Case Study

Using Climate Forecasts across a State's Emergency Management Network

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Abstract: This paper examines the application by emergency managers in rural areas of forecasts of El Niño and other seasonal climate events to (1) improve the understanding of how diffuse networks can help overcome the obstacles to the use of complex scientific information and (2) to widen the use of seasonal forecasts to improve flood management. The investigation draws on ethnographic techniques of observation and conversation with emergency management networks in the state of Oregon, interviews of nearly 50 emergency managers in the state, and two detailed case studies of Oregon counties that have used seasonal climate forecasts to improve flood management. Emergency managers are more likely to use climate information tied to a time-specific and place-specific forecast and to feasible actions, and when the emergency managers are part of robust professional networks that include scientific professionals as well as end-users of forecast information.
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Introduction

In theory, the complex scientific information available in the age of Big Data and evidence-based management should help emergency managers better prepare for disasters (Jennings and Hall 2012). In practice, many obstacles stand in the way. Data are often ambiguous and not directly related to the problem at hand, uncertainties ubiquitous, or the information unavailable at a scale that local decision makers can use. Even in cases where the technical aspects of the information might be clear, it may lack obvious implications for practice. Finally, even when science offers clear data and implications, the political economy of the situation or financial barriers may not favor action (Hammond et al. 1983; Sylves 2014, pp. 126–153).

Such obstacles to the use of scientific information in emergency management are multiplied when a diffuse network must interpret and make use of the data. In rural America, for example, long distances between emergency managers and scientists in a region post barriers to communication. A rural county may have only one full-time emergency manager—if that—and a larger region comprising multiple counties only one expert in climate and weather science (Kartez and Lindell 1987; Rubin 2007).

The burgeoning literature on network governance and decision making under conditions of uncertainty has begun to address how rural communities can prepare for and respond to disaster. For example, Louise Comfort (2005, p. 335) has laid out a research agenda for how "informed action" through networks rather than hierarchies holds promise for improving disaster management. One of the preconditions for improving disaster management in rural networks is the presence of a visible policy entrepreneur since rural networks often lack sustained capacity or institutional processes (Cigler 1999). Rural networks also often lack adequate communication networks, especially among vulnerable groups (Kapucu et al. 2013a, p. 6). Scholars of network governance and disaster management in rural areas have identified preconditions for building capacity and resilient processes, but these take place over years rather than months (Kapucu et al. 2013a, b). At the short to medium timescale of 3 to 6 months, emergency managers are key nodes for interpreting information and making decisions. However, Jensen (2009) finds that emergency managers' interpretations of National Incident Management System guidance can vary substantially, and lead to varying outcomes.

Making progress in understanding rural emergency management networks requires identifying how rural emergency managers process information and decide whether to take action. Another next step is to identify the structural conditions that give rise to "identifiable bureaucratic entrepreneurs" who lead decision processes (Cigler 1999, pp. 96–98). This reviews the literature on network management to identify four concepts that are important for network effectiveness in other contests—turf, tools, capacity, and framing (Agranoff and McGuire 2001; Bardach 1998; Kapucu and Garayev 2013; McGuire and Agranoff 2011; Scharpf 1994; Waddell 2011). These concepts help structure interview data and develop expectations. Investigating emergency management network decision processes is a new avenue for scholarly investigation. The existing literature can reveal what questions remain unanswered and suggest categories for framing questions and interpreting data, but it does not offer a ready-made set of hypotheses or expectations because research in this domain is still exploratory.

This project uses the application of seasonal climate forecasts by emergency managers to examine how to overcome the obstacles to the use of complex scientific information in practice in nonurban areas, thereby providing knowledge useful for practitioners who intend to use these forecasts, as well as knowledge that contributes to building theories about how statewide emergency management

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networks process and use scientific information. Seasonal climate forecasts in this context refer to a forecast with a multiple-month lead time for a particular region that predicts the likelihood of precipitation or temperature that deviates from normal trends. While emergency managers routinely pay attention to 24-, 36-, and 48-h weather forecasts, they are less likely to use seasonal climate forecasts of abnormal weather that may be 3 or 6 months out. Such a timescale may be too far in advance to make the need to take action obvious, even when the science is as clear as it can possibly be.

Despite these obstacles, preliminary evidence suggests that diffuse, informal networks can make use of scientific information to improve emergency management (Wernstedt et al. 2009b, a). To identify and clarify how these networks might operate, this project investigates a particular set of diffuse networks responsible for flood preparations in rural Oregon. The project examines why and how some emergency mangers have used seasonal climate information and why others have not. It finds that the characteristics of the information matter, as do the characteristics of emergency management networks. Emergency managers were more likely to use climate information if it was tied to a time-specific and place-specific forecast, and to an action or set of actions they could take. The emergency managers who accessed and interpreted the information were part of robust professional networks that included scientific professionals, primarily at the National Weather Service, as well as end-users of the information who could implement steps to prepare for floods.

This article's aims are twofold. First, at the practical level, it seeks to widen the use of seasonal forecasts to improve hazard management. Second, and more theoretically, the project aims to better understand how and why diffuse emergency management networks can use complex scientific information in an era in which the promise of Big Data often outstrips its actual use. The study contributes to a theory for how public managers use climate forecasts, as well as to broadening theories about how networks govern in rural areas, and how local public managers cope with uncertainty.

Theory and Evidence: Seasonal Climate Forecasts

Scientists have identified strong evidence of a relationship between intermediate-term climate fluctuations—such as the seasonal El Niño–Southern Oscillation (ENSO) cycle, the quasi-biennial oscillation, and the Pacific Decadal Oscillation—and changes in the frequency or intensity of flooding, droughts, hurricanes, and other weather-related extreme events (Gray 1994; Gray and Landsea 1992; Landsea and Gray 1992; Gershunov and Barnett 1998; Van der Dool 2006; Reeves and de Jersey Gemmill 2004). For example, indicators representing the ENSO state—the coupling of the El Niño phenomenon that warms or cools sea surface temperatures in the central-eastern Pacific, and the Southern Oscillation that shifts atmospheric pressure across the central-eastern Pacific and the western Pacific—appear highly correlated with seasonal precipitation and temperature in the western United States (Glantz 2000; Meehl et al. 2007), and associated changes in unregulated streamflows (Cayan et al. 1999). ENSO conditions also correlate with increased snowpack in the Columbia River basin and with the timing of snowmelt (Clark et al. 2001; Beebee and Manga 2004), while another fluctuation, the Madden–Julian Oscillation, has a statistically significant relationship with winter flooding in western Washington state (Bond and Vecchi 2003).

