Risk, Hazards & Crisis in Public Policy
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Learning in the Aftermath of Extreme Floods: Community Damage and Stakeholder Perceptions of Future Risk

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Policy learning in the aftermath of extreme events can happen as a result of changes in beliefs, attitudes, behaviors, and perceptions of stakeholders acting in a coordinated manner. Understanding the factors that impact these beliefs may prove critical in understanding policy learning and change, since these can mean the difference between ongoing flood vulnerability as a consequence of extreme weather events rather than long-term resilience. Data from in-depth interviews, stakeholder surveys, public meeting documents, and community demographics were used to analyze stakeholder processes and risk perceptions in seven Colorado communities that were flooded in 2013. Differences in extent of damages and resource capacity have led to a diversity of venues and participatory processes to manage flood recovery across the case communities. The results of the stakeholder survey suggest that perceptions of problem severity are linked to past flood experiences, type of expertise and job position. Taken together, these results suggest who participates in flood recovery processes, specifically their position and field of expertise, may influence how flood risks are perceived at the community level.

KEY WORDS: risk perception, disaster recovery

Introduction

One of the most damaging natural hazards, flooding annually causes billions of dollars in damage, response, and recovery losses for U.S. communities and these costs appear to be increasing (Brody, Zahran, Highfield, Bernhardt, & Vedlitz, 2009). As more people move into flood prone areas, communities are becoming more vulnerable to floods. The locus of flood management has shifted from the federal to the local level and communities are now more responsible for making decisions about the adoption of flood-related policies (Brody et al., 2009). Globally, flooding is predicted to increase as climate changes and communities continue to build in floodplains, setting up the potential for long-term challenges.

Local-level processes drive decisions about mitigating future flood risks, such as if, how, and where to rebuild, as well as changes in zoning practices, building codes and public outreach programs. Because of their potentially recurring nature, floods offer an opportunity for communities to learn from and adapt to these

Published by Wiley Periodicals, Inc., 350 Main Street, Malden, MA 02148, USA, and 9600 Garsington Road, Oxford, OX4 2DQ.

experiences with the goal of increasing resiliency through reflection, modification of former policies, and adoption of new policies. A key component of a community's ability to learn from disaster is whether decision-makers and community members perceive that the risk of disaster is constant or increasing over time. Perceptions of future risks and learning about long-term risks may shift in response to experiencing a flood event, as may preferences for various policies put in place to help a community recover (Brilly & Polic, 2005; Wachinger, Renn, Begg, & Kuhlicke, 2013). By following the response to catastrophic floods that happened in September 2013 in Colorado, within seven Colorado communities, we examine if perceptions of flooding differ across stakeholders in flood-related decision-making processes and whether there is variation across causal understanding of flooding, and if so, if this variation can be linked to differences in collaborative processes conducted during community flood recovery, which may influence community recovery movement towards resilience.

Stakeholder Processes

The type of participatory processes that communities use to make decisions in the wake of disasters such as floods may help explain the degree of change towards resilience communities undergo. Over the past several decades, municipalities in the United States, as well as elsewhere, have employed a variety of participatory, collaborative, and stakeholder processes, especially in the realm of environmental management. These processes vary along a number of dimensions, including type of participants (e.g., government, civil society organizations, experts, citizens); scale of process (e.g., local, regional, national) (Margerum, 2008); the level of governance (e.g., government-led, citizen-led, hybrid) (Moore & Koontz, 2003; Steelman & Carmin, 2002); and method or intensity of participation (e.g., public hearings, public advisory committee, consensus meetings) (Arnstein, 1969; Beierle, 2002; Rowe & Frewer, 2000; Sten Hansen & Mäenpää, 2008). These processes range from bottom-up approaches of locally-initiated collaborations to top-down government-led programs.

Koontz and Thomas (2006) pose the question of whether and to what extent outcomes from collaborative processes differ from non-collaborative processes. While it is too early in the post-flood timeline to evaluate the eventual outcomes of Colorado community flood recovery, we seek to understand the connection between risk perceptions and the processes that communities use to involve stakeholders in recovery. In this paper we ask *whether problem perceptions differ across stakeholders and among community-level stakeholder processes*.

Stakeholder Problem Definition

How policy makers and stakeholders define issues and problems is critical to the formation of policy alternatives (Kingdon, 2003), although the process of how problems are defined is understudied (Adams, Brockington, Dyson, & Vira, 2003). Much of the policy process literature examines how policy elites or experts perceive policy problems, while less emphasis has been placed on how stakeholders perceive problems. Whether explicitly acknowledged or not, stakeholders bring perceptions, knowledge, and deeply held beliefs to participatory processes (Adams et al., 2003). Differing perspectives may stem from knowledge and information acquired through a diversity of sources, including, but not limited to, professional and personal experiences and education, both formal and informal. If we are to understand how stakeholders and policy experts reach policy decisions in disaster recovery, we must first understand how stakeholders participating in these processes perceive and think about the problems under consideration.

