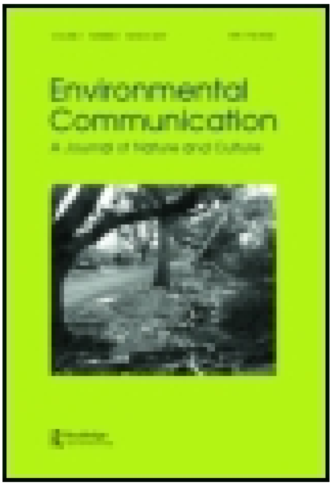

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J. Stuart Carlton & Susan K. Jacobson
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Using Expert and Non-expert Models of Climate Change to Enhance Communication

J. Stuart Carlton & Susan K. Jacobson

Climate change is a significant global risk that is predicted to be particularly devastating to coastal communities. Climate change adaptation and mitigation have been hindered by many factors, including psychological barriers, ineffective outreach and communication, and knowledge gaps. This qualitative study compares an expert model of climate change risks to county administrators' "mental" models of climate change and related coastal environmental hazards in Crystal River, Florida, USA. There were 24 common nodes in the expert and the combined non-expert models, mainly related to hurricanes, property damage, and economic concerns. Seven nodes mentioned by non-experts fit within, but were not a part of, the expert model, primarily related to ecological concerns about water quality. The findings suggest that effective climate outreach and communication could focus on compatible parts of the models and incorporate local concerns to find less controversial ways to discuss climate-related hazards.

Keywords: *climate change; mental models; climate communication; coastal environmental hazards; qualitative research*

Introduction

Climate change is a significant global risk that is predicted to be particularly devastating to coastal communities because of the effects of sea-level rise, coastal flooding, and increased storm activity. Climate change will likely erode shorelines,

J. S. Carlton (Ph.D.) was Healthy Coastal Ecosystems & Social Science Specialist, School of Natural Resources & Environment/Wildlife Ecology and Conservation, University of Florida, USA, at the time of the work. Susan K. Jacobson (Ph.D.) is Professor, Department of Wildlife Ecology and Conservation, University of Florida, USA. Correspondence to: J. S. Carlton, Texas Sea Grant College Program, Texas A&M University, Box 1675, Galveston, TX 77553, USA. Email: stuartcarlton@tamu.edu.

raise estuarine salinity (Intergovernmental Panel on Climate Change [IPCC], 2007), and cause significant disruptions in marine fisheries (Cheung et al., 2009). Climate change might amplify other stresses to the coastal environment such as water pollution, habitat loss, and overuse of natural resources (Tobey et al., 2010).

Despite climate change-related risks, many coastal communities are unprepared for either adapting to or mitigating the effects of climate change. A 2008 survey of coastal states, commonwealths, and territories in the USA and Canada found that 84% of them do not have a completed sea-level rise adaptation plan, and 56% have yet to begin development of such a plan (Coastal States Organization [CSO], 2008). A lack of appropriate physical and socioeconomic data (CSO, 2008) and competition over limited resources (Parkinson & McCue, 2011; Titus et al., 2009) may hinder institutional response to climate change. Lack of preparation goes beyond state and local governments: in a recent survey of Oregon coast professionals, defined as those who work in private or public sector jobs near the coast, less than half of respondents indicated that they were prepared to devote time or resources to climate change (Borberg, Jodice, Harte, & Corcoran, 2009).

Slow action on climate change is a result of individual and societal values, perceptions, processes, and power structures (Adger et al., 2009). Climate change is complex and remains controversial among the public, despite the consensus among climate scientists (IPCC, 2007; Leiserowitz, Smith, & Marlon, 2010). The public generally lacks knowledge of, or is confused about, the existence, causes, and effects of climate change, hindering action (Bord, Fisher, & O'Connor, 1998; Leiserowitz et al., 2010; Wolf & Moser, 2011).

Given the importance of local adaptation to climate change (Adger, Arnell, & Tompkins, 2005), successfully engaging with local policy-makers to spur adaptive and mitigative action is an important goal for climate outreach. There is evidence that local governments may be willing to take mitigative actions that offer other "co-benefits" such as financial savings (Kousky & Schneider, 2003). This study uses a mental models approach to compare government administrators' mental models of coastal environmental hazards to a more general model of the effects of climate change developed by Florida Sea Grant extension specialists. By focusing on environmental hazards in general, rather than climate change specifically, we hope to find co-beneficial "hooks," or common beliefs among experts and non-experts, for use in developing climate policy, outreach and communication. In doing so, we hope to achieve the practical goal of enabling better outreach while increasing our understanding of how the threat of climate change relates to other environmental hazards in non-experts' cognitive models.

The Wicked Problem of Climate Change Outreach and Communication

Given that climate is a statistical phenomenon that is not observable on a daily basis (Weber, 2010), people form their attitudes toward climate change indirectly. Psychological factors have been shown to affect this process. People's perception of climate change is affected by their attitudes and values, including environmental attitudes and political affiliation (Carlton & Jacobson, 2013). The cultural cognition of risk suggests that individual risk perception is influenced by group values, including those related to individualism, community, authority, and equality (Kahan, 2010). Cultural cognition also influences which data and experts are perceived as credible, causing disagreements about even the basic facts of climate change (Kahan, Jenkins-Smith, & Braman, 2011).

Incorrect or incomplete knowledge is not the only factor hindering public action on climate change. Psychological research has revealed several other challenges to action. Climate change is a long-term threat that is not attributable to specific actions, individuals, or institutions, and people tend to ignore those sorts of risks in favor of more salient and immediate risks (Moser & Dilling, 2004; Stern, 1992). The tendency to ignore climate change is exacerbated by the fact that the majority of US citizens tend to view climate change as a hazard that will affect people who are either geographically or temporally distant from the present-day USA (Leiserowitz, 2005). Scientists may have contributed to the perceived distance of climate change by defining global warming largely in future-oriented terms (Ungar, 2000). Even if climate change is perceived as a threat, people may be slow to take adaptive or mitigating actions because of (correctly or incorrectly) perceived risks of taking such action (Gifford, 2011).