Forecast products for such climate fluctuations currently exist, such as from the Climate Prediction Center at the National Oceanic and Atmospheric Administration (NOAA), and they can provide long lead times with some degree of skill (Livezey and Timofeyeva 2008). Insofar as the largest disaster losses in many communities derive from flooding, high-skill forecasts provide a potentially valuable piece of information for emergency managers. However, these forecasts, of a particularly wet winter in a region for example, lack sufficient detail on critical features such as precipitation intensity and its timing to allow ready identification of the specific rivers that will experience flooding. A high degree of uncertainty therefore exists about whether a forecasted general event will have a specific impact in a particular jurisdiction for which an emergency manager is responsible, making problematic the choice of whether to incur costs to take action. Moreover, even if forecasters could narrow precipitation and flood forecasts to specific river stretches, that may not be enough to motivate an emergency manager to make changes since she can wait until weeks or days before a predicted event to take action. In addition, the uncertainty in climate and weather forecasts is amplified by the uncertainty inherent in the political economy of emergency management. The costs of taking action in advance of an event are relatively certain in terms of money, time, attention, and reputation, but the benefits of taking action are not so clear (Drabek 1985; Kunreuther 2006). State and local emergency management budgets are limited, and the situation is unlikely to improve any time soon (Federal Emergency Management Agency 2011).

The difficulties are compounded in more rural environments, where resources for emergency managers typically are more limited than in urban areas, and the emergency management network more diffuse (Comfort et al. 2011). For example, climate scientists that may provide climate forecasts typically work far away from rural emergency managers and policymakers who make decisions about data use, and distance may weaken their relationships.

Notwithstanding these challenges, some communities have used seasonal climate information successfully to prepare for floods. Forecasts of a strong ENSO anomaly prior to the 1997–1998 flood season led California state and county officials to organize a community preparedness summit prior to the flood season to identify measures local governments could take to mitigate the potential impacts of seasonal storms. After subsequent flooding associated with the anomaly, climate forecasters and federal and state emergency planners noted that without the early warning, damages to property and loss of life likely would have been worse (Federal Emergency Management Agency 1998; Flick 1998). Two years later, rural Tillamook County, Oregon used a seasonal ENSO forecast to argue for (and to secure) federal funding for the construction of infrastructure to mitigate the effects of possible flooding during the 1999–2000 flood season (Wernstedt and Hersh 2004). Local officials credit these measures with helping to reduce flood damages by more than 90% compared to previous years. In addition to these specifics cases, results from a small convenience sample of participants in the 2008 Federal Emergency Management Agency (FEMA) Higher Education conference reported by Wernstedt et al. (2009b) indicate that a substantial share (44%) of emergency managers who responded to the survey use long-term climate information in their work. However, it is not clear whether the results indicate familiarity with rather than actual use of the information.

Theories of Network Governance and Climate Forecasts

Given the promise of using climate forecasts to prepare for floods, and some evidence that some jurisdictions had tried to take advantage of these forecasts to improve hazard management (Wernstedt and Hersh 2004), why do some counties take advantage of seasonal climate information to improve flood planning and management

while most others do not? How and whether to use climate forecasts to improve preparations for floods at the local level constitutes what public administration and policy scholars call a *wicked* problem. It has a broad scope spanning social and physical systems, and it is complicated by a variety of perspectives on what the problem is and how to address it (Rittel and Webber 1973; Weber and Khademian 2008).

Networks are held up as one response to these wicked problems, since their decentralized character allows participation by many different stakeholders, ideally facilitating the merging of shared perspectives on a difficult problem and the emergence of cross-sector partnerships (Alter and Hage 1993; Drabek and McEntire 2002; Jones et al. 1997; Lovegrove and Thomas 2013). Yet the spatial distance and diversity of professions involved in emergency management networks means that no single person or organization necessarily assumes responsibility for interpreting and using seasonal climate forecasts to prepare for floods.

One theory that explains why some networks might use complex scientific information in their work is that wealthier, larger networks will have more resources to interpret and communicate this information than poorer, smaller networks. Research in the resource dependency tradition supports this prediction (Barney et al. 2011; Grant 1991; Verbruggen et al. 2011). For example, Scharpf (1994, p. 49) finds that network effectiveness depends on the "pre-existing distribution of strong and weak ties among formally independent individual and organizational actors . . . " In other words, power among networks may be unequal and affect network performance (Agranoff and McGuire 2001).

It would not come as a surprise if well-resourced urban emergency management networks used seasonal climate forecasts, but it is more of a puzzle as to how some small, rural networks manage to take advantage of complex scientific information. If even a few small, diffuse, rural, less well-resourced networks are able to use seasonal climate forecasts, maybe others might be able to do so if only they had the right combination of factors.

The literature on public management networks offers three concepts, *turf*, *technical tools*, *and framing*, that appear to be particularly important to network success. There are outlined with reference to their general meaning, expectations, and how they relate to the context of climate forecasts. Specifically, the literature suggests that networks that successfully employ scientific information (1) move from thinking in terms of turf to thinking in terms of common problems and tools; (2) have a technical solution present; (3) have adequate capacity; and (4) frame the utility of the information as a solution to a crisis.

Turf is an informal term referring to "the domain of problems, opportunities and actions over which an agency exercises legitimate authority" (Bardach 1998, p. 164). To incorporate scientific information into local emergency management network requires convincing network members to move from protecting their turf to finding common ground (Waddell 2011). Easier said than done, but perhaps the most important tactic is the "need to lead even when you are not in charge" (Huxham and Vangen 2005, p. 225). Other tactics include being open to the plurality of views in a network and thus being more likely to accommodate them, being open to intermediate successes, and engaging in joint activities to create common symbols and identities (Koppenjan and Klijn 2004, p. 162). Turf is not good or bad in itself. It can be useful if it encourages public managers to take responsibility, but detrimental if it harms cooperation on important, boundary-spanning, wicked problems.