Risk Perception

Humans are cognitively limited and prone to bias when making judgments about the likelihood of future events, especially those events that are rare. Risk perception, the combination of perceived likelihood of event occurrence and expected damage incurred, is a function of disaster experiences, the characteristics of the individual (Slovic, 1987), and social processes (Ho, Shaw, Lin, & Chiu, 2008; Lin, Shaw, & Ho, 2008; Rogers & Prentice-Dunn, 1997). When faced with a disaster such as a flood, stakeholders may cognitively select from their experiences in such a way as to confirm their already held beliefs or actively ignore information that contradicts their understanding of the problem (Lord et al., 1979; Nohrstedt & Weible, 2010). Extreme floods, causing community-, neighborhood- and individual-level damage, may alter how groups (i.e., community staff, public officials, the public) perceive future risks. These perceptions may in turn influence what policies are developed and implemented to mitigate future flood risk. This connection between individual-level risk perceptions and policy learning at the community-level may result, in part, through individual learning from past events, such as the Colorado floods of 2013.

Experts and the Public: Variation in Risk Perception

Individuals' risk perceptions also depend on level of knowledge and expertise, as well as their worldview (Sjöberg, 1999; Wildavsky & Dake, 1990). It has been asserted that experts perceive risk through a more narrow process, compared to the general public, by evaluating probabilities and severity of consequences, while the public may take a broader social, psychological, and cultural interpretation of risk (Dessai et al., 2004; Leiserowitz, 2005). That said, experts and the public are prone to the same biases in risk perception (Slovic, 1987). Experts in a specific field often view risks related to that field to be smaller than those same risks perceived by the public (Sjöberg, 1999). These findings have held in studies of risk perception of nuclear accidents among the public and experts. Sjöberg (1999) argues that the difference in public versus expert risk perception may depend on differing definitions of risk—such that the expert focuses on probabilities of occurrence, whereas the layperson may focus on the consequence of the event, both of which are at the heart of understanding risk but may result in differing risk perceptions depending on which risk characteristic is weighed more heavily by an individual. Further, experts may perceive that they have a higher level of control over risks, as compared to the public. This last point may be essential to understanding risk perceptions in the context of extreme events since infrastructure improvements and risk mitigation in communities may help reduce vulnerability to extreme events and may lead experts to perceive less future risk if these mitigation improvements have been made.

Experience of Floods

Individuals who have experienced flooding typically have more knowledge and understanding of past floods (Kellens, Terpstra, & De Maeyer, 2013; Pagneux, Gisladottir, & Jonsdottir, 2011), but prior studies of flood risk exposure conflict as to whether direct and indirect personal experience with floods shows a positive or negative relationship with the perception of the likelihood of events occurring in the future (Wachinger et al., 2013). When individuals lack direct experience with floods, they may tend to underestimate the risk, while those who have direct experience may overestimate future risk (Ruin, Gaillard, and Lutoff, 2007). Alternatively, some studies report that individuals who have experienced natural hazards (e.g., at the community level), but not directly, may underestimate the risk (Meletti & O'Brien, 1992; Wachinger et al., 2013). The severity of flood damage personally experienced may be positively linked with future flood risk perception, while less direct experience may lead to the feeling that an individual escaped the risk, which may lead to an underestimation of the risk of the hazards.

Research Hypotheses

Prior studies predict that individual learning from direct and indirect experiences with hazards and professional expertise may shape beliefs about causality, risks, and seriousness of the hazard. We previously analyzed the participatory processes emerging in each community in the wake of the September 2013 floods (Albright & Crow, 2015), which informs the broader analysis presented here. Based on the literature outlined above related to risk perception of hazards and extreme events, along with our own previous analysis, the following hypotheses are proposed for analysis in this paper:

> H1: Participatory processes will vary across communities based on extent and type of flood damage and resource availability.

> H2: Perceptions of future flood risk, problem severity, and causal understanding of the floods will vary across individuals based on expertise (technical, environmental, social) and personal past flood experiences.

Next, research methods for this study will be outlined, including the cases included in this analysis.

Research Methods

This study employs a comparative multi-method case study research design wherein seven case communities were studied to examine recovery in the aftermath of extreme flooding (Yin, 2003). Table 1 includes all communities in this study, along with the basic characteristics of the community and the damage experienced from the flood. These seven communities located in Colorado's three hardest hit counties from the September 2013 floods (Federal Emergency Management Agency, 2013) provide excellent units of analysis for understanding how resources, risk perceptions, and decision processes influence recovery in the aftermath of extreme events. Three sources of data were used to conduct the analysis presented below.