The challenges described above suggest that climate change is an "unobtrusive" issue for most people, in which they have little personal involvement or knowledge. The media are often the main source of public information on unobtrusive issues (Lee, 2004). However media coverage reconstructs, rather than reflects, climate science (Carvalho, 2007) and is subject to partisan influence (Dotson, Jacobson, Kaid, & Carlton, 2012) and overinflating the level of scientific controversy about climate change to provide journalistic "balance" (Boykoff, 2007). Media coverage has often used climate skeptics to define climate change, framing the issue in terms of scientific uncertainty and controversy (Antilla, 2005). In short, the media have framed climate change in terms of controversy and conflict, reflecting and amplifying America's political divisions on the topic, rather than reflecting the scientific consensus on the issue (Nisbet, 2009).

Despite nearly 30 years of effort, climate change outreach and communication programs have not overcome skepticism and inaction to spur widespread public climate adaptation or mitigation (Wolf & Moser, 2011). Moser and Dilling (2011) make a compelling case that climate outreach and communication have been unsuccessful because of four faulty assumptions made by communicators, namely that: (1) the public does not act due to a lack of information and understanding; (2) the public would be motivated to act by fear; (3) describing climate change in scientific terms is the most persuasive way to frame the issue; and (4) mass communication is the best medium for communicating about climate change. The manner in which climate change communication is presented can heavily influence public reaction to the information (Spence & Pidgeon, 2010). By addressing these faulty assumptions, managers, policy-makers, and climate communicators can design outreach and communication campaigns that are more likely to inspire public action.

Qualitative research is an important, often overlooked component of designing education and outreach programs (Jacobson, 2009; Jacobson, McDuff, & Monroe, 2006) that can help address these assumptions. It can provide in-depth contextual information for understanding a system and can reveal important, potentially hidden concerns that might be missed in general quantitative studies (Patton, 2002). Such knowledge can help managers, communicators, and policy-makers frame management strategies, communication products, and policies to reflect the reality of what audience perception *is* rather than a theoretical conception of what audience perception *might* or *should* be.

Mental Models

Analysis of cognitive or "mental" models is a qualitative research approach that allows researchers to better understand the psychological context of an issue (Morgan, Fischhoff, Bostrom, & Atman, 2002). Mental models are simplified cognitive representations of a perceived situation (Johnson-Laird, 1983). Typically, people do not think of a piece of information or a situation in isolation, but as a part of a domain of knowledge with interweaving sets of relationships among concepts. These concepts and relationships collectively form a mental model representing someone's internal representations of an external system (Chi, 2008) and are a source for people's expectations about how a system works (Wickens, 1984).

An individual's mental model is informed by their experiences, attitudes, and values (Gentner & Stevens, 1983). Mental models are constructed through an iterative process in which an individual receives new information and filters it through their existing models. People tend to reject novel information that conflicts with, and accept information that agrees with, their existing mental models, though new information can cause a mental model to shift over time (Morgan, Fischhoff, Bostrom, & Atman, 2002). The personal nature of mental model construction means that an individual's mental model may be basic or thorough, accurate or error-ridden (Norman, 1983). Individuals use contextually relevant mental models as a basis for interacting with each other and mental model compatibility is a critical component of team performance (Cannon-Bowers, Salas, & Converse, 1993). Analyzing mental models reveals people's understanding of the relationships among different aspects of an issue.

Because of the individual nature of mental model construction, experts and non-experts tend to have different mental models for a given phenomenon (Bostrom, Morgan, & Fischhoff, 1994). Experts' mental models tend to be much more thorough, rational, and accurate than non-expert models, and experts may actually be able to "run" potential actions through their model to accurately predict the consequences of these actions (Klein, 1989). The expert/non-expert gap hinders communication when factors that experts consider relevant and important within a system are not relevant or important to non-experts, and vice versa (e.g., Zaksek & Arvai, 2004). Climate change is an area in which an expert/non-expert gap persists (Bord et al., 1998; Bostrom et al., 1994; Leiserowitz et al., 2010) in terms of knowledge and confidence in knowledge (Sundblad, Biel, & Gärling, 2009). Relatively low levels of knowledge and confidence in knowledge make it less likely that people will process new information about climate change (Böhm & Pfister, 2001), contributing to the relative ineffectiveness of climate outreach.

One strategy for climate outreach and communication is to find non-controversial ways to frame climate information (Carlton & Jacobson, 2013; Center for Research on Environmental Decisions [CRED], 2009; Hardisty, Johnson, & Weber, 2010). Focusing on mental models allows researchers and communicators to find specific topics, areas, and concepts to emphasize that are climate-related but avoid the controversy often associated with climate change. A similar approach was used in a study of models of genetic disease inheritance, which found that people tended to have one of three general mental models, a fact that could be used to design educational materials to aid in genetic counseling sessions (Henderson & Maguire, 2000).

Mental models have been used to understand risk perceptions in a variety of systems. For example, researchers studied expert and non-expert models of chemical hazards to reveal information gaps, including areas where users were not appropriately concerned with proper chemical safety (Cox et al., 2003; Niewöhner, Cox, Gerrard, & Pidgeon, 2004). This information was used to develop workplace communications, and the mental models were found to be an important part of improving such communications (Niewöhner et al., 2004). This approach has been applied to other risks, including radon (Bostrom, Fischhoff, & Morgan, 1992) and risks from flash floods (Wagner, 2007).

Several studies have examined mental models of climate change. A mental models approach was used to compare expert and non-expert views of climate change in Pittsburgh, PA (Bostrom et al., 1994; Read, Bostrom, Morgan, Fischhoff, & Smuts, 1994). Researchers compared the mental models of adults and found that people were concerned about climate change but were confused about many aspects, such as the difference between climate and weather. Additionally, respondents were not necessarily aware of regulatory actions being taken (Bostrom et al., 1994). A subsequent survey showed that these misunderstandings were relatively common and that people tended to confuse good environmental practices with specific strategies to prevent climate change (Read et al., 1994).