The scientific community views its turf as the production of valid scientific information, even if this information is not connected to action. Emergency managers view their turf as geographically specific work related to the four phases of their field: mitigation, preparation, response, and recovery. They view themselves as consumers of scientific information, but the practice of science is part of another, separate domain. Incorporating the use of scientific information in decision making requires bridging scientific and operational turf by connecting the scientific information to possible emergency management actions.

While members of a network may cooperate across turf boundaries to address a problem, effective cooperation also requires adequate *technical tools*. Technical tools can support communication within and across emergency management networks (Kapucu and Garayev 2013). They can also support the creation of new solutions. For example, in environmental policy, adequate technical tools to create alternatives to septic systems did not emerge until the 2000s, when it became financially feasible to install these systems in rural communities to meet economic goals and environmental targets (McGuire and Agranoff 2011, p. 271). In seasonal climate forecasts, an adequate understanding of La Niña and the ability to make seasonal forecasts has emerged only over the past few decades, and recent advances in computational power have made these forecasts more useful. Based on these recent developments in forecast products, science can inform the mitigation and preparation aspects of the hazard management cycle by showing the association between ENSO signals and an increased likelihood of extreme events such as heavy rains and drought in a particular region. The advances in science made the network for the use of seasonal climate forecasts possible, and climate scientists remain important members of the network since only they can interpret the ENSO signals and produce the forecasts. Even meteorologists may not have sufficient training to make sense of climate signals on a seasonal scale.

Even if appropriate technical tools exist, a network needs the necessary *capacity* to interpret a problem and deliver a solution. The literature on public sector networks finds that public agencies play important roles in providing expertise and in "creating the goals of their nongovernmental partners" by mobilizing the network and serving as a network broker (Agranoff 2005; Fosler 1992; Wukich and Robinson 2013). In some cases, capacity is more fundamental than the existence of network structures across organizations (Kapucu et al. 2010); if there is not sufficient capacity to carry out a task, no partnering short of outright outsourcing will be sufficient.

In the case of climate forecasts, the capacity need only be enough to make use of the scientific information and to make decisions to hasten flood preparations. Here, the light hand of the state may be better than a heavy one (Roberts 2014). Radin et al. (1996) found that state and federal agencies were so dominant in rural development that they squelched participation from other members of state councils, to the detriment of rural development. Network leaders at the local level could wield influence, however, if they engaged in less threatening behaviors such as providing information or offering to demonstrate a new approach to a problem (Radin et al. 1996, p. 203). Local emergency managers and National Weather Service forecasters are in a good position to take these light-handed approaches, in part because of their limited formal control over the network. Simply creating a program for climate forecasts within a federal agency would not likely make local emergency managers more likely to use the forecasts in practice because use requires network-wide capacity and buy in.

One of the defining features of a network is that network members often lack authority over one another (O'Toole 1997; Agranoff 2005, 2007). Their effectiveness lies in their power to persuade. Network leaders can structure a problem by establishing decision rules and norms, and activate a solution by introducing new ideas into the network (Agranoff and McGuire 2001). These ideas might

be to rank hazards to draw attention to them, or to provide examples for how to use forecasts to accomplish a network goal, such as reducing the damage caused by flood.

Framing is especially important for climate forecasts because how one should respond to the information is not self-evident. One scientist interviewed for the project blithely observed that if climate forecasts were useful, emergency managers would use them since "science is just science," meaning that the facts are clear. Other research finds scientific information may be seen as an interesting descriptive observation but unconnected to their decision environment (Weichselgartner and Kasperson 2010).

Method

The research design involved three stages of investigation, but was reflexive throughout (Yanow and Schwartz-Shea 2013, p. 320; Taylor 1977, p. 103), taking research questions to the field, structuring field observations according to concepts developed in the broader literature on decision making and emergency management, and throughout the process refining both the concepts and the observations from the field. The assumptions of interpretive methods served as a starting point and rationale, even as the authors took advantage of email address lists for quickly contacting a large number of subjects to identify critical cases of the use of climate forecasts at the county level outside urban areas (Patton 2002, p. 236).

The first, exploratory stage of research involved making three trips to the state from 2012 to 2013 to attend emergency management conferences and conduct interviews with emergency and water resource managers and other experts at the federal, state, and local levels. This stage employed ethnographic techniques of observation and conversation to better appreciate the shared construction of roles within emergency management networks (Bevir and Richards 2009). Approximately 40 people involved in managing flood and water hazards were asked about how they encountered climate forecasts and how they decided whether to use them.

In the second phase, the authors contacted via email all 62 Oregon emergency managers and related officials listed on the Oregon Office of Emergency Management's contact list for 2012 (excluding metro Portland) to determine the officials' willingness to be interviewed. Fourteen officials did not respond to two email requests for interviews, making it impossible to know if they used forecasts, but were too busy to respond, or did not see the relevance of forecasts to their work. For the other 48 individuals who responded positively, the authors followed up with another email presenting 10 specific questions about their experience with using climate forecasts. Of these 48 interviewees, many of whom work in areas of the state with weaker climate signals, few saw the relevance of climate forecasts to their work. All told, only 2 of the 48 emergency managers who were interviewed reported using climate forecasts that led them to take action before a flood.

The authors then proceeded to conduct in-depth interviews of officials in these two counties (Yanow and Schwartz-Shea 2013, p. 170) and consult government documents and news reports from different sources (Yanow and Schwartz-Shea 2013). The authors also conducted formal interviews and had informal conservations with other officials related to emergency management, at universities, in state and federal offices, and at the 2012 and 2013 state-level emergency management meetings in Oregon to gather contextual information and establish credibility.

The study focused on Oregon because the climate signals are strong in the western part of the state, and coastal watersheds lack significant runoff storage capacity (Wernstedt and Hersh 2002). In addition, project team members have worked in Oregon before and are familiar with the geography and the emergency management community.

All emergency and water resource managers that were interviewed indicated that they were aware of the El Niño and La Niña phenomena, and some seemed able to make sense of the forecasts maps and tables linking a strong La Niña year to increased probability of flooding in some areas. As noted earlier, however, few appeared able to translate this knowledge into action to prepare for floods.