Data Sources: Personnel Interviews

In November and December 2013, in-depth semi-structured interviews (Rubin & Rubin, 2005) were conducted within each community, when each community transitioned from 'response' to 'recovery' phases (for example, Lyons did not move into recovery until December 18, 2013 when the National Guard and FEMA ended their emergency response). These interviews were conducted with key personnel in charge of or involved with flood recovery in each community ($n = 24$) and provided background information on flood damages, flood recovery processes, and general flood experiences within each case. The interviews were conducted in person and digitally recorded. Interview transcripts were analyzed focusing on the major variables presented above: recovery processes, risk perceptions, and actions taken by local governments in the wake of the floods (i.e., increasing wastewater fees to pay for infrastructure repairs, or convening stakeholder processes). When quotations are used from interview data they are

Table 1. Case Study Community Characteristics

County (Population)	Community	Approx. Size (2010 Census)	Extent and Type of Flood Damage
Boulder (295,169)	Boulder	101,800	Moderate infrastructure and residential, in specific zones
	Longmont	88,600	Significant, but in specific zones focused on city infrastructure with moderate residential damage
	Lyons	2,000	Significant throughout town to both infrastructure and residential
Larimer (299,630)	Loveland	67,039	Moderate, in specific zones to mostly infrastructure and commercial
	Estes Park	6,000	Minor to moderate, in specific zones to residential, infrastructure, and commercial
Weld (254,241)	Greeley	95,300	No lasting damage, only moderate debris removal from the event
	Evans	19,500	Significant, in specific zones to both infrastructure and residential

cited according to an alpha-numeric identifier for the community and subject ID. For example, a Lyons interview may be LY-01.

Data Sources: Community Recovery and Planning Documents

All documents related to flood management planning, participatory processes, evaluation of policies, and community responses to the floods across the seven case communities were gathered and analyzed. This includes all web content and public or media outreach; city council minutes and memos; minutes from commissions, boards, and task force meetings; planning session documents; and other documents as appropriate to each community from September 2013 to August 2014.

For this paper, coding of all of the documents (n = 773) was conducted to identify major concepts and patterns across cases. The documents were coded for process variables (e.g., meeting frequency, topic, and type, and public participation mechanisms). Coded data were analyzed to examine variations and similarities among variables and cases (Miles & Huberman, 2013).

Data Sources: Stakeholder Survey

An online survey was also conducted to solicit experiences, opinions, and policy preferences from participants in community-level flood recovery processes across the seven case communities. The online survey was administered in September 2014, after the 1-year anniversary of the floods. Municipal officials and staff who are working on flood recovery efforts were included in the sample, along with members of community planning, economics development, housing, parks & recreation, and similar boards and commissions. Finally, citizens involved in recovery task forces were also included in the sample. The survey sample included 58 individuals, a response rate of approximately 30 percent (177 survey invitations were sent).

The online survey included a series of questions regarding (i) past flood experiences, (ii) perceived damages resulting from the floods, and (iii) perceived future flood risks and preferred policy alternatives for managing future flood risks. This survey (iv) captured the progress being made within each community, including any new policies, programs, and changes that have occurred since the recovery process began in late 2013. Another set of questions measured (v) values, beliefs, and policy preferences regarding flood policy/management and emergency response. The survey also asked (vi) the extent and manner to which local government has involved the public in the recovery process, along with questions about (vii) community resource availability, including financial, professional/leadership, and networks/relationships.

Findings: Variation in Damages

It is critical to understand the type and extent of damage experienced in each community as these damages may directly or indirectly influence the type of community-level participatory processes that stem from the floods, as well as stakeholder perceptions of future flood risks. Flood-related costs for each case study community, as reported by interview subjects and community documents, are outlined in Table 2.

Extent and type of flood damages varied widely among the case communities. For example, Lyons lost approximately 20 percent of its total housing stock and experienced significant municipal infrastructure damage, while Greeley suffered only minimal damage. Estes Park suffered direct flood impacts including damages to infrastructure in its creek corridors, as well as indirect impacts of lost revenue from a reduction in tourists travelling to Rocky Mountain National Park. Estes Park also had to navigate the federal shutdown in October 2013, which closed the Park and other surrounding federal lands. Historically, river-based tourism has propelled the local economy of Lyons, a small town located between Boulder and Estes Park, but post-flood river corridor damages have reduced tourism revenue. In-depth interviews help describe each community's flood damage:

> We have several streams go through town and immediately we had a lot of disruption and downtown was closed, downtown there was a river flowing right through the middle of the town… We'll have to wait and see…whether it makes sense to leave the river where it is. In some places the river moved as much as 50 feet. There are some places where people had building rights or they had property and now it's gone. And people lost a large portion of their property. (EP-01)

> Within a matter of 15 minutes or less, the water went from about ankle-deep to about neck-deep on our rescuers and our police officers down there, and literally they were carrying people—hauling people out of the water as homes floated past them behind them. So it happened really very quickly once the levee was breached. All—at the end of the day, we calculated there were 26 breaches of that levee system, you know, up and down our side of the river. (EV-01)

> So what we essentially saw at several points were essentially two rivers that we were trying to deal with. So it flooded that entire industrial area and then when it crossed Main Street is was almost a mile wide again. (LG-01)

> And the creeks which normally run at high flow around 1,000 cubic feet per second (cfs), best estimates that we've gotten so far are that it was near the 20,000 cfs… And when the water came through it ripped out all of the underground utilities with it. And so we lost all connections to our wastewater plant, gas lines, electric lines, sewer lines, communication lines. And then as we lost all accesses in and out of Lyons were impaired. In some cases the—the roads and the bridges were totally washed out… So the flood waters within Lyons created six separate islands that our town was divided into. No one in, no one out, and no communications.