Another study using a modified mental models approach found that highly educated adults—graduate students at MIT—had mental models of climate change that implicitly violated the law of conservation of matter (Sterman, 2008; Sterman & Sweeney, 2007). A different study focused solely on experts to describe three conceptualizations of climate-related danger: human influence upon the climate system, impacts upon natural and human communities, and threats posed to the status quo by the costs and difficulty of mitigation measures (Lowe & Lorenzoni, 2007).

While these prior studies provide valuable information about public perception of climate change, they have focused on students (Sterman, 2008), experts (Lowe & Lorenzoni, 2007), or members of the general public (Bostrom et al., 1994). However, climate adaptation happens at multiple scales. Successful communication with policy-makers is a component of building adaptive capacity (Adger et al., 2005), and there is a need to understand how climate change is perceived by policy-makers. Additionally, prior climate change mental models research largely focused on climate change in isolation. This study takes a new approach, comparing policy-makers' models of relevant environmental hazards to an expert model of climate change to look for areas where adaptation to climate change overlaps with adaptation to other environmental risks. Focusing on locally relevant environmental hazards, rather than just climate change, allows us to look for specific targets for outreach and communication.

Research Question

How do county government administrators' mental models of coastal hazards compare to an expert model of climate change hazards?

Methods

Study Site: Crystal River, Florida

Crystal River is a city of approximately 3300 people (US Census Bureau, 2013) located on the Gulf coast in north-central Florida near an eponymous river. The Crystal River-King's Bay area is known for clear, spring-fed waters, a sizable ecotourism industry, and has become a winter haven for the endangered West Indian manatee (*Trichechus manatus*). Crystal River is part of Citrus County, which has approximately 140,000 residents.

Mental Models Interviews

Semi-structured, open-ended mental models interviews were conducted in the spring of 2011 with eight government administrators in Crystal River and Citrus County, Florida. These administrators compose the non-experts in this study and were identified as key informants by long-tenured county extension personnel who were well-integrated into the local community. While confidentiality agreements prevent reporting the specific names/job titles of the interview subjects, respondents included 4 of the 12 administrators at or above the Assistant County Administrator level (up to and including County Commissioners), 4 of the 26 administrators within relevant county departments (public works, water resources, etc.), for a total of 8 of the 38 (21%) highest-level administrators in the county. On average, respondents had worked in Citrus County Government for 12.8 years. Previous mental models studies have shown that a small number of interviews are sufficient to identify most widely held beliefs about the system (Morgan, Fischhoff, Bostrom, & Atman, 2002). Thus, this purposive sample likely captures much of the diversity of people contributing to policy decisions and should be large enough to reveal many, though not all, of the relevant beliefs.

An interview guide was developed based on an "expert model" created and provided by cooperative extension personnel and scientists at Florida Sea Grant (Figure 1). Florida Sea Grant is a university-based partnership between the University

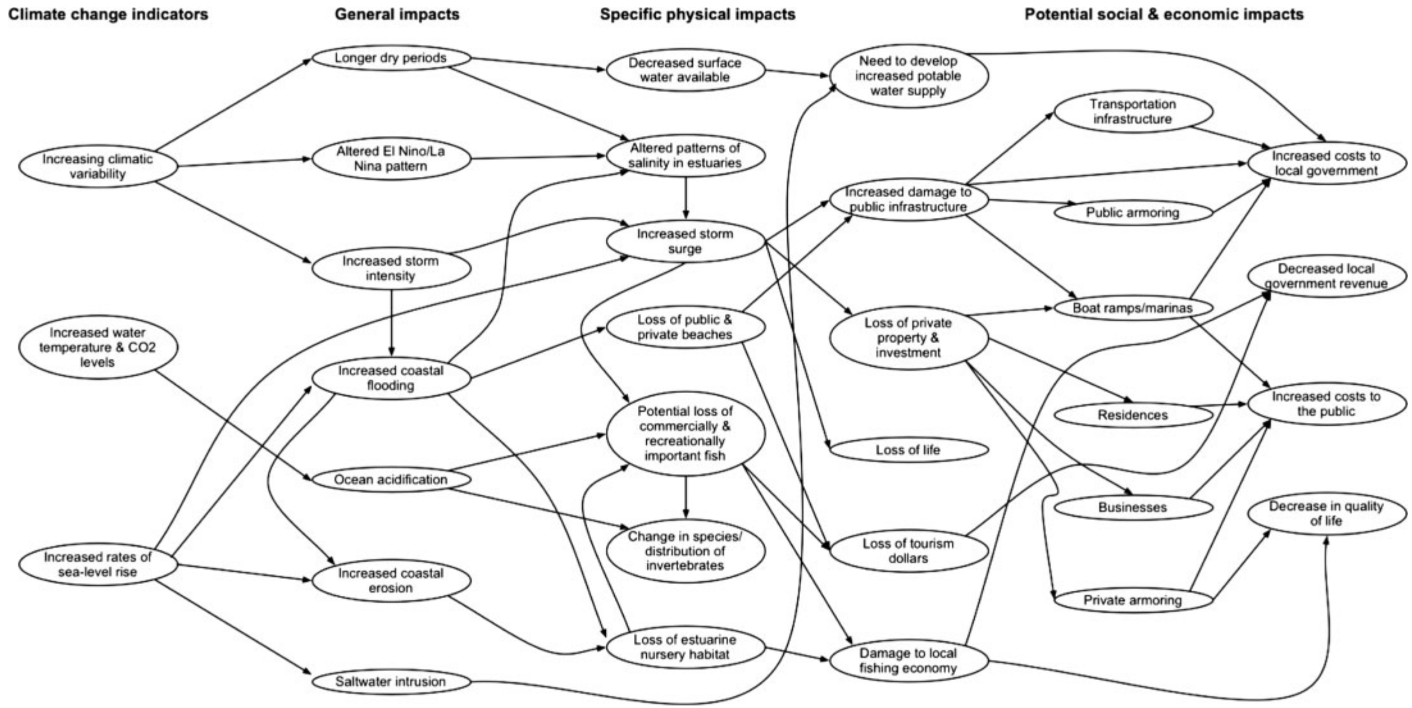

Figure 1. Climate change expert model, developed by Florida Sea Grant outreach personnel.
Note: Arrows indicate a causal or influential relationship.