Findings: Climate Forecast Use in Rural Oregon

Emergency managers in two very different Oregon counties, Lane and Harney, both used climate forecasts to better prepare for winter storms in 2010–2011. The different experiences and different contexts of the two counties highlight the common factors that allowed both to buck the odds that made other counties in the state nonusers of climate forecasts.

Lane County, Oregon

In fall of 2010, Lane County emergency manager Linda Cook (personal communication, 2012) learned that it was a La Niña year. She learned about climate and weather forecasts by attending an Oregon-specific National Weather Service briefing in the fall as well as subscribing to NOAA winter outlook emails, and attending web meetings with weather service officials from Oregon. The weather service is the "most trusted" and "objective" of all these sources, according to Cook (personal communication, 2012). "Any decisions we make around weather have to be defensible," she said. Since "it involves public safety," she explained that she wanted to make decisions about how to prepare for floods based on evidence and not intuition alone.

As the winter of 2010 began, full riverbanks confirmed the weather service forecast: it was going to be a wet winter. Cook (personal communication, 2012) organized a preparedness meeting for officials in Lane County where she walked through the weather outlook for the season. Based on weather service seasonal forecasts, she told attendees to be on the lookout for heavy snowpack followed by a warming trend: a recipe for flooding. The attendance list shows that 54 people from the county's public agencies attended. Cook left it up to each agency to decide how to prepare. Some agencies checked river gauges, while others monitored the weather more closely. All were more attentive to developing winter conditions.

The fact that the meeting occurred at all was testament to Cook's foresight and initiative. Oregon emergency managers had been operating under tight resource constraints in recent years, even as their portfolio had expanded to include new threats such as terrorism and active shooters. Oregonians take the active shooter threat seriously, especially since a 2012 shooting at Clackamas Town Center mall that killed two people and seriously injured a third (Oregon Emergency Management Association 2014). In 1984, Oregon was the site of what may be the nation's first bioterrorism attack, when a cult sickened 751 people by contaminating salad bars in 10 restaurants in The Dalles, Oregon, in hopes that voters not sympathetic to the cult's candidates would be forced to stay home on election day (Keyes 2014).

After the World Trade Center and Pentagon terrorist attacks of 2001, Lane County officials participated in a number of workshops designed to build bridges in emergency management across agencies and across the state, but money for those activities dried up as the terrorist threat receded. "After 9-11 we had a lot of meetings and relationship building, but now we don't have as much time

for relationship building," Cook (personal communication, 2012) said. Deciding to hold a county winter preparedness meeting required the initiative of an emergency manager who was persuaded by the climate and weather forecasts and who thought that it was worth her time to call attention to the forecasts and encourage the participation of county agencies. In Oregon, cities often have to go through counties to access state resources; therefore, city offices in Lane County looked to Cook to help access disaster and emergency related funds. In this regard, Oregon counties have more legal authority and capacity than counties in some other states. Cook (personal communication, 2012) also noted that Oregon county emergency managers typically plan for at least eight outreach events per year. The emergency manager's network coordination function is institutionalized at least as far as planning these eight events.

Cook's campaign to draw attention to the seasonal forecasts did not stop with one meeting for public agencies. She spoke to community groups about the winter weather, foregoing technical language and focusing on the potential consequences of a wet winter and increased flooding, and then addressing what particular communities might do to prepare. Some could monitor river gauges. Others could think about elevating homes and other structures. Still others might purchase flood insurance. Cook had spoken to some of these groups before, including about 70 people in the unincorporated town of Marcola, Oregon, along the flood-prone Mohawk River. In Springfield, Cook spoke to a group of women new to the area, all of whom wanted to better understand the region's hazards.

In the end, Lane County was spared severe flood damage despite heavy rains and runoff in the winter of 2010–2011. The specter of La Niña and the associated climate forecasts drew attention to winter weather preparations, and officials followed by taking action. Some checked river gauges in their regions, and others simply monitored the weather more closely to be ready to shore up defenses or move out of harm's way before a flood. Lane County government is relatively large and well resourced compared to other Oregon counties, and climate forecasts served primarily to focus attention before the winter storms. The Lane County emergency manager recognized that her turf was the coordination of public agencies and community groups before winter storms arrived. She was open to new information beyond her operational realm, and seasonal climate forecasts predicting the increased likelihood of downpours and early snowmelt as well as the resonance of the term La Niña contributed to her decision to take action. Cook was skilled enough to be able to connect the forecast to actions that public managers and concerned citizens could take. Even so, the forecasts left a lot to Cook's (personal communication, 2012) interpretation, intuition, and discretion. "It would be nice to know more about the confidence level of the [seasonal climate] forecasts," she said. "We need better information on that. It would also be useful to have a one-page fact sheet on the science behind La Niña, about what is happening, and what to do, and relate that to climate change. We could also put La Niña in an operations plan, and show a La Niña forecast and a series of actions in response." Cook used the forecast to help identify a danger, and to make her case for taking action, but how and when she took action were left to her discretion. When it comes to organizing actions, the domain of emergency management is more important than climate and weather science.

In Lane County, however, scientific consultation was institutionalized as part of emergency management practice. Cook routinely read weather service briefings and publications from emergency management professional associations, but she was more deliberate in seeking scientific support for her actions when the stakes were high. Consultation with scientific authorities became a "situated preparedness" practice that was repeated at least annually but could be adapted to a new situation (Baker 2014). For example, 2 years later following a winter weather meeting, Cook (personal communication, 2012) asked the weather service for specific predictions about the likelihood and consequences of flooding before ordering the evacuation of the Mapleton and Mohawk River areas (Lane County Hazard Mitigation Committee 2012, p. 40).

