planning and climate change*. Retrieved from https://www.planning.org/policy/guides/pdf/climatechange.pdf

Bierbaum, R., Smith, J., Lee, A., Blair, M., Carter, L., Chapin, F. S. I., . . .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*, 361-406.

Bord, R., O'Connor, R. E., & Fisher, A. (2000). In what sense does the public need to understand global climate change? *Public Understanding of Science*, *9*, 205-218.

Brewer, G. D., & Stern, P. C. (2005). *Decision making for the environment: Social and behavioral science research priorities*. Washington, DC: National Academies Press.

Brewer, N., Weinstein, N., Cuite, C., & Herrington, J. (2004). Risk perceptions and their relation to risk behavior. *Annals of Behavioral Medicine*, *27*, 125-130.

Budescu, D. V., Por, H.-H., & Broomell, S. B. (2012). Effective communication of uncertainty in the IPCC reports. *Climatic Change*, *113*, 181-200.

Cicchetti, D. V., Showalter, D., & Tyrer, P. J. (1985). The effect of number of rating scale categories on levels of interrater reliability: A Monte Carlo investigation. *Applied Psychological Measurement*, *9*, 31-36.

Collins, M. R., Knutti, R., Arblaster, J., Dufresne, J.-L., Fichefet, T., Friedlingstein, P., . . . Wehner, M. (2013). Long-term Climate Change: Projections, Commitments and Irreversibility. In T.F. Stocker, D. Qin, & G.-K. Plattner, et al. (Eds.), *Climate Change 2013: The Physical Science Basis. Contributions of Working Group 1 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1029-1136). Cambridge, United Kingdom and New York, NY: Cambridge University Press.

Cullingworth, J. B., & Caves, R. (2009). *Planning in the USA* (3rd ed.). New York, NY: Routledge.

Dessai, S., O'Brien, K., & Hulme, M. (2007). Editorial: On uncertainty and climate change. *Global Environmental Change*, *17*, 1-3.

Dietz, T., Dan, A., & Swhwom, R. (2007). Support for climate change policy: Social psychological and social structural influences. *Rural Sociology*, *72*, 185-214.

Dillman, D. A. (2000). *Mail and Internet surveys: The tailored design method* (2nd ed.). New York, NY: John Wiley.

Duncan, R. B. (1972). Characteristics of organizational environments and perceived environmental uncertainty. *Administrative Science Quarterly*, *1713*, 313-327.

Earle, T. C. (2010). Trust in risk management: A model-based review of empirical research. *Risk Analysis*, *30*, 541-574.

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global and Planetary Change*, *16*, 253-267.

Fussel, H. M. (2007). Adaptation planning for climate change: Concepts, assessment approaches, and key lessons. *Sustainability Science*, *2*, 265-275.

Gagnon-Lebrun, F., & Agrawala, S. (2006). *Progress on adaptation to climate change in developed countries: An analysis of broad trends*. Paris, France: Organisation for Economic Co-operation and Development.

Gore, C., & Robinson, P. (2009). Local government response to climate change: Our last, best hope? In H. Selin & S. VanDeveer (Eds.), *Changing climates in North American politics* (pp. 137-158). Cambridge, MA: MIT Press.

Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change*, *15*, 199-213.

Haywood, B., Brennan, A., Dow, K., Kettle, N., & Lackstrom, K. (2014). Negotiating a mainstreaming spectrum: Climate change response and communication in the Carolinas. *Journal of Environmental Policy & Planning*, *16*, 75-94.

Jones, N., & Clark, J. R. A. (2013). Social capital and climate change mitigation in coastal areas: A review of current debates and identification of future research directions. *Ocean & Coastal Management*, *80*, 12-19.

Jones, N., & Clark, J. R. A. (2014). Social capital and the public acceptability of climate change adaptation policies: A case study in Romney Marsh, UK. *Climatic Change*, *123*, 133-145.

Kettle, N. P. (2012a). *Coastal climate change adaptation: The influence of perceived risk, uncertainty, trust, and scale* (Doctoral dissertation). University of South Carolina, Columbia, S.C.