Table 2. Extent of Flood-Related Damage Across Sectors in Each Community

Community	Public Works & Infrastructure	Residential	River Corridor	Parks, Trails & Open Space
Boulder	Fifty municipal/facilities significantly damaged Sewer and stormwater infrastructure and treatment facilities damaged Sixty miles of debris-covered road	Fifty housing units uninhabitable	Applying for $500,000–1 million from FEMA for debris/sediment removal	Twenty-five damaged areas of trail system Hundreds of open space and mountain parks areas damaged
Longmont	Storm drainage $74 million Street repair $17 million Sewer $4.6 million	Mobile home park area experienced most damage	$48 million in damage	Parks $21 million damage Two park closures
Lyons	Significant damage to roads	>20% of residences destroyed or severely damaged	Significant damage, including shifting of river	
Loveland	$20–30 million in infrastructure damage	Minor, little development in the floodplain		Extensive damage to two city parks
Estes Park	$30–40 million in damage, mostly to roads, bridges, and sewers	Minor, along two specific river corridors	Moderate to significant debris deposits River moved up to 50 feet in some locations	
Evans	Significant damage to infrastructure Sewer system down 8 days	Significant damage in specific mobile home parks		Significant damage Park closure
Greeley	Minor	Minor	Moderate debris removal costs	Minor

Minor damage denotes minor debris clean-up, street flooding in scattered areas throughout the community, but not significant damage.

> All businesses were closed for a full eight weeks, some ten weeks. All homes had to be evacuated…the soonest back in was at about seven weeks. Schools had to be closed of course. (LY-01)

Beyond an accounting of flood damages, it is important to understand these damages in the context of each community's capacity to recover from the impacts. Limits in staff (human capacity), community budgets (fiscal capacity), and technical capacity, constrain all communities to varying degrees. These limitations may influence a community's ability to implement participatory processes, as previous findings suggest (Albright & Crow, 2015). Each community in the study qualified for some level of FEMA reimbursement. As set by federal policy, the standard FEMA cost-share is set at 75 percent of costs not covered by insurance. Of the remaining 25 percent of the costs, the State of Colorado and the community will each cover 12.5 percent of the costs.[1] It is important to note that FEMA reimbursement may not cover all costs of recovery, for example river corridor restoration or park planning processes, unless recovery-related costs can be directly linked to flood hazard mitigation.

Findings: Variation in Participatory Processes

In response to the floods, each community has engaged in discussions about the flood, the damages left in its wake, and how best to recover from the event. Our previous work analyzed participatory processes emerging in the seven communities (Albright & Crow, 2015), which is presented here to inform the broader discussion of risk perceptions. Among case communities, these discussions differ in focus, venue, and extent of stakeholder and public participation. The topical foci of these processes vary across communities as well, with a greater focus on open space, trails, and parks in Boulder, Loveland, and Longmont, and greater emphasis on infrastructure in Longmont, Loveland, and Estes Park (Table 3).

Documents and interviews indicate that Greeley, a community with only minimal flood damage, has not conducted flood recovery meetings with significant public engagement. Flood-related discussions have occurred in a variety of venues in each of the communities, whether in newly structured venues such as flood task forces (Lyons and Evans) and public meetings, or in pre-existing venues (e.g., commissions, boards, and town councils).

Loveland has engaged the public in flood recovery similar to public involvement in large-scale capital projects, with stakeholder input collected through design workshops, but with only limited deliberative public discussions. The residents of Longmont have been involved in a large number of meetings, primarily focused on park and river corridor restoration (Table 3). Boulder has held a large number of public meetings to involve the public in both floodplain management and open space and trail redevelopment (Table 3). In Estes Park, the public and a diversity of stakeholders have been involved in a river corridor planning process funded by the Colorado Water Conservation Board, with over 140 individuals attending public meetings. In Evans, the city council appointed a flood recovery task force that met

Table 3. Summary of Local-Level Meetings September 2013–July 2014 (Summarized From Albright & Crow, 2015)

Community	Primary Venue of Flood Discussions	Number of Total Meetings	Focus of Meetings	Depth. of Engagement
Boulder	Public meetings, commissions	45	Open space, broad recovery, floodplain management	Consultation: Community-wide and neighborhood open public fora
Longmont	City council, commissions, public meetings	57	Broad recovery, open space, public works	Delegate Power: Stakeholder process for redevelopment of park
Lyons	Flood recovery task forces	41	Broad recovery, housing	Citizen control: Multiple sector-specific stakeholder process
Loveland	Commissions, City council	44	Broad recovery, open space, public works	Zero to limited input from public in infrastructure, Consultation in future park redevelopment
Estes Park	City council, commissions	43	Broad recovery, public works	Consultation/Delegate Power: Large-sized public forum, advisory committee
Evans	City council	18	Broad recovery, landuse/ floodplain	Citizen Control/Delegate Power: Stakeholder process develops draft flood plan
Greeley	Commissions, City council	10	Broad recovery	None

twice per month and was tasked with developing a draft plan for flood recovery and redevelopment of the downtown area.