Harney County, Oregon

The second case of climate forecast use appeared in Harney County that same 2010–2011 winter, but occurred in a very different context. Lane is a county of 350,000 people that extends from the Pacific Ocean to the Cascades, with roughly one-half of the county along the Interstate 5 corridor and relatively urban, and the other one-half stretching west to the Pacific Ocean through rural timber country. In contrast, Harney is an entirely rural county east of the Cascades, far from the major interstate. It has a population of 7,422, and it is the ninth largest county in area in the United States, a combination that gives it an average density of one person per square mile. The differences between the counties extend to politics, too. While Lane County has a majority of Democrats, Harney like other eastern Oregon counties has a majority of Republicans (Allen 2014). In addition, Lane County has a professional emergency manager, while in Harney a county judge wore the emergency manager's hat in addition to his other duties. (In 2012, the county hired a full-time emergency preparedness coordinator.)

Officials from the National Weather Service (NWS) joined with the state emergency management office to instruct local officials in Harney County in "thinking about climate" before winter weather set in. NWS officials in the state had been conducting winter weather meetings for about a decade. "At first we did some promoting, saying here's what we can tell you, but now the word's out," said Andy Bryant, a hydrologist with NOAA in Portland (A. Bryant, personal communication, 2012). Emergency managers throughout Oregon know and attend National Weather Service briefings in person or via webcast. Climate scientists in NOAA offices in Washington, DC and elsewhere outside of Oregon produce forecasts at the decadal, annual, and seasonal scales, and the NWS specializes in short-term to medium-term timescales of less than a season. NWS officials in each state are the messengers for this information, explaining its meaning and relevance for people in particular regions.

Presentations included seasonal climate forecast data provided by the National Weather Service's Climate Prediction Center. Les Miller (personal communication, 2012), chief of the Army Corps of Engineers Readiness Branch in Portland, Oregon, recalls giving a presentation about the La Niña year and its implications for providing the *fuel* for potential floods as snowpack accumulated and melted and as riverbanks swelled. The relationship between La Niña conditions, increased snowpack, and the increased likelihood of flooding in some regions requires complex, probabilistic reasoning that is normally the provenance of experts. However, given context, a causal story about the effects of the climate signals, and having had experience with floods, "locals understood it," Miller said. Miller is known as "Mr. Sandbag" for his advocacy of portable, easily assembled barriers that can be automatically filled with sand, an advance over heavy traditional sandbags (Feder 2002). He was known for using barriers to mount a flood fight, and perhaps his presence at the meetings provided a particularly visible connection between climate forecasts and the actions that people could take.

Officials in Harney County huddled after the weather meeting. Among these officials was County Judge Steve Grasty, who also served as emergency manager. Grasty reasoned that a flood was likely enough that he should take action. He used his local knowledge of the conditions and terrain coupled with the La Niña forecast to take preemptive flood damage prevention measures beginning in

January 2011 to protect Burns, the county seat and largest city, with 2,800 residents. Grasty alerted public officials and community groups to take action, and in January they checked river gauges and fortified defenses along the Silvies River more intensely than usual, and they repeated these actions in April and May when water overtopped the banks.

As predicted, the winter of 2010 brought heavy rains combined with a large snowpack in the mountains. By May 18, the river poured over its banks and onto streets and highways, and the county declared a state of emergency. Officials rerouted traffic around the flooded roads, but the swelling river threatened approximately 100 homes and businesses as it seeped over a dike along Broadway Avenue, a main thoroughfare (Parks 2011). The situation had worsened, and it was time to move from preparing for the flood to responding. Grasty and others organized sandbagging efforts to protect homes and business in the center of town. "Once it started, the county and city were on it," Randy Parks, editor of the *Burns Times-Herald* recalls. As the flood waters rose, the county had to move the water away from roads and structures, or relocate infrastructure. "There were several ideas on how, and where, to move the water and a portion of the highway was cut and a culvert put in" (R. Parks, personal communication, 2013). Volunteers pitched in much of the labor, and the city provided much of the equipment and some of the people who led the effort.

The city's saints and sinners pitched in; relief crews included church groups and parolees. Harney County Parole and Probation supervisor Darrell Williams led his crew through the town's ditches to pull out limbs, bushes and trash, and cut fences to increase the flow of water through the ditches and away from people and property. Williams also contributed to the sandbagging effort. "I've been cursed, cussed and called everything in the book by people in both the town and county," Williams said. "Some people said we did too much, others said we didn't do enough" (Parks 2011). Residents whose fences were cut open to increase the flow of water were taken aback by the crew, but in the end the daring measures proved wise since they spared the town greater flood losses. No one at the County Court meetings questioned the wisdom of a flood fight, but some did question its expense, and even Grasty noted the toll it took on a small county. "It's taxing both the people and the money," Grasty said at a county court meeting in May (Raney 2011).

If the flood fight effort was so costly and risked the ire of residents, how did the county manage to prepare itself long before the event, and be ready when the waters rose? Collaborative leadership in the county was one key. Grasty, the county judge since 1999, used his knowledge of the terrain and its hazards to make the call for extra attention and effort to fight a potential flood. The decision proved wise, as flood losses were negligible that year despite heavy rains and snow melt and waters that breached levees. The winter weather information was one piece of information among several that led the country to take action to prepare for the flood, and preparation weeks in advance led to a flood fight during the event.

While Grasty exercised great judgment that winter, he was part of a county that was well embedded in larger governmental and emergency management networks. Harney County paid attention to emergency management, even though the county court, the central governing body, had its plate full with other business. The county was planning to hire a full-time emergency manager in the fall, and, in December, it advertised for the position (Harney County Court 2011b). Harney was also in the planning stages of a Silvies Watershed Risk Map Partnership agreement with FEMA. This involved voluntary efforts between the county and FEMA to share data, communicate findings, and plan mitigation activities to reduce citizens' exposure to hazards, and particularly floods (Harney County Court 2011a). Furthermore, in November 2011 Harney County began a sister county relationship with Clackamas County, just outside Portland, the first such arrangement in Oregon. Both counties have large swaths of rural land and hoped to learn from one another. Clackamas County Commissioner Jamie Damon said, "As I talked with the County Court there, I realized we could really benefit in Clackamas County with having a relationship with a more rural county so we can learn what they're doing to overcome issues" (Zheng 2011; Harney County Court 2012). Grasty himself had served as president of the Oregon Association of Counties and had established relationships across the state.