Kettle, N. P. (2012b). Exposing compounding uncertainties in sea level rise assessments. *Journal of Coastal Research*, *28*, 161-173.

Kettle, N. P., & Dow, K. (in press). Cross-level differences and similarities in coastal climate change adaptation planning. *Environmental Science and Policy*.

Klein, R. J. T., Midgley, G. F., Preston, B. L., Alam, M., Berkhout, F. G. H., Dow, K., & Shaw, M. R. (2014). Adaptation opportunities, constraints and limits. In C. B. Field et al. (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 Intergovernmental Panel on Climate Change* (p. 46). Cambridge, United Kingdom and New York, NY: Cambridge University Press.

Lackstrom, K., Dow, K., Haywood, B., Brennan, A., Kettle, N. P., & Brosius, A. (2012). *Engaging climate-sensitive sectors in the Carolinas* (Technical Report: CISA-2012-03). Columbia, SC: Carolinas Integrated Sciences and Assessments.

Laurian, L. (2009). Trust in planning: Theoretical and practical considerations for participatory and deliberative planning. *Planning Theory & Practice*, *10*, 369-391.

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climate Change*, *77*, 45-72.

Leiserowitz, A., Maibach, E., & Roser-Renouf, C. (2008). *Climate change in the American mind: Americans' climate change beliefs, attitudes, policy preferences, and action*. Center for Climate Change Communication, George Mason University. Retrieved from http://www.climatechangecommunication.org/images/files/Climate_Change_in_the_American_Mind.pdf

Lindell, M., & Perry, R. (2000). Household adjustment to earthquake hazard: A review of research. *Environment and Behavior*, *32*, 461-501.

Luhmann, N. (1988). Familiarity, confidence, trust: Problems and alternatives. In D. Gambetta (Ed.), *Trust: Making and breaking cooperative relations* (pp. 94-108). Oxford, UK: Basil Blackwell.

McMullen, J. S., & Shepherd, D. A. (2006). Entrepreneurial action and the role of uncertainty in the theory of entrepreneur. *Academy of Management Review*, *31*, 132-152.

Mimura, N., Pulwarty, R., Duc, M. D., Elshinnaway, I., Redsteer, M. H., Huang, H.-Q., . . .Sourminski, S. (2014). Adaptation planning and implementation. In C.B. Field et al. (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 Intergovernmental Panel on Climate Change* (p. 46). Cambridge, United Kingdom and New York, NY: Cambridge University Press.

Moser, S. C. (2005). Impact assessments and policy responses to sea-level rise in three US states: An exploration of human-dimension uncertainties. *Global Environmental Change*, *14*, 353-369.

Moser, S. C. (2009). Governance as a cross-cutting theme in human dimensions science. *IHDP Update Issue 3*, 31-36.

Moser, S. C., Davidson, M. A., Kirshen, P., Mulvaney, P., Murley, J. F., Neumann, J. E., . . .Reed, D. (2014). Coastal zone development and ecosystems. In J. M. Melillo et al. (Eds.), *Climate change impacts in the United States: The third national climate assessment* (pp. 579-618). U.S. Global Change Research Program. Retrieved from http://nca2014.globalchange.gov/downloads

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*, *107*, 22026-22031.

MRAG Americas. (2009). *Systematic review of the needs and issues of the U.S. coastal resource management community*. Charleston, SC: National Oceanic and Atmospheric Administration Coastal Services Center. Retrieved from https://www.mragamericas.com/

National Oceanic and Atmospheric Administration. (2012). *State coastal zone boundaries*. Retrieved from http://coastalmanagement.noaa.gov/mystate/docs/StateCZBoundaries.pdf

National Research Council. (2011). *America's climate choices: Adapting to the impacts of climate change*. Washington, DC: National Academies Press.

O'Connor, R. E., Bord, R. J., & Fisher, A. (1999). Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Analysis*, *19*, 461-471.

O'Connor, R. E., Bord, R. J., Fisher, A., Staneva, M., Kozhouharova-Zhivkova, V., & Dobreva, S. (1999). Determinants of support for climate change policies in Bulgaria and the USA. *Risk Decision and Policy*, *4*, 255-269.