Interview subjects' descriptions of community flood recovery participatory processes differ across community and provide evidence of the post-flood process variation:

> We're asking the residents to come tell us what their experience was and also what they think, and it's been fascinating to watch them come to the flood maps and say, "No, that's not how it happened; this is how it happened." So it's really just—it's kind of letting the community vent, but also debrief, because that will help us gather data. (BO-01)

> So we've done a series of open houses to make sure we had a clear understanding of how things played out across the community and more than anything to let people tell their stories and be heard, but we've accumulated a massive amount of data from that and probably more long-term that'll feed into our master planning. (BO-02)

> The public meetings there were two or three of them right at the very—in the first week, and then after that there were ones for just impacted property owners. And there pretty much all over with now. You know, it just kind of lost its urgency. . .what was really interesting with the public

> meetings is . . . we had some public meetings that had nobody from the mobile home parks [that were destroyed by the flood], none whatsoever come. (EV-02)

> We're going to be talking to the public about it. We also want to be really cautious to. . .in certain areas it's going to be a really engineering-based decision. So one of the things that we don't want to do is . . . we don't want them to think they have the ability to decide when in reality the engineering is going to decide the issue. Because the last thing that we want to do is have some type of corrective action that occurs that actually exacerbates the potential for flooding. And so. . . definitely a public process but we're going to be really focused to say here we have options, here we don't have options. (LG-01)

> Yeah, they would be driven really not as a special overall flood recovery process but individual projects. (LV-01)

> And so last night after we talked about the timeframe and the different areas that people can get involved in, we had them break in to those eight groups last night and commit to being part of this process the next eight weeks. And then the state is providing a facilitator for every meeting so . . . it's not taking up that person locally to facilitate, that they can be involved. We had probably 78, 80 people in each group last night. (LY-01)

Findings: Individual-Level Perceptions of the Colorado 2013 Floods

In addition to the 24 in-depth interviews conducted for this study, a total of 58 staff, board members, and elected officials across the case communities responded to the survey (Table 4).

The communities of Lyons and Boulder, both located in Boulder County, had the greatest number of responses. Based on the hypothesis outlined above, a series of fixed effect multiple linear regression and ordered logistic models were developed to predict the variation in risk flood risk perception (H2), problem severity (H2), and causal understanding of the extreme floods in 2013 (H2) (Tables 5 and 6).

Table 4. Counts of Survey Respondents by Community

Community	Count	Percent (%)
Boulder	18	31.0
Lyons	15	25.9
Longmont	10	17.2
Loveland	5	8.6
Estes Park	6	10.3
Greeley	1	1.7
Evans	2	3.4
Total	58	100

Table 5. Survey Outcome Measures With Associated Scale and Variable Name

Outcome Measures	Scale	Variable Name
Perceived likelihood of 100-year flood occurrence in next 10 years in Colorado	0–100%	Flood risk state
The belief the risk of flooding in Colorado has increased over the past 20 years	Likert scale 1 (SD) to 5 (SA)	Flood risk state increase
Flooding in our community is a severe problem	Likert scale 1 (SD) to 5 (SA)	Flood problem community

The explanatory variables included measures of perceived flood damage, respondent's work position, field of expertise, number of years of work experience, and gender (Table 7).

The survey analysis builds on case study interview data analysis. Interview subjects described ongoing risk from flood events, although they did not describe risk increasing due to climate change or other factors. Many subjects referenced a perception of helplessness from Mother Nature's extreme events or long-term periodic flooding in their community:

> The fear has always been that there would be a weather system that parked itself over a specific area. And we always thought it would be Boulder Creek and so that's why so much focus was on Boulder Creek. And what this event did was it actually parked itself everywhere, and so inundated all of the tributaries... Boulder is one of the communities that's most susceptible to a flashflood, so we're prepared. (BO-01)

> There have been these events over centuries and even more than that. (BO-04)

> This is more somewhere along Lake Flood which happened in '82. That did flood downtown, it actually destroyed a lot of the downtown but it didn't affect the ability to get here. The '76 flood was more of a tragedy from the loss of life. I think 135 people lost their lives that night. And it took several years, it took almost 4 years for the road to get rebuilt that time. ... But I don't know, I don't know how you get too prepared for something like this that frankly no one has ever seen in Colorado before, this kind of a widespread damage. (EP-01)

Table 6. Summary Statistics of Outcome Measures of Perceptions of Flood Risk, Flood Problem Severity, and Role of Climate Change in Flood Occurrence