of Florida, the Florida Board of Education, and the National Oceanic and Atmospheric Administration to support research, education, and extension to conserve coastal resources and enhance economic opportunities for the people of Florida. The expert model was created by outreach personnel at Florida Sea Grant for this project, and was intended to represent the outreach personnel's understanding of the effects of climate change in coastal Florida. The authors of this study did not participate in the creation of the expert model. Since the goal of the study was to compare the models and not assess their validity, and the expert model represented the understanding of the extension specialists, no effort was made to verify the expert model for accuracy or validity. The interview guide for policy-makers was pilot tested with six members of the public unassociated with the study and minor revisions were made to question clarity. As with many mental models studies (e.g., Morgan, Fischhoff, Bostrom, & Atman, 2002), the expert model was used as a starting point for the non-expert interview guide to draw conclusions about improving communication, but the format of mental models interviews ensured that participants' responses were not restricted to information found in the expert model.

Mental model interview questions are intentionally vague, allowing respondents to free-associate among concepts with minimal direction from the interviewer (Morgan, Fischhoff, Bostrom, & Atman, 2002). Interviews for this study, which focused on environmental risks in the City of Crystal River, began with a general question: "What comes to mind when you think of living in Crystal River, especially as it relates to the natural environment?" After exhausting the response to this question, follow-up prompts were asked, such as "Anything else?" After the introductory question and follow-up, a slightly more directed question was asked: "Are there any hazards or dangers associated with the natural environment in Crystal River?" This question was followed by general prompts for more information (e.g., "what else can you tell me about hazard x?," "can you explain hazard x?," "what causes hazard x?," etc.) or for additional hazards (e.g., "are there more environment-related hazards that come to mind?").

Once the topics raised by the general questions were exhausted, directed questions were asked to ensure that four major areas from the expert model (climate change, sea-level rise, storm surge, and coastal erosion) were covered in the interview. The directed questions were followed up in a similar manner to the general questions. The movement from general to specific in mental models interviews allows the respondent to discuss the issues that are most important to them while ensuring that the interview covers all of the topics required for comparison.

Interviews were 25–100 minutes long, depending on the respondent. Interviews were recorded, transcribed, and made anonymous for coding and analysis.

Constructing the Models

Interview transcripts were coded by a single coder (Miles, Huberman, & Saldaña, 2014) for three types of information: environmental risks, causes of environmental risks, and effects of environmental risks. These themes were chosen because the purpose of the study was to use qualitative techniques to focus specifically on the causes and consequences of environmental hazards to develop a more nuanced understanding of the system for outreach purposes. Pilot-test interviews were used to develop a code book that was revised and refined in consultation with a second researcher. The final coding was done by a single coder (JSC). Though mental models are complex, they can be represented by mental models diagrams of nodes and links between them (Morgan, Fischhoff, Bostrom, & Atman, 2002). The diagrams were created in an emergent process in which each individual risk, cause, or effect was considered a "node" in the mental model, and nodes that respondents explicitly connected were joined with "links." Only risks, causes, or effects that were explicitly mentioned by the respondent were included in the models. Causes could be mentioned either before or after effects, but the nodes were only connected if there was a direct cause–effect relationship mentioned.

To explore the relationship between the expert and non-expert models, the individual mental models were melded with the expert model to create a combined model. This model gives a visual sense of the overlap and discrepancy between the expert and non-expert models. To create the combined model, each node and link on the expert model was marked with the number of respondents (i.e., up to eight) who had the node in their mental model of coastal environmental hazards. Additionally, any risk, cause, or effect that was not on the expert model but was connected to existing nodes on the expert model was added as a node to the combined diagram. When possible, similar concepts were combined into a single node to aid in interpretation. This combined model was used to make specific communication recommendations. All model diagrams were created manually using OmniGraffle Pro 5 (The Omni Group, Seattle, Washington). Though this is a qualitative study, descriptive statistics were calculated to provide a rough measure of the relative frequency of different topics.

Results and Analysis

The results are presented in an order adapted from suggestions made by Morgan, Fischhoff, Bostrom, and Atman (2002), with two example mental models presented before a description of the areas of overlap between the experts and non-experts. The expert model was described in the Methods section, above, and presented in Figure 1. Additionally, further qualitative detail on the nodes is provided to help elucidate similarities and differences between the expert and non-expert models.

Non-expert Mental Models

The first example non-expert model came from an elected, high-level county administrator and consisted of 29 nodes with 35 links (Figure 2). Fourteen of the nodes "mapped" (i.e., fit within an existing node) onto the expert model: climate change, sea-level rise, coastal erosion, drought, aquifer drawdown, severe weather extremes, hurricanes and non-hurricane storm events (mapped to "increased storm intensity" on the expert model), storm surge, coastal flooding, property and