O'Connor, R. E., Yarnal, B., Dow, K., Jocoy, C. L., & Carbone, G. J. (2005). Feeling at risk matters: Water managers and the decision to use forecasts. *Risk Analysis*, *25*, 1265-1275.

Pielke, R. J., Prins, G., Rayner, S., & Sarewitz, D. (2007). Lifting the taboo on adaptation. *Nature*, *445*, 597-598.

Poortinga, W., & Pidgeon, N. F. (2003). Exploring the dimensionality of trust in risk regulation. *Risk Analysis*, *23*, 961-972.

Rabinovich, A., Morton, T. A., & Birney, M. (2012). Communicating climate science: The role of perceived communicator's motives. *Journal of Environmental Psychology*, *32*, 11-18.

Rasmussen, J. L. (1989). Analysis of likert-scale data: A reinterpretation of Gregoire and Driver. *Psychological Bulletin*, *105*, 167-170.

Siegrist, M., Earle, T. C., & Gutscher, H. (2007). *Trust in cooperative risk management*. London, England: Earthscan.

Slovic, P., Finucane, M. L., Peters, E., & MacGreg, D. G. (2004). Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Analysis*, *24*, 311-322.

Southeast Florida Regional Climate Change Compact. (2011). *A unified sea level rise projection for Southeast Florida* (A document prepared for the Southeast Florida: Southeast Florida Regional Climate Change Compact Technical Ad hoc Work Group, Regional Climate Change Compact Steering Committee). Retrieved from http://southeastfloridaclimatecompact.files.wordpress.com/2014/05/sea-level-rise.pdf

Stern, P. C. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *56*, 407-424.

Tam, J., & McDaniels, T. (2013). Understanding individual risk perceptions and preferences for climate change adaptations in biological conservation. *Environmental Science & Policy*, *27*, 114-123.

Tribbia, J., & Moser, S. C. (2008). More than information: What coastal managers need to plan for climate change. *Environmental Science & Policy*, *11*, 315-328.

von Mises, L. (1963). *Human action: A treatise on economics* (4th ed.). San Francisco, CA: Fox & Wilkes.

Walker, W. E., Harremoes, P., Rotmans, J., Van der Sluijs, J. P., Janssen, P., & Krayer von Krauss, M. P. (2003). Defining uncertainty: A conceptual basis for uncertainty management in model-based decision support. *Integrated Assessment*, *4*(1), 5-17.

Whitmarsh, L. (2009). What's in a name? Commonalities and differences in public understanding of "climate change" and "global warming." *Public Understanding of Science*, *18*, 401-420.

Wong, P. P., Losada, I. J., Gattuso, J.-P., Hinkel, J., Khattabi, A., McInnes, K., Saito, Y., Sallenger, A. (2014). Coastal systems and low-lying areas. In C.B. Field, V.R. Barros, D.J. Dokken et al. (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 Intergovernmental Panel on Climate Change* (p. 85). Cambridge, United Kingdom and New York, NY: Cambridge University Press

Zahran, S., Brody, S. D., Grover, H., & Vedlitz, A. (2006). Climate change vulnerability and policy support. *Society & Natural Resources*, *19*, 1-19.

Zahran, S., Brody, S. D., Vedlitz, A., Grover, H., & Miller, C. (2008). Vulnerability and capacity: Explaining local commitment to climate-change policy. *Environment and Planning C: Government and Policy*, *26*, 544-562.

Author Biographies

Nathan P. Kettle is a postdoctoral research fellow for the Alaska Center for Climate Assessment and Policy and Alaska Climate Science Center. His research focuses on the human dimensions of global environmental change, risk and uncertainty, trust, and the role of networks in climate change adaptation.

Kirstin Dow is a professor of geography at the University of South Carolina. Her research addresses vulnerability, adaptation, and decision making with respect to climate variability and change. She is a principal investigator for the Carolinas Integrated Sciences and Assessments, a National Oceanic and Atmospheric Administration (NOAA)-sponsored program, which seeks to link climate information and decision making.