Networked organizational forms such as Oregon's emergency management system are vulnerable when one node in the network is replaced or a network tie cut. It can be difficult to institutionalize complex network tasks such as the use of climate forecasts in preparing for floods over the long term. Even though Grasty turned over emergency management operations to a new manager, Harney County successfully institutionalized its use of climate forecasts along with a range of emergency management network tasks. By the fall of 2012, the county hired a full-time Emergency Preparedness Coordinator, Tom Sharp. Though Sharp did not have the same top-level government experience as Grasty, he did continue to use seasonal climate forecasts and was able to marry scientific information with knowledge of local conditions. "I use those [seasonal climate forecasts]. It's one bit of data that is a package we use to prepare for floods . . . including looking at other things like the snowpack," Sharp (personal communication, 2012) said. "I make a call for the county about whether conditions are such that we would see a flood. In 2012–2013, I said no, we wouldn't, and we've seen a drought." Sharp makes the call about whether to take action before a flood by advising the county commissioners and Judge Grasty, who turned over day-to-day emergency management duties to Sharp. "I like data driven decisions," he said. If he had predicted a flood, Sharp said, he would have taken a closer look at actions that would mitigate its effects, such as shoring up the same levees that were breached in the 2011 floods and monitoring river levels and rates of flow along the Silvies River. Sharp had long owned property in Harney County, but the MBA graduate spent the bulk of his career working for an electric company in Portland before moving to Harney County full time in 2007 and focusing on cattle ranching. Sharp's work provides evidence that the use of climate forecast was institutionalized in Harney County, beyond a season or two and beyond the tenure of any single public official.

Findings: Forecast Use in Two Counties

Despite the differences, both Lane and Harney County managed to use climate forecasts to aid flood preparation. Lane County experienced heavy rains and runoff but not severe flooding, while precipitation and snowpack runoff were so heavy in Harney that the county mounted a flood fight even after taking steps to prepare and mitigate.

It would not be possible to control for all possible confounding variables that led these counties to incorporate climate forecasts in their preparations for flood hazards, but it is possible to think about the most important factors as independent variables, and to gather data on these. The dependent variable in the case studies is the use of climate forecasts. Use covers a wider range of activities than simple influence (Goggin et al. 2014, p. 2; Kirkhart 2000; Pulwarty and Redmond 1997). For example, public managers could use climate forecasts to draw attention to flood preparation, to change the minds of the emergency manager or politicians about a decision, or to ratify and support a decision that emergency managers

Table 1. Network Characteristics

County	Lane	Harney
Turf	Long-term preparation and warning to protect the county from flood damages (with much of the implementation left to others)	Long-term preparation and warning to protect the county from flood damages (with much of the implementation left to others)
Tools	Moderate development of ENSO forecast products	Moderate development of ENSO forecast products
Capacity	Moderate level of county resources, highly networked emergency management structure	Low level of county government resources; highly networked emergency management structure
Framing	Climate forecasts as warning tied to locally specific or agency-specific actions	Climate forecasts as warning tied to locally specific or agency-specific actions

or politicians had already made. In Lane County, Cook used climate forecasts as part of a package of information that called attention to the likely severity of the coming winter and the propensity for flooding. In Harney County, Grasty used climate forecasts in conjunction with information from others including representatives from the National Weather Service and Army Corps of Engineers to develop a picture of the flood danger for the year and to motivate action around flood preparations. The network governance concepts introduced in the theory portion of the paper and summarized in Table 1 offer concepts that aid in interpreting how and why managers used climate forecasts in flood fights in both cases.

Turf

Emergency managers in both counties envisioned their role as to provide flood warnings each season to public officials primarily, but also to citizens. How an emergency manager conceives of her role in relation to the people, organizations, and terrain around her is a process of defining turf. The county's top politicians were an important audience in both cases since they could provide additional resources and political support for actions in advance of a flood or during a flood fight. Jay Wilson (personal communication, 2012), the hazard mitigation coordinator for Clackamas County, described the emergency manager's role as one of speaking truth to power. "You are there to stand up to and talk to your decision makers and bring up things that are out of sight and out of mind," he said. In both Lane and Harney counties, the emergency manager conceived of his role as calling attention to the problem of floods as indicated by the region's vulnerability, the visible signs of rain and snowpack, and the predictions offered by climate forecasts.

Tools

While Oregonians have been familiar with the El Niño and La Niña phenomena for decades, climate forecasts as tools have improved gradually since then. The first time a newspaper mentioned El Niño in connection with disaster assistance in Oregon was 1963, when the governor blamed a poor fishing season on the effects of El Niño (Bacon 1963). The governor asked the Small Business Administration for disaster assistance because of the storm's effects on fisherman along Oregon's coast. Since then, the science of seasonal forecasts has progressed, and by the 1980s scientists had identified correlations between El Niño, La Niña, and wetter and drier than average seasons in some areas. While La Niña is typically associated with wetter conditions in Oregon, the El Niño of 1983 was so unusually strong that it affected weather patterns in California and in the southern part of the Oregon. That year, El Niño became a widely recognized cultural phenomenon and made headlines as an explanation for the state's record rainfall in some areas, and the *Eugene Register-Guard* listed it as one of the 10 biggest news events of the year (Wyant 1984). Giant waves crashed against the shoreline, the salmon seemed to disappear from rivers, and the central part of the state experienced record rainfall and its first white Christmas since 1924. "We were due for a dry year–and we didn't get it. I think El Niño has to be the reason," Bill Isabel, meteorologist at Mahlon Sweet weather station said in 1983 (Wyant 1983). By the 1990s and 2000s, state climatologists began to refer to ENSO regularly in their seasonal forecasts. The terms also became more common to the public, and the Lane County fair now features an amusement ride called the El Niño (Bolt 2010; Photo 2015).

"If the Cascade mountains were a line of dancers, right now they'd be what you call scantily clad," the Eugene *Register Guard* told readers in the winter of 2010. "Blame it on El Niño, the weather phenomenon driven by abnormally warm water in the central Pacific Ocean" (Bolt 2010). By 2010, the conventional wisdom had become that El Niño winters will be dry, and La Niña winters will be wet. Most emergency managers worked roughly at this level of interpretation according to evidence gathered from interviews, and this may be enough to spur action, but the tools of climatology have advanced beyond these broad correlations. It is unclear, however, whether emergency managers require or could make use of more fine-grained predictions.