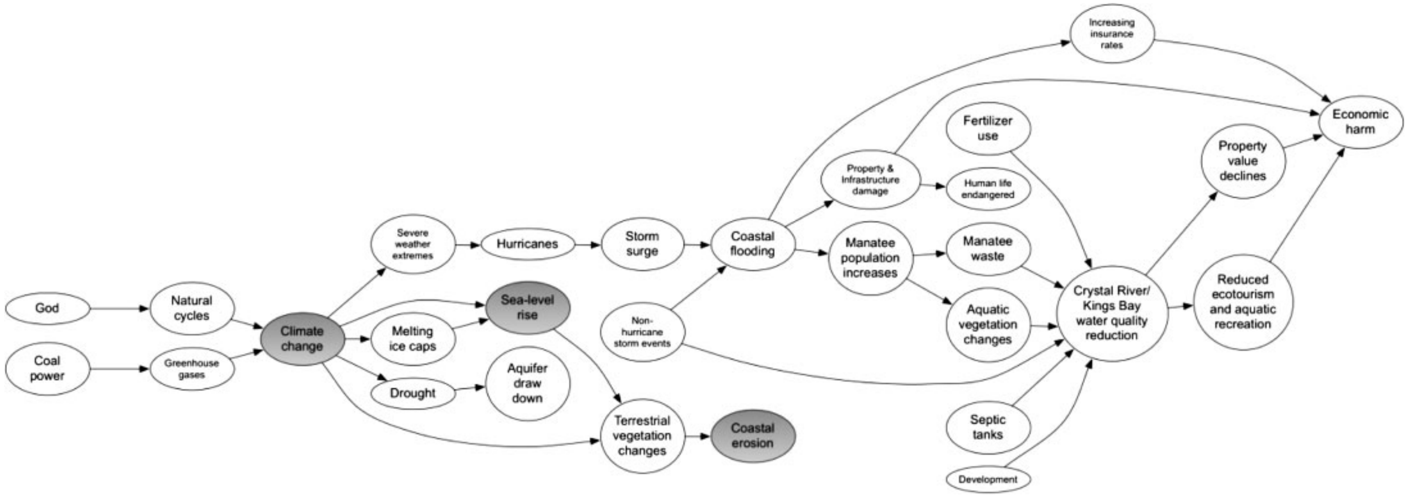

Figure 2. Sample high-level administrator mental model of climate change and coastal environmental hazards in Crystal River, Florida. Note: Shaded nodes were verbal cues raised by the interviewer.

infrastructure damage (mapped to "increased damage to public infrastructure" and "loss of private property"), human life endangerment, reduced ecotourism, and economic harm. Fifteen of the nodes did not map to the expert model, including several causes of climate change (God, natural cycles, coal power, and greenhouse gases), effects of climate change (melting ice caps, terrestrial vegetation changes, water quality reduction in Crystal River/King's Bay, manatee population increases, manatee waste, aquatic vegetation changes), local environmental issues (development, septic tank-related pollution, fertilizer use), and local economic issues related to environmental risks (property value declines and increasing insurance rates).

The second example non-expert model came from a departmental administrator who works in a natural resource-related department (Figure 3). The model comprised 37 nodes with 49 links. Seventeen nodes mapped onto the expert model: climate change, sea-level rise, coastal erosion, severe weather extremes, drought, hurricanes and non-hurricane storm events (mapped to "increased storm intensity"), storm surge, coastal flooding, aquifer drawdown (mapped to "decreased surface water available"), property and infrastructure damage, human life endangerment, loss of coastline, saltwater intrusion, fish population declines (mapped to "damage to local fishing economy"), reduced ecotourism and aquatic recreation, and economic harm. Twenty nodes did not map to the expert model: greenhouse gases as a cause of climate change; terrestrial vegetation changes and natural limestone loss as a cause of coastal erosion; lack of swamp buffers as a cause of property and infrastructure damage; Crystal River/King's Bay water quality reduction; manatee population increases, aquatic vegetation changes, boat traffic, septic tanks, increases in aquatic nitrate levels, fertilizer use, nutrification, algae blooms, and shoreline hardening as causes of water quality reduction; increases in aquatic parasites, human health problems, invasive aquatic plants, and loss of native plants as an effect of water quality reduction, and property value declines and increasing insurance rates as causes of economic harm.

Comparing the Non-expert and Expert Models

Including the four discussion guide topics, the combined model contained 24 nodes common to the expert model and one or more of the non-expert mental models (Figure 4). Most of the climate change impacts that were common between the models were related to hurricanes and other storms, property damage, and economic harm. For clarity, nodes common to the expert and at least four non-expert models are listed in Table 1. The nodes common to the expert model and all eight of the non-expert models are described below, with node names presented in italicized text.

In the case of hurricanes and other storms, *increased storm intensity and storm surge* were mentioned by all eight of the non-experts. This worry was mentioned both in terms of wind damage and storm surge, as exemplified by one high-ranking elected official:

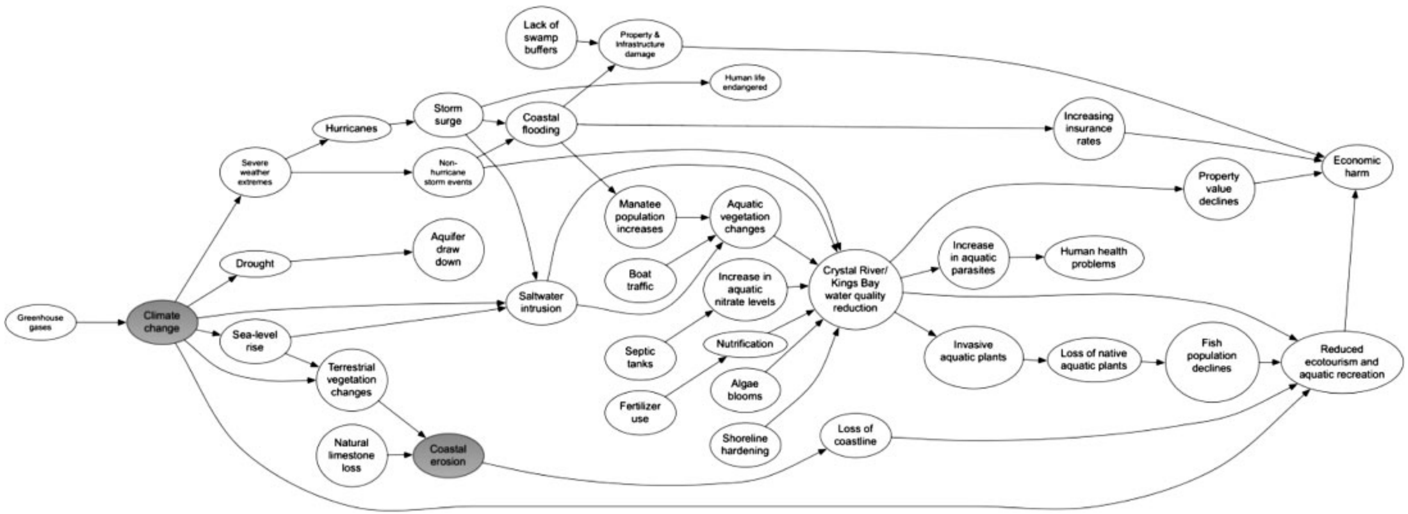

Figure 3. Sample department-level administrator mental model of climate change and coastal environmental hazards in Crystal River, Florida.