Variable	Mean	Median	SD	N
Flood risk state	65.8	76.0	32.5	33
Flood risk state increase	3.79	4	1.2	33
Flood problem community	3.58	4	0.97	33

Table 7. Key Survey Explanatory Measures With Associated Scale and Variable Name

Explanatory Measures	Scale
Extent of 2013 flood damage incurred in neighborhood	1–5
Gender	Male = 1
Social department	Respondent works in a department focuses on human social services
Infrastructure department	Respondent works in a department that focuses on utilities and municipal infrastructure (e.g., roads)
Environment department	Respondent works in a department that focuses on environmental management
Position years	Number of years respondent has been in position
Elected official	The respondent is an elected official
Board or Task Force member	The respondent is on a municipal commission or task force

> I think there's a great resistance to recognizing risk. You know, that it hasn't happened before, or it's not going to happen here, or it's not going to be as bad, or we've had this before...Well, no, we have actually newspaper clippings of when it's happened before. You know, it happened in 1960-something. It happened in 1920-something. And even this flood that we've had out here, we've got old maps of the city around, and you can see where it's flooded the same places before. So I think we have, you know, that complacency, "It's not going to happen." (EV-02)

> But those who are the engineers and public works and certainly in... the city management office and stuff there's a real recognition that we need to do something different for the *next time*. (LG-02)

> Mother Nature, you know, part of it, there was nothing we could do anything about. (EV-02)

> We—our lifespan is so short and our knowledge is so short, and be the Earth four billion years old, like some people think it is, we don't have a clue. We set up shop here at Greeley or wherever... And then we get a 17-inch rain, and everyone freaks out. Well, this is probably the way things work. I mean, this is the way things work. If you look at the mountains, you look at the floodplain, the erosion that's gone on here over millennia or however. (GR-01)

Some subjects attributed long-term risk reductions to engineering or hydrologic knowledge advancements, while others attributed increasing risk to the instability of river corridors post-2013 floods:

> Because, at least looking at the climate change side of things, if the normal for the future is that we get one big snowstorm and one big rainstorm a year, instead of evenly distributed, there are a lot of things that come with that. (BO-01)

> I think the risk has gone down, for all of the reasons that we've already talked about, all the things that we've done. The knowledge that we have, the monitors in the river, the communication, the relationships, everything. The ability to know when it's coming and what it's going to do, where's the floodway at, GIS mapping, all the things we have now that we didn't have 30 years ago. (GR-01)

> Because the river's going to flow again. And the other question that you have in this is, there's going to be stage two in the spring when the water flows, because there's river banks and there's other things out there that you don't know are as bad off as they are, and you don't know until the system flexes its muscle again what exactly that river's going to do. (LV-02)

These interviews with flood recovery personnel provide insight into the types of perceptions seen among flood recovery stakeholders, but they cannot predict whether (1) personal experience with floods or (2) professional expertise makes an individual more likely to perceive flood risk increasing over time. The survey analysis presented below provides this analytic lens.

Risk Perception Models

Using a slider in the online survey, the respondents were asked to estimate the probability of a 100-year flood occurring in Colorado in the near future (Table 6). The responses varied widely, with a mean of 65.8 percent likelihood and a standard deviation of 32.5. A multilevel (individuals nested in communities) fixed effects model with clustered robust standard errors was developed to explain variation in the risk perceptions of future floods in Colorado (Table 8).

The major drivers of flood risk perception were the respondent's department in which they work and their gender (Table 8). Individuals who work in departments

Table 8. Fixed Effects (Community) Multiple Linear Regression Predicting Perceptions of Risk of 100-Year Flood Occurrence in the State of Colorado (Risk State)

Variable	Coefficient (Robust Clustered SE)
Damage neighborhood	0.129 (6.26)
Environment department	6.70 (18.7)
Infrastructure department	−24.08 (11.3)*
Social department	9.02 (6.45)
Board or Task Force member	3.55 (14.8)
Elected official	−14.54 (12.0)
Years in position	1.97 (1.61)
Gender (1 = male)	34.29 (34.3)*
N	28
R2-within	0.554
R2-overall	0.707
AIC	9.516

*Denotes significance at the 0.05 level.

that focus on infrastructure management perceive a significantly lower risk of future floods than those individuals associated with general administration, all else constant ($p = 0.035$). Male respondents perceived a significantly greater risk of floods compared to female respondents ($p = 0.005$). The extent of flood damage experienced, as measured as damage to neighborhood, was not significant in this model.

In addition to the risk perception question asking for a direct assessment of perceived future risk, the respondents were asked their views on the extent to which the risk of flooding is increasing in their community and across Colorado (see Tables 5 and 6 above). A fixed effects ordered logistic model was developed (Table 9) to explain variation in these measures of risk using the same explanatory variables in Table 5.

The results of this model were similar to the previous model in which individuals in infrastructure-focused departments were less likely to view the risk of floods increasing, all else constant ($p = 0.081$). Again males were more likely to perceive an increase in flood risk in the State of Colorado, all else constant ($p = 0.092$). In addition, the number of years a respondent has worked in his/her position was associated with a perception of increased flood risk, all else constant ($p = 0.017$).