During the 1990s and 2000s, the Climate Prediction Center's forecasts gradually incorporated increasingly sophisticated ENSO measures showing the relationship between La Niña and the increased likelihood of precipitation in particular regions of Oregon. The National Weather Service's Climate Prediction Center generated forecast data, usually presented as maps listing higher, lower, or "equal chances" probabilities of precipitation in a season for a given region. These forecasts are specific enough that they can highlight a region's vulnerability during a La Niña year, and, just as important, they are produced by the well-respected National Weather Service, which routinely ranks high on lists of government agency reputations (Fine 2009).

Capacity

Lane and Harney counties both have well-developed emergency management networks that extend beyond the counties, but they differ in their relative capacity. Lane extends over a smaller area, and it includes the relatively dense town of Eugene, home of the University of Oregon. Harney is Oregon's largest county in size, and it is relatively sparse and far from population centers. Lane had a full-time emergency manager, while Harney created a full-time position only recently. Both counties relied on climate and weather information provided by federal officials located in Oregon. While these connections were maintained by the Internet and telephone, they also included in-person meetings and briefings. Emergency mangers in both counties were well networked, rather than operating alone. Emergency managers in both counties also conceived of their job as calling attention to a problem and working with climate and weather experts, public officials, citizens, and county political leaders to devise appropriate actions in response.

It remains difficult to capture the attention of elected and appointed politicians, however, since they have more immediate problems than preparing for natural disasters on a seasonal timescale. Oregon state legislator Tobias Read (2013) explained that "One of the shortcomings of the political system is that we tend to be attracted to things that pay off in the short term, usually coinciding with elections, but not in the long term." Read is one of Oregon's advocates for hazard mitigation, but his exceptional concern is a case that proves the rule that the political system rewards politician who can provide benefits that constituents can realize by election time (Fiorina 1989).

The emergency managers in Lane and Harney had earned the trust of politicians through their long and well-respected service to the county. As an elected county judge, Grasty carried the authority of his office, and also bore more of the political risk. Emergency managers can also bring the trust placed in other institutions into their work. In the interviews, officials responsible for hazards management repeatedly mentioned the credibility of the National Weather Service or the state climatologist as important in convincing citizens and public officials to take action in response to a forecast of seasonal flooding.

Framing

With limited resources under their direct control, emergency mangers in both cases framed climate forecasts in combination with other information as a warning about the likelihood of severe flooding. The interviews provided evidence that emergency managers were more likely to use climate information if it was tied to a seasonal and geographically specific forecast, and if it was tied to a specific threat, such as melting snowpack and a specific area relevant to their responsibilities and in which they could intervene. In practice, the facts must be interpreted and framed as information that is legitimate and feasible.

Cook and Grasty tied the warning to specific actions that made sense to their multiple audiences. As a number of studies of the policy process have observed, policies are not made in the abstract: they are routed through particular interpretive communities (Majone 1989; Yanow 1993). Residents want to know whether they should purchase flood insurance, prepare flood barriers, or prepare to evacuate before a likely period of flooding. The school district superintendent and facilities managers want to know whether they will have to cancel school, open shelters, and offer volunteers for sandbagging. (High school students were particularly helpful and physically robust volunteers in Harney County.) Climate forecasts rarely if ever will impel action by themselves, but they may raise actions only under contemplation above a threshold to actual implementation. Seasonal climate forecasts do not automatically outweigh other factors, but they might tip the balance in favor of action when presented with other information such as a history of floods in the same area, basin-specific flood loss estimates, and information about river flows and snow pack.

Sometimes, framing is a matter of getting people's attention. Marion County emergency management community coordinator Erik Anderson (personal communication, 2012) follows weather and climate forecasts, but his job is to encourage community members to prepare for floods. "We have to make it [the threat of flooding] real to them," he explained. "Coming from a government official, they [community members] might take it more seriously." Anderson uses verbal persuasion as well as graphic imagery; he has shown videos of devastating tsunamis to managers of nursing homes to alert them to what might happen if they are not prepared. Climate forecasts are not self-interpreting; therefore, they must be provided as part of a larger picture of flood risks tied to specific actions relevant to the audience. The *boots on the ground* work of emergency managers may require startling imagery and appeals to crisis to capture people's attention.

Discussion: The Current Status of Climate Forecasts Across Oregon

Climate forecasts are distributed through NOAA's Climate Prediction Center website to anyone with access to the Internet. They also are issued to emergency managers and related officials through in-person and electronic National Weather Service briefings. When asked why they do not incorporate climate forecasts into their emergency management routines, the managers gave a variety of answers relating to competing pressures and the difficulty of interpreting the information. Some were more worried about other hazards, such as tsunamis. Others thought that the climate forecasts were not accurate enough to provide enough information to take action. "When we have damaging floods in both [La Niña and non-La Niña years], how do we go back to elected officials and say we need to prepare?" one emergency manager asked during the interviews.

Despite widespread skepticism about forecast accuracy and utility, emergency managers generally praised the National Weather Service (NWS) and welcomed more climate and weather forecasts. "The best thing the Weather Service does is their webinar program," one emergency manger told us. NWS offices in Oregon schedule webinars when they anticipate a seasonal or other change in weather that could increase the possibility of disaster losses. The emergency managers praised the webinars' timeliness on a seasonal or sooner scale, and their use of graphics. One emergency manager added that, "It doesn't help when they [the NWS] start using the weather lingo." By "weather lingo," emergency managers referred to the language of probability used in the forecasts. The term "equal chances" was too equivocal for managers to use it to justify a decision. The equivocation is intentional, however, since climate forecasts are often uncertain, and emergency managers should base their decision to take action on other factors. Sometimes the actions they take are important no matter what the forecasts.

Even if emergency managers wanted to use climate forecasts to justify actions, their political superiors may be reluctant to devote additional resources to prepare for events on a seasonal or annual timescale. "I get the sense that they [the board of commissioners] don't care about looking at 3π6 months out. They are worried about budgets, department heads with a problem, that sort of thing," one emergency manager said. From the point of view of politicians, annual emergency management budgets reflect the county's priorities, and politicians use reserve or additional funds for very immediate crises. Yet, studies have found that prevention and mitigation activity can save money in the long run. According to a study of FEMA grants between 1993 and 2003, a dollar spent by FEMA on hazard mitigation saved the nation about $4 in future benefits (Multihazard Mitigation Council 2005). Convincing politicians to take advantage of these benefits has proven difficult, however (Roberts 2006, 2009).