Note: Shaded nodes were verbal cues raised by the interviewer.

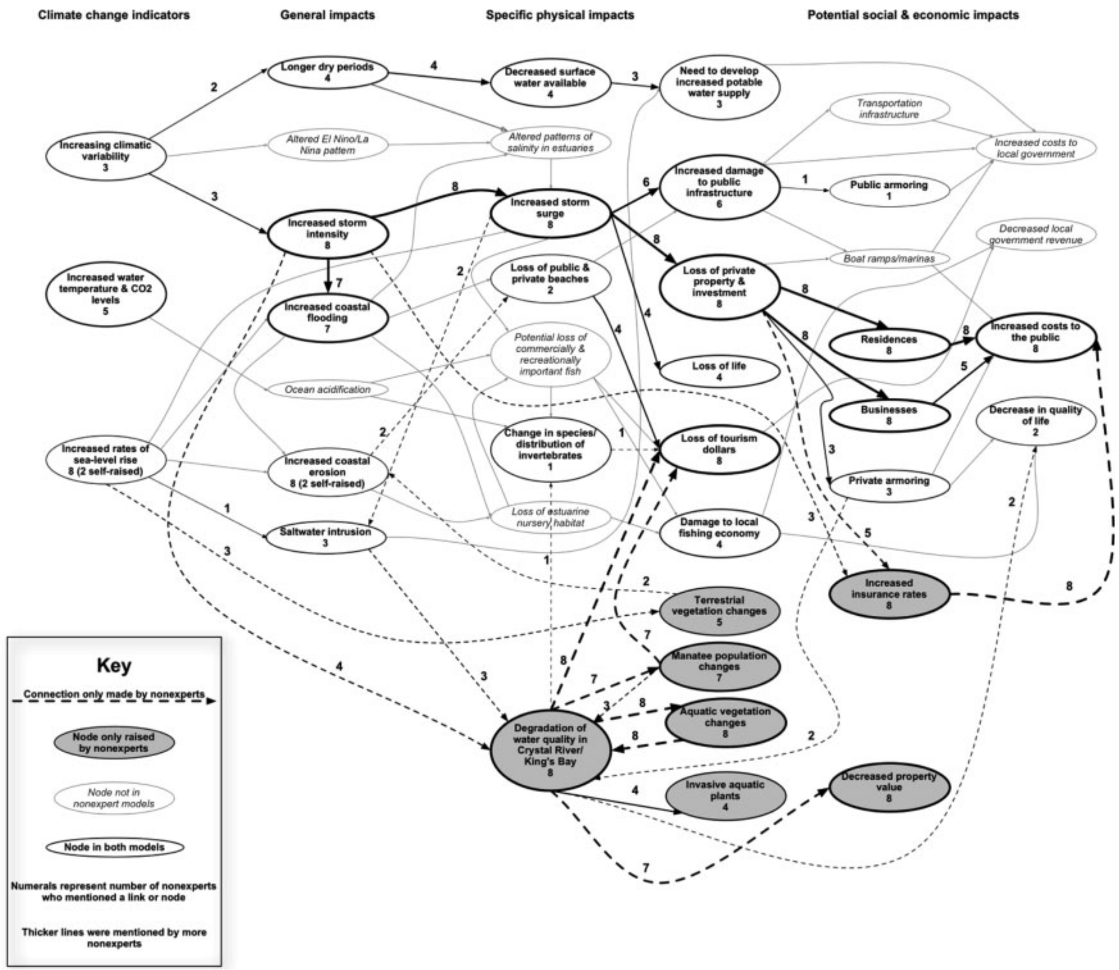

Figure 4. Expert model of climate change hazards in Crystal River, Florida with non-expert nodes added.

Table 1. Key nodes common to the expert model and non-expert models.

Items	Unprompted non-expert mentions
Increased storm intensity	8
Increased storm surge	8
Loss of private property and investment	8
Loss of tourism dollars	8
Damage to local residences	8
Damage to local businesses	8
Increased costs to the public	8
Increased coastal flooding	7
Increased damage to public infrastructure	6
Increased water temperature/CO_2 levels	5
Longer dry periods	4
Decreased surface water availability	4
Loss of life	4
Damage to local fishing economy	4

Note: Nodes included in this table were mentioned without prompting by four or more non-experts.

> The Sheriff's Office, who handles emergency management for Citrus County, put out their annual hurricane guide a couple years ago, and the cover of that was a picture of this building with a storm surge about five feet above it. (With) that really major storm surge, like a Category 4, Category 5 storm, this whole town goes under water … we can't stop the storm surge. Even though we're seven miles removed from The Gulf, it's all flat. There's nothing to really stop high water, other than the seven miles. We would have very significant difficulty if we got that kind of a storm surge.

More specifically, the non-experts were concerned that hurricanes and other storm events would cause *loss of private property* and infrastructure damage to homes and businesses:

> A storm surge [from a] Category 2 (hurricane) is gonna wipe out a huge percentage of the homes … the [new homes] that are up on pilings ten feet above sea level, probably will survive, but we'll have huge infrastructure disruption. The coastal roads will be wiped out.

Another common concern for non-experts was a reduction in ecotourism and a *loss of tourism* dollars, a major part of the local economy. This concern seemed directly tied to local environmental quality as a driver of tourism:

> [A]s the water quality declines, we may lose some of that tourist base, and there's nothing to step up and replace that. And that's a clean industry. And since we have retirees, we don't have a good diverse economic base at this time, [loss of ecotourism] is a real concern to everybody. We'd like to keep that, because that's a clean industry.

The final concern mentioned by all of the non-experts was a general degradation to the economy, specific costs related to recovery from a severe hurricane or storm, or property value declines resulting in *increased costs to the public*, as illustrated in this quote from a department-level administrator:

> At some point in time, either through man's actions such as regulation and controls or through environmental degradation, the ecotourism is going to start to drop off. And that's a major component in this economy.