Problem Severity Model

In addition to the series of risk perception measures described above, the respondents were asked about their perceptions of the severity of flooding as a problem for their community (Table 10) ($p = 0.037$). In the multilevel, fixed effects ordered logistic model, perceptions of neighborhood-level damage were positively and significantly related to the perception that flooding is a severe problem for their community. Also, respondents who are either elected officials or

Table 9. Fixed Effects (Community) Ordered Logistic Regression Predicting Perceptions of Increasing Flood Risk for the State of Colorado

Variable	Coefficient (Robust Clustered SE)	Odds Ratio (Robust Clustered SE)
Damage neighborhood	0.791 (0.510)	2.21 (1.12)
Environment department	0.872 (1.09)	2.39 (2.61)
Infrastructure department	−2.43 (1.39)*	0.088 (0.122)*
Social department	1.20 (1.20)	3.33 (9.89)
Board or Task force member	0.121 (2.97)	3.55 (2.14)
Elected official	4.09 (3.34)	59.5 (199.3)
Years in position	0.153 (0.0644)**	1.17 (0.075)**
Gender (1 = male)	1.30 (0.773)	3.68 (2.85)*
N	28	
Pseudo-R2	0.18	
AIC	3.610	
Log pseudolikelihood	−32.53	
Likelihood ratio test	14.293 ($p = 0.001$)	

*Denotes significance at the 0.10 level.
**Denotes significance at the 0.05 level.

Table 10. Fixed Effects (Community) Ordered Logistic Regression Predicting Perceptions of Flooding As a Problem for the Respondent's Community

Variable	Coefficient (Robust Clustered SE)	Odds Ratio (Robust Clustered SE)
Damage neighborhood	1.28 (0.614)*	3.61 (2.22)*
Environment department	2.64 (1.82)	14.0 (25.4)
Infrastructure department	-5.60 (1.69)*	0.0037 (0.00627)*
Social department	0.583 (1.95)	1.79 (3.49)
Board or Task force member	−3.63 (1.30)*	0.0264 (0.0343)*
Elected official	−4.29 (1.54)*	0.014 (0.210)*
Years in position	−0.146 (0.178)	0.864 (0.154)
Gender (1 = male)	2.02 (1.30)	7.53 (9.77)
N	28	
Pseudo-R2	0.42	
AIC	2.693	
Pseudo Loglikelihood	−20.705	
Likelihood ratio test	29.82 ($p < 0.001$)	

*Denotes significance at the 0.05 level.

appointed board or flood task force members were less likely to perceive flooding as a severe problem as compared to community staff ($p = 0.005$ and 0.005, respectively).

Discussion

Two hypotheses guided the study and the findings presented above: (H1) *Participatory processes will vary across communities based on extent and type of flood damage and resource availability*; *and* (*H2*) *Perceptions of future flood risk*, *problem severity*, *and causal understanding of the floods will vary across individuals based on expertise (technical*, *environmental*, *social) and personal past flood experiences*.

The content analysis of flood-related documents and interview data suggest a variation in the venue, participation, and topical foci of flood-related discussions across communities (Table 3). Results suggest that the damages experienced and resource availability have led communities to select differing participatory processes to guide flood recovery. For example, Lyons, a town devastated by the floods across a number of sectors has developed a highly participatory process managed by a number of flood task forces led by community members. Boulder's recovery has involved staff members and public outreach through large public meetings. If the risk perception literature holds, these differences in who participates in the flood recovery process may be linked to differences in how the risk of floods is perceived.

Much of the risk perception literature asserts that those individuals who hold expertise in their professional field will perceive smaller risks from long-term flood events (Sjöberg, 1999). To test whether these findings hold in the flood realm, we surveyed participants in flood recovery processes and asked about how they perceive flood severity and risks. We developed a series of models to explain variation in risk perception and problem severity of floods based on type of position they hold and experience with floods. According to the models, individuals' professional role (e.g., infrastructure vs. more broad administrative management) was found to be significantly associated with flood risk perception and perceptions of problem severity. *Individuals involved in the management of community infrastructure* (*i.e., utilities, road networks*) *where less likely to view floods as a problem and perceive a smaller risk of future floods for the State of Colorado*. This result supports findings in the literature that asserts experts tend to perceive smaller risks than those in the general public. However, staff, broadly defined, viewed flood severity as greater than those on tasks forces and elected officials. Counter to much of the risk perception literature focusing on the general public, it was found that males perceive significantly greater flood risk and increasing flood risk compared to females. These counterintuitive results may be a function of our sampled population, local level experts and officials (as opposed to the general public). This gender effect will be investigated further in additional rounds of expert and resident surveys in Colorado.