Conclusion: Challenges to the Use of Climate Forecasts

Seasonal forecasts have progressed in scientific accuracy, but emergency managers sometimes still scratch their heads about how to use these forecasts in practice because the predictive context of science is different than their decision context. One state official puzzled that, "60% call that it's wet, and that means 40% that it's

not. Do you make a huge decision based on that? I hate the equal chances product on the CPC [Climate Prediction Center] website. People misinterpret that as average. People don't think in terciles" (A. B. Smith, personal communication, 2012). Nevertheless, "equal chances" and terciles appear in seasonal climate forecasts for a reason—the science detects a high degree of uncertainty in future outcomes.

The National Weather Service acknowledges the difficulty with translating nuanced forecasts into practice by communicating the data behind climate forecasts as a single "wet winter" prediction for a region. NWS officials in Portland and Medford, Oregon said that their audiences find the language of climate forecasts confusing. Other interviews confirmed that seasonal predictions of "equal chances," "a little above normal," and "a lot above normal" caused confusion among people responsible for flood and emergency management because these terms were not connected to particular actions. Ryan Sandler, the Warning Coordination Meteorologist at the Medford, Oregon NWS office said that NWS officials sometimes responded to the confusion by summing up the seasonal forecasts with a single weather prediction for winter. "It's more when we have a strong La Niña that we say it's going to be a wet winter, and we use the years," R. Sandler (personal communication, 2012) said.

In addition to this mismatch between the predictive and decision context of climate and emergency management, concepts from network governance help explain some of the obstacles to the effective use of seasonal climate information. Because emergency managers have relatively few resources under their direct control, they rely on activating other parts of the emergency management network over which they may not have formal control. This was a problem in the preparations for and response to Hurricane Katrina in 2006 in the southern United States, and it plays out on a smaller scale in flood events that occur every year. Without large budgets or large staffs, emergency managers rely on other assets. The persuasiveness of scientific information is one asset, and the trust they inspire in others is another. Taken together, these two assets compelled officials to take action in Lane and Harney counties, but they apparently were not enough in other parts of the state.

Why were Lane and Harney so different from other counties? One difference is that they institutionalized trusted networks to receive, interpret, and publicize climate forecast information to a degree that other counties did not. Previous work on the use of scientific information found that it is difficult to move from science to action "because of the lack of trust that prevails between stakeholders. Governments and scientists still often dismiss the contribution of local communities, while communities and NGOs are frequently suspicious about governments and scientists' intentions" (Gaillard and Mercer 2013, p. 99). The mistrust might stem from the fact that scientists and mangers have different goals and therefore different appetites for uncertainty. Perhaps the forums that Lane and Harney counties used to interpret information helped develop a form of trust by building networks according to the steps outlined in Table 1 (including thinking in terms of common problems and tools, having a technical solution and capacity, and framing a solution). Urban counties are likely to have capacity at equal or greater levels than Lane and Harney, and future research should investigate whether the dense environment of urban counties offers resources that make use of scientific information more likely, or if the density creates obstacles because decision processes in urban areas are more complicated. The Portland emergency manager cannot easily call a winter weather meeting and have nearly all relevant officials in the county fit into one room.

Not all counties have emergency managers with the technical capacity to interpret climate forecasts or even pay attention to seasonal issues when they have more immediate concerns. The Newport, Oregon emergency manager is a staff member of the police department, for instance, and most of his emergency management priorities concern protecting the fishing fleet off the coast. The county's emergency manager said that he is open to the idea of using climate forecasts in his work, but he does not use them currently because he has so many other concerns (Newport Emergency Manager, personal communication, 2012). "I just have a few patrol cars that drive around town, not a battalion of emergency managers," he said. Most Oregon counties have emergency managers that wear multiple hats and have little time for long-term hazard mitigation or seasonal climate forecasts.

In Lane and Harney counties, emergency managers had access to sufficient technical capacity to interpret the forecasts and took action to mitigate potential damages, but this is not always the case. In other counties in Oregon, emergency managers acknowledged paying attention to climate forecasts but did not acknowledge using them as part of seasonal preparations. In some of these cases, emergency managers said that they relied on other information to identify the increased likelihood of flooding and additional action. As one long-time emergency manager put it, "Most people that have been around here know what stream gauges are and what they mean." In other words, palpable information about high streamflows or increased snowpack in the mountains was more likely to persuade others to take action than the vagaries of climate science.

While the forecasts do not carry the weight of a *smoking gun* in convincing others, that may be too much to ask of complex scientific information in a managerial context. The debates over climate change suggest that complex scientific information alone is too uncertain to provoke action for most people. In many cases, complex scientific information may be only a justification after the fact for actions that emergency managers would take anyway. A state fire official told the authors that he read seasonal climate forecasts as part of a package of information used to prepare for forest fires, but he was skeptical that the information mattered at the operational level. He said that, "These guys are firefighters. It's the adrenaline rush that drives them. They are going to do what they are going to do. If they can find scientific information, forecasts that have scientific authority that support what they are going to do, then they will use it because of the aura of science and authority." The official described much of the seasonal forecast information as "eyewash" beyond the single binary category of La Niña or not a La Niña year. Many emergency managers share the fire official's skepticism toward scientific information even as they respect its authority.

Seasonal climate forecasts were more than eyewash in Lane and Harney counties. They contributed to the recognition of an increased likelihood of floods, and they helped emergency mangers convince others to take action. The utility of seasonal climate forecasts like other complex scientific information should not be oversold, however, even if the science is convincing. The capacities of particular emergency managers and their counties matter as much or more than the forecasts for motivating action. Emergency managers who take seriously their role in motivating others to take action before a disaster, who are well networked, and who have adequate capacity to interpret and communicate about hazards and disasters and tie that information to specific actions, appear to be most likely to use seasonal climate forecasts, and most likely to have the tools required to prepare their counties for hazards and disasters.

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