Seven nodes were only raised by non-experts but still fit within the expert model classification scheme of "general impacts," "specific physical impacts," and "potential socioeconomic impacts." The nodes are summarized in Table 2 and those common to all eight non-expert models are described below.

Many of the non-experts' ecological concerns were related to *reduced water quality in Crystal River/King's Bay.* These specific local problems, which were absent from the expert model, were often related to water clarity loss and other problems:

> For anybody who has been here for a fairly reasonable amount of time, it's obviously degraded significantly from what they were used to, or what they remember. And that's a major concern within this community … visibility is poor. The bottom has gotten a lot of sedimentation.

The importance of Crystal River and King's Bay water quality manifested itself in other ways that were not explicitly contained in the expert model. For example, each respondent expressed worry about current and future *property value declines*, especially as resulting from the effects of water quality reduction, such as in this quote from a department-level administrator:

> [W]hen that river was gin clear, and the water was crystal blue [waterfront properties] would be a jewel. And now, when [the Crystal River] is just green, pea green, it's just a regular river, and [the property is] not as valuable.

Additionally, each of the non-experts was worried about *aquatic vegetation changes*, such as shifts in species composition and algal blooms. This concern was often linked to manatees, as stated by a county-level administrator:

> I know that when we think about manatees, they're a wonderful thing to look at, and they're a big attraction, but what are they doing about the natural grasses that they're eating, that clean and filter the water? You can't grow it back fast enough. They did a replanting in (a nearby spring), and after eight or nine months the (manatees) knocked it down and ate it, so there wasn't enough time to get a natural replanting growth back in there.

Table 2. Non-expert nodes absent from the expert model.

Items	Non-expert mentions
Water quality loss in Crystal River/King's Bay	8
Aquatic vegetation changes	8
Increased insurance rates	8
Decreased property value	8
Manatee population changes	7
Terrestrial vegetation changes	5
Invasive aquatic plants	4

Other ecological concerns mentioned by all of the non-experts but not in the expert model included *terrestrial vegetation changes* that might result from sea-level rise and climate change:

> We are seeing vegetation that has a low salinity tolerance dying off, and many of those are canopy-type trees. And so, we're seeing that vegetation shift. When those trees die off, they in turn present opportunities for invasive species like Brazilian Pepper to come in.

Finally, each of the non-experts was concerned about the potential for *increased insurance rates*, particularly in response to flooding or hurricane risks:

> Oh, yes. I mean, not only is (flooding) a problem … when it gets into homes and causes damage … look at the insurance industry. The insurance industry for the most part won't even write policies anymore in Florida … I can tell you this, if you live west of (US Route) 19, your chances of getting a policy are slim to none and you're gonna pay through the nose.

Climate Change: Unobtrusive and Secondary

Though the interview guide included several questions about climate change, respondents often engaged in little discussion of climate change compared to other environmental risks. Climate change was mentioned unprompted by only three of the non-experts (Figure 4). The indicators of climate change described in the expert model (increased climatic variability, increased temperatures and CO_2 levels, and increased sea-level rise) were rarely mentioned by respondents (Table 3). One possible reason for this discrepancy is that respondents perceived climate change as less important than other environmental hazards:

> There are more pertinent issues. How to deal with the nitrates? How to deal with the (water) nutrient standards? And quite frankly, we need to deal with the stormwater runoff, but we don't have the money right now.

When climate change was mentioned, it was often presented as something affecting other places than Crystal River:

> climate change, you can see the effects on the small Pacific Islands that are inhabited where they can't grow crops anymore because there's no freshwater lens anymore on those islands. Impact on our coast is gonna be minimal … it's an interesting phenomena, one I'm certainly not going to solve.

Table 3. Expert model climate change indicators mentioned by non-experts without prompting by the interviewer.

Climate change indicators	Non-expert mentions
Increased water temperature and CO_2 levels	5
Increasing climatic variability	3
Increased rates of sea-level rise	2

The issue of local control, raised in the last quote, was common as well, as several respondents indicated that they were less concerned with climate change than other environmental issues because of a perceived or actual lack of ability to affect climate change: "(Climate change) is natural evolution. You're not going to stop it." Perceived instrumentality (that is, an individual's belief that their actions will influence an outcome) can influence whether or not people take actions to mitigate climate change (Spence, Poortinga, Butler, & Pidgeon, 2011), and this effect may be especially strong when there are other issues perceived as more pressing.

Conclusions

A mental models approach is effective in identifying and mitigating communication gaps in a specific system (e.g. Byram, Fischhoff, Embrey, de Bruin, & Thorne, 2001; Kovacs, Fischhoff, & Small, 2001; Wagner, 2007). A mental models approach was effective in supporting the design of better communications about chemical risk in the workplace (Niewöhner et al., 2004). Other researchers compared an expert model on breast implant risks from the scientific literature with mental model interviews with women patients (Byram et al., 2001). They were able to make recommendations about specific facts and educational programs for better targeting misconceptions and improving the decision-making process.

One of the strengths of a mental models approach is that it elicits interwoven sets of causes and effects that can contain relationships that are explicit and direct or implicit and indirect. By comparing non-expert mental models of environmental hazards to an expert model of climate change, this study showed how considering the relationships between the models allows communicators and policy-makers to find areas of commonality in otherwise controversial topics. The results suggest that a path to effective climate outreach and communication may lie in focusing on non-controversial areas that may be only indirectly related to climate.

Implications for Climate Change Communication and Outreach

When comparing the models, the combined non-expert models did not map perfectly onto the expert model, which is typical for mental models studies (e.g., Bostrom et al., 1994; Cox et al., 2003; Niewöhner et al., 2004). Additionally, the higher frequency of the unique non-expert nodes (which were mentioned by 6.9 respondents on average), which tended to be about local environmental or ecological problems, than the "combined" nodes (averaging 4.83 mentions per node), which tended to be more about climate change directly, supports prior research showing that people in the USA tend to view climate change as less salient than other environmental concerns (Leiserowitz, 2005).