Directly experiencing flood damage at the neighborhood level was found to be positively and significantly related to perceptions of problem severity at the community level. It was not, however, significantly related to respondent perceptions of the likelihood of a 100-year flood happening again. These results are similar to several studies in the risk perception literature (Kellens et al., 2013; Ruin et al., 2007; Siegrist & Gutscher, 2006). While the majority of studies of risk perception focus on public perceptions, *this study suggests that flood managers and stakeholders perceive flooding as a problem if they personally experienced flood damage in their neighborhood*.

Conclusion

These findings offer preliminary partial support of the two hypotheses posed in the introduction. Differences in extent of flood damages and resource availability have led to a diversity of venues and participatory processes to manage flood recovery (H1). This variation is not, however, consistently and clearly tied to the variables of resource availability and extent of damage. This is best highlighted in the differences between Lyons and Evans, both resource-limited communities that experienced significant damage. Lyons developed a highly deliberative process while Evans used a mostly top-down government-led process including staff as well as other city council-nominated stakeholders.

The survey results of flood recovery stakeholders suggest that perceptions of problem severity (H2) are linked to past flood experiences and type of expertise. The results also point to a difference between how community staff and elected officials and board members perceive problem severity. This is an interesting finding and may play out in differences in future policy changes and learning across communities, as communities vary on the relative authority staff, elected officials, or flood task force members hold. The findings suggest that the extent of damage, category of expertise, and type of position (staff vs. elected officials) are related to the beliefs held by key stakeholders in flood recovery processes. If risk perceptions are linked to policy change towards flood resilience, a community in which non-staff board and flood task forces have greater decision authority may differ in risk perceptions and views on problem severity, subsequently affecting the extent of policy changes that may occur.

The findings presented here offer insight in developing a greater understanding of the factors that influence the perceptions of flooding in communities recovering from disasters such as the Colorado floods of 2013. The literature suggests that risk perceptions at the individual-level influence behavioral and policy change. If this holds, communities in which individuals perceive an increased level of flood risk may be more willing to change policies to help mitigate this risk. Going forward we will continue to monitor changes in policies and shifts in risk perceptions to understand whether these beliefs are linked to policy change and learning across communities, continuing to gather data from interviews, document analysis, and surveys. This study will follow the seven flood-affected communities over a 3-year period to measure actual changes in beliefs, learning, and policy change through time.

While the findings presented above help move scholarship forward, particularly with regard to understanding beliefs among stakeholders who have personal experience with floods, there are two weaknesses of this study that should be considered. Due to the small population of flood stakeholders, findings presented here are tentative. Despite a reasonable response rate, this study employs a relatively small sample size. Moving forward, researchers may be able to remedy this issue, at least in part, by increasing sample size in communities that are underrepresented and employing multiple imputation techniques to deal with the missing data issue.

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Note

This research is funded through the Infrastructure, Management, and Extreme Events Program of the National Science Foundation, Award #1461923, 1461565. The Natural Hazards Center at the University of Colorado Boulder supported initial data collection for this project under the Quick Response Grant Program funded by National Science Foundation grand number CMMI1030670.

1. All of these figures apply after insurance has been paid on covered properties or assets.

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Appendix A

Table 1. Pooled Logistic Regression Predicting Perceptions of Increasing Flood Risk for the State of Colorado

Variable	Expertise Model Coefficient (Robust Clustered SE)	Expertise Model Odds Ratio (Robust Clustered SE)
Damage neighborhood	0.155 (0.269)	1.17 (0.314)
Environment department	1.82 (1.78)	6.18 (11)
Infrastructure department	0.27 (1.47)	1.31 (1.92)
Social department	1.44 (2.35)	4.22 (9.92)
Board or Task Force member	−1.09 (1.75)	0.336 (0.587)
Elected official	1.12 (1.39)	3.07 (4.28)
Years in position	−0.13 (0.0589)*	0.878 (0.0517)
Gender (1 = male)	−0.404 (0.522)	0.667 (0.348)
N	28	
Pseudo-R2	0.12	
Log pseudolikelihood	−15.4	
Likelihood ratio test	4.352 ($p = 0.500$)	
AIC	1.743	

Table 2. Logistic Regression Predicting Perceptions of Flooding as a Problem for the Respondent's Community

Variable	Expertise Model Coefficient (Robust Clustered SE)	Expertise Model Odds Ratio (Robust Clustered SE)
Damage neighborhood	2.08 (0.704)**	7.98 (5.61)**
Environment department	0.889 (0.762)	2.43 (1.85)
Infrastructure department	-2.70 (1.30)**	0.067 (0.0876)**
Social department	-0.139 (1.60)	0.870 (1.39)
Board or Task Force member	-2.91 (1.73)*	0.0545 (0.0941)*
Elected official	-5.22 (1.83)**	0.00538 (0.00983)**
Years in position	-0.088 (0.0545)	0.915 (0.0498)
Gender (1 = male)	0.700 (0.545)	2.02 (1.10)
N	28	
Pseudo-R2	0.30	
Pseudo Loglikelihood	−13.080	
Likelihood ratio test	11.361 ($p = 0.045$)	
AIC	1.58	