The often-simplistic descriptions of climate change, and the perception of climate change as less important than other hazards, supported the idea that climate change is an unobtrusive issue for many of the respondents. Though mass media are an important source of information for unobtrusive issues (e.g., Lee, 2004), targeted outreach may be a better channel for climate communication (Moser & Dilling, 2011). This research suggests specific strategies for targeting climate communication by focusing on the combined expert/non-expert model, which gives a general sense of the understanding of a diversity of people who contribute to policy decisions in Crystal River.

Researchers have found that people tend to ignore threats that are distant, general, or not caused by specific, identifiable actions (CRED, 2009; Moser & Dilling, 2004; Stern, 1992). The common nodes in this model reveal threats that are more specific, local concerns that the non-experts are more likely to act on. However, the non-experts' more immediate concerns about the ecological health of the Crystal River/King's Bay area may be a good source for targeted communication, as well. Water is a key local characteristic, as water and water-quality issues were the most nuanced and detailed part of the models. Prior research has shown that a sense of nature-based place attachment is associated with pro-environmental behaviors (Gifford, 2011; Vaske & Kobrin, 2001). These results revealed a sense of nature-based attachment to Crystal River, especially around the concept of water:

> The (name) "Crystal River" in and of itself indicates that the water is going to be clear, clean and fresh and just because I'm familiar with the different river systems I just always think of … water when I think of Crystal River specifically.

Despite the local importance of water quality in supporting a thriving tourism industry, water quality was a minor focus in the expert model. Moreover, hazards that might have initially seemed important to external experts were not necessarily important in the local mental models. For example, the risks associated with fish population declines did not seem salient or important to respondents compared to other hazards. This was an unexpected result, as Crystal River is a coastal community with an active fishing industry.

Linking climate change effects and adaptation strategies to more relevant, local issues might harness people's sense of attachment to Crystal River and increase the likelihood of climate action. Local issues like water quality may be more "available" than climate change (Kahneman & Tversky, 1982), and are therefore more likely to overcome the cultural biases against action on climate change (Kahan et al., 2011). Additionally, focusing on issues that are already concerning to local policy-makers and residents increases the chance of recognizing co-benefits (Kousky & Schneider, 2003) between acting to adapt to or mitigate climate change and other locally relevant goals. Here, we have shown how a community of policy-makers can have concerns that may be addressable in a way that is co-beneficial with climate change adaptation.

Because it is impractical for communicators and policy-makers to have detailed knowledge of every community at hand, it is important to incorporate local qualitative research when working with communities. As this research shows, locally based qualitative data can provide an empirical, context-specific understanding to improve climate outreach and communication. The information contained in the local non-expert models might not be apparent to distant scientists or communicators. Involving stakeholders to create collaborative, cultural models of risk, as opposed to a one-way, technical model, can improve risk communication (Cox, 2006). Non-experts and experts working together to define locally relevant, climate-related risks may increase risk salience and perceived instrumentality, increasing the likelihood of climate change adaptation and mitigation. Climate change inaction is partially a result of climate change seeming less important and distant (Gifford, 2011). Increasing the amount of qualitative research defining and contextualizing local understanding of climate change can help communicators make climate change more salient and pressing. As the use of qualitative research to improve communication expands, these strategies need to be empirically tested, and the results shared, to further our knowledge of the efficacy of communication strategies based on local knowledge (Kahan, 2014).

Implications for Mental Models Research

A mental models approach is useful for enhancing communication programs for a number of reasons: a mental models approach can be used to detect people's basic knowledge on a specific concept; discrepancies between expert models and lay person's models can be identified and addressed, with communication programs building on current knowledge; more in-depth information can be obtained with an open-ended, gently guided response format, that also provides an opportunity for researchers to clarify responses during the interviews; and findings from mental models can be used to develop salient questions for quantitative research (Fischhoff, Riley, Kovacs, & Small, 1998; Morgan, Fischhoff, Bostrom, & Atman, 2002, Wu, 2009).

Mental models are used to describe a target concept, explain the system, and predict its future (Rouse & Morris, 1986). Much of the research using mental models has focused on aiding communication related to a single risk phenomenon, such as radon exposure (Bostrom et al., 1992), chemical hazards (Cox et al., 2003, Niewöhner et al., 2004), or flash floods (Wagner, 2007). Even the early work on climate change mental models (Bostrom et al., 1994; Read, Bostrom, Morgan, Fischhoff, & Smuts, 1994) had a fairly narrow focus on specific climate change phenomena.

This study took a different approach, expanding beyond the risks of climate change and into related environmental risks and hazards, and mapping respondents' models of these hazards to an expert model. By examining the broader context of the relationship between the risks of climate change and other risks, new connections were revealed and the number of potentially relevant nodes was expanded. The mental models interview process revealed not just respondents' understanding of the hazards in the system but also cause–effect relationships between the hazards. Combining the expert and non-expert nodes on a single diagram enables a direct, visual comparison between expert and non-expert views of a system. The combined diagram can improve communication among experts and non-experts by telling a powerful visual story about how experts and non-experts agree and disagree about the hazards within a system. This can help communicators identify, as Kaplan (2000) termed it, multiply desirable solutions. A mental models approach should be useful in other situations involving controversial phenomena when, as with climate change, there is significant disagreement about even the most basic concepts.

Limitations

This study has several limitations. As qualitative research with a small number of individuals in one coastal community in Florida, the specific results cannot be generalized. Additionally, the difference in the process of creating the expert model and creating the non-expert models may have contributed to some of the discrepancies between the models. The non-expert models were created from a single interview with each respondent, and likely do not contain all of the information known by the subject about climate change and other coastal environmental hazards. Additionally, some detail in the non-expert models may have been lost as specific concepts were combined into general nodes. Finally, the expert model likely does not perfectly represent either the scientific consensus of the effects of climate change in Crystal River or how all outreach and communication specialists, not just those at Florida Sea Grant, feel about the system.

However, we believe that the models created in these interviews are a reasonable representation of the aspects of coastal environmental hazards that were most salient to the respondents. While the similarities and differences between the expert and non-expert models might not be canonical, they are instructive, and point to the critical importance of on-the-ground research when designing effective outreach.

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ORCID

J. Carlton http://orcid.org/0000-0003-2530-8